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Yield and Economics of Maize (*Zea mays*) Preceded by Greengram as Influenced by Irrigation Schedules and Nitrogen Levels

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A B S T R A C T

A field study was conducted over two years (during *kharif* and *rabi* seasons of 2013 and 2014) to evaluate the yield and returns from maize under different irrigation schedules and nitrogen levels at S.V. Agricultural College, wet land farm, Tirupati, Andhra Pradesh. During *kharif,* greengram was raised as bulk crop. The *rabi* maize experiment was laid out in a split plot design with three replications by taking four irrigation schedules as main plots and three nitrogen levels as sub plots. Yield of maize was found to be higher with weekly check basin method, which was on par to those obtained with drip irrigation at 0.9 IW/CPE ratio. With regard to nitrogen levels tried, these values 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 yield was observed with scheduling irrigation either by weekly check basin method or by drip irrigation at 0.9 IW/CPE ratio along with 240 kg N ha^{-1}. But the gross and net returns were higher with drip irrigation scheduled at 0.9 IW/CPE ratio along with 240 kg N ha^{-1}. The experimental results revealed that growing of greengram preceded by maize was economical than maize alone and maize crop can be grown economically with limited water supply at 0.9 IW/CPE ratio through drip irrigation along with 240 kg N ha^{-1}.

Introduction

Maize, a miracle crop, is grown throughout the year over a wide range of soils in India. Because of its high grain productivity, it has an enormous potentiality in ensuring food security. With reference to Southern Agro Climatic Zone of Andhra Pradesh, besides as a food crop, maize has been gaining importance due to well established market of poultry feed units. Water and nitrogen are two important resources for maize production. Yields in maize respond positively with an increase in the amount of water and nitrogen applied and reaches the plateau at their optimum doses. It has been reported, that maize grown under limited water supply requires less nitrogen to achieve maximum grain yield than that required with well water supply (Moser *et al.,* 2006). Meager information is available on scheduling of irrigation through drip and nitrogen rates in maize. Hence, the present study was under taken to examine the appropriate irrigation schedule through drip as well as nitrogen application rate.

Materials and Methods

A field experiment was carried out during *kharif* and *rabi* seasons of 2013-14 and 2014-15 at S.V. Agricultural College, wet land farm, Tirupati. The experimental site was located at 13.5°N latitude, 79.3°E longitude and at an altitude of 182.9 m above the mean sea level, in the Southern Agro-climatic Zone of Andhra Pradesh. The soil was sandy loam in texture, neutral in reaction (7.9), low in organic carbon (0.25 %) and available nitrogen (178 kg ha^{-1}) and medium in available phosphorus (24.9 kg ha^{-1}) and available potassium (174 kg ha^{-1}). During *kharif*, greengram was raised as bulk crop by following the recommended package of practices. After manual picking of greengram pods, the haulms were incorporated in to the soil. The *rabi* maize experiment was laid out in a split plot design with three replications. The treatments comprised of four main plots viz., M_1 (drip irrigation at 0.7 IW/CPE ratio), M_2 (drip irrigation at 0.8 IW/CPE ratio), M_3 (drip irrigation at 0.9 IW/CPE ratio) and M_4 (weekly check basin irrigation) and three sub plots viz., N_1 (160 kg N ha^{-1}), N_2 (200 kg N ha^{-1}) and N_3 (240 kg N ha^{-1}). Separately, unreplicated observational plot was also maintained with same treatments to maize but without preceding greengram for comparative study. The test variety of maize was DHM-117. Paired rows were made by hand hoe with a distance of 60/30 cm and seeds were dibbled @ 2 seeds $hill^{-1}$ at a spacing of 20 cm. Nitrogen was applied as per the prescribed sub plot treatments in three splits *i.e.,* half at basal, one fourth at knee high stage and remaining one fourth at tasseling stage. Recommended dose of phosphorus and potassium each @ 80 kg ha^{-1} were applied basally. Atrazine @ 1.25 kg *a.i* ha^{-1} was sprayed as pre-emergence to control the weed emergence during early stages of crop growth. One hand weeding was done during vegetative stage to control the weeds at later stages. All other recommended package of practices for growing of maize was followed. Irrigations were scheduled as per the prescribed sub plot treatments. To schedule the drip irrigation at prescribed IW/CPE ratios the treatments were maintained to field capacity in the top 0-45 cm depth i.e. only effective root zone depth, whereas for check basin irrigation the depth of water was 50 cm. The quantity of water applied to each plot was determined by considering number of laterals, emitter spacing and discharge rate. The total quantity of water applied at different IW/CPE ratios was kept the same (Table 1).

Total quantity of water applied (litres)=

$$\frac{\text{Plot size } (m^2) \times \text{depth of water (mm)}}{1000} \times 1000$$

Results and Discussion

Yield

Yields (kernel and straw) of maize were significantly influenced by the irrigation schedules and nitrogen levels as well as their interaction, during both the years of investigation. The highest yields (grain and straw) of maize were recorded under weekly check basin irrigation (M_4), which was on par with those recorded under IW/CPE ratio of 0.9 through drip irrigation (M_3) than rest of the irrigation schedules tried. In weekly check basin irrigation, because of adequate turgidity inside the plant, the growth and development of cob was better. In addition to this, adequate turgidity prevailed inside the plant might have been congenial to translocate the photosynthates efficiently from the source to the development of sink consequently yield (Paolo and Rinaldi 2008). 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). The decrease in tissue water potential affects the several physiological processes. Plant water deficit affects the final yield through its influence on various physiological processes. These results are in conformity with the findings of Aulakh *et al.*, (2013). Among the nitrogen levels, application of nitrogen at 240 kg ha^{-1} (N_3) produced significantly higher values of all the yield attributes and yields as compared to the lower doses of nitrogen. This might be because of better pollination under higher nitrogen levels, helping to maintain the sink capacity thereby causing well filled kernels in cob (Zakkam *et al.*, 2012) (Table 2).

Regarding interaction, weekly irrigations with 240 kg N ha^{-1} (M_4N_3) registered the highest yield (grain and straw), which were statistically on par to those recorded with the combination of drip irrigation at 0.9 IW/CPE ratio and 240 kg N ha^{-1} (M_3N_3), during both the years of study. This might be due to the combined effect of adequate moisture under high nitrogen level, leading to better partitioning and translocation of photosynthates from source to sink (Singh, 2001). Drip irrigation at 0.7 IW/CPE ratio with nitrogen level of 160 kg ha^{-1} (M_1N_1) recorded the lowest stature of yield components and yield during both the years.

Economics

Influence of different irrigation schedules and nitrogen levels on economics of maize as well as greengram-maize cropping system in terms of gross returns and net returns were worked out and presented below. The trend in economics of maize crop alone was similar to that of economics realized with the greengram-maize cropping system, during both the years of study.

Gross returns and net returns were realized under maize preceded by greengram with crop residue incorporation were relatively low as compared to no residue incorporation.

Gross returns

Different irrigation schedules and nitrogen levels as well as their interaction exerted significant influence on gross returns, during both the years of study, with unaltered trend (Table 3 and 4). The higher gross returns were realized with weekly check basin irrigation, which was on par to that obtained with irrigation at IW/CPE ratio of 0.9 through drip and both of them were significantly superior to drip irrigation at 0.8 IW/CPE ratio. The lowest gross returns were realized with drip irrigation at 0.7 IW/CPE ratio. Among the nitrogen levels, application of higher level of nitrogen at 240 kg ha^{-1} accrued significantly higher gross returns than the remaining doses. The next best treatment was application of nitrogen at 200 kg ha^{-1}, whereas the lower gross returns were realized with nitrogen level of 160 kg ha^{-1}.

Interaction indicated that higher levels of irrigation schedules produced on par gross returns at any level of nitrogen. Higher nitrogen doses of 240 and 200 kg ha^{-1} realized the comparable gross returns at any irrigation level, during both the years. A treatment combination of weekly check basin irrigation and 240 kg N ha^{-1} produced higher gross returns, which was statistically on par with the treatment combination of drip irrigation at IW/CPE ratio of 0.8 along with the same dose of nitrogen and with weekly check basin irrigation along with 200 kg ha^{-1}. The lowest gross returns were resulted with the combination of drip irrigation at 0.7 IW/CPE ratio along with 160 kg N ha^{-1}.

Net returns

Irrigation schedules, levels of nitrogen and their interaction exerted significant effect on net returns from maize alone and greengram-maize cropping system as well following similar trend, during both the years of study (Table 5 and 6). Net returns were found to be the highest with the scheduling of irrigation through drip irrigation at 0.9 IW/CPE ratio followed by weekly irrigation, with no significant difference between them and both of them were significantly superior to drip irrigation at IW/CPE ratio of 0.8, during both the years. Significantly, the lowest net returns were recorded with drip irrigation at IW/CPE ratio of 0.7.Application of 240 kg ha^{-1} resulted in higher net returns, which was significantly superior to 200 kg ha^{-1}, while the lowest net returns were noticed with160 kg N ha^{-1}.

Regarding the interaction effect, net returns were higher with frequent irrigation regimes along with the nitrogen doses of 200 and 240 kg ha^{-1}. The higher net returns were obtained with drip irrigation at 0.9 IW/CPE ratio with nitrogen dose of 240 kg ha^{-1}, which was comparable with weekly check basin method of irrigation at same nitrogen dose and drip irrigation at 0.9 IW/CPE with 200 kg N ha^{-1}. However, the lowest net returns were observed under drip irrigation at IW/CPE of 0.7 along with 160 kg N ha^{-1}, during both the years of study.

Among the irrigation schedules, the higher gross returns realized with weekly irrigations, which was on par to that of drip irrigation at IW/CPE ratio of 0.9. This might be due to increased yields under higher irrigation levels. The net returns were higher with drip irrigation at 0.9 IW/CPE ratio, which was statistically on par with the weekly irrigations during both the years of study. Drip irrigation at 0.7 IW/CPE ratio resulted in the lowest monetary returns. Relatively higher moisture content increased the grain and stover yield, which finally reflected in the gross returns and net returns. On the other hand, where the crop was subjected to moisture stress, ultimately resulted in lower monetary returns. Similar findings have been reported by Reddy *et al.*, (2012) and Reddy and Padmaja (2014).

With regard to nitrogen levels, increase in nitrogen from 160 to 240 kg ha^{-1} significantly increased the gross returns and net returns. This might be because of increased yields under higher nitrogen levels which might have resulted in the remunerative returns. These results corroborate with the findings of Reddy *et al.*, (2012), Paramasivan *et al.*, (2013) and Om *et al.*, (2014).

Table.1 The details of drip irrigation is furnished below

Treatments	Cumulative Epan for irrigation (mm)	Lateral spacing (cm)	Emitter spacing (cm)	Flow rate (l hr^{-1})	Irrigation duration (hours)
IW/CPE of 0.7	50.0	90	40	4	3.24
IW/CPE of 0.8	43.7	90	40	4	3.24
IW/CPE of 0.9	38.8	90	40	4	3.24

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

Treatments	2013-14				2014-15			
	N_1 : 160	N_2 : 200	N_3 : 240	Mean	N_1 : 160	N_2 : 200	N_3 : 240	Mean
M_1 : 0.7 IW/CPE	2073	2743	2929	2582	2339	2763	3049	**2717**
M_2 : 0.8 IW/CPE	3063	4065	4194	3774	3101	4103	4236	**3813**
M_3 : 0.9 IW/CPE	3759	4907	5051	4572	3723	4838	5015	**4525**
M_4 : Weekly check basin	3813	4948	5128	4630	3992	4976	5204	**4724**
Mean	3177	4166	4326		3289	4170	4376	
	S.Em±		CD (P=0.05)		S.Em±		CD (P=0.05)	
M	128		453		141		**498**	
N	34		102		40		**122**	
M at N	140		482		155		**536**	
N at M	223		472		244		**517**	
Kernel yield (kg ha^{-1}) of maize in unreplicated observational plot without greengram								
M_1 : 0.7 IW/CPE	1986	2578	2636	2400	2128	2652	2745	**2508**
M_2 : 0.8 IW/CPE	2834	3742	3979	3518	2984	3827	4015	**3609**
M_3 : 0.9 IW/CPE	3658	4769	4978	4468	3694	4786	4985	**4488**
M_4 : Weekly check basin	3774	4815	5082	4557	3754	4886	5116	**4585**
Mean	**3063**	**3976**	**4169**		**3140**	**4038**	**4108**	

Table.3 Stover yield (kg ha^{-1}) of maize as influenced by irrigation schedules and nitrogen levels under drip irrigation preceded by greengram

Treatments	2013-14				2014-15			
	N_1 : 160	N_2 : 200	N_3 : 240	Mean	N_1 : 160	N_2 : 200	N_3 : 240	Mean
M_1 : 0.7 IW/CPE	2458	3635	4078	3390	2897	3714	4298	**3636**
M_2 : 0.8 IW/CPE	3920	5812	6333	5355	4035	5852	7026	**5637**
M_3 : 0.9 IW/CPE	5059	7420	8095	6858	5094	7301	8079	**6825**
M_4 : Weekly check basin	5383	7945	8700	7343	5702	7929	8911	**7514**
Mean	4205	6203	6801		4432	6199	7078	
	S.Em±		**CD (P=0.05)**		**S.Em±**		**CD (P=0.05)**	
M	190		671		222		**784**	
N	52		158		120		**364**	
M at N	208		718		297		**982**	
N at M	329		697		385		**797**	
Stover yield (kg ha^{-1}) of maize unreplicated observational plot without greengram								
M_1 : 0.7 IW/CPE	2681	3558	3664	3301	2875	3670	3820	**3455**
M_2 : 0.8 IW/CPE	3883	5238	5650	4924	4091	5457	5712	**5087**
M_3 : 0.9 IW/CPE	5231	7153	7716	6700	5316	7195	7750	**6754**
M_4 : Weekly check basin	5925	7704	7878	7169	5956	7845	7925	**7242**
Mean	**4430**	**5913**	**6227**		**4560**	**6042**	**6312**	

Table.4 Gross returns (` ha^{-1}) of maize as influenced by irrigation schedules and nitrogen levels under drip irrigation preceded by greengram

Treatments	2013-14				2014-15			
	N_1 : 160	N_2 : 200	N_3 : 240	Mean	N_1 : 160	N_2 : 200	N_3 : 240	Mean
M_1 : 0.7 IW/CPE	35626	47528	50953	44703	40327	47927	53093	**47116**
M_2 : 0.8 IW/CPE	52930	70853	73446	65743	53662	71506	74807	**66658**
M_3 : 0.9 IW/CPE	65214	85938	88911	80021	64673	84715	88325	**79238**
M_4 : Weekly check basin	66397	87124	90759	81427	69575	87556	92181	**83104**
Mean	55042	72861	76017		57059	72926	77102	
	S.Em±		**CD (P=0.05)**		**S.Em±**		**CD (P=0.05)**	
M	2246		7923		2455		**8663**	
N	596		1804		727		**2200**	
M at N	2448		8441		2728		**9363**	
N at M	3890		8246		4253		**9016**	
Gross returns (` ha^{-1}) of maize in unreplicated observational plot without greengram								
M_1 : 0.7 IW/CPE	34457	44806	45840	41701	36923	46102	47740	**43588**
M_2 : 0.8 IW/CPE	49227	65110	69314	61217	51835	66689	69952	**62825**
M_3 : 0.9 IW/CPE	63759	83457	87364	78193	64420	83771	87510	**78567**
M_4 : Weekly check basin	66309	84744	89190	80081	66020	86021	89781	**80607**
Mean	**53438**	**69529**	**72927**		**54800**	**70646**	**73746**	

Table.5 Gross returns (₹ ha^{-1}) of greengram-maize cropping system as influenced by irrigation schedules and nitrogen levels under drip irrigation

Treatments	2013-14				2014-15			
	N_1 : 160	N_2 : 200	N_3 : 240	Mean	N_1 : 160	N_2 : 200	N_3 : 240	Mean
M_1 : 0.7 IW/CPE	59916	71818	75243	68993	65387	72987	78153	**72176**
M_2 : 0.8 IW/CPE	77220	95143	97736	90033	78722	96566	99867	**91718**
M_3 : 0.9 IW/CPE	89504	110228	113201	104311	89733	109775	113385	**104298**
M_4 : Weekly check basin	90687	111414	115049	105717	94635	112616	117241	**108164**
Mean	79332	97151	100307		82119	97986	102162	

	2013-14 S.Em±	2013-14 CD (P=0.05)	2014-15 S.Em±	2014-15 CD (P=0.05)
M	2246	7923	2455	**8663**
N	596	1804	727	**2200**
M at N	2448	8441	2728	**9363**
N at M	**3890**	**8246**	**4253**	**9016**

Table.6 Net returns (₹ ha^{-1}) of maize as influenced by irrigation schedules and nitrogen levels under drip irrigation preceded by greengram

Treatments	2013-14				2014-15			
	N_1 : 160	N_2 : 200	N_3 : 240	Mean	N_1 : 160	N_2 : 200	N_3 : 240	Mean
M_1 : 0.7 IW/CPE	1557	12964	15894	10139	6258	13363	18034	**12552**
M_2 : 0.8 IW/CPE	18200	35628	37726	30518	18932	36281	39087	**31433**
M_3 : 0.9 IW/CPE	29824	50053	52531	44136	29283	48830	51945	**43353**
M_4 : Weekly check basin	27545	47777	50917	42080	29721	47207	51337	**42755**
Mean	19282	36605	39267		21048	36420	40101	
	S.Em±		**CD (P=0.05)**		**S.Em±**		**CD (P=0.05)**	
M	2246		7923		2455		**8663**	
N	596		1804		727		**2200**	
M at N	2448		8441		2728		**9363**	
N at M	3890		8246		4253		**9016**	
Net returns (` ha^{-1}) of maize in unreplicated observational plot without greengram								
M_1 : 0.7 IW/CPE	388	10242	10781	7137	2854	11538	12681	**9024**
M_2 : 0.8 IW/CPE	14497	29885	33594	25992	17105	31464	34232	**27600**
M_3 : 0.9 IW/CPE	28369	47572	50984	42308	29030	47886	51130	**42682**
M_4 : Weekly check basin	27457	45397	49348	40734	26166	45672	48937	**40258**
Mean	**17678**	**33274**	**36177**		**18789**	**34140**	**36745**	

Table.7 Net returns (` ha^{-1}) of greengram-maize cropping system as influenced by irrigation schedules and nitrogen levels under drip irrigation

Treatments	2013-14				2014-15			
	N_1 : 160	N_2 : 200	N_3 : 240	Mean	N_1 : 160	N_2 : 200	N_3 : 240	Mean
M_1 : 0.7 IW/CPE	12340	23747	26677	20922	17811	24916	29587	**24105**
M_2 : 0.8 IW/CPE	28983	46411	48509	41301	30485	47834	50640	**42986**
M_3 : 0.9 IW/CPE	40607	60836	63314	54919	40836	60383	63498	**54906**
M_4 : Weekly check basin	38328	58560	61700	52863	41274	58760	62890	**54308**
Mean	**30065**	**47388**	**50050**		**32601**	**47973**	**51654**	

	S.Em±	CD (P=0.05)	S.Em±	CD (P=0.05)
M	2246	7923	2455	**8663**
N	596	1804	727	**2200**
M at N	2448	8441	2728	**9363**
N at M	**3890**	**8246**	**4253**	**9016**

The highest monetary returns under higher irrigation regimes of 0.9 IW/CPE ratios through drip and weekly irrigations using check basin method along with higher nitrogen doses might be due to increased kernel and stover yields under favourable moisture conditions coupled with ample supply of nitrogen (Table 7). The lowest monetary returns were noticed in drip irrigation at 0.7 IW/ CPE ratio along with 160 kg N ha^{-1}, which might be due to reduced yields. Present investigations confirmed the results of Pennaiah (2005).

Remunerative returns obtained with the greengram-maize cropping system along with crop residue incorporation, were found to be more than with no residue incorporation.

This was due to the reason that additional yield and monetary returns from greengram increased returns from the system. These results are supported by the findings of Devkota *et al.,* (2006), Mala (2008), Sharma and Behera (2009).

Based on the outcome of the investigation, it could be inferred that for maximum yield, and monetary returns drip irrigation scheduled at 0.9 IW/CPE ratio coupled with 240 kg N ha^{-1} was the better combination under limited water conditions. Growing greengram, as a preceding crop and incorporation of residues after realizing the economic produce will be a promising option for maintaining soil fertility status with additional advantage of greengram seed.

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