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Effect of Posphorus and different irrigation regimes on the yield and yield components of maize (*Zea mays* L.)

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Proper amount of irrigation water along with the adequate supply of macronutrients play an important role in increasing yield and yield components of maize crop. This study was undertaken to determine the growth and yield response of maize under different levels of irrigation viz.3 irrigations, 5 irrigations,6 irrigations, 7 irrigations and three levels of phosphorus in sub plot (60, 90, 120 kg ha^{-1}). Results showed that full irrigation enhanced leaf area index (2.1), stem diameter (2.00), grain weight per cob (124.71g), 1000- grain weight (0.29 kg). whereas phosphorous application at the rate of 120 kg ha^{-1} had improved 1000 grain weight (0.28 kg), grain yield (141.73 mounds/ha), grain yield (5.66 t ha^{-1}) and biological yield (15.73 t ha^{-1}).Our results showed that irrigation level I_4 with combine application of phosphorous treatment P_3improved yield and yield components.

Key Words: irrigation levels, Drought, vegetative stage, Phosphorus, Zea mays.

INTRODUCTION

Maize (*Zea mays* L.) belongs to family poaceae and has an important position in crop husbandry because of its short duration and high yield potential. It is an important cereal crop and ranks 3rd in grain production after wheat and rice in worldwide. In Pakistan, maize contribution in total food grains production is about 6.4%. It is cultivated on an area of 1085 thousand hectares with total annual grain production of 4631 thousand tons and average grain yield is 4268 kg ha^{-1}. The major maize growing provinces are Punjab and KPK which contribute the bulk (98%) of the total production and remaining 2% is produced in the provinces of Sindh and Balochistan. While in Khyber Pakhtunkhwa it accounts for 57% of the total area under cultivation with 68% of total grain production while Punjab with 38% area under cultivation contributes 30% of total grain production (GOP, 2013). It has high nutritional value as it contains about 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 1.7% ash (Chaudhary, 1993). Efficient use of scarce water resources though improved irrigation techniques has been the focus of investigations during the past two decades. Water is essential for every phase of development starting from seed germination to maturity. Plant growth and survival depends on adequate water availability, it is required to provide constant turgor pressure which supports the plant and facilitates cell enlargement. Growth results from cell division and cell enlargement which involves extensibility of cell wall. Low water availability inhibits growth which leads to the reduction of individual leaf area that may be considered to be plant's first line of defense against drought, so under limited water supply growth becomes dependent upon the rate of water supply (Jones, 1992). Water stress inhibits the growth, development and contributes towards the grain yield instability. On other hand, under scarce and costly water supplies, it may sometimes be advantageous to stress the crop to some degree. The water stress certainly reduces the crop yield to some extent but it will remain economically feasible as long as the marginal benefit from reduced cost of water is equal or greater than marginal cost of reduced yield (Oteguі*et al*., 1995). Water being a scarce commodity in Pakistan is to be used efficiently for maximum potential yield (Li-ping *et al*., 2006). Maize cultivars required large quantities of water seasonally for each developmental stage starting from seed germination to plant maturation (Rashid and Rasul, 2010). The water deficit at grain filling stage can decrease the maize yield about 33% by affecting the 1000-grain weight, grain yield, harvest index and water use efficiency (Sajjedi*et al*., 2009). The most important sensitive period of water stress and has ultimate impact on final grain yield is the heading to milking stage (Hussaini*et al.,* 2008).Maize crop having higher potential than other cereals absorb large quantity of nutrients from the soil during different growth stages. Among the essential nutrients, P is used for higher yield in large quantity (Chen *et al.,* 1994) and controls mainly the reproductive growth of plant (Wojnowska*et al.,* 1995). It is needed for growth, utilization of sugar and starch, photosynthesis, cell division, fat and albumen formation. Energy from photosynthesis and the metabolism of carbohydrates is stored in phosphate compound for later use in growth and reproduction (Ayub*et al.,* 2002). Phosphorous is necessary in large quantities, in meristematic tissues, where cells are rapidly dividing and enlarging (Brady and Weil, 2002). Phosphorus deficiency is wide spread in Pakistani soils its deficiency is about 90%. The application of phosphatic fertilizers is considered essential for crop production and its deficiency will slow overall plant growth (Rashid and Memon, 2001). Cob yield is not adversely affected by the excess Phosphorous, this practice has led to increased production costs and may have negative effects on the environment (Schaffer and O'Hair 2001). The objectives of study were to evaluate the effect of different irrigation and phosphorus levels on growth and productivity of maize. To determine the interactive effect of irrigation and phosphorus levels on the growth and yield of maize.

MATERIALS AND METHODS

The hybrid maize R-2303 was planted 75 cm apart rows on ridges with the help of labour using a seed rate of 25 kg ha^{-1}. The P × P distance was maintained approximately 20 cm by thinning out the surplus plants at four leaf stage. The experiment was conducted at University of Agriculture, Faisalabadduring July, 2012 and laid out in Randomized Complete Block Design with split plot arrangement having three replications with a net plot size of 3.0m x 6.0m.Four irrigation levels were usedI_1: 3 irrigations (1st at grand vegetative stage, 2nd at silking stage and 3rd at soft dough stage)I_2: 4 irrigations (1st at grand vegetative stage, 2nd at tasseling, 3rd at silking, 4th at soft dough stage) I_3: 6 irrigations (1st at grand vegetative stage, 2nd at tasseling, 3rd at silking, 4th at soft dough stage, 5th at hard dough stage, 6th at physiological maturity) I_4: 7 irrigations (1st at grand vegetative stage, 2nd at tasseling, 3rd at silking, 4th at soft dough stage, 5th at hard dough stage, 6th at physiological maturity and 7th at grain filling stage). Three Phosphorous levels (60, 90, 120 kg ha^{-1}) were applied. Leaf area index, Stem diameter, Grain weight per cob, 1000- Grain weight, Grain yield ha^{-1}, Grain yield ton ha^{-1}, Biological yield ton per ha^{-1} were measured.

$$\text{LAI} = \frac{\text{Leaf area plant}^{-1}}{\text{Ground area } (0.94\ \text{m}^{-2})}$$

$$\text{Biological yield} = \frac{\text{Biological yield } (\text{t ha}^{-1})}{\text{Row –row (75 cm) distance x Row length(5) x No.of rows (2)}} \times 1000$$

$$\text{Grain yield} = \frac{\text{Grain yield t ha}^{-1}}{\text{Row –row (75 cm) distance x Row length(5) x No.of rows (2)}} \times 1000$$

Statistical Analysis

The data were analyzed statistically using the Fisher's analysis of variance. Least significant difference (LSD) test at 5% probability level was used to compare the differences among treatments' means when F-value is significant for observations (Steel *et al.,* 1997).

RESULTS AND DISCUSSION

Statistical analysis of the data revealed that irrigation levels and foliar application of boron had highly significant effect for all the parameters.

Leaf area index

Statistical analysis showed that Irrigation and Phosphorous levels significantly affected LAI while the interactions were non-significant.

Maximum leaf area index (2.1) was recorded in irrigation treatment I_4 and minimum leaf area index (1.3) was observed in irrigation treatment I_1. These results confirm the findings of Mansouri-Far *et al*., (2010) who reported that in maize crop LAI was significantly reduced when the water deficit occurred. Maximum leaf area index (1.8) was found in phosphorous level P_3 and minimum leaf area index (1.5) was found in phosphorous level P_1. These results are in agreement with Ayub*et al*., (2002) who observed significant effect of phosphorous application on leaf area.

Stem diameter

Stem diameter was significantly affected by Irrigation and phosphorous levels. Maximum stem diameter (2.00) was obtained in irrigation treatment I_4 and minimum stem diameter (1.93) was obtained in irrigation treatment $I_{1.}$These results are in line with the finding of Shah (2001) who reported that stem diameter significantly increased with increased in irrigation. Maximum stem diameter (1.98) was obtained in phosphorous level P_3 treatment (120 kg ha^{-1}) and minimum stem diameter (1.95) was obtained in phosphorous level P_1treatment (60 kg ha^{-1}). Turk *et al*., (2002) who observed that Plants receiving inadequate phosphorous may show different deficiency symptoms such as dwarf growth and purpling of the leaves. Interaction between irrigation levels and phosphorous levels were found to be non-significant.

Grain weight per cob

Irrigation levels significantly affected Grain weight per cob while the interactions were non significant. Maximum value for grain weight per cob (124.71g) was obtained in irrigation treatment I_4 and minimum grain weight per cob (114.04 g) was obtained in irrigation treatment $I_{1.}$ Roy and Tripathi (1987) reported that increasing irrigation frequency significantly increased in grain weight per cob.

1000- Grain weight:

Analysis showed that irrigation and phosphorous levels significantly affected 100-Grain weight.

Irrigation treatment I_4 gave maximum value for 1000-grain weight (0.29 kg) and minimum value was observed in irrigation treatment I_1 for 1000-grain weight (0.25 kg). Shah (2001) observed that 1000-grain weight significantly increased with higher irrigation frequencies. Similarly Maximum 1000 grain weight (0.28 kg) was obtained in phosphorous level P_3 treatment (120 kg ha^{-1}) and minimum 1000-grain weight (0.26 kg) was obtained in phosphorous level P_1 treatment (60 kg ha^{-1}). Leon (1999) who observed that 1000-grain weight significantly affected by phosphorous rates. Interaction between irrigation levels and phosphorous levels were found to be non-significant (Table 1).

Grain yield per hectare:

Phosphorous and irrigation levels have highly significant affect on grain yield per hectare. Maximum grain yield (151.39mounds/ha) was obtained in irrigation treatment I_4 and minimum grain yield (129.69 mounds/ha) was obtained in irrigation treatment I_1. Similarly Maximum grain yield (141.73 mounds/ha) was obtained in phosphorous level P_3treatment (120 kg ha^{-1}) and minimum grain yield (139.02 mounds/ha) was obtained in phosphorous level P_1treatment (60 kg ha^{-1}). Interaction between irrigation levels and phosphorous levels was found to be significant. Wajid (1990) reported that the enhancement in the yield of maize crop is actually due to the proper amount of irrigation at the right time. Rehman*et al*., (1983) reported that application of DAP and NP in full dose at the time of sowing to maize produced maximum yield.

Grain yield t ha^{-1}:

Grain yield t ha^{-1} was found to be significant for irrigation and phosphorous levels. Maximum grain yield (6.05 t ha^{-1}) was obtained in irrigation treatment I_4 and minimum grain yield (5.18 t ha^{-1}) was observed in irrigation treatment $I_{1.}$Whereas maximum grain yield (5.66 t ha^{-1}) was obtained in phosphorous level P_3 and minimum grain yield (5.56 t ha^{-1}) was found in phosphorous level P_1 (60 kg ha^{-1}). Interaction between irrigation levels and phosphorous levels was found to be significant. Karam*et al*., (2003) reported that drought reduce grain yield significantly. Turk *et al*., (2002) reported that plants receiving inadequate phosphorous may show different deficiency symptoms such as dwarf growth and purpling of the leaves.

Biological yield (t ha^{-1}):

Irrigation levels showed significant results for biological yield (t ha^{-1}). Maximum biological yield (16.79 t ha^{-1}) was found in irrigation treatment I_4 and minimum biological yield (14.5 0 t ha^{-1}) was in irrigation treatment I_1.These results are supported by the work of Wajid (1990) and Shah (2001) who reported that biological yield and dry matter yield increased significantly by increasing irrigation frequencies.

Similarly phosphorous have highly significant affect on biological yield. Maximum biological yield (15.73 t ha^{-1}) was obtained in phosphorous level P_3 treatment (120

Table 1. Effect of phosphorous, irrigation and their interactions for all parameters.

	Leaf Area Index	Stem Diameter	Grain Weight per cob	1000-grain weight	Grain Yield per hectare	Grain Yield t ha^{-1}	Biological Yield t ha^{-1}
I_1	1.3 B	1.93 B	114.04 C	0.25 D	129.69 C	5.18 C	14.50 C
I_2	1.6 AB	1.96 B	117.61 BC	0.27 C	137.78 BC	5.51 BC	15.17 BC
I_3	1.8 A	1.95 B	121.60 AB	0.28 B	142.14 AB	5.68 AB	16.13 AB
I_4	2.1 A	2.00 A	124.71 A	0.29 A	151.39 A	6.05 A	16.79 A
LSD	0.482	0.035	4.89	9.153	9.69	0.387	1.250
P_1	1.5 C	1.95 B	117.91 C	0.26 C	139.02 C	5.56C	15.58 C
P_2	1.6 B	1.95 B	119.42 B	0.27 B	140.00 B	5.60 B	15.64 B
P_3	1.8 A	1.98 A	121.14 A	0.28 A	141.73 A	5.66 A	15.73 A
LSD	0.083	0.010	0.572	5.100	0.588	0.023	0.040
P_1 x I_1	1.2	1.93	112.97	0.24	128.67 e	5.14 i	14.45
P_1 x I_2	1.5	1.95	115.93	0.26	136.97 d	5.47 g	15.11
P_1 x I_3	1.7	1.93	119.71	0.26	141.33 c	5.65 e	16.03
P_1 x I_4	1.9	1.98	123.03	0.28	149.20 b	5.96 c	16.72
P_2 x I_1	1.2	1.92	113.92	0.25	129.60 e	5.18 i	14.50
P_2 x I_2	1.5	1.95	117.51	0.26	137.70 d	5.50 g	15.16
P_2 x I_3	1.7	1.95	121.75	0.28	141.87 c	5.67 e	16.11
P_2 x I_4	1.9	2.00	124.49	0.29	150.93 b	6.03 b	16.78
P_3 x I_1	1.4	1.95	115.23	0.26	130.87 e	5.23 b	14.55
P_3 x I_2	1.8	1.97	119.38	0.28	138.80 d	5.55 f	15.25
P_3 x I_3	2.0	1.98	123.33	0.29	143.30 c	5.73 d	16.26
P_3 x I_4	2.3	2.03	126.60	0.30	154.13 a	6.16 a	16.87
LSD	NS	NS	NS	NS	1.177	0.047	NS

kg/ha) and minimum biological yield (15.58 t ha^{-1}) was obtained in phosphorous level P_1 treatment (60 kg ha^{-1}). These results are also supported by the work of Ahmed (1989) who reported that biological yield increased significantly with application of phosphorous. Interaction between irrigation levels and phosphorous levels was found to be non-significant.

CONCLUSION

From the above results it was concluded that irrigation level I_4: 7 irrigations (1st at grand vegetative stage, 2nd at tasseling, 3rd at silking, 4th at soft dough stage, 5th at hard dough stage, 6th at physiological maturity and 7th at grain filling stage) with combination of P_3 increased yield and yield components of hybrid R-2303.

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