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Effect of Irrigation Schedules and Planting Densities on Growth Parameters of Maize

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ABSTRACT

A field experiment entitled "Response of maize to irrigation at different planting densities under late *rabi* conditions" was conducted during *rabi*, 2021-2022 on sandy loam soils of the Agricultural College Farm, Bapatla. The experiment was laid out in split plot design with four main plots and three sub plots and replicated thrice. The treatments consisted of four irrigation levels: M_1: 1.2 IW/CPE Ratio, M_2: 1.0 IW/CPE, M_3: 0.8 IW/CPE, M_4: 0.6 IW/CPE and three planting densities: S_1: 75 cm×20 cm, S_2: 60 cm× 20 cm, S_3: 45 cm × 20 cm. Among irrigation schedule the highest values of growth parameters *viz.*, plant height, drymatter accumulation and crop growth rate was recorded with M_1 (IW/CPE ratio) while the lowest growth parameters were observed in M_4 treatment (0.6 IW/CPE ratio). Among planting densities S_3 (45 cm x 20 cm) registered the highest growth parameters while the lowest values of these parameters were recorded in S_1 (75 cm x 20 cm) treatment.

Keywords: *Crop growth rate, Irrigation schedules and Planting densities.*

Maize (*Zea mays* L.) is called 'queen of cereal' as it is grown throughout the year due to its photo-thermo insensitive character and highest genetic yield potential among the cereals. Maize is one of the major cereal crops that occupies third position among the cereals after rice and wheat, since it is representing 24 % of total cereal production in the world. Being a C4 plant, maize is capable of utilizing solar radiation more efficiently compared to other cereals. It contains about 70 to 75 % starch, 8 to 12 % protein, 3 to 8 % oil and carbohydrates 1 to 3 %. It is cultivated as a food and feed crop under varying soil topography, seasons and management practices throughout the country (Singh *et al*., 2007). In India, it occupies an area of 9.38 m ha with a production of 28.75 m t and average productivity of 3065 kg $ha^{-1.}$ In Andhra Pradeshit is cultivated in an area of 3.01 lakh ha with a production of 21.21 lakh tones and average productivity of 7055 kg ha^{-1} (Directorate of Economics & Statistics, AP 2019-20).

Maize crop bears high yield potential and responds to various agro management practices. Low yield of maize is due to many constraints but among them, proper irrigation and lack of optimal crop stand are the factors of prime importance. Sometimes the sowing of maize gets delayed due to late harvest of preceeding crops and also frequent heavy rains due to cyclonic activity that occur in the months of October and November. As late *rabi* maize is grown under water is a crucial input for maintaining the sustainable agriculture production. The supply of assured irrigation is one of the important factor for determining the success during the critical stages. Among the various irrigation scheduling approaches, climatological approach has been found to be better, since it integrates all the weather parameters giving them their natural weightage in a given climate-water-plant continuum (Prihar and Sandh,1987).

The vital plant physiological processes like cell elongation, cell division, cell wall synthesis, nitrate reductase activity and photosynthesis are very sensitive to plant water status. Therefore, performance of a plant in terms of its growth and yield is mainly dependent on plant water status which can be maintained at optimum level by following an optimum irrigation schedule. Availability of optimum moisture in the soil enhances the efficiency of applied nutrients, and any reduction of soil moisture at these stages will considerably reduce the grain yield. So proper irrigation scheduling is essential for efficient use of water and crop production. Concept of IW/CPE ratio incorporates the climatic factors into consideration while scheduling the irrigation and has been found to be a reliable, economical and practical basis for scheduling irrigation.

Among the agronomic factors that influence crop production, plant population is the most important one. Very high population may lead to more competition for the nutrients, moisture and light *etc*. while very low plant population may lead to less exploitation of the available resources resulting in poor yield so maintaining optimum plant population besides other agronomic practice is of paramount importance in realizing the full yield potential of the maize under late *rabi* conditions.

It is imperative that maize should be planted using versatile spacing that ensures effective uptake of nutrients and minimum mutual over shading and inter plant competition along with the most appropriate dose of fertilizer producing the maximum yield by exploiting the yield potential of the hybrids. Hence, there is need to study the integrated effect of different irrigation schedules and optimum plant population of maize under late *rabi* conditions to improve the water productivity. As the information available under late sown *rabi* conditions is very meagre.

MATERIAL AND METHODS

The field experiment was conducted during *rabi* season of 2021 and 2022 at the Agricultural College Farm, Bapatla, Acharya N.G. Ranga Agricultural University, Andhra Pradesh. The experiment was conducted on sandy loam soil which was alkaline in reaction (pH - 8.5), low in organic carbon (0.38 per cent) and available nitrogen (160.3 kg ha^{-1}), medium in available P2O5 (35.3 kg ha^{-1}) and available K2O (268.8 kg ha^{-1}).

The experiment was laid out in split plot Design with four main plots and three sub plots replicated thrice. The treatments consisted of four Irrigation levels: M1: 1.2 IW/CPE Ratio, M2: 1.0 IW/CPE, M3: 0.8 IW/CPE, M4: 0.6 IW/CPE and three planting densities: S1: 75 cm × 20 cm, S2: 60 cm × 20 cm, S3: 45 cm × 20 cm. P-3396 was the test variety taken was sown on 07-01-2022 and harvested on 27-04-2022.

The growth parameters *viz.*, plant height (cm), drymatter accumulation (kg ha^{-1}) and crop growth rate (g m^{-2} day^{-1}) were recorded and statistically analyzed.

RESULTS AND DISCUSSION

Plant Height

At 30 DAS, irrigations were scheduled at 1.2 IW/CPE ratio observed with significantly higher plant height (74.0 cm) over that of 0.8 and 0.6 IW/CPE ratios. It was found comparable with the plant height noticed at 1.0 IW/ CPE ration. However, the differences in plant heights recorded among the treatments 1.0, 0.8 and 0.6 IW/CPE ratios were not significant. Taller plants observed with irrigation at 1.2 IW/CPE ratio were found on a par with that of 1.0 IW/CPE ratio at 60 DAS. These two treatments were observed with significantly higher plant height over that of 8.0 and 0.6 IW/CPE ratios. The lowest plant height noticed with that of 0.6 IW/CPE ratio was found on a par with that of irrigation scheduled at 0.8 IW/ CPE ratio.

Plant height at 90 DAS revealed that irrigation scheduled at 1.2 followed by 1.0 IW/CPE ratios were found with significantly higher plant height than that of 0.8 and 0.6 IW/CPE ratios. Whereas, the lower plant height measured at 0.6 IW/CPE ratio was comparable with that of 0.8 IW/ CPE ratio. Similar trend of plant height at 60 DAS was observed at harvest also. At harvest significantly highest plant height recorded at 1.2 IW/CPE ratio was comparable with 1.0 IW/CPE ratio. These were found superior over 0.8 and 0.6 IW/CPE ratio. The lowest plant height was recorded at 0.6 IW/CPE ratio which was inferior to rest of the treatments.

The taller plants at all of the crop growth stages with 1.2 IW/CPE ratio could be attributed to adequate supply of moisture in the soil, where nine irrigations were applied based on cumulative evaporation, which might have coincided with all significant stages of crop growth. Earlier, Hussain *et al.* (2001), Shivakumar *et al.* (2011) and Adamu *et al.* (2014) were also reported on the increase in plant height in response to more irrigations.

In case of plant density, the plant height considerably increased at 60, 90 DAS and at harvest as the plant density increased from 66,666 (S1) to 1,11,111 (S3) plants ha^{-1}. Plant density of 1, 11,111 plants ha^{-1} recorded significantly greater plant height than that of 66,666 plants ha^{-1} (197.0 cm at 90DAS). It was followed by the treatment S2, where the differences between S1 and S2 are not significant. However, the lower plant height recorded with 66666 plant density was found on a par with that of 83,333 plants ha^{-1}. Whereas, at harvest the treatment S3 produced the taller plants significantly superior than that of the treatments S2 and S1.

At low plant densities, interplant competition was lower, and the plants observed in these treatments remained dwarf. However, at higher plant densities overcrowding of plants caused interplant competition resulted in more cell division and cell elongation in search of light and other natural resources. These observations are in accordance with that of Gouzubenli (2003), Singh *et al.* (2012) and Vinodkumar *et al.* (2012).

Interaction effect between irrigation and plant density was found non-significant at all stages of crop growth.

Drymatter accumulation (kg ha-1)

The maximum drymatter accumulation resulted when irrigations were scheduled at 1.2 IW/ CPE ratio at all the growth stages of crop was significantly superior to that of other treatments. However, the differences between 1.2 and 1.0 IW/ CPE ratios were not significant except at harvest. The lower drymatter noticed with 0.6 IW/CPE ratio was significantly inferior in plant height compared to all other treatments at all stages of crop growth. Whereas, at 60DAS, the plant height of treatments M2 and M3was comparable with each other.

Maintenance of adequate moisture had a positive impact on the maximum total drymatter at 1.2 IW/CPE ratio (M1). A rising trend in drymatter accumulation was clearly seen throughout all stages of the crop growth as the plant water stress reduced from 0.6 to 1.2 IW/CPE ratio. Additionally, increased nutrient mobility combined with higher water uptake under a higher irrigation regime may have increased photosynthetic activity, which in turn increased the dry weight of plants. Higher plant height at all stages may have also contributed to the accumulation of more drymatter under the M1 regime than under the M2 and M3 and M4 regimes.

At all crop growth stages, drymatter accumulation at greater planting densities

(1,11,111plants ha^{-1}) was noticeably superior to that of lower planting densities (83,333 plants ha^{-1} and 66,666 plants ha^{-1}). The plant density of (S3) 45 cm x 20 cm produced the largest drymatter accumulation at all the stages of crop growth period. It was found significantly higher than that of other planting densities. It was followed by 60 cm x 20 cm (S2) at all the stages of crop growth; however, it was comparable with 75 cm x 20 cm (S1) at 30 and 60 DAS. Drymatter accumulation with the treatment S1 was significantly inferior compared to that of other planting densities at 90 DAS and at harvest.

The maximum accumulation of drymatter at higher planting densities (S3) might bedue to more plants per square meter. Similar findings of increased drymatter at higher planting densities relative to lower planting densities were obtained by Singh and Singh (2006) and Suryavanshi *et al.* (2009).

Crop growth rate (g m-2 day-1)

From 30-60 DAS highest crop growth rate observed at 1.2 IW/CPE ratio(M1)was significantly superior over that of M3and M4 However, CGR recorded with the treatment M2 was found on a par with that of M1 and M3treatments.Same trend as that of 30 -60 DAS was obtained at 60- 90 DAS and90 DAS-at harvest.

The highest CGR recorded with spacing of 45 cm x 20 cm (10.1 g m^{-2} day^{-1}) was significantly superior to that of 75 x 20 cm (8.9 g m^{-2} day^{-1}) and 60 X 20 cm. However, the CGR measured with the treatments S1 and S2were found on a par with each other at 30-60 DAS.

At 60-90 DAS the crop growth rate at higher planting density (S3) was found superior over that of S2and S1. The CGR recorded with the treatment S1 was found significantly inferior to that of both S2 and S3 treatments. Similar trend as that of 60-90 DAS was also observed at 90 DAS - harvest.

Table 1. Plant height (cm) of maize as influenced by irrigation scheduling and planting densities

Treatments	30DAS	60DAS	90DAS	At harvest
Irrigation schedule				
M_1-1.2 IW/CPE	74.0	175.2	224.7	227.5
M_2- 1.0 IW/CPE	67.1	168.8	218.5	221.9
M_3- 0.8 IW/CPE	59.4	122.7	194.3	197.8
M_4- 0.6 IW/CPE	59.3	114.7	171.9	174.5
SEm ±	2.7	4.0	3.4	4.1
CD (p=0.05)	9.1	13.8	11.8	14.2
CV (%)	12.2	8.2	5.0	6.0
Planting densities				
S_1-75 x 20	65.9	141.2	197.0	200.8
S_2-60 X 20	65.4	144.7	200.9	203.0
S_3-45 X 20	63.6	149.9	209.2	212.2
SEm ±	1.1	2.2	3.2	3.0
CD (p=0.05)	NS	6.4	9.6	8.8
CV (%)	6.0	5.1	5.4	5.0
Interaction	NS	NS	NS	NS

Table 2. Drymatter accumulation (kg ha-1) of maize as influenced by irrigation scheduling and planting densities

Treatments	30DAS	60DAS	90DAS	At harvest
Irrigation schedule				
M_1-1.2 IW/CPE	992.4	4092.7	10453.4	16998.7
M_2- 1.0 IW/CPE	943.7	3809.1	9966.2	14868.1
M_3- 0.8 IW/CPE	780.9	3596	9132.56	11961.6
M_4- 0.6 IW/CPE	675	3146	9132.56	9760.6
SEm ±	26.87	93.73	206.17	356.81
CD(p=0.05)	92.98	324.3	713.4	1234.7
CV (%)	9.5	7.6	6.5	7.9
Planting densities				
S_1-75 cm x 20 cm	737.9	3399.4	8342.2	11921
S_2-45 cm x 20 cm	798.2	3559.8	9165.3	12942
S_3-60 cm x 20 cm	1007.9	4023.6	10792.1	15328.9
SEm ±	22.28	58.86	122.26	219.96
CD(p=0.05)	66.8	176.48	366.56	659.4
CV (%)	9.1	5.5	4.9	5.6

Table 3. Crop growth rate (g m^{-2} day^{-1}) of maize as influenced by irrigation scheduling and planting densities.

Treatments	30-60DAS	60-90DAS	90-HARVEST
Irrigation schedule			
M_1-1.2 IW/CPE	10.3	21.2	32.8
M_2- 1.0 IW/CPE	9.6	20.5	24.5
M_3- 0.8 IW/CPE	9.4	18.5	14.3
M_4- 0.6 IW/CPE	8.2	16.8	8
SEm ±	0.3	0.7	0.83
CD (p=0.05)	1.1	2.4	2.9
CV (%)	9.5	11	12.6
Planting densities			
S_1-75 cm x 20 cm	8.9	16.5	17.9
S_2-45 cm x 20 cm	9.2	18.7	18.6
S_3-60 cm x 20 cm	10.1	22.6	22.5
SEm ±	0.22	0.47	1.07
CD (p=0.05)	0.6	1.4	3.2
CV (%)	8.2	8.5	18.6
Interaction	NS	NS	NS

CONCLUSION

The present study revealed that superior growth parameters *i.e.*, plant height, drymatter accumulation and crop growth rate of maize was observed with 1.2 IW/CPE along with planting densitiy of 1,11,111 plants ha^{-1}. While, the lowest growth parameters were obtained in 0.6 IW/CPE ratio and in 66666 plants ha^{-1}.

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