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RESEARCH PAPER

Effect of irrigation and nutrient management approaches on maximizing productivity and economics of maize (*Zea mays* L.)- chickpea (*Cicer arietinum* L.) cropping sequence under command area

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Abstract : A field experiment was conducted at AICRP on water management, Belavatagi, UAS, Dharwad, during 2013-14 on soil deficient in available nutrients to study the effect of irrigation and nutrient management approaches on maximizing productivity, and economics of maize (*Zea mays* L.)-chickpea (*Cicer arietinum* L.) cropping sequence under command area. The results revealed that, crop receiving irrigation at 0.8 IW/CPE recorded significantly higher maize grain yield (70.80 q/ha) with higher gross return (Rs.88,924 ha^{-1}), net return (Rs. 65,804 ha^{-1}) and B-C ratio (3.84) compared to other treatment. However, in pooled analysis, the yields were on par with different irrigation levels. Among different level of boron applied to soil or through foliar application from 2 to 6 kg granubour/ha increased the yield over no boron application. But significant results obtained at 6 kg granubour/ha application and foliar application of 0.5 % of $FeSO_4$ and 0.5 % of $ZnSO_4$ with borax @ 0.1 % at 30 and 45 DAS. The interaction effects between irrigation and boron levels showed that, irrigating the crop at 0.8 IW/CPE along with foliar application of 0.5 % $FeSO_4$ and 0.5 % $ZnSO_4$ with borax @ 0.1 % at 30 and 45 DAS recorded higher yield, higher gross returns, net returns, B-C ratio and WUE over the treatments. But, it was on par with all the treatments that receive the boron either through soil or foliar application. During *Rabi* season chickpea was grown as succeeding crop after maize in *Kharif* the results showed that, irrigating at 0.8 IW/CPE with Granubor (boron) @ 6 kg/ha followed by growing of chickpea with 0.6 IW/CPE recorded significantly yield and economics.

Key Words : Irrigation, Nutrients, Yield of maize, Chickpea, Economics

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INTRODUCTION

Due to serious water shortages the great challenge for the coming decades is the task of increasing food production with less water, particularly in countries with limited water, land resources.Therefore, techniques are needed to increase the water use efficiency. Irrigation scheduling and nutrient management has conventionally aimed to achieve an optimum water supply to crop for

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enhancing the productivity, with soil water content being maintained close to field capacity. The increasing worldwide shortages of water and costs of irrigation are leading to an emphasis on developing methods of irrigation that minimize water use and maximize the water use efficiency in crop. Maize-chickpea cropping sequence has been profitability. Cropping sequence is traditionally a low cost input agriculture system. Information on nutrient management on individual crops is available, while cropping system, it is lacking. More ever, the single nutrient approach has been replaced by multinutreint to proved balanced nutrients to boost up crop productivity and nutrient use efficiency. Beside nutrient management in cropping system is more efficient and judicious than individual crop, as following crop take care of the residual effects of nutrients. Maize-chickpea is the predominant cropping sequence of command area. (Rajkumara *et al.,* 2009). Maize (*Zea mays* L.) is an ideal crop owing to its quick growing habit, high yielding ability, palatability and nutritiousness. It is efficient utilizer of solar energy and has immense potential for higher yield. It can be grown in any season and is one of the most important cereal crop of the world and as such each climatic zone has its own characteristics and as such different hybrids, composites and local varieties maturing in 60 to 150 days are being grown (Jain *et al.,* 1981). It can be fed to cattle at any stage, as there is no problem of poisoning to cattle with HCN or oxalic acid in plant unlike sorghum and therefore, it is called as "Queen of cereals and King of fodder". The father of green revolution renowned nobel laureate Dr. Norman E. Borlaug, has mentioned maize as the crop of future. In future maize can play vital role in ensuring food security as well as nutritional security by use of quality protein maize for the country as well as world as a whole. Among the several technologies of precision agriculture, farming has to be treated as any other business and we must try to exploit the available resources like water and nutrients in a judicious and efficient manner. Recent studies proved that maize is a potential winter season crop having three times higher yield potential than *Kharif* crop (Desai and Deore, 2010 and Nayak *et al*., 2007). Water and nutrient are the key factor to increase the productivity of this crop. As it is scarce during winter, its efficient utilization is necessary. However, information regarding irrigation scheduling and use of integrated sources of nutrients is meagre; hence, to overcome these issues present experiment was conducted. Macro and micro nutrient management best management practices with cereals–leguminous crop due importance of inclusion of legumes will be required for sustainable management of emerging maize based cropping system in the country. Hence, the study on yield potential well as their economics is needed in maize-chickpea sequence system on *Vertisol* of command area.

Material and Methods

A field experiment was conducted at AICRP on Water Management, Belvatagi, University of Agricultural Sciences, Dharwad, during 2013-14 and 2014-15. The *Vertisols* of Malaprabha command area is deficit in micronutrients particularly zinc (< 0.57 ppm), iron (< 4.10 ppm) and boron (< 0.12 ppm) due to calcareous nature of soils (soil properties are given in Table A).

Table A : Physical and chemical characteristics of the experimental soil

Properties	Values
Soil type	Chromustert
Soil	Clay
pH	8.30
O.C	0.51%
Av. P_2O_5	31 kg/ha
Av. K_2O	791 kg/ha
F.C.	38.0 %
PWP	20.0 %

Experiment was laid out in split-plot design with three replications. The treatments are: Main plot; Two irrigation levels (I_1 = 0.8 IW/CPE, I_2 = Farmers practice *i.e.,* irrigating at critical stages) and Sub plot: Five micronutrients combination (N_1 = RDF (N,P,K,Zn, Fe and FYM), N_2 = RDF+2 kg/ha Granubor, N_3= RDF+4 kg/ha Granubor N_4= RDF+6 kg/ha Granubor,N_5= RDF + Foliar spray of 0.5% $ZnSO_4$ +0.5% $FeSO_4$ + 0.1% Borax twice at 30 and 45 DAS were assigned. Along with these treatments a control treatment with one ploughing and two harrowing was practice ploughing before planting of maize in summer followed by harrowing during the cropping period of both maize and chickpea. The dimensions of individual plots were of 4.8 m x 3.6 m. A recommended fertilizer dose of 150–75–37.5 kg N, P_2O_5, K_2O/ha was applied to maize during *Kharif*. Entire dose of phosphorus and potassium was applied at the time of planting, while N was applied in three splits (1/3[rd] at sowing, 1/3[rd] at knee height stage and 1/3[rd] at silking stage). Cargill 900 M hybrid was planted with 60 cm × 20 cm spacing in *Kharif* followed by A–1 chickpea with 30 cm × 10 cm spacing in *Rabi*. Planting was done by hand dibbling in both the crops. Fertilizer dose of 25 – 50 – 0 NP_2O_5 K_2O kg/ha was applied to chickpea as a single application at the time of planting. Maize and chickpea seeds were treated with captan @ 2 g/kg of seeds before planting. Scheduling of irrigation was done based on IW/CPE approach with a irrigation water depth of 60 mm. USWB Pan Evaporimeter was used to measure daily evaporation and cumulative pan evaporation was computed. In control treatment, irrigation was scheduled at 0.8 IW/CPE in maize while, 0.6 IW/CPE in chickpea.

Water use efficiency was worked out by the formula:

$$\text{WUE (kg/ha – mm)} = \frac{\text{Grain yield in kg}}{\text{Water used in mm}}$$

The water used by the crop in the season was computed by the summation of soil moisture contribution, effective rainfall and irrigation water applied.

Results and Discussion

Soil moisture directly influences the availability of nutrients for plants. Cropreceiving irrigation at 0.8 IW/CPE recorded significantly higher maize grain yields (70.80 q/ha) with higher gross returns (Rs.88,924/ha) and net returns (Rs. 65,804/ha) with B-C ratio (3.84) as compared to other treatment (Table 1 and 2). However, during 2013, 2014 and in pooled analysis, the yields were on par with different irrigation levels.The results confirm the findings of Shinde *et al.* (2014). Irrigation scheduled at 0.75 IW/CPE ratio compared with irrigation scheduled at CGS, owing to improvement in important growth and yield attributes. Therefore, irrigation to maize with 0.75 IW/CPE ratio is good for higher grain yield.In rest of the years, rainfall received was sufficient to meet the moisture requirement of maize since the requirement of maize in Northern Dry Zone of Karnataka is 500-600 mm (Anonymous, 2011). Among different levels of boron applied to soil or through foliar application from 2 to 6 kg Granubor/ha increased the yield over no boron application. But, significant results obtained at 6 kg Granubor/ha application and foliar application of 0.5 % of $FeSO_4$ and 0.5 % of $ZnSO_4$ with borax @ 0.1 % foliar application at 30 and 45 DAS.The marked response in grain yield of maize due to B application may be attributed to deficiency of B in the experimental soil (Sakal *et al*., 1988). Also, B application increased the fruiting in maize (reduced empty ears) as stated by Yiying and Lang (1997).

The increase in the length of cob, number of grains per cob and 100 seed weight by B fertilization have contributed for the increased grain yield over control. Moreover, B fertilization or otherwise the correction of B deficiency apart from influencing the uptake of

Table 1 : Grain yield (q ha^{-1}) and economics of maize as influenced by irrigation and boron levels (during the years 2013 and 2014 (pooled data of 2 years)

Treatments	Maize yield (q/ha)			Gross returns (Rs./ha)			Net returns (Rs./ha)		
	Irrigation levels (I)			Irrigation levels (I)			Irrigation levels (I)		
	0.8 IW/CPE	Critical stages	Mean	0.8 IW/CPE	Critical stages	Mean	0.8 IW/CPE	Critical stages	Mean
N_1- RDF (N, P, K, Zn, Fe and FYM)	79.6	75.9	77.8	94,238	91,850	93,044	58,987	57,050	58,018
N_2- RDF + 2 kg Granubor/ha	82.1	81.4	81.8	95,862	94,300	95,081	60,487	59,375	59,931
N_3- RDF + 4 kg Granubor/ha	81.6	85.8	83.7	97,000	96,000	96,500	61,459	60,910	61,185
N_4- RDF + 6 kg Granubor/ha	86.3	88.0	87.2	99,963	97,771	98,867	64,076	62,334	63,205
N_5- RDF + foliar spray of 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + 0.1% Borax twice at 30 and 45 DAS	92.5	88.5	90.5	1,10,058	99,333	1,04,696	74,008	63,798	68,903
Mean	84.4	83.9		99,424	95,851		63,803	60,693	
Sources	S.E. ±	C.D. (P=0.05)		S.E. ±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)	
Main plot (I)	2.2	NS		4,118	NS		4,120	NS	
Sub plot (F)	2.6	7.8		4,929	14,777		4,930	14,779	
M x S	3.9	11.7		6,970	20,897		6,972	20,901	

NS= Non-significant

Table 2 : B-C ratio and WUE kg/ha mm of maize as influenced by irrigation and boron levels in maize and their interaction during the years 2013 and 2014 (pooled data of 2 years)

Treatments	B:C			WUE kg/ha mm		
	Irrigation levels (I)			Irrigation levels (I)		
	0.8 IW/CPE	Critical stages	Mean	0.8 IW/CPE	Critical stages	Mean
N_1 - RDF (N, P, K, Zn, Fe and FYM)	3.41	3.37	3.39	16.70	19.34	18.02
N_2 - RDF + 2 kg/ha Granubor	3.45	3.45	3.45	16.93	19.73	18.33
N_3 - RDF + 4 kg/ha Granubor	3.48	3.50	3.49	17.51	20.14	18.83
N_4 - RDF + 6 kg/ha Granubor	3.55	3.52	3.53	19.48	20.52	20.00
N_5 - RDF+ foliar spray of 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + 0.1% Borax twice at 30 and 45 DAS	3.92	3.57	3.74	17.40	19.70	18.55
Mean	3.41	3.37	-	18.46	19.81	-
Sources	S.E. ±	C.D.(P=0.05)		S.E. ±	C.D. (P=0.05)	
Main plot (I)	0.17	NS		0.73	NS	
Sub plot (F)	0.20	0.60		0.87	2.54	
M x S	0.28	0.85		1.31	3.90	

NS= Non-significant

nutrients *viz.,*N,P,K, Zn, Cu, Fe, Mn and B was also helpful in increasing the maize yield. Increased yield by boron application was also reported by Rai and Dighe (1971). Shaaban *et al.* (2012) revealed that boron at certain levels was effective when applied through foliar application to enhance growth in maize crop. Accelerated growth and assimilation of mineral revealed that the boron as a micronutrient was very effective and can be applied practically and is also extendable to other crops.

Potarzycki *et al.* (2015) observed that the zinc application to maize is a factor affecting positively its yielding potential. The yield forming effect of this nutrient prevailed in early stages of maize growth, resulting in a higher number of grains per cob. Shanti *et al.* (1997) and Barbara *et al.* (2018) reported that, the result emphasizes the importance of adequate N supply for the crop in obtaining large-size cobs having more grains, with heavier and bold seeds that contribute to higher harvest indices and in turn higher grain yield1. Foliar application of Zn and Mn along with enhanced doses of NPK favourably influenced the growth parameters of maize as reported by Mahmoud (2001). Interaction

Table 3 : Grain yield (q ha^{-1}), gross returns (Rs./ha) and net returns (Rs./ha) of chickpea as influenced by irrigation and boron levels and their residual effect during *Rabi* season in maize –chickpea sequence

Treatments	Chickpea grain yield (kg/ha) 2013-14			Chickpea gross returns (Rs./ha) 2013-14			Chickpea net returns (Rs./ha) 2013-14		
	Irrigation levels (I)			Irrigation levels (I)			Irrigation levels (I)		
	0.8 IW/ CPE	Critical stages	Mean	0.8 IW/CPE	Critical stages	Mean	0.8 IW/ CPE	Critical stages	Mean
N_1 - RDF (N.P.K.Zn,Fe and FYM)	1556	1733	1645	37,360	41,600	39,480	21,860	26,100	23,980
N_2 - RDF (N.P.K.Zn, Fe and FYM) + 2 kg/ha Granubor	1633	1765	1699	39,200	42,360	40,780	23,700	26,860	25,280
N_3 - RDF (N.P.K.Zn, Fe and FYM) + 4 kg/ha Granubor	1931	1826	1879	46,360	43,840	45,100	30,860	28,340	29,600
N_4 - RDF (N.P.K.Zn, Fe and FYM) + 6 kg/ha Granubor	1640	1680	1660	39,360	40,320	39,840	23,860	24,820	24,340
N_5 - N_1 + foliar spray of 0.5% $ZnSO_4$ 0.5% $FeSO_4$ + 0.1% Borax twice at 30 and 45 DAS	2006	1951	1979	48,160	46,840	47,500	32,660	31,340	32,000
Mean	1753	1791		42,088	42,992		26,588	27,492	
Sources	S.E. ±	C.D. (P=0.05)		S.E. ±	C.D. (P=0.05)		S.E. ±	C.D. (P=0.05)	
Main plot (I)	32.39	NS		777.46	NS		777	NS	
Sub plot (F)	33.63	100.83		807.14	2,419.81		807	2,419	
M x S	47.56	142.59		1,141.47	3,422.13		1141	3,422	

NS= Non-significant

Table 4 : Chickpea B:C ratio and WUE (kg/ha mm) as influenced by residual effect of irrigation and boron levels in maize –chickpea sequence and their interaction

Treatments	Chickpea B:C ratio			Chickpea WUE (kg/ha. mm)		
	Irrigation levels (I)			Irrigation levels (I)		
	0.8 IW/CPE	Critical stages	Mean	0.8 IW/ CPE	Critical stages	Mean
N_1 - RDF (N.P.K.Zn,Fe and FYM)	2.41	2.68	2.54	8.65	9.63	9.14
N_2 - RDF (N.P.K.Zn,Fe and FYM) + 2 kg/ha Granubor	2.52	2.73	2.63	9.07	9.80	9.44
N_3 - RDF (N.P.K.Zn,Fe and FYM) + 4 kg/ha Granubor	2.99	2.82	2.91	10.73	10.14	10.44
N_4 - RDF (N.P.K.Zn,Fe and FYM) + 6 kg/ha Granubor	2.54	2.60	2.57	9.11	9.33	9.22
N_5 - N_1 + foliar spray of 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + 0.1% Borax twice at 30 and 45 DAS	3.10	3.02	3.06	11.15	10.84	10.99
Mean	2.71	2.77		9.74	9.95	
Sources	S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)	
Main plot (I)	0.05	NS		0.18	NS	
Sub plot (F)	0.05	0.16		0.19	0.56	
M x S	0.07	0.22		0.26	0.79	

NS= Non-significant

effects between irrigation and boron levels showed that, irrigating the crop at 0.8 IW/CPE along with foliar application of 0.5 % $FeSO_4$ and 0.5 % $ZnSO_4$ with borax @ 0.1 % at 30 and 45 DAS recorded higher yield (92.5 q/ha), gross returns (Rs.1,10,058/ha), net returns (Rs.74,008/ha), B-C ratio (3.92) and WUE (19.48) over rest of the treatments. But, it was on par with all the treatments that receive the boron either through soil or foliar, indicating the favourable influence of foliar spray of nutrients to hybrid maize(Pooled of two years). Similarly, Abou (2002) reported that foliar sprays with EDTA micro nutrient compound containing Fe, Mn, Zn and N had significant effect on growth and nutrient content of maize. Irrigating the crop at 0.8 IW/CPE along with foliar application of 0.5 % $FeSO_4$ and 0.5 % $ZnSO_4$ with borax @ 0.1 % at foliar application30 and 45 DAS recorded higher yield, economics and water use efficiency. From the field investigation, it can be concluded that in *Vertisol*, effects between irrigation and boron levels showed that, irrigating the crop at 0.8 IW/ CPE along with foliar application of 0.5 % $FeSO_4$ and 0.5 % $ZnSO_4$ with borax @ 0.1 % at 30 and 45 DAS recorded higher yield,economics and WUE (Table 1 and 2).

During *Rabi* season chickpea was grown as succeeding crop after maize in *Kharif* the results showed that, growing of maize with RPP + foliar spray of 0.5% $ZnSO_4$+0.5% $FeSO_4$ + 0.1% Borax twice at 30 and 45 DAS recorded significantly higher yield (1979 kg/ha), gross return (47, 500), net return (32,000), B:C ration (3.06) and WUE (10.99 kg/ha-mm) compare to other treatments. The same treatments recorded higer net returns, B:C ratio and WUE.The results are in conformity with the findings of Gawai and Pawar (2005) that the residual effect of application of 100 per cent RDF and 5 t FYM ha^{-1} to proceeding crop sorghum resulted in significantly higher grain and haulm yield of chickpea. Growing of maize in *Kharif* by irrigating at 0.8 IW/CPE with Granubor (boron) @ 6 kg/ha followed by growing of chickpea with 0.6 IW/CPE recorded significantly higher gross returns of Rs. 1.47.718 with a net returns of Rs.1.08.668. Irrigation at lower frequency resulted in lower net returns and B:C ratio. This system seems to be more remunerative to the farmers of Malaprabha command area.

Conclusion:

From the field investigation, it can be concluded that in *Vertisols,* crop receiving irrigation at 0.8 IW/CPE recorded significantly higher maize sequence chickpea yield grain yields with economics as compared to other treatment. Among different level of boron applied to soil or through foliar application from 2 to 6 kg Granubor /ha increased the yield over no boron application. But, significant results obtained at 6 kg/ha Granubor application and foliar application of 0.5 % of $FeSO_4$ and 0.5 % of $ZnSO_4$ with borax @ 0.1 % at 30 and 45 DAS and residual effect of chickpea yield. The interaction effects between irrigation and boron levels showed that, irrigating the crop at 0.8 IW/CPE along with foliar application of

0.5 % $FeSO_4$ and 0.5 % $ZnSO_4$ with borax @ 0.1 % at 30 and 45 DAS recorded higher maize and chickpea yield components and economics. But, it was on par with all the treatments receive the boron either through soil or foliar.

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