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Influence of Different Irrigation Methods and Band Placement of Nitrogen on Maize Productivity

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ABSTRACT

Agro-physiological response of a maize hybrid R-2205 to irrigation *viz*. flood irrigation, furrow irrigation and alternate furrow irrigation and nitrogen application by broadcast method and band placement was studied during the autumn season of 2001. Furrow irrigation method with band placement of N considerably increased leaf area plant-1, CGR, NAR, number of grains cob-1, 1000-grain weight and grain yield of maize. Application of irrigation by furrow and flood methods enhanced grain yield by 91.91 and 83.02%, respectively over alternate furrow irrigation method, and band placement of N increased grain yield by 6.72% than broadcast method.

Key Words: Maize; Irrigation; Nitrogen

INTRODUCTION

Maize (*Zea mays* L.) is widely grown in Pakistan as a spring and autumn crop. Moisture supply is an important determinant of crop yield and it is associated with many developmental processes in plants. Efficient use of scarce water resources through improved irrigation techniques has been the focus of investigations during the past two decades. Furrow-bed method of irrigation saves considerable quantity of water and improves the fertilizer-use efficiency through line source application (Choudhry *et al*., 1994). According to Kemper *et al*. (1975) irrigation by flooding water over the entire field results in leaching down the nitrates from the root zone causing loss of fertilizer. Over irrigation often leads to greater leaching loss of fertilizer and thereby reduces the final plant height, dry matter accumulation and grain yield of maize (Mahal *et al*., 2000). Furrow irrigation permits more efficient use of irrigation water as compared to other surface irrigation systems (Khan *et al*., 1998). Selvaraju and Iruthayaraj (1993) reported that application of irrigation water in furrows gave higher LAI, CGR, NAR and grain yield of maize than alternate or paired skip furrow irrigation. Fischbach and Mulliner (1974) obtained similar corn yield with alternate-furrow and every-furrow irrigation. However, water stress reduced plant height, leaf area plant^{-1}, production of assimilates, CGR, leaves plant^{-1}, grains cob^{-1}, grain weight cob^{-1} and 1000-grain weight (Mcpherson & Boyer, 1977; Grant *et al*., 1989; El- Noemani *et al*., 1990).

Maize is a nitrogen positive crop. Placement of fertilizer is an integral part of efficient crop management. It can affect both crop yield and nutrient-use efficiency (Johnston & Flower, 1991). Rafique and Afzal (1982) reported that banding of nitrogen fertilizer was superior to broadcast method. Band application of fertilizer gave higher yield than broadcast and incorporation (Hussain, 1976; Khattak *et al*., 1988). While some researchers have reported that fertilizer application either by broad or placement methods did not affect growth, yield, yield components and grain protein content of maize. (Faungfupong & Sakhunkhu, 1985; Girardin *et al*., 1992; Klepker & Anginoni, 1996).

Keeping the above information in view, the present study was planned to determine the effect of different irrigation methods and nitrogen application techniques on agro-physiological traits of maize.

MATERIALS AND METHODS

The study was conducted at the research area of Agronomy Department, University of Agriculture, Faisalabad during the autumn season, 2001. The experiment was laid out in a randomized complete block design with factorial arrangement in three replicates. The net plot size was 3.6 x 7.5 m. The irrigation methods comprised flood irrigation (I1) furrow irrigation (I2) and alternate furrow irrigation (I3), while nitrogen was applied by broadcast method (N1) and band placement (N2).

The crop was sown by dibbling method on 6th of August, 2001 on a well prepared seedbed in 90 cm apart double row strips, using the seed of a maize hybrid R-2205. A basal dose of 200 kg N + 100 kg P2O5 ha^{-1} was applied to the crop. Full dose of phosphorus and 1/3 of nitrogen was applied at the time of sowing in the form of triple super phosphate (TSP) and urea, respectively. The remaining 1/3 of nitrogen was applied at knee height and 1/3 at tasseling stage. In all, seven irrigations were applied to mature the crop. First irrigation was applied 15 days after sowing while subsequent were given as and when required. Irrigation water to each plot was applied using a cut throat flume

(3'x8" size) installed in the water course. The time required to irrigate the plot and flow rate were recorded to estimate the amount of water applied to each plot. The depth of water applied to each plot was calculated using the following formula

$$d = Qt/A$$

Where 'd' is the depth in inches 'Q' is the discharge in cusecs, 't' is the time in hours and 'A' is the area in acres. The amount of water applied, however, varied according to time taken under each method of irrigation. At four leaf stage plant to plant distance of 15 cm was maintained in all the plots. All other agronomic practices were kept normal and uniform for all the treatments under study. The crop was harvested on 8th of November, 2001 at full maturity.

Observations on growth and yield components *viz*. leaf area plant^{-1}, seasonal CGR, average NAR, grains cob^{-1}, 1000-grain weight, and grain yield were recorded using standard procedures. CGR and NAR were determined by using the formulae of Beadle (1987). The data collected were statistically analyzed using Fisher's analysis of variance technique and least significant difference (LSD) test at 5% probability level was employed to compare the treatment's means (Steel & Torrie, 1984).

RESULTS AND DISCUSSION

Volume and depth of water applied to each irrigation treatment are given in Table I. All the irrigation methods received same number of irrigation (7). However, total amount of water applied to flood, furrow and alternate furrow irrigation consisted of 685.9, 488.8 and 276.6 mm, respectively (Table I). Furrow and alternative furrow irrigation methods saved about 29 and 59% of irrigation water as compared with flood irrigation.

Leaf area plant^{-1}. Both irrigation methods and nitrogen application techniques had significant effect on leaf area plant^{-1} (Table II). Significantly the highest leaf area plant^{-1} (5311.26 cm^2) was recorded in furrow irrigated plots closely followed by flood irrigation method (5106.34 cm^2), against significantly the lowest (3883.02 cm^2) in case of alternate furrow irrigation method. Probably the crop grown with alternate furrow irrigation did not receive the water that fulfilled its requirements which resulted in reduced leaf area plant^{-1}. These results are in conformity with those of Mcpherson and Boyer (1977), El-Noemani (1990) and Selvaraju and Iruthayaraj (1993).

Band placement of N gave significantly higher leaf area plant-1 (4886.54 cm^2) than that recorded for broadcast method (4647.20 cm^2). It was probably due to the better utilization of N by plants in this method. However, Faungfupong and Sakhunkhu (1985) reported that different fertilizer application methods did not affect leaf area plant^{-1} significantly.

The interactive effects of irrigation methods and nitrogen application techniques on leaf area plant-1 were non-significant.

Crop growth rate (CGR). The crop irrigated by furrow method exhibited significantly the maximum seasonal crop growth rate (CGR) of 20.15 g m^{-2} d^{-1} which was closely followed by flood irrigation method (19.67 g m^{-2} d^{-1}), against the minimum (12.43 g m^{-2} d^{-1}) in alternate furrow irrigation method. Slower growth in alternate furrow irrigation was due to the reduced DW plant^{-1} because of decreased plant height (data not shown) and leaf area plant^{-1}. Similar results were reported by Mcpherson and Boyer (1977) and Selvaraju and Iruthayaraj (1993). Band placement of N gave significantly higher seasonal CGR (17.67 g m^{-2} d^{-1}) than broadcast method (17.15 g m^{-2} d^{-1}). The increase in CGR in band placement was due to increased leaf area and DW plant^{-1}. These results are contradictory to those of Faungfupong and Sakhunkhu (1985) and Klepker and Anghinoni (1996) who reported that different fertilizer application methods did not affect CGR significantly. The interactive effects of both the factors were non-significant.

Net assimilation rate (NAR). Irrigation methods had significant effect on net assimilation rate. The maximum and statistically similar average NAR of 8.80 and 8.78 g m^{-2} d^{-1} were recorded in the crop irrigated by furrow and flood systems of irrigation, respectively, against significantly the minimum of 8.18 g m^{-2} d^{-1} in alternative furrow irrigation system. An increase in NAR in response to furrow irrigation might be due to enhanced DW plant^{-1} as NAR is directly related to the size of the vegetative cover of the plant. These results are quite in line with those of Mcpherson and Boyer

Table I. Volume (m^3) and depth (mm) of water applied per treatment

Irrigation	Flood irrigation		Furrow irrigation		Alternate furrow irrigation	
	Volume (m^3)	Depth (mm)	Volume (m^3)	Depth (mm)	Volume (m^3)	Depth (mm)
First (Full)	2.46	61.11	1.72	63.70	1.72	63.70
Second	2.46	91.11	1.72	63.70	0.88	31.85
Third	2.81	104.07	2.03	75.18	1.02	37.78
Fourth	2.94	108.89	2.16	80.00	1.08	40.00
Fifth	2.88	106.67	1.99	73.70	0.99	36.67
Sixth	2.60	96.30	1.84	68.15	0.93	34.44
Seventh	2.37	87.78	1.74	64.44	0.87	32.22
Total	18.52	685.93	13.20	488.87	7.42	276.66

*Volume and depth of irrigation water from post emergence to maturity

Table II. Role of different irrigation methods and nitrogen placement on the growth and yield of maize

Treatments	Leaf area plant^{-1} ((cm^2)	Seasonal CGR (g m^{-2} d^{-1})	Average NAR (g m^{-2} d^{-1})	Number of grains cob^{-1}	1000-Grain weight (g)	Grain yield (t ha^{-1})
I_1 = Flood irrigation	5106.337b	19.667b	8.780a	384.322b	218.450b	6.788b
I_2 = Furrow irrigation	5311.265a	20.152a	8.800a	394.183a	230.018a	7.123a
I_3 = Alternate furrow irrigation	3883.017c	12.432c	8.180b	338.032c	189.453c	3.708c
LSD (5%)	121.500	0.4584	0.0576	7.392	2.030	0.04068
N_1 = Broadcast	4647.206b	17.146b	8.560b	362.741b	204.220b	5.682b
N_2 = Band placement	4886.540a	17.688a	8.610a	381.617a	221.061a	6.064a
LSD (5%)	-	-	-	-	-	-
I_1N_1	5006.430	19.483	8.790	375.013	209.613d	6.583d
I_1N_2	5206.423	19.850	8.800	393.630	227.287b	6.993b
I_2N_1	5151.590	19.833	8.770	384.050	223.277c	6.870c
I_2N_2	5470.940	20.470	8.830	404.317	236.760a	7.377a
I_3N_1	3783.597	12.120	8.150	329.160	179.770f	3.593f
I_3N_2	3982.437	12.743	8.210	346.903	199.13e	3.823e
LSD (5%)	*NS*	*NS*	*NS*	*NS*	*2.870*	*0.05753*

NS= non-significant; CGR- Crop growth rate; NAR= Net assimilation rate

(1977) and Selvaraju and Iruthayaraj (1993). By contrast, nitrogen placement methods had non-significant effect on NAR which varied from 8.56 to 8.61 g m^{-2} d^{-1}.

Number of grains cob^{-1}. Irrigation by different methods had significant effect on the number of grains cob^{-1}. The crop irrigated by furrow method produced significantly the maximum number of grains cob^{-1} (394.18) followed by flood irrigation method (384.32), while significantly the minimum number of grains cob^{-1} (338.03) was recorded by alternate furrow irrigation method. Less number of grains cob-1 in alternate furrow irrigation might be due to water stress. These results are in conformity with the findings of Grant *et al*. (1989).

Nitrogen placement techniques also had significant effect on grains cob^{-1}. Significantly more number of grains cob^{-1} (381.62) was recorded for the crop given fertilizer by band placement against the minimum of 362.74 in broadcast. More grains cob^{-1} under band placement was probably due to better utilization of N by plants. The results reported by Girardin *et al*. (1992) are not in line with these findings.

1000-Grain weight. There was significant difference in 1000-grain weight among irrigation methods. The crop irrigated by furrow system produced higher 1000-grain weight (230.02 g) followed by flood irrigation system, as against 218.45 g per 1000-grain in case of alternate furrow irrigation system. Reduction in grain weight under alternate furrow irrigation system was probably due to enhanced water stress. These results are supported by the findings of El-Noemani *et al*. (1990).

Nitrogen placement techniques also affected the 1000-grain weight to a significant level. Band placement of N fertilizer produced significantly heavier grains than the placement by broadcast. These results are in agreement with those of Rafique and Afzal (1982).

The interactive effects of irrigation methods and nitrogen application techniques on 1000-grain weight were also significant. The crop irrigated by furrow irrigation system and given nitrogen by band placement (I2N2) gave significantly the maximum 1000-grain weight of 236.76g.

Grain yield. Furrow irrigation system produced significantly higher grain yield (7.12 t ha^{-1}) than other two methods which also differed significantly from each other and produced grain yield of 6.79 and 3.71 t ha^{-1}, respectively. Higher grain yield under furrow irrigation was associated with higher grain number cob^{-1}, more 1000-grain weight and higher grain weight cob^{-1}. These results are supported by the findings of El-Noemani *et al*. (1990), Selvaraju and Iruthayaraj (1993) and Mahal *et al*. (2000) but are contrary to those of Fischbach and Mulliner (1974).

Band placement of nitrogen produced significantly higher grain yield (6.06 t ha^{-1}) than broadcast application (5.68 t ha^{-1}). It might be due to more N uptake by plants. Similar results were reported by Hussain (1976), Rafique & Afzal (1982) and Khattak *et al*. (1988). However, contradictory results were reported by Faungfupong and Sakhunkhu (1985), Girardin *et al*. (1992) and Klepher and Anghinoni (1996).

The interactive effects of both the factors under study were also significant. The crop irrigated by furrow method and applied nitrogen by and placement produced significantly the highest grain yield of 7.38 t ha^{-1}. While the crop irrigated by alternate furrow system and given nitrogen by broadcast gave significantly the lowest grain yield of 3.59 t ha^{-1}.

CONCLUSION

The results led to the conclusion that maize should preferably be irrigated by furrow method with nitrogen to be applied by band placement.

REFERENCES

Beadle, C.L., 1989. Plant growth analysis. *In: Techniques in Bio productivity and Photosynthesis.* 2nd Ed., Coombs, J., D.O. Hall, S.P. Long and J.M.O. Scureock (eds.), pp: 21–3. Pergamon Press, Oxford, New York.

Choudhry, M.R., A.D. Choudhry, S. Akbar, M. Iqbal and M. Asif, 1994. Water and fertilizer conservation by improved irrigation methods. *Pakistan J. Agri. Sci.,* 31: 87–90.

El–Noemani, A.A., A.K.A. El-Halim and H.A. El-Zeiny, 1990. Response of maize (Zea mays L.) to irrigation intervals under different levels of nitrogen fertilization. *Egyptian J. Agron.,* 15: 147–58 *(Irri. and Drain. Absts.,* 19: 259; 1993).

Faungfupong, S. and S. Sakhunkhu, 1985. Effect of tillage systems and methods of fertilizer application on maize productivity. *Kasetsart J.,* 19: 173–9. *(Field Crop Absts.,* 39: 5651; 1986).

Fischbach, P.E. and H.R. Mulliner, 1974. Every-other furrow irrigation of corn. *Trans. ASAE,* 17: 426–8.

Girardin, P.H., R. Trendel, J.J. Meyer, M. Biraentazle and P. Freyss, 1992. Effect of conventional and multiple N application by fertilization on maize grain yields and NO_3-N residues. *Developments in Plant and Soil Sci.,* 53 (*Field Crop Absts.*, 47: 7016; 1994).

Grant, R.F., B.S. Jackson, J.R. Kiniry and G.F. Arkim, 1989. Water deficit timing effects on yield components in maize. *Agron. J.,* 81: 61–5.

Hussain, L.A., 1976. The yield of maize as influenced by NP level and their method of application. *M.Sc. (Hons.) thesis*, Univ. of Agric., Faisalabad, Pakistan.

Johnston, A.M. and D.B. Flower, 1991. No–till winter wheat production: Response to spring applied N fertilizer form and placement. *Agron. J.*, 83: 722–8.

Kemper, W.D., W. Clyma, R. Ali and G. Haider, 1975. Water management and nitrogen fertilizer movement and utilization in soils. *Annual Progress Report. Water Management Res. Project.* CSU, Fort Collins. USA.

Kelpker, D. and I. Anghinoni, 1996. Fertilizer placement and maize nutrient uptake and yield under different soil cultivation techniques. *Pesquisa Agropecuaria Gaucha,* 2: 79–86 *(Field Crop Absts.,* 51: 860; 1998).

Khan, F.H., N.A. Rai, J.K. Sial and I. Ahmad, 1998. Effect of different irrigation techniques on seed cotton yield. *Sci. Tech. Dev.,* 17: 39–42.

Khattak, M.J., M. Anwar and M. Shah, 1988. Evaluation of methods of NPK fertilizers to maize crop. *Sarhad J. Agric.,* 4: 349–54.

Mahal, S.S., D.G. Dejenu and M.S. Gill, 2000. Growth and yield of maize (*Zea mays* L.) as influenced by flood under different planting methods and nitrogen levels. *Env. Ecology,* 18: 789–92 (*CAB Absts*., 2000).

Mcpherson, H.G. and J.S. Boyer, 1977. Regulation of grain yield by photosynthesis in maize subjected to water deficiency. *Agron. J*., 65: 714–6.

Rafique, M. and M. Afzal, 1982. Efficiency of nitrogen sources and placement methods for increasing productivity of wheat. *J. Agric. Res.,* 20: 17–24.

Selvaraju, R. and M.R. Iruthayaraj, 1993. Effect of irrigation scheduling, methods of irrigation and nitrogen levels on growth analysis parameters of maize. *Madras Agric. J.,* 80: 562–5 *(Field Crop Absts.,* 49: 1561; 1996).

Steel, R.G.D. and J.H. Torrie, 1984. *Principles and Procedures of Statistics.* McGraw Hill Book Co. Inc., Singapore. Pp: 173–7.

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