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RESEARCH PAPER

Drip irrigation, foliar nutrition of micronutrients and growth regulators in chickpea (*Cicer arietinum* L.)

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Abstract: A field experiment was conducted to study the "effect of irrigation levels, micronutrients and growth regulators on chickpea under drip irrigation in medium black soil at instructional Farm, College of Agriculture, Vijayapur during *Kharif* 2018. The experiment was laid out under strip-split plot design with three replications. There were 20 treatment combinations comprising of five irrigation levels assited in main plots and four sub plot treatments having foliar application of micronutrients and growth regulators. The results of the study showed that, scheduling of irrigation at 60 mm Ep recorded significantly higher number of pods (36.99), pod weight (10.61 g) and seed weight (9.5 g) per plant, grain yield (1794 kg ha^{-1}), net returns (₹ 69,169 ha^{-1}) and benefit cost ratio (3.51) as compared to other irrigation schedules. Among different growth regulators and micronutrients, foliar application of NAA (40ppm) + Salicylic acid (200 ppm) + boron (0.05 %) + $ZnSO_4$, (0.5 %) and 19:19:19 NPK at 1.5 per cent recorded significantly higher number of pods (39.76), pod weight (10.53g) seed weight (9.12 g), grain yield (1706 kg ha^{-1}), net return (₹ 49,338 ha^{-1}) and benefit cost ratio (2.80) than other growth regulators. Among the interaction effects, scheduling of irrigation at 60 mm Ep along with foliar spray of NAA (40 ppm) + Salicylic acid (200 ppm) + boron (0.05 %) + $ZnSO_4$ (0.5 %) and 19:19:19 NPK at 1.5 per cent recorded significantly higher number of pods (46.57), pod weight (13.01g) and seed weight (12.89 g) per plant, grain yield (2151 kg ha^{-1}), net returns (₹ 69, 169 ha^{-1}) and benefit cost ratio (3.51). Irrigation at 60 mm Ep with application of micronutrients B and Zn and growth regulators NAA and Salicylic acid produced significantly higher seed yield and net profits in Nortern dry zone of Karnataka.

Key words: Chickpea, Growth regulators, Irrigation levels, Micro-nutrients

Introduction

Chickpea (*Cicer arietinum* L.) is commonly known as gram or bengal gram is one of the most important pulse crop traditionally grown during rabi season in India and cultivated mainly in semi-arid regions of the world. It is used for both human consumption and livestock feeding. The haulm, dal husks and pieces are useful feed for cattle. The malic and oxalic acid present in green leaves are very useful for recovering from intestinal disorder. Chickpea contains 21.1 per cent protein, 61.5 per cent carbohydrates and 4.5 per cent fat. It is rich in calcium, iron and niacin.

Chickpea accounts for more than 20 per cent of world pulse production and much of the world chickpea supply (80-90 %) comes from India. India ranked first in area and production in the world, with an area of 83.99 lakh ha, production of 70.58 lakh tonnes and productivity of 840 kg ha^{-1} (Anonymous, 2017). Karnataka is one of the major chickpea producing state in the country. In Karnataka, it is grown in rabi season over an area of 14.20 lakh ha under rainfed conditions with an annual production of 6.62 lakh tonnes, with an average productivity of 460 kg ha^{-1} (Anony., 2017).

The national average productivity of chickpea is much lower than the world average productivity, as it is grown both under rainfed as well as irrigated conditions. Further state average productivity (640 kg ha^{-1}) is much lower than the national average (840 kg ha^{-1}). In the state, low productivity of chickpea is mainly attributed to rainfed crop undergo moisture stress at different stages of crop growth, especially terminal stress, inadequate nutrition, weed control and pod borer problem. The moisture stress at different stages of crop growth induce hormonal imbalance which lead to flower drop in pulses (Rana *et al*., 2016) especially in chickpea. Water is a scarce commodity required for any crop production, especially in arid and semi-arid regions where the availability of irrigation water is limited (Rajanna *et al*., 2018; Rajanna *et al*., 2019) and it poses a serious threat to the sustainability of chickpea production. Among the various factors, irrigation scheduling is the key factor to increase crop productivity (Rajanna *et al*., 2019). The harvested rain water in the check dam, farm pond and tanks can be effectively used as protective irrigation by following suitable method of irrigation mainly drip irrigation. Since the water in the soil is maintained at near-field capacity throughout growing period, plants take water easily and never subjected to moisture stress.

Another important critical factor for low productivity is inadequate plant nutrition (Omran *et al*., 2018; Rana *et al*., 2018). The incidence of nutrient deficiencies mainly micronutrients has increased significantly in recent years due to intensive crop production, the depletion of top soil due to erosion and losses of micronutrients as a result of leaching (Rana *et al*., 2018; Omran *et al*., 2020). The deficiency of micronutrients, Zn, B, and Mo are common in chickpea and it responded well to application of these micronutrients (Verma *et al*., 2004). Use of plant growth regulators have great promise due to modified crop growth by changing the rate or pattern of growth

(Nickel, 1982). Plant growth regulators are known to influence the growth and development of plants and ultimately the yield attributing characters and yield. Their use in many crops has been reported to delay senescence of leaves and to retard the abscission of reproductive organs. Hence, they are known to increase flowering, fruiting and grain filling. Application of NAA (Naphthalene Acetic Acid) and Salicylic acid are effective in increasing flowering and pod setting in chickpea (Solanki *et al*., 2012). There is a scope to increase the productivity of chickpea by providing irrigation, foliar application of micronutrients and growth regulators, under drip method of irrigation. With this background a field experiment was conducted with an objective to find out optimum schedule of irrigation, foliar application of micronutrients and growth regulators in chickpea under drip irrigation.

Material and methods

A field experiment was conducted during the *rabi* season of 2018 at College of Agriculture, Vijayapur, Karnataka on medium deep black soils having pH 8.5 and EC 0.41 dS m^{-1}. The soil was medium in organic carbon (0.36 %), available nitrogen (112.5 kg ha^{-1}), available phosphorus (12 kg ha^{-1}) and available potassium (492.8 kg ha^{-1}) which are medium, low, medium and high respectively. The experimental site was located at a 16° 49' North latitude, 75° 43' East longitude and at an altitude of 593.8 m above the mean sea level. The experimental site comes under the Northern Dry Zone of Karnataka (Zone 3).

The experiment consisted of 20 treatment combinations designed through strip-split plot technique with three replications, having five treatments of scheduling of irrigation at 80 mm Ep, 60 mm Ep, 40 mm Ep, critical stages and surface irrigation assisted in main plots and four treatment of foliar application of growth regulators and micronutrients *viz.* NAA 40 ppm + Salicylic acid (200 ppm) + boron (0.05 %) + $ZnSO_4$ (0.5 %) and 19:19:19 NPK at 1.5 percent at flower initiation and pod formation stage assisted in sub plots. All the recommended package of practices for nutrition, weed control and plant protection were carried out. The crop was sown on 5th November 2018. The growth and yield observations and yield were recorded from the net plots area of 3.6 × 5 m. The economics of each system was computed with prevailing market prices. The yield was further computed for gross and net returns as well B:C to assess the profitability.

Results and discussion

Effect on growth, yield and yield attributes

In the present investigation, the growth as well as yield attributing characters of chickpea were found to be significantly influenced by irrigation levels and foliar application of micronutrients and growth regulators. Significantly higher grain yield (1,942 kg ha^{-1}) was recorded with scheduling of irrigation at 60mm Ep as compared to control (1,794 kg ha^{-1}) but it was statistically on par (1,744 kg ha^{-1}) with scheduling of irrigation at 40mm Ep (Table 1). The increase in yield with scheduling of irrigation at 60 mm Ep (250 mm of water) over control was 48 per cent and it was mainly attributed to optimization of the availability of water throughout the crop growing period through drip irrigation. These findings are in conformity with those of Muniyappa *et al* (2017) in chickpea and Rajanna *et al*. (2016) in cluster bean.

Among different foliar sprays of micronutrients and growth regulators at flowering and pod filling stages of chickpea, foliar spray of NAA 40ppm + Salicylic acid (200 ppm) + boron (0.05 %) + $ZnSO_4$ (0.5 %) and 19:19:19 NPK @ 1.5 per cent recorded significantly higher grain yield (1,706 kg ha^{-1}) compared to no spray, which noticed significantly lower grain yield (1,115 kg ha^{-1}). NAA stimulates the apical dominance, cells enlargement and enhances the cell division. It stimulates the shoot development, prompts uniform flowering and enhances the number of flowers and fruit set. Foliar spray of micronutrients improves the production of carbohydrates and protein and their translocation to the location of seed formation (Rajesh *et al.,* 2015).

Table 1. Yield and yield parameters of chickpea as influenced by irrigation levels, micronutrients and growth regulators

Treatment	Pods $plant^{-1}$	Pod weight $plant^{-1}$ (g)	Seed weight $plant^{-1}$ (g)	Seed Yield (kg ha^{-1})
Drip irrigation levels(M)				
M_1	35.2	09.62	8.81	1744
M_2	37.0	10.69	9.52	1794
M_3	31.5	08.77	6.16	1359
M_4	29.7	07.28	5.89	1046
M_5	31.6	08.20	6.51	1207
S.Em.±	1.07	0.201	0.191	71
LSD at (0.05)	3.90	0.73	0.69	257
Foliar spray of growth regulators and micro nutrients (F)				
F_1	31.7	08.89	07.29	1393
F_2	33.9	09.59	07.67	1505
F_3	39.8	10.53	09.12	1706
F_4	26.6	06.62	05.44	1115
S.Em.±	0.94	0.257	0.284	61
LSD at (0.05)	2.72	0.74	0.82	178
Interaction (MxF)				
M_1F_1	35.4	09.30	08.78	1619
M_1F_2	35.7	10.13	09.13	2051
M_1F_3	43.3	12.00	10.97	1871
M_1F_4	26.5	07.03	6.35	1435
M_2F_1	35.0	10.93	8.92	1869
M_2F_2	38.1	12.04	9.92	1665
M_2F_3	46.6	13.01	12.89	2151
M_2F_4	28.3	06.77	6.37	1490
M_3F_1	29.6	08.84	6.12	1359
M_3F_2	30.4	09.10	6.18	1311
M_3F_3	39.9	09.83	7.35	1721
M_3F_4	26.2	07.31	5.00	1045
M_4F_1	28.9	07.62	6.14	965
M_4F_2	30.0	07.59	6.33	1165
M_4F_3	33.1	08.20	6.66	1258
M_4F_4	26.8	05.69	4.42	797
M_5F_1	29.8	07.78	6.47	1153
M_5F_2	32.3	09.11	6.80	1334
M_5F_3	39.0	09.60	7.74	1529
M_5F_4	25.4	06.29	5.03	810
S.Em.±	1.89	0.51	0.5	124
LSD at (0.05)	5.45	1.48	1.64	357

Scheduling of irrigation at 60 mm Ep gave higher yield traits mainly number of pods plant^{-1} (36.99), pod weight plant^{-1} (10.61g) and seed weight plant^{-1} (9.52g) of chickpea compared to surface irrigation (31.61 plant^{-1}, 08.20 g plant^{-1} and 6.51g, respectively). Higher yield attributes with irrigation at 60 mm Ep was mainly attributed to adequate soil moisture in the soil to meet the water requirement of the crop. Likewise, foliar spray of NAA 40 ppm + Salicylic acid (200 ppm) + Boron (0.05 %) + $ZnSO_4$ (0.5 %) and 19:19:19 NPK at 1.5 per cent in chickpea recorded significantly higher number of pods plant^{-1} (46.57), pod weight plant^{-1}(13.01g) seed weight plant^{-1} (12.89g), grain yield (2151 kg ha^{-1}) compared to control (26.63 plant^{-1}, 06.62 g plant^{-1} and 05.44g and 1115 kg ha^{-1} respectively). It was largely because of increased number of flower and increased number of pod set plant^{-1} with foliar spray of micronutrients and growth regulators.

Boron treatment might have played a critical role in reducing the flower and pod drop probably by avoiding abscission layer development and is also involved in translocation of sugars from source which ultimately lead to increased yield (Rajesh *et al.,* 2015; Divyashree, 2016). Similarly, Boron plays a dominant role in pigeonpea crop at reproductive phase for increasing seed fill and seed set (Sonawane *et al*., 2015).

Interactions effect

Significantly higher grain yield (2,151 kg ha^{-1}) was recorded with scheduling of irrigation at 60 mm Ep along with foliar spray of NAA (40ppm) + Salicylic acid (200) ppm + Boron (0.05 %) + $ZnSO_4$ (0.5 %) and 19:19:19 NPK @ 1.5 per cent when compared to other treatment combinations except the scheduling of irrigation at 40 mm Ep in combination with foliar application of NAA 40 ppm + Salicylic acid 200 ppm + 19:19:19 water soluble fertilizer @ 1.5 per cent + $ZnSO_4$ (0.5 %) + Boron (0.05 %) (1871 kg ha^{-1}), which were on par with each other (Table 1). Similar results were recorded in chickpea by (Mudalagiriyappa *et al.,* 2016). Application of RDF(20:40:20:20 kg N:P_2O_5, K_2O:S/ha) along with Urea @ 2% + Salicylic acid @ 75 ppm spray produced higher grain yield which is attributed to the increased nutrient supply and reduced flower drop and ultimately enhanced the pod setting and resulted in higher seed yield of mungbean (Nitu Kumari *et al*., 2019). At Dharwad, significantly higher grain yield was recorded with foliar spray of Salicylic acid (0.02%) + $ZnSO_4$ (0.5%) + Boron (0.2%) in pigeonpea (Lavanya *et al*., 2020) .

Among the treatment combinations, significantly higher net returns was obtained with scheduling of irrigation at 60 mm Ep along with the foliar spray of NAA 40 ppm + Salicylic acid 200 ppm + Boron (0.05 %) + $ZnSO_4$ (0.5 %) and 19:19:19 NPK @ 1.5 per cent (69,169 Rs. ha^{-1}) than surface irrigation with no spray (₹18,422 ha^{-1}). Further it was statistically at par with scheduling of irrigation in combination with foliar spray treatment combinations mainly M_1F_2, M_1F_3, M_2F_1 (66,999, 56,569, and 59,257 Rs. ha^{-1}, respectively) (Table 2).

Among the treatment combinations significantly higher B:C was obtained with scheduling of irrigation at 40 mm Ep along with the foliar spray of boron (0.05 %) + $ZnSO_4$ (0.5 %) and 19:19:19 NPK at 1.5 per cent (3.65) than surface irrigation with no spray (1.90).The former treatment waswas statistically at par with scheduling of irrigation with foliar spray treatment combinations mainly M_2F_3, M_2F_4, M_1F_3, M_1F_4 (3.51,3.15,3.05,3.02 respectively). Similar results were recorded in (Muniyappa *et al*. (2017) (Table 2).

Conclusion

It can be concluded from the above results that, in chickpea scheduling of irrigation at 60 mm Ep along with foliar application of NAA (40 ppm) + Salicylic acid (200 ppm) + boron (0.05 %) + $ZnSO_4$ (0.5 %) and 19:19:19 NPK @ 1.5 per cent produced higher yield, yield parameters, net returns and benefit cost ratio. In dryland areas, providing irrigation by using the water harvested in the farm pond or tube well water and application of micronutrients and growth regulators will help to enhance the productivity of chickpea.

Table 2. Gross and net returns and B:C of chickpea as influenced by irrigation levels, micronutrients and growth regulators.

Treatment	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C
Drip irrigation levels (M)			
M_1	95,916	53,720	3.17
M_2	98,650	55,957	3.25
M_3	74,747	36,401	2.45
M_4	57,536	22,319	1.89
M_5	66,359	31,025	2.28
S.Em.±	3,893	3,167	0.12
LSD at (0.05)	14151	11,512	0.45
Foliar application of growth regulators and micro nutrients (F)			
F_1	76,604	38,025	2.54
F_2	82,791	42,604	2.69
F_3	93,822	49,338	2.80
F_4	61,349	29,570	2.40
S.Em.±	3,398	2,767	0.10
LSD at (0.05)	9,815	7,991	0.32
Interaction (MxF)			
M_1F_1	89,058	48,035	2.93
M_1F_2	1,12,826	66,999	3.65
M_1F_3	1,02,881	56,569	3.05
M_1F_4	78,898	43,278	3.03
M_2F_1	1,02,774	59,257	3.39
M_2F_2	91,571	49,608	2.96
M_2F_3	1,18,281	69,169	3.51
M_2F_4	81,973	45,794	3.15
M_3F_1	74,727	36,310	2.46
M_3F_2	72,107	33,683	2.33
M_3F_3	94,673	49,853	2.81
M_3F_4	57,483	25,756	2.21
M_4F_1	53,071	1,8591	1.75
M_4F_2	64,060	27,099	2.07
M_4F_3	69,166	28,985	2.05
M_4F_4	43,847	14,600	1.69
M_5F_1	63,391	27,935	2.17
M_5F_2	73,391	35,633	2.46
M_5F_3	84,112	42,113	2.58
M_5F_4	44,542	18,422	1.90
S.Em.±	6,797	5,534	0.22
LSD at (0.05)	19,631	15,983	0.63

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