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Growth and yield of chickpea (*Cicer arietinum* L.) as influenced by irrigation scheduling and zinc application

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Abstract
A field experiment was conducted during rabi season of 2015-16 at Agriculture Farm, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal on lateritic soil condition to study the growth and yield of chickpea(*Cicer arietinum* L.) as influenced by irrigation scheduling and zinc application. The experiment was conducted at split plot design having 5 main plot treatments (I_1: irrigation at pre flowering, I_2: irrigation at branching + pod development, I_3: irrigation at branching + pre flowering, I_4: irrigation at branching + pre flowering + pod development, I_5: irrigation at 0.8 bar soil moisture tension) and 3 sub plot treatments viz. Zn_0: control, Zn_1: zinc sulphate @ 0.25%, Zn_2: zinc sulphate @ 0.5%. The results of the experiment revealed that treatment I_4 (i.e. irrigation at branching + pre flowering + pod development) and Zn_2 (0.5% zinc sulphate) recorded highest plant height (43.28 cm), no of branches plant^{-1} (5.85), dry matter accumulation (231.33 g m^{-2}), leaf area index (1.24), and seed yield (973 kg ha^{-1}), among all the treatments. Interaction effect of I_4 irrigation scheduling and zinc sulphate @ 0.5% showed significantly crop growth rate, seed yield and stalk yield.

Keywords: chickpea, irrigation scheduling, zinc, growth, yield

Introduction
Chickpea is the most important *rabi* pulse crop of India. In the World, it occupies an area of 13.54 million hectares with an annual production of 13.31 million metric tons and the average productivity of 971 kg ha^{-1} (FAO 2014) [5]. Overall, India's contribution towards global chickpea area and production is about 70%, so the global trend follows the Indian trend in chickpea area and production (FAOSTAT, 2015). During 2015-16, 25.26 million hectares of the chickpea and 16.47 million metric tons production was in India (GOI 2016). In Madhya Pradesh, it is cultivated in 3.31 million hectares of land with an annual production of 3.81 million metric tons and productivity of 1219 kg ha^{-1} (DOE 2014). Gram seeds, leaves and straw are used in many ways viz., as dal, besan, crushed or whole grain, sweet making, green leaves and grain as vegetables. Its seeds are considered to have medicinal effects and are used for blood purification. The seed contains 21 % protein, 61.5 % carbohydrates, and 4.5 % fat and also rich in calcium, iron and niacin. Malic and oxalic acids collected from green leaves are prescribed for intentional disorders. Straw forms an excellent fodder for cattle. Out of the several factors responsible for higher productivity of chickpea land preparation, water, nutrient and weed management are more crucial and assumes great importance for successful cultivation of chickpea. It is grown either rainfed or in rice-wheat based cropping system in the double cropping. The low yield of chickpea is due to the shorter period available for crop growth and increase of terminal drought (Anonymous 2003) [1]. Chickpea is mainly cultivated as rainfed crop and water stress affects both the productivity and yield stability of the crop. If chickpea crop is given irrigation at the flowering time significantly improved the chickpea grain yield (Anonymous 2000) [2]. Irrigation plays a vital role in not only increasing the productivity of chickpea but also improving the physicochemical properties of soil in intensive cropping systems.

Micronutrients are highly essential for proper growth and development of plant and to increase the quality though they are required in small amount (Imtiaz *et al.*, 2010) [8] In India, zinc (Zn) is now considered as fourth most important yield limiting nutrient in agricultural crops. Zinc plays an important role in plant reproductive development for initiation of flowering, floral development, male and female gametogenesis, fertilisation and seed development.

Zinc deficiency can lead to change in stigmatic size, morphology, exudation, and inhibit the pollen stigma interaction (Pandey *et al.*, 2006 and 2009) [13, 14]. Hence, an experiment was laid out to study the effect of irrigation scheduling and zinc application on growth and productivity of chickpea.

Materials and Methods

A field experiments were laid out during 2015-16 at at Agriculture Farm, Institute of Agriculture, Visva Bharati, Sriniketan, West Bengal on lateritic soil having acidic pH (6.1), low in nitrogen (167.86 kg ha^{-1}), medium in available phosphorus (29.50 kg ha^{-1}), low potassium (160.50 kg ha^{-1}) and low in zinc (0.4 ppm) of upper 0-30 cm soil depth. A rainfall of 88.9 mm was recorded during the crop growing season in the year.

Treatments and experimental design

The experiment comprising five irrigation treatments, viz. I_1: Irrigation at pre flowering, I_2: Irrigation at branching + pod development, I_3: irrigation at branching + pre flowering, I_4: Irrigation at branching + pre flowering + pod development, I_5: Irrigation at 0.8 bar soil moisture tension and their zinc treatments viz. Zn_0: Control, Zn_1: Zinc sulphate @ 0.25%, Zn_2: Zinc sulphate @ 0.5%. Lime was mixed with the zinc sulphate @ 50% above zinc dose, was arranged in a split plot design keeping different irrigation scheduling in the main plot and zinc application in sub plot design with three replication. Sowing was done on 2nd December 2015 in lines following the recommended line to line distance of 30 cm and plant to plant distance of 10 cm. The recommended dose of nitrogen 20 kg ha^{-1}, phosphorus 60 kg ha^{-1}, and potassium was 40 kg ha^{-1} through urea, single super phosphate, murate of potash, respectively uniformly applied to each plot as basal dose. As per the treatments, zinc was supplied through zinc sulphate at branching and pre flowering stage. Various intercultural operations such as thinning of plants, weeding and spraying of insecticides were accomplished whenever required to keep the plants healthy and the field weed free. The crop was harvested at maturity on 27th may 2016. The harvested crop of each plot was bundled separately.

Ten plants from each plot were selected at random and were tagged for the data collection. Data were collected at harvesting stage. The height of these plants was measured from ground level to the tip of the plant on four dates and average height was expressed in cm plant^{-1}. The branches were counted on four and average number of branches plant^{-1} of each treatment was recorded. Plant of each plot were separated into green leaves, stem, capsule, and dried in a hot air oven, kept at 650C for 48 hour till constant weight were obtained. The dry weight of leave, stem, and pods were recorded and used for determination of dry matter accumulation. LAI is area of leaf surface per unit land surface (Watson, 1952) it was obtained by multiplying the area/weight ratio with the dry weight of green leaves obtained per unit of land area.

Crop growth rate (CGR)

Crop growth rates during the period of 30, 50, 70 and 90 DAS were determined with the following formula:

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \quad (g\ m^{-2}\ day^{-1})$$

Where, W2 and W1 were the final and initial dry weights of all plant parts per unit land area at times t_1 and t_2, respectively.

Results and Discussion

Growth parameters (Plant height^{-1}, number of branches plant^{-1}, dry mater accumulation (gm^{-2}), crop growth rate (g m^{-1}d^{-1}) and leaf area index)

Plant height^{-1}

The present results have indicated that plant heights were significantly affected by irrigation scheduling and application of zinc sulphate in table 1. Interaction effect was not statistically significant. The most significant plant height (43.28 cm and 41.03 cm) at 90 DAS were obtained by irrigation at branching, pre flowering and pod development (treatment I_4) and application of zinc sulphate @0.5% (treatment Zn_2), respectively. The increase in number of irrigation, the plant height was also increased. These findings are closely related with those of Mustafa *et al.* (2008) [12]. Zinc helps in production of auxin which regulated the growth hormone enhance plant growth resulted increased in plant height. Similar findings were also reported by Kayan *et al.* (2015) [9].

Number of branches plant^{-1}

The results presented in Table 1 have demonstrated that number of branches per plant was influenced by irrigation scheduling and zinc application. Among various treatments, the irrigation at branching + pre flowering + pod development (I_4) has indicated maximum increase in number of branches plant^{-1} (5.85) and also recorded by application of zinc sulphate@0.5% (5.19) at 90 DAS. These could be ascribed to the resultant effect of irrigation scheduling which maintained the water potential and net assimilation which transformed into vegetative growth i.e. number of branches. These findings also corroborated with the results reported by Patidar *et al.* (2015) [16] and Singh (2016) [19].

Dry mater accumulation (g m^{-2})

The results indicated that dry matter accumulation was significantly affected by irrigation scheduling and application of zinc sulphate in table 1. The most significant dry matter accumulation (231.33 g m^{-2} and 216.96 g m^{-2}) at 90 days after sowing were obtain by irrigation at branching + pre flowering + pod development (I_4) and application of zinc sulphate @0.5% (treatment Zn_2), respectively. The increase in dry matter production is due to the fact that the availability of optimum soil moisture at the critical growth stages of crop growth was ensured at treatment I4 only. Thus, it makes the sense clear that irrigation is imperative for crop growth and accumulation of dry matter production. The increase in dry matter production is due to the fact that with the application of zinc, carbohydrate metabolism is enhanced which one of the crucial factors for crop growth is. The results are agreement with finding of Reddy and Ahlawat (1998) [18].

Crop growth rate (g m^{-1}d^{-1})

The results presented in Table 1 have demonstrated that crop growth rate was influenced by irrigation scheduling and zinc application. The most significant crop growth rate (5.133 g m^{-2} d^{-1} and 5.068 g m^{-2} d^{-1}) at 50-70 days after sowing were obtain by irrigation at branching + pre flowering + pod development (I_4) and application of zinc sulphate @0.5% (treatment Zn_2), respectively.

Interaction

The interaction effect between irrigation scheduling and zinc application was found significant at

50-70 days after sowing. The highest crop growth rate (5.22 g m-2d-1) was recorded in crop receiving irrigation at branching + pre flowering + pod development with application @ 0.5 % zinc sulphate. These findings are closely related with those of Singh *et al*. (2014) [20].

Leaf area index

The Leaf area index of chickpea was significantly influenced by irrigation scheduling and zinc application Table 1. At 70 DAS, the highest (1.24) value of LAI was recorded with irrigation at branching + pre flowering + pod development (treatment I4) stage which was significantly higher than that of other treatments and the lowest (1.09) value of LAI was found in irrigation at 0.8bar soil moisture tension and without zinc spray. The interaction effect between irrigation scheduling and zinc application did not show significant variation at entire growth stage of chickpea. These findings are closely related with those of Manlkandan and Sivasubramaniam (2014) [11].

Yields (seed yield and stalk yield,)

Chickpea yields in different treatments as influenced by irrigation scheduling and zinc application are presented in Table 1. The maximum seed yield (973kg ha^{-1}) and stalk yield (1509 kg ha^{-1}) of chickpea was observed in irrigation at branching + pre flowering + pod development (I_4). The irrigation applied all the critical growth stages of the crop might have improved growth and yield components of the crop resulted maximum crop yield under this irrigation treatment similar observations were also reported by Parmar *et al*. (2014) [15] and Singh (2016) [21]. Spraying of zinc sulphate at branching and pre flowering @ 0.5% probably helped the crop to produce good growth and development of chickpea and hence, it recorded maximum seed yield (840 kg ha^{-1}) and stalk yield (1444 kg ha^{-1}). The results are in the similar trend as observed by Dayanand (2013) [3] and Kayan (15) [10].

Interaction

The treatment combination of irrigation scheduling and zinc application was found statistically significant Table 2. Irrigation scheduled at irrigation at branching + pre flowering + pod development combine with spraying of zinc @ 0.5% showed the significantly higher seed yield (1166 kg ha^{-1}) and stalk yield (1652 kg ha^{-1}). As compare to other treatment combination. The lowest seed yield and stalk yield were found irrigation applied at 0.8 bar soil moisture tension and without zinc spray. The results corroborated with the findings of hadi *et al.* (2013) [6] and patidar *et al.* (2015) [16].

Conclusion

It is clear from the present study that irrigation scheduling and zinc application manipulates the growth parameters of chickpea, resulting in beneficial changes in yield. The highest plant height, no of branches, dry matter accumulation, crop growth rate and also grain yield and stalk yield was obtained by irrigation scheduling (I_4: at branching, pre flowering, pod development) and zinc sulphate @ 0.5% (Zn_2) under lateritic condition of west Bengal. Although, irrigation scheduling could decrease effects of water stress on chickpea growth and seed yield. Thus, application of zinc can be helpful in increasing of growth and yield of chickpea.

Table 1: Effect of irrigation scheduling and zinc application on growth parameters and yields of chickpea

Treatment	Plant height^{-1} (cm) (90 DAS)	No of branches plant^{-1} (90 DAS)	Dry matter accumulation (gm^{-2}) (90 DAS)	Crop growth Rate (g m^{-2}d^{-1}) (50-70 DAS)	Leaf area Index (70 DAS)	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
Irrigation scheduling							
I_1	36.44	4.39	201.17	4.934	1.10	592	1283
I_2	42.56	5.42	223.33	5.076	1.22	798	1369
I_3	39.36	5.04	212.14	4.859	1.18	672	1360
I_4	43.28	5.85	231.33	5.133	1.24	973	1509
I_5	36.72	4.66	192.08	4.537	1.09	583	1278
SEm (±)	0.68	0.11	3.25	0.109	0.026	2.74	5.93
CD at 5%	2.20	0.34	10.60	0.355	0.086	8.93	19.33
CV (%)	5.11	9.05	4.60	0.067	6.78	1.13	1.31
Zinc application							
(Zn_0) Control	38.13	4.94	207.62	4.640	1.13	596	1291
(Zn_1) Zinc sulphate @ 0.25%	39.85	5.08	211.45	5.016	1.17	735	1344
(Zn_2) Zinc sulphate @ 0.5%	41.03	5.19	216.96	5.068	1.21	840	1444
SEm (±)	0.63	0.03	1.87	0.072	0.010	4.92	4.79
CD at 5%	1.85	0.13	5.52	0.212	0.028	14.52	14.14
CV (%)	6.14	3.63	3.41	0.057	3.20	1.18	1.36

I_1: Irrigation at pre flowering, I_2: Irrigation at branching + pod development, I_3: Irrigation at branching + pre flowering, I_4: Irrigation at branching + pre flowering + pod development, I_5: Irrigation at 0.8 bar soil moisture tension.

Table 2: Interaction effect of irrigation scheduling and zinc application on crop growth rate and yields of chickpea

Treatment	Crop growth rate (g m^{-2}d^{-1}) (50-70 DAS)			Seed yield (kg ha^{-1})			Stalk yield (kg ha^{-1})		
Irrigation scheduling	Zinc application			Zinc application			Zinc application		
	Zn_0	Zn_1	Zn_2	Zn_0	Zn_1	Zn_2	Zn_0	Zn_1	Zn_2
I_1	4.89	4.94	4.97	533	602	642	1250	1268	1330
I_2	5.02	5.08	5.13	610	791	993	1315	1323	1468
I_3	4.52	5	5.07	590	662	765	1307	1327	1445
I_4	4.99	5.19	5.22	715	1037	1166	1337	1540	1652

I_5	3.79	4.87	4.95	532	584	632	1245	1263	1325
I × Zn									
SEm (±)		0.161			4.92			10.72	
CD at 5%		0.475			14.52			31.61	
Zn × I									
SEm (±)		0.118			4.88			10.57	
CD at 5%		0.348			15.90			31.17	

I_1: Irrigation at pre flowering, I_2: Irrigation at branching + pod development, I_3: Irrigation at branching + pre flowering, I_4: Irrigation at branching + pre flowering + pod development, I_5: Irrigation at 0.8 bar soil moisture tension, Zn_0: control, Zn_1: zinc sulphate @ 0.25%, Zn_2: zinc sulphate @ 0.5%

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