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YIELD AND NUTRIENT UPTAKE OF MAIZE AS INFLUENCED BY DRIP IRRIGATION AND NITROGEN LEVELS

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ABSTRACT

A field study was conducted during *rabi* seasons of 2013-14 and 2014-15 at S.V. Agricultural College, Tirupati. The field experiments laid out in spilt plot design, replicated thrice by taking irrigation schedules (surface drip irrigation at 0.7, 0.8 and 0.9 IW/CPE ratios and weekly check basin irrigation) as main plots and nitrogen levels (160, 200 and 240 kg ha^{-1}) as sub plots. The higher dry matter, kernel and stover yields and nutrient uptake by maize was found to be the highest when irrigations were scheduled at weekly intervals by check basin method, which was on par to that of drip irrigation at 0.9 IW/CPE ratio. As regards to nitrogen levels tried, all the parameters were found to be superior with the nitrogen dose of 240 kg N ha^{-1}. The interaction between the irrigation schedules and nitrogen levels indicated that higher yields and nutrient uptake was recorded with scheduling irrigation either at weekly intervals through check basin method or by drip irrigation at 0.9 IW/CPE ratio along with 240 kg N ha^{-1}. The experimental results concluded that maize crop can be grown economically at 0.9 IW/CPE ratio through surface drip irrigation with 240 kg N ha^{-1}.

KEYWORDS: Maize, Drip irrigation, Grain yield, Nutrient uptake

Maize is a multipurpose crop, which can supply food, feed and fuel in relatively large quantities as compared to other cereal crops. It has the highest average yield per hectare and stands third after wheat and rice in area and total production in the world. Though, the crop is mainly grown as rainfed crop during *kharif*, it is also being cultivated as irrigated crop during *rabi*. The shortage of water resources is a worldwide problem and the phenomenon of water stress is very obvious. Proper growth and development of maize needs favorable soil moisture in root zone. The moisture content in the soil gradually decreases with the passing of time during dry season. Limited water supply during the growing season results in soil and plant water deficits and reduces maize yields. With drip irrigation the water is delivered slowly and constantly, creating the ideal balance of water and oxygen in the rhizosphere and benefiting the maize plants which dislike over-compacted soil. In this particular study, the concept of IW/CPE ratio which is a reliable, economical and practical method for scheduling of irrigation as suggested by Prihar *et al.* (1976) has been adopted.

Nitrogen has a dominant role in plant physiology as it is an integral part of protoplasm, chlorophyll, proteins, enzymes, amino acids and nucleic acids. Optimum application of nitrogen is a pre-requisite for production of maize. Not only the grain yield of maize, but the quality of grains is also affected to a great extent by nitrogen availability. It has been reported that grain yield of maize gets increased by N application (Tafteh and Sepaskhah, 2012). For this purpose, maize was grown under different combinations of irrigation schedules and nitrogen levels and the study was focused on irrigation and nitrogen management impacts on maize yield and nutrient uptake.

MATERIAL AND METHODS

The present investigation carried out during two consecutive *rabi* seasons of 2013-14 and 2014-15 on sandy clay loam soils of S.V. Agricultural College farm, Tirupati campus of Acharya NG Ranga Agricultural University of Andhra Pradesh. The soil was sandy loam in texture, neutral in reaction, low in organic carbon and available nitrogen and medium in available phosphorus and available potassium, during both the years of study. The field experiment was laid out with maize crop in a split plot design with three replications, by taking irrigation schedules (surface drip irrigation at 0.7, 0.8 and 0.9 IW/CPE ratios and weekly check basin irrigation) as main plots and nitrogen levels (160, 200 and 240 kg ha^{-1}) as sub plots. The test variety of maize "DHM-117" was

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sown at 60/30 × 20 cm (paired row planting) and nitrogen was applied as per the treatments in three splits *i.e.,* half at basal, one fourth at knee high stage and remaining one fourth at taselling stage, whereas, recommended dose of phosphorous and potassium each of @ 80 kg ha^{-1} was applied basally to entire crop. The irrigation water through surface drip irrigation was delivered through in line emitters, spaced at 40 cm apart with a discharge rate of 4 l hr^{-1}. Treatments were imposed strictly as per the plan and the quantity of water applied to each plot was determined by considering number of laterals, emitter spacing and discharge rate. The total depth of water applied at different IW/CPE ratios was kept same.

RESULTS AND DISCUSSION

Dry matter production

During both the years of study, dry matter production was significantly higher with the irrigation at weekly intervals in check basin, which was statistically on par with that of drip irrigation at 0.9 IW/CPE ratio (Table 1). This might be attributed to more nutrient mobility coupled with higher water uptake under frequent irrigation regime which might have increased the photosynthetic activity and LAI inturn enhancing the dry weight of plant (Aulakh *et al*., 2013). These results are in agreement with those of Reddy and Padmaja (2014). The lowest dry matter production was recorded with drip irrigation at 0.7 IW/CPE ratio.

Application of nitrogen at 240 kg ha^{-1} was found to be the highest with respect to dry matter production, which was distinctly superior to that of 200 kg ha^{-1}, where as the lowest dry matter production was obtained with 160 kg ha^{-1} , during both the years. This indicated the positive effect of nitrogen in boosting the crop growth. Terman *et al.* (1977) also observed that application of nitrogen increased the plant height by increasing length and number of internodes, leaf number and size resulting in increased photosynthetic apparatus by increasing total leaf area of the crop consequently enhanced the assimilates production. This has direct bearing on dry matter production $plant^{-1}$ and unit $area^{-1}$. Mansouri-Far *et al.* (2010) quoted that LAI and leaf greenness determine the capture and use efficiency of solar radiation by maize plant and thereby affecting the conversion rate of available radiation to dry matter accumulation. The interaction between the IW/CPE ratio and nitrogen levels was significant in affecting the drymatter production of main crop.

Yield

Different drip irrigation schedules, nitrogen levels and their interaction significantly influenced the kernel and stover yields of maize, during both the years (Table 2).

The kernel and stover yields were significantly higher with scheduling irrigation conventionally at weekly intervals in check basin, which were on par with the yields obtained under drip irrigation at 0.9 IW/CPE ratio. This can be attributed to the fact that frequent irrigations provides adequate moisture in the surface layer, in which most of maize roots exists. This resulted in better crop growth and yield attributes consequently higher yield. Similar results were also quoted by Elzubeir and Mohamed (2011). Increase in kernel yield under drip irrigation at 0.9 IW/CPE was mainly due to increased soil moisture in the upper 30 cm soil layer leading to higher plant relative water content and less negative leaf water potential as quoted by Viswanatha *et al.* (2002). These results are in conformity with the findings of Aulakh *et al.* (2013). Significantly, the lowest kernel and straw yield was noticed under irrigation schedule of 0.7 IW/CPE ratio through drip, during both the years of study.

Maize fertilized with 240 kg N ha^{-1} significantly produced the highest kernel and stover yields over rest of the tried nitrogen levels i.e 200 and 160 kg ha^{-1}. This might be due to favourable effect at higher nitrogen level leading to better crop growth and increase in yield attributes which was reflected in kernel yield of maize. In physiological terms, the grain yield of maize is largely governed by source and sink relationships as it is directly related to nitrogen. These results are in accordance with the findings of Mala (2008). The lowest kernel and stover yield was registered with the application of nitrogen at 160 kg ha^{-1}, during both the years due to reduced availability of nitrogen as per the plant requirements.

Interaction between conventional irrigation at weekly intervals in check basin method along with 240 kg N ha^{-1} resulted in the highest yields of kernel and stover followed by drip irrigation at 0.9 IW/CPE ratio in combination with same level of nitrogen. This might be due to the better availability of nutrients under higher soil moisture and at high nitrogen available conditions, which might have increased the crop growth and better translocation of photosynthates from source to sink. Similar evidence on complementary use of moisture and nitrogen was reported by Patil *et al.* (2012). Combination of drip irrigation at

Table 1. Dry matter and nutrient uptake of maize at harvest as influenced by drip irrigation and nitrogen levels

Treatments	Dry matter production (kg ha^{-1})		Nitrogen uptake (kg ha^{-1})		Phosphorus uptake (kg ha^{-1})		Potassium uptake (kg ha^{-1})	
	2013-14	**2014-15**	**2013-14**	**2014-15**	**2013-14**	**2014-15**	**2013-14**	**2014-15**
Drip irrigation schedules								
0.7 IW/CPE	6263	6712	72.2	74.3	26.7	27.3	143.0	147.5
0.8 IW/CPE	9247	9734	87.6	89.8	29.1	30.3	154.9	159.2
0.9 IW/CPE	10965	11022	110.7	112.9	31.2	32.3	171.6	176.4
Weekly check basin	11087	11269	116.6	120.0	32.0	33.7	173.2	177.8
CD (p= 0.05)	518	304	7.9	8.6	1.3	1.6	5.6	4.0
Nitrogen levels								
160	8964	8860	87.7	90.1	28.5	29.7	154.0	159.2
200	9467	9964	99.3	101.7	29.8	30.9	160.6	165.0
240	9740	10229	103.5	106.0	30.9	32.2	166.9	171.5
CD (p= 0.05)	131	198	3.6	3.6	0.5	0.7	NS	NS

Table 2. Kernel yield stover yield (kg ha^{-1}) of maize as influenced by drip irrigation and nitrogen levels

Drip irrigation schedules	Grain yield								Stover yield							
	2013-14				2014-15				2013-14				2014-15			
	Nitrogen (kg ha^{-1})				Nitrogen (kg ha^{-1})				Nitrogen (kg ha^{-1})				Nitrogen (kg ha^{-1})			
	160	200	240	Mean	160	200	240	Mean	160	200	240	Mean	160	200	240	Mean
0.7 IW/CPE	2073	2743	2929	2582	2339	2763	3049	2717	2458	3635	4078	3390	2897	3714	4298	3636
0.8 IW/CPE	3063	4065	4194	3774	3101	4103	4236	3813	3920	5812	6333	5355	4035	5852	7026	5637
0.9 IW/CPE	3759	4907	5051	4572	3723	4838	5015	4525	5059	7420	8095	6858	5094	7301	8079	6825
Weekly check basin	3813	4948	5128	4630	3992	4976	5204	4724	5383	7945	8700	7343	5702	7929	8911	7514
Mean	3177	4166	4326		3289	4170	4376		4205	6203	6801		4432	6199	7078	
	CD (P=0.05)				CD (P=0.05)				CD (P=0.05)				CD (P=0.05)			
Irrigation (I)	453				498				671				784			
Nitrogen (N)	102				122				158				364			
I at N	482				536				718				982			
N at I	234				278				360				797			

0.7 IW/CPE ratio with the lowest nitrogen level of 160 kg ha^{-1} recorded significantly the lowest kernel and stover yields, during both the years of study, due to limited availability of moisture and nitrogen to the crop.

NUTRIENT UPTAKE BY MAIZE

Nitrogen uptake

Irrigation schedules and nitrogen levels as well as their interaction significantly influenced the nutrient uptake of maize at harvest with unaltered trend, during both the years of study.

The highest nitrogen uptake (Table 1) was noticed with scheduling of irrigation conventionally at weekly intervals through check basin method, which was on par with drip irrigation at 0.9 IW/CPE ratio and significantly superior over drip irrigation at 0.8 IW/CPE ratio. The lowest nitrogen uptake was recorded with drip irrigation scheduled at 0.7 IW/CPE ratio, during both the years. Increase in irrigation frequency increased the nitrogen uptake due to the increased mobility of nitrogen with increase in soil moisture content, resulting in increased availability of nitrogen, which finally increased the uptake of nitrogen. These results are in conformity with the findings of Reddy and Padmaja (2014).

During both the years of investigation, application of nitrogen at 240 kg ha^{-1} recorded significantly higher nitrogen uptake by maize than at 200 kg N ha^{-1}, where as the lowest nitrogen uptake was noticed with application of nitrogen at 160 kg ha^{-1}. Uptake of nitrogen increased significantly with each successive increment in nitrogen which might be due to increased root cation exchange capacity, which might have enhanced the absorption of entire dose of applied nitrogen (Mala, 2008).

Phosphorus and potassium uptake

Irrigation schedules and nitrogen levels differed conspicuously with respect to phosphorus and potassium uptake of maize at harvest and showed similar trend, during both the years of study (Table 1). Maize irrigated at weekly intervals by check basin method registered significantly the higher phosphorus and potassium uptake, which inturn was on par with drip irrigation at 0.9 IW/CPE ratio and both of them were distinctly superior to that resulted with drip irrigation at 0.8 IW/CPE ratio. Drip irrigation scheduled at 0.7 IW/CPE resulted in the lower phosphorus and potassium uptake.

Phosphorus and potassium uptake of maize was significantly higher with the application of nitrogen at 240 kg ha^{-1} than that obtained with 200 kg N ha^{-1}. Crop fertilized with 160 kg N ha^{-1} showed the lower phosphorus and potassium uptake in both the years. The increased uptake of phosphorus and potassium might be due to the fact that increased supply of nitrogen might have increased the root growth, leading to explore more soil volume for absorption of nutrients. These results are in agreement with the findings of Sobhana *et al.* (2013).

CONCLUSION

Based on the outcome of the investigation, it could be inferred that for maximizing the maize kernel yield and nutrient uptake, weekly irrigation by check basin method was optimum. But under the conditions of limited water availability, surface drip irrigation scheduled at 0.9 IW/CPE ratio with 240 kg N ha^{-1} was optimum for high productivity of *rabi* maize in Southern Agro Climatic Zone of Andhra Pradesh.

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