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ECONOMIC EVALUATION OF IRRIGATION SCHEDULING AND NUTRIENT MANAGEMENT ON SWEET CORN (*ZEA MAYS L. SACCHARATA*) - CHICKPEA (*CICER ARIETINUM*) CROPPING SEQUENCE

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Abstract

A field experiment was conducted at the instructional/research farm of MGM college of Agricultural Biotechnology, Aurangabad, Maharashtra during the kharif seasons of 2016-17 and 2017-18, to evaluate irrigation scheduling and fertilizer levels on yield and economics of sweet corn-chickpea system. The soil of the experimental site was clay loam in texture, low in organic carbon, available N, medium in available phosphorus and high in potassium. Treatments consisted of eighteen treatment combinations of three irrigation scheduling *viz.,* I_1: two irrigations at knee height and tasseling stage, I_2: three irrigations at knee height, tasseling and early dough stage, I_3: four irrigations at knee height, tasseling, silking and early dough stage in main plot main plots and factorial combination of three fertilizer levels *viz.*, NPK_1: 120:60:60 kg NPK ha^{-1}, NPK_2: 150:75:75 kg NPK ha^{-1}, NPK_3: 180:90:90 kg NPK ha^{-1} and two methods of zinc application *viz.*, Zn_1: soil application@ 25kg $ZnSO_4.7H_2O$ ha^{-1} and Zn_2: seed priming @ 1% $ZnSO_4.7H_2O$ assigned to sub plots. Four irrigations (I_3) recorded higher cob yield (32.41 and 33.14 t ha^{-1}) and green fodder yield (63.81 and 63.41 t ha^{-1}) of sweet corn as compared to other irrigation scheduling during first and second year, respectively. Among the fertilizer levels application of 180:90:90 kg NPK ha^{-1} recorded cob yield (29.91 and 30.59 t ha^{-1}) and green fodder yield (59.31 and 59.81 t ha^{-1}) of sweet corn as compared to other fertilizer levels. System productivity of the cropping sequence indicated that significantly higher gross returns (432381 and 455749 ha^{-1}), net returns (349729 and 427740 ha^{-1}) and benefit: cost ratio (5.22 and 5.33) is recorded with application of four irrigations. Application of 180:90:90 kg NPK ha^{-1} recorded significantly highest gross returns (398259 and 423857 ha^{-1}), net returns (315248 and 393323 ha^{-1}) and benefit: cost ratio (4.79 and 4.93) is recorded with application of 180:90:90 kg NPK ha^{-1} in both years.

Key words: Fertilizer levels, irrigation scheduling, sweet corn, chickpea and economics

Introduction

Sweet corn (*Zea mays* L. *saccharata*) is a sugary-seeded kind of maize and has great adaptability to wide range of agro-climatic regions. The great advantages are that crop is short duration, high grain and forage yield, high nutritive value and can be grown in all the three seasons *viz.,* pre-*kharif, kharif* and *rabi*. Irrigation is one of the most essential natural input for agricultural production particularly in arid and semi-arid regions where rainfall is inadequate and erratic. Irrigation has become a primary tool to enhance and sustain agricultural productivity in drought prone area. Maize is very sensitive to water stress (Kuscu and Demir, 2013) and Payero *et al.,* (2009) reported that water stress can affect growth, development and physiological processes of maize plants, which reduce biomass yield. The peak water requirement of the maize coincides with reproductive period (Farré and Faci, 2009). The most critical growth stage at which moisture stress has been observed to be the most yield limiting in maize is the two weeks prior and the two weeks following silking (Singh and Singh, 1995). Irrigation during the reproductive stages can still produce optimum grain yields and maximize WUE (Pandey *et al*., 2000 and Kang *et al*., 2000).

In India area under maize crop is 72.7 million hectares with production of 1586 million tones and productivity is 2181 kg ha^{-1} (Chitransha *et al*., 2019) whereas productivity of maize-growing countries of the world (5.16

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t ha^{-1}). So, there is a big gap in productivity this may be due to gradual decline in soil fertility, monocropping, delayed supply and high cost of inorganic fertilizer and imbalanced use of plant nutrients. In crop production fertilizer play a vital role in enhancing the maize yield and their contribution is about 40-50 per cent. Balanced and optimum use of nitrogen, phosphorous and potassium fertilizer play an important role in increasing yield of cereals (Asghar *et al.*, 2010).

Nitrogen (N) is a vital plant nutrient and a major determining factor required for maize production (Shanti, 1997). It takes part in different metabolic path ways in plants and participates in the protein synthesis. It directly affects the production of dry matter of the plants. It is also a component of a chemical essential to the reactions of carbohydrate synthesis and degradation (Bashir, 2012). Phosphorus also plays an important role in photosynthesis, respiration, synthesis of protoplasm, which is responsible for rapid cell division (plant shape and size). It improves the production of grain and fodder yield in (Singh *et al*., 2003). Potassium (K) is a primary nutrient for corn as the plant absorbs adequate quantity throughout its growth period. K is an activator for many enzymes and metabolic pathways like photosynthesis and protein and starch formation in grain. It also plays an important role in the flow of water, nutrients, and carbohydrates within the plant as well as strengthening cell wall and cellulose production. Zn deficiency is a worldwide nutritional constraint for crop production especially cereals (Cakmak, 2008). Maize (*Zea mays* L.) is known to be very sensitive to Zn deficiency (Lindsay and Norvell, 1977). Zn is involved in completing many vital physiological functions such as protein synthesis, energy production and maintenance of membrane integrity (Hansch and Mendel, 2009). Yield gap in maize is not only due to appropriate irrigation scheduling but also due to inadequate and imbalanced fertilization and lack of distinct fertilizer recommendations for high-yielding single-cross hybrids (Mohan Kumar *et al*., 2015 and Hasim *et al*., 2015). Similarly, chickpea is also an important crop which suites to the rabi season in cropping sequence. For getting higher productivity and profitability adopt appropriate sequence crop, irrigation scheduling along with balanced nutrition particularly of NPK and Zn.

Materials and Methods

Description of study area

The experiments were conducted during the kharif season of 2016-17 and 2017-18 at the instructional/ research farm of MGM college of Agricultural Biotechnology, Aurangabad, Maharashtra is lies between 19^0 80'N Latitude and 75^0 39'E longitude. The altitude varies from 578 to 589 meters above mean sea level. This tract is lying on the Eastern side of Western Ghat and falls under rain shadow area. Climatologically, it falls in semi-arid tropics with an annual rainfall varying from 498 to 860 mm. The average annual precipitation is 710 mm. The total rainfall received during the period of August 2016 (34^{th} meteorological week) to Nov 2016 (47^{th} meteorological week) was 178.5mm in 12 rainy days during 2016-17 and 380mm in 20 rainy days during 2017-18. The initial fertility status of the experimental field soil was 120.09 kg ha^{-1} alkaline permanganate oxidizable nitrogen (N), 14.85 kg ha^{-1} available phosphorus (P), 436.24 kg exchangeable potassium (K) and 0.41% organic. The pH of soil was 7.98. The field capacity and permanent wilting point was 38.97 and 19.02 percent, respectively with bulk density 1.38 Mg m^{-3}.

Experimental treatments and design

The field experiment was laid in a split-plot design, with the main plots consisting of three irrigation scheduling *viz.*, I_1: Two irrigations at knee height and tasseling stage, I_2: three irrigations at knee height, tasseling and early dough stage, I_3: Four irrigations at knee height, tasseling, silking and early dough stage and sub-plots consisting of three fertility levels *viz.*, NPK_1: 120:60:60 kg NPK ha^{-1}, NPK_2: 150:75:75 kg NPK ha^{-1}, NPK_3: 180:90:90 kg NPK ha^{-1} and two methods of zinc application *viz.*, Zn_1: Soil application @ 25 kg $ZnSO_4.7H_2O$ ha^{-1} and Zn_2: Seed priming @ 1% $ZnSO_4.7H_2O$ with three replications.

Crop husbandry and treatment imposed

After land preparation, the sowing of the sweet corn was done as per land configuration at spacing of 60 cm x 20 cm spacing on 25^{th} August 2016 and 27^{th} August 2017, during 2016-17 and 2017-18, respectively. The dose of fertilizers was applied through 10:26:26 and Urea. The full dose of phosphorus and potassium as basal dose applied just before dibbling of sweet corn and nitrogen was applied in two equal splits i.e. ½ at planting and remaining ½ at 30 DAS by band placement method as per the treatment. Irrigation was applied immediately after sowing and subsequently second irrigation was applied on 4 days after sowing for better germination. Thereafter irrigations were applied as per the treatment.

Cob yield and stover yield of maize

The green cobs were harvested at dough stage of corn seeds. After removal of green cob, the remaining portion of the plant also harvested as green fodder. Harvesting of crop was done on 18^{th} November 2016 and 20^{th} November 2017 during 2016-17 and 2017-18, respectively.

Grain and stover yield of chickpea

The harvested plants were dried for 3-4 days to bring down the moisture content to around 14 per cent. The weight of the harvested plants after sun drying and before threshing was recorded. After threshing, the seeds were cleaned and sundried and their weight was recorded. The yields in kg / plot were converted to t/ha.

Economics

The gross returns were calculated by multiplying the prevalent market price of grain and stover of maize and chickpea with their respective yields, and net returns were calculated by subtracting cost of cultivation from the gross returns. Benefit: cost ratio was calculated by dividing the gross returns with cost of cultivation under the respective treatment.

Statistical analysis

The experimental data pertaining to each character was analysed statistically by using the technique of 'Analysis of variance' for split plot design (Panse and Sukhatme, 1985) and significance was tested by 'F' test. Standard error of mean [SEm (±)] and critical difference (CD at 5%) were worked out for each character studied to evaluate difference between the treatments and interaction effects at 5 % levels of significance.

Results and Discussion

Green cob yield of sweet corn

The green cob yield was significantly influenced by irrigation scheduling table 1. The mean green cob yield was 25.62 and 26.33 t ha^{-1} for first year and second year, respectively. The four irrigations at knee height, tasseling, silking and early dough stage at harvest stage recorded significantly higher green cob yield of 32.41 and 33.14 t ha^{-1} during first year and second year, respectively. The significantly lowest green cob yield of 18.81 and 19.55 t ha^{-1} was recorded with two irrigation in 1^{st} and 2^{nd} year, respectively. The higher cob yield with four irrigations might be due to optimum supply of moisture and nutrients leading to more development of photosynthetic area and remain active for longer period. The results are in agreement with Sanjeev *et al.*, (2006) and Asim *et al.*, (2011). The application of 180:90:90 kg NPK ha^{-1} produced significantly more green cob yield (29.91 and 30.59 t ha^{-1}) and it was significantly over 150:75:75 kg NPK ha^{-1} (26.06 and 26.80 t ha^{-1}) and 120:60:60 kg NPK ha^{-1} (20.90 and 21.61 t ha^{-1}) in 2016-17 and 2017-18, respectively. It has been well emphasized that balanced NPK fertilization to the tune of 180:90:90 kg ha^{-1} play vital role in improving three major aspects of yield determination i.e., formation of vegetative structure for nutrient absorption, photosynthesis and strong sink length through development of reproductive structure and production of assimilates to fill economically improved sink (source strength). The observed results are in close conformity with findings of Abdullah (2008) and Nath *et al.*, (2009).

Table 1: Effect of irrigation scheduling and nutrient management on cob yield, green fodder yield of Sweet corn and yield of chickpea as sequence crop.

Treatments	Sweet corn				Chickpea crop			
	Cob yield (t ha^{-1})		Green fodder yield(t ha^{-1})		Grain yield (t ha^{-1})		Stover yield (t ha^{-1})	
	2016	2017	2016	2017	2016	2017	2016	2017
Irrigation scheduling (I)								
I_1-Two irrigations	18.81	19.55	39.20	40.26	2.38	3.07	3.70	4.80
I_2-Three irrigations	25.65	26.31	50.09	50.10	2.35	2.93	3.64	4.54
I_3-Four irrigations	32.41	33.14	63.81	63.41	2.25	2.85	3.51	4.43
SEm (±)	0.70	0.77	1.40	1.76	0.07	0.09	0.11	0.15
CD (at 5%)	2.75	3.02	5.51	6.91	NS	NS	NS	NS
NPK levels (kg ha^{-1})								
NPK_1-120:60:60	20.91	21.61	42.17	42.36	2.67	3.37	4.12	5.24
NPK_2-150:75:75	26.06	26.80	51.62	51.59	2.29	2.87	3.56	4.48
NPK_3-180:90:90	29.91	30.59	59.31	59.81	2.02	2.61	3.16	4.05
SEm (±)	0.55	0.55	1.23	1.37	0.06	0.07	0.09	0.11
CD (at 5%)	1.58	1.59	3.55	3.97	0.16	0.21	0.25	0.32
Method of zinc application (Zn)								
Zn_1-Soil application	25.57	26.32	51.06	51.20	2.32	2.98	3.59	4.65
Zn_2-Seed priming	25.67	26.35	51.01	51.31	2.33	2.92	3.64	4.53
SEm (±)	0.45	0.45	1.00	1.12	0.05	0.06	0.07	0.09
CD (at 5%)	NS	NS	NS	NS	NS	NS	NS	NS
GM	25.62	26.33	51.03	51.25	2.32	2.95	3.61	4.58

Application of zinc sulphate as seed priming was at par with soil application zinc sulphate.

Green fodder yield of sweet corn

Similarly, four irrigations at knee height, tasseling, silking and early dough stage at harvest stage recorded significantly higher green fodder yield of 63.81 and 63.40 t ha^{-1} over three irrigations (50.08 and 50.10 t ha^{-1}) and two irrigations (39.20 and 40.25 t ha^{-1}) in 1^{st} and 2^{nd} year, respectively. The increase in green stover yield under four irrigations might be due to increase the availability and maintaining of higher soil moisture in the root zone throughout the crop period. Similar results were also reported by Patel *et al.,* (2009), Mugalkhod *et al.,* (2011) and Patil *et al.,* (2011). Crop receiving 180:90:90 kg NPK ha^{-1} produced significantly more fodder yield (59.31 and 59.81 t ha^{-1}) and it was significantly over application of 150:75:75 kg NPK ha^{-1} (51.62 and 51.59 t ha^{-1}) and application of 120:60:60 kg NPK ha^{-1} (42.17 and 42.36 t ha^{-1}) in 2016-17 and 2017-18, respectively. Higher green fodder yield might be due to balanced application of NPK fertilizers which enhance photosynthesis efficiency and nutrient accumulation. The results are in close conformity with findings of Abdullah (2008), Nath *et al*., (2009) and Suthar *et al*., (2014). There was no significant difference between seed priming @ 1% $ZnSO_4.7H_2O$ and soil application $ZnSO_4.7H_2O$ @ 25kg ha^{-1}.

Yield of Chickpea as residual crop

Grain yield (t ha^{-1})

Results table 1 showed that two irrigations recorded higher grain yield of chickpea over three and four irrigation but all irrigation scheduling treatments were at par. Application of 120:60:60 kg NPK ha^{-1} produced significantly highest grain yield (2.66 and 3.37 t ha^{-1}) and it was significantly superior over application of 150:75:75 kg NPK ha^{-1} (2.28 and 2.86 t ha^{-1}) and application of 180:90:90 kg NPK ha^{-1} (2.02 and 2.61 t ha^{-1}) in 2016-17 and 2017-18. The grain yield t ha^{-1} of chickpea crop did not differ significantly due to the residual effect of methods of zinc application during both the years.

Stover yield (t ha^{-1})

The stover yield of chickpea crop was not differed significantly due to the residual effect of irrigation scheduling during both the years. Application of 120:60:60 kg NPK ha^{-1} produced significantly highest stover yield (4.12 and 5.23 t ha^{-1}) and it was significantly superior over application of 150:75:75 kg NPK ha^{-1} (3.56 and 4.47 t ha^{-1}) and application of 180:90:90 kg NPK ha^{-1} (3.15 and 4.04 t ha^{-1}) in 1^{st} and 2^{nd} year, respectively.

Economics of sweet corn crop-chickpea cropping sequence

Gross return (ha^{-1})

The four irrigations recorded significantly maximum gross returns (432381 and 455749 ha^{-1}) over three irrigations and two irrigations table 2. I_2 recorded second gross return (360641 and 384258 ha^{-1}) and found significantly superior over I_1 (294841 and 326097 ha^{-1}) in year 2016-17 and 2017-18, respectively. These findings are in conformity with findings of Patel *et al.,* (2014) and Hiremath *et al.,* (2016). Crop receiving 180:90:90 kg NPK ha^{-1} produced significantly highest gross returns (398259 and 423857 ha^{-1}) and it was significantly superior over application of 150:75:75 kg NPK ha^{-1} (365257 and 389151 ha^{-1}) and application of 120:60:60 kg NPK ha^{-1} (324347 and 353096 ha^{-1}) in 1^{st} and 2^{nd} year, respectively. Application of zinc sulphate through seed priming was at par with soil application.

Net returns (ha^{-1})

The four irrigations to sweet corn crop-chickpea cropping sequence recorded significantly higher net returns 349729 and 371698 ha^{-1} as compared to three irrigations (279239 and 301456 ha^{-1}) and two irrigations (214689 and 244545 ha^{-1})

Table 2: Effect of irrigation scheduling and nutrient management on economics of sweet corn crop-chickpea cropping sequence.

Treatments	Gross returns(ha^{-1})		Net returns(ha^{-1})		B: C Ratio	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Irrigation scheduling (I)						
I_1-Two irrigations	294841	326097	214689	244545	3.68	4.00
I_2-Three irrigations	360641	384258	279239	301456	4.43	4.64
I_3-Four irrigations	432381	455749	349729	371698	5.22	5.42
SEm (±)	9257	10502	9257	10502	0.11	0.13
CD (at 5%)	36335	41224	36335	41224	0.45	0.50
NPK levels (kg ha^{-1})						
NPK_1-120:60:60	324347	353096	244553	271902	4.06	4.34
NPK_2-150:75:75	365257	389151	283855	306349	4.48	4.69
NPK_3-180:90:90	398259	423857	315248	339447	4.79	5.01
SEm (±)	5900	6691	5900	6691	0.07	0.08
CD (at 5%)	17035	19319	17035	19319	0.21	0.23
Method of zinc application (Zn)						
Zn_1-Soil application	362236	389625	280694	306683	4.43	4.69
Zn_2-Seed priming	363005	387778	281743	305116	4.45	4.68
SEm (±)	4817	5463	4817	5463	0.06	0.07
CD (at 5%)	NS	NS	NS	NS	NS	NS
GM	362621	388701	281219	358887	4.44	4.68

which was significantly lowest than I_3 and I_2. Crop receiving 180:90:90 kg NPK ha^{-1} produced significantly highest net returns (315248 and 339447 ha^{-1}) and it was significantly superior over application of 150:75:75 kg NPK ha^{-1} (283855 and 306349 ha^{-1}) and application of 120:60:60 kg NPK ha^{-1} (244553 and 271902 ha^{-1}) in 2016-17 and 2017-18, respectively. These findings are in line with those of Mohan Kumar (2015). The seed priming @ 1% $ZnSO_4.7H_2O$ produced more net returns (281743 and 305116 ha^{-1}) as compared to soil application $ZnSO_4.7H_2O$ @ 25kg ha^{-1} (280694 and 306683 ha^{-1}).

Benefit cost ratio (B:C ratio)

The mean B:C ratio of sweet corn crop-chickpea cropping sequence was 4.44 and 4.68 for first year and second year, respectively. The four irrigations at knee height, tasseling, silking, early dough stage recorded significantly higher B:C ratio 5.22 and 5.42 during first year and second year, respectively. I_2 also recorded B:C ratio of 4.43 and 4.64 and found significantly superior over I_1 (3.68 and 4.00) in both years. Similarly crop grown with 180:90:90 kg NPK ha^{-1} produced significantly highest B: C ratio (4.79 and 5.01) and it was significantly superior over application of 150:75:75 kg NPK ha^{-1} (4.48 and 4.69) and application of 120:60:60 kg NPK ha^{-1} (4.06 and 4.34) in 2016-17 and 2017-18, respectively. There was no significant difference between seed priming and soil application.

Conclusion

From the above, it can be inferred that the sweet corn– chick pea cropping sequence may be recommended for higher productivity and fetching higher economic returns and B:C ratio under four irrigation at knee height, tasseling, silking and early dough stage and application of 180:90:90 kg NPK ha^{-1} with application of zinc sulphate either seed priming or soil application.

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