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RESEARCH PAPER

Performance of hybrid maize at different irrigation levels and spacing under subsurface drip irrigation

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Abstract : A field experiment was conducted during *Rabi* season, 2013 to study the effect of different levels of irrigation and crop geometry on growth parameters, yield attributes and yield of maize. Progressive increase in yield attributes like cob length, cob girth, kernel weight per cob and hundred grain weight was observed due to increased irrigation levels from I_1 (IW: CPE ratio of 0.6) to I_3 (IW: CPE ratio of 1.0). IW: CPE ratio of 1.0 produced significantly higher grain and stover yield which was at par with I_2 (IW: CPE ratio of 0.8). With regard to crop geometry, yield attributes like longest cobs, highest cob girth, higher kernel weight per cob and increased hundred seed weight were obtained at a spacing of 30/90 x 20 cm which was at par with 60 x 20 cm and higher grain yield was obtained at a spacing of 30/90 x 20 cm.

Key Words : Irrigation, Crop geometry, *Rabi* maize

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INTRODUCTION

Water scarcity is an increasingly important issue in many parts of the world. Climate change predictions of increase in temperature and decrease in rainfall mean water will become even scarcer. Since agriculture is the major water user, efficient use of water in agriculture is needed for the conservation of this limited resource. Increase in water use-efficiency (WUE) for enhanced drought tolerance can be achieved by strategies like change to crops capable of producing acceptable yields under deficit irrigation or rainfed situations (Zwart and Bastiaanssen, 2004 and Farre and Marya, 2006).

Maize (*Zea mays* L.) is a miracle crop. Globally maize is the third most important cereal grain crop after wheat and rice. Maize is gaining popularity among the farmers in India due to its versatile characteristics of suitability and adaptability to various agro-climates. Maize is the most efficient coarse cereal crop species in utilizing radiant energy and has the highest capacity to generate carbohydrates per day as compared to other cereals. The crop is less susceptible to environmental hazards and cost of production per kg of grain is less compared to other cereals, which lead to drawing the attention of the farmers of Andhra Pradesh and India.

In India it is cultivated in an area of 8.71 million hectares with grain production of 21.57 million tones and productivity of 2476 kg ha^{-1} (*www.indiastat.com*). In Andhra Pradesh it is cultivated in an area of 0.86 million

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hectares with grain production of 3.7 million tonnes and productivity of 4232 kg ha^{-1}. Maize yield is a function of climate, soil, variety and cultural practices. Correlating these functions to produce the highest possible yields with the greatest efficacy has been the aim of research workers ever since the maize production began. Since there is a limited scope to increase the area under maize cultivation because of competition from other cereals and commercial crops, the only alternative is through increasing the productivity of maize by various management factors. Among the factors limiting the grain yield of maize in many areas is inadequate irrigation and low plant population.

Water is the prime natural resource, which is often costly and limiting input particularly in semi arid tropics and needs judicious use to reap the maximum benefit of other inputs. Drip irrigation plays an important role in water limiting areas by maintaining the optimum soil moisture in soil root zone with increased yield and provides the efficient use of limited water with higher water use efficiency. The utilization of water by crop varies with different irrigation levels and methods. Optimum irrigation levels with suitable plant density would help in enhancing both the grain and fodder yields of maize apart from higher water use efficiency.

In addition to irrigation management, optimum plant population also play crucial role in enhancement of crop productivity. It is an established fact that higher yield depends on optimum plant population and adequate nutrient application, particularly nitrogen. In addition to plant population, it is the proper crop geometry which is important from the point of intercepting sunlight for photosynthesis besides efficient use of plant nutrients and soil moisture. Correlating these functions to produce the highest possible yields with greatest efficiency has been the aim of research workers since maize production began. Therefore, matching irrigation schedule with optimum plant stand is essential to achieve targeted yields.

MATERIAL AND METHODS

A field experiment was conducted during *Rabi*, 2013 at college farm, S.V. Agricultural College, Tirupati, Acharya N.G. Ranga Agricultural University. The soil of the experimental site was sandy clay loam and it was slightly alkaline in reaction with a pH of 7.9, electrical conductivity of 0.24 dSm^{-1} and low in organic carbon (0.29%) and available nitrogen (186 kg ha^{-1}), medium in available phosphorus (23.4 kg P_2O_5 ha^{-1}) and high in available potassium (174.3 kg K_2O ha^{-1}). The experiment was laid out in a Split Plot Design and replicated thrice. The treatments consisted of three IW:CPE ratios of 0.6, 0.8and 1.0 and four crop geometries *viz.,* 60 x 15 cm, 30/90 x 15 cm, 60 x 20 cm and 30/90 x 20 cm. Maize hybrid DHM-117 which matures in 100-105 days was tested in this experiment. Recommended dose of fertilizers (150, 60 and 40 kg N, P_2O_5 and K_2O ha^{-1}) was applied. Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and muriate of potash. Nitrogen was applied in three splits *i.e.,* one fourth at the time of sowing, half at 35 DAS and one fourth at tasseling stage. The entire phosphorus and potassium were applied as basal at the time of sowing. Atrazine @ 1.5 kg *a.i.* ha^{-1} was applied as pre-emergence followed by one hand weeding at 30 DAS. Irrigation was given based on IW: CPE ratio and a total of 4, 5 and 6 irrigations had been given to IW: CPE ratio of 0.6, 0.8 and 1.0, respectively.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Growth parameters :

Growth parameters like plant height, leaf area index and dry matter production were recorded higher with IW: CPE ratio of 1.0 (I_3) which was at par with IW: CPE ratio of 0.8 (I_2). The lowest values were recorded with IW: CPE ratio of 0.6 (I_1) (Table 1). Increase in plant height might be due to optimum soil moisture availability favouring the nutrient uptake, resulting in better growth of the crop (Ertek and Kara, 2013). Increase in LAI might be due to the beneficial effect of adequate soil moisture in maintaining the cell turgidity and cell elongation, thus, producing more leaf area (Bharati *et al.*, 2007). Higher dry matter production could be mainly attributed to increased plant height and higher leaf area maintained throughout the crop period resulting in enhanced carbohydrate synthesis (Kumar *et al.*,2006).

Plants of tallest stature, higher LAI and highest dry matter production were observed with a spacing of 60 x 15 cm (G_1) and 30/90 x15 cm (G_2) with no significant difference between them. The next best treatment was 60 x 20 cm (G_3) and 30/90 x 20 cm (G_4) resulted in the lowest values of all these attributes. As the mutual shading increases at high plant densities, the plant tends to grow taller (Aravinth *et al.*, 2011). Increase in LAI was due to increased plant density which accommodates more number of plants per unit area thereby increased the functional leaves and in turn enhanced the LAI (Wasnik *et al.,* 2012). Higher drymatter production might be due to more plant height and increased LAI (Aravinth *et al.*, 2011).

Interaction effect was significant with respect to plant height and dry matter production at 60 DAS and I_3G_1 (irrigation at IW: CPE ratio of 1.0 along with a spacing of 60 x 15 cm) resulted in the highest plant height and dry matter production and the lowest values were recorded with I_1G_4 (irrigation at IW: CPE ratio of 0.6 along with a spacing of 30/90 x 20 cm). This might be due to increased availability of nutrients in the presence of sufficient soil moisture and by maintaining higher plant density, which would have stimulated the crop growth leading to increased plant height and dry matter production (Choudhary *et al.*, 2006).

Days to 50 per cent flowering :

Early flowering occurred with the highest level of irrigation tried *i.e.* I_3 (IW: CPE ratio of 1.0), which was however, comparable with I_2 (IW: CPE ratio of 0.8) but significantly lesser than with those under I_1 (IW: CPE ratio of 0.6), which resulted in delayed flowering (Table 1). This might be due to better growth of the crop which favoured early cessation of vegetative growth leading to earlier initiation of reproductive phase as reported by Jain *et al*. (1989). Less number of days for 50 per cent flowering was recorded with G_4 (30/90 x 20 cm), which was significantly lesser than with all other spacings tried. This was followed by G_3 (60 x 20 cm) and significantly lesser than with G_2 (30/90 x 15 cm) and G_1 (60 x 15 cm), which were at par with each other, which has resulted in delayed flowering. Translocation of food materials from source (leaf) to sink (reproductive parts) was more with low plant density. Plants in low density level produced early flowering because of vigorous growth due to less competition among the plants, thereby inducing early flowering (Wasnik *et al.*,2012).

Yield attributes :

Higher cob length, cob girth, kernel weight per cob and hundred seed weight were recorded with IW: CPE ratio of 1.0 (I_3) and IW: CPE ratio of 0.8 (I_2) with no significant difference between them. IW: CPE ratio of 0.6 (I_1) resulted in lowest values of all the yield attributes (Table 2). Higher cob length might be due to more vigorous and luxuriant vegetative growth, which in turn favoured a better partitioning of assimilates from source to sink (Ertek and Kara, 2013). Reduced cob girth at I_1 might be due to water stress resulting in poor growth due to the restriction imposed on nutrient translocation, photosynthesis and metabolic activity in the plant system

Table 1: Growth parameters at harvest and days to 50 per cent flowering as influenced by different irrigation levels and spacing

Treatments	Plant height (cm)	Leaf area index (LAI)	Dry matter production (g)	Days to 50 per cent tasselling	Days to 50 per cent silking
Irrigation levels					
0.6 (I_1)	184.9	0.56	7454.4	57.38	64.83
0.8(I_2)	200.6	0.84	9120.4	56.32	63.83
1.0(I_3)	207.6	0.89	9627.4	55.99	63.63
S.E.±	2.1	0.03	203.5	0.09	0.07
C.D. (P=0.05)	8.4	0.12	799.0	0.35	0.28
Spacing					
60 x 15 cm (G_1)	204.5	0.81	9191.4	56.93	64.41
30/90 x 15 cm (G_2)	199.9	0.83	9148.0	56.77	64.28
60 x 20 cm (G_3)	194.2	0.75	8451.2	56.36	63.92
30/90 x 20 cm (G_4)	192.2	0.66	8145.7	56.18	63.78
S.E.±	1.2	0.04	161.6	0.06	0.05
C.D. (P=0.05)	3.5	0.11	480.0	0.18	0.19
Interaction					
C.D. (P=0.05)	NS	NS	NS	NS	NS

NS= Non-significant

(Ertek and Kara, 2013). Higher kernel weight per cob and hundred seed weight might be due to better growth of crop, efficient dry matter partitioning and better translocation to the sink, leading to the formation of large sized grains (Bharathi *et al.*,2007 and Salah *et al.*, 2008).

Among the crop geometry practices tried, the highest yield parameters were recorded with G_4 (30/90 x 20 cm), which was at par with G_3 (60 x 20 cm). The next best treatment was G_2 and G_1 (60 x 15 cm) with no significant difference between them, which produced the lowest values of all the yield parameters. This might be due to better growth of individual plant in low density populations and resultant utilization of accumulated photosynthates influenced the growth and development of yield attributes (Tyagi *et al.*,1998 and Narayanaswamy and Siddaraju, 2011).

Regarding the interaction effect, I_3G_4 (irrigation at IW: CPE ratio of 1.0 along with a spacing of 30/90 x 20 cm) resulted in the highest kernel weight per cob. This might be due to reduced competition among the plants due to decreased plant density along with sufficient moisture prevailing in the soil leading to higher kernel weight per cob (Salah *et al.*, 2008).

Yield :

The higher grain and stover yield were recorded with the highest level of irrigation tried *i.e.*, IW: CPE ratio of 1.0 (I_3), which was, however, comparable with IW: CPE ratio of 0.8 (I_2) but significantly higher than with IW: CPE ratio of 0.6 (I_1), which has resulted in lowest yield (Table 2). Higher grain yield due to irrigation might be accounted to their favourable influence on the crop growth and yield attributes (Ertek and Kara, 2013). The increased stover yield might be due to better vegetative growth and higher dry matter production (Choudhary *et al.*,2006).

As regards the crop geometry practices, highest grain yield was recorded with a spacing of 30/90 x 20 cm (G_4), which was at par with 60 x 20 cm (G_3) followed by 30/90 x 15 cm (G_2) and G_1 (60 x 15 cm) with no significant difference between them, which produced the lowest grain yield. As plant density increased, changes may occur in the allocation of assimilates to different plant parts as a result of which a greater proportion of plants may become barren and also there may be a critical period for light in relation to grain formation at higher population levels (Singh *et al.*, 2012). Higher stover yield was recorded with G_1 (60 x 15 cm), which was comparable with G_2 (30/90 x 15 cm). The next best treatment was G_3 (60 x 20 cm) which was at par with G_4 (30/90 x 20 cm) which produced the lowest stover yield. This is due to increased number of plants per unit area and increased growth of plants *i.e.*, plant height, leaf area, drymatter production (Singh *et al.*, 2012).

The interaction effect of irrigation levels and crop geometry practices with respect to grain yield was

Table 2 : Yield attributes and yield of maize as influenced by different irrigation levels and spacing

Treatments	Cob length (cm)	Cob girth (cm)	Kernel weight per cob (g)	Hundred seed weight (g)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
Irrigation levels						
0.6 (I_1)	15.8	15.4	78.0	20.8	2615	4079
0.8(I_2)	18.7	16.2	104.7	25.0	4658	6489
1.0(I_3)	19.8	16.4	110.0	27.0	4919	6753
S.E.±	0.4	0.1	2.3	1.0	87	140
C.D. (P=0.05)	1.4	0.2	8.9	3.9	343	551
Spacing						
60 x 15 cm (G_1)	17.0	15.8	92.5	22.6	3483	6079
30/90 x 15 cm (G_2)	17.2	15.8	93.7	23.1	3553	6023
60 x 20 cm (G_3)	18.9	16.1	101.3	25.3	4575	5501
30/90 x 20 cm (G_4)	19.2	16.2	102.5	25.8	4644	5491
S.E.±	0.1	0.1	0.4	0.3	26	18
C.D. (P=0.05)	0.3	0.1	1.2	0.8	78	56
Interaction						
C.D. (P=0.05)	NS	NS	Sig.	NS	Sig.	Sig.

NS= Non-significant

significant, with the highest yield being produced with I_3G_4 (the highest level of irrigation in combination with a spacing of 30/90 x 20 cm) and I_1G_1 (the lowest level of irrigation in combination with a spacing of 60 x 15 cm) recorded the lowest yield. This is due to more cobs ha^{-1} under adequate moisture availability which had direct bearing on the production of highest yield (Salah *et al.*, 2008). The interaction effect of irrigation levels and crop geometry practices with respect to stover yield was significant, with the higher stover yield being produced with I_3G_1 (the highest level of irrigation in combination with a spacing of 60 x15 cm) and I_1G_4 (the lowest level of irrigation in combination with a spacing of 30/90 x 20 cm) produced the lowest stover yield. It was due to increased leaf area index and leaf area duration at harvest (Choudhary *et al.*,2006).

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