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Effect of Soil fertility and irrigation on water use, productivity and uptake of nutrients in chickpea (*Cicer arietinum*) in Gird zone of Madhya Pradesh

HARENDRA SINGH BHADORIA

College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior (M.P.) - 474002

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ABSTRACT

A field experiment was conducted at Banthari Village of Gwalior (M.P.) to study the effect of soil fertility and irrigation on water use, productivity and uptake of nutrients in chickpea (Cicer arietinum L). Treatments comprising fertility levels (no fertilizer, 50% RD of NPK and 100% NPK) and irrigation schedule (0.4, 0.6 and 0.8 IW:CPE ratio) were evaluated in randomized block design with three replications. The growth and yield attributes increased significantly with fertility levels over no fertilizers and maximum values of these attributes were recorded with 100% recommended dose of NPK fertilizers. The maximum seed and straw yields (23.61 and 26.48 q ha^{-1}) were recorded with 100% NPK fertilizers. The uptake of nutrients was also highest at 100% NPK. With an increase in irrigation frequency from IW:CPE ratio 0.4 to 0.8, yield and most of the growth and yield attributes increased significantly. Similarly uptake of nutrients was also higher with higher levels of irrigation. The water use efficiency increased with irrigation and fertility levels. The irrigation at different IW:CPE ratios did not affect the protein content in chickpea, but protein content increased significantly with fertility levels.

Keywords: Fertility, irrigation, water use efficiency, nutrient uptake, yield, chickpea

INTRODUCTION

Pulses occupy a very significant place in Indian farming as well as in a predominantly vegetarian diet of our people. The per capita availability of pulses has also gone down from 78.6 g / capita per day to 39.4 g/ capita per day. Chickpea (*Cicer arietinum*) is the most important crop during rabi season which is mostly grown in dry lands with no input and water management. The most serious constraint is concomitant occurrence of moisture and nutrient stresses. The nutrients and water requirements are very closely and positively related and fertilizer can increase the efficiency of water use substantially (Pramanik *et al.* 2009). Thus, augmenting of the nutrient supply assumes prime significance to improve chickpea production. Water is a key input for all recommended package of practices and, therefore, efficient utilization of irrigation water is essential for chickpea by adopting proper irrigation schedules (Yadav *et al.* 2009). Fertilizers have contributed substantially to the spectacular increase in yield of pulse crops (Singh and Singh 2017). However, growing crop with indiscrimnate use of fertilizers has resulted in deterioration of soil fertility and decline the crop yield with poor quality of produce. Hence the present investigation was undertaken to test the effect of different levels of fertility and irrigation on seed yield and nutrient uptake by chickpea in Gird zone of Madhya Pradesh.

MATERIALS AND METHODS

A field experiment was conducted during winter season on sandy loam soil at Banthari village of Gwalior (M.P. in randomized block design with three replications. The treatments comprised three fertility levels (control, 50% NPK and 100% NPK) and three levels of irrigation (IW:CPE ratio 0.4, 0.6 and 0.8). A presowing irrigation of 100mm was applied for field preparation and to ensure germination and thereafter each irrigation of 60mm depth was applied as per treatments. One common irrigation was applied 20 day after sowing for proper establishment of the crop. Nitrogen, phosphorus and potassium were applied as diammonium phosphate and muriate of potash, respectively. The recommended dose of NPK fertilizers (100% NPK) was 20 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}. The soil was sandy loam, having pH (1: 2.5) 8.0, EC 0.2 dSm^{-1}, organic carbon 3.9 g kg^{-1}, available N 172 kg ha^{-1}, available P and K 9.5 and 180 kg ha^{-1},

respectively. The crop was sown on last week of October with seed rate of 60 kg ha^{-1}. Row to row spacing was 45 cm. Irrigation water was measured by parshall flume and 2, 3 and 4 irrigation of 5 cm each at IW:CPE ratio 0.4, 0.6 and 0.8, respectively were provided during both the years. Periodic soil samples at 15 cm interval up to 75 cm depth with the help of screw auger were taken and dried at 105^0 C till constant weight is attained. Soil moisture percentage and consumptive use of water (CUW) were worked out by using the formula suggested by Dastane (1972). Growth parameters (plant height and dry matter accumulation at 25/cm row length) and yields of seed and straw were recorded at maturity. Seed and straw samples were analysed for their nitrogen content by modified Kjeldahl method. These samples were digested in HNO_3 : $HClO_4$ mixture and P and K in the digest were determined by vanadomolybdate yellow colour method and flame photometer, respectively. The uptake of nutrients was calculated by multiplying the yield data with nutrient concentration. The trend of response of irrigation scheduling and fertility levels was same during both the years, therefore, the pooled data are presented for drawing valid conclusion.

RESULTS AND DISCUSSION

Growth and yield

Data (Table 1) revealed that the increase in irrigation schedule (IW:CPEratio) resulted in a greater height of the plants. The maximum and minimum values of plant height were recorded under IW:CPE ratio 0.8 and IW:CPE ratio 0.4, respectively. Pramanik et al (2009) also reported similar results. The plants of chickpea became markedly taller in fertilized plots than in control plots. The variation in the plant height between 50 and 100% NPK was more pronounced and statistically significant. The beneficial effect of fertilizer on plant hight was also reported by Pramanik *et al.* (2009) and Singh (2017). Data evince that the variations between different IW:CPE ratios were significant and highest dry matter accumulation was obtained with 0.8 IW: CPE ratio. The dry matter production is the result of better plant growth as reported by Pramanik *et al.* (2009). Every increase in the level of fertility increased significantly the dry matter production in chickpea and maximum value was recorded with 100% NPK. Yadav *et al.* (2009) and Chauhan *et al.* (2017) reported similar results.

Table 1: Effect of various treatments on growth, yield and quality of chickpea (mean of 2 years)

Treatments	Plant height (cm)	Dry matter / 25cm row length (g)	Seed yield (q ha^{-1})	% response	Straw yield (q ha^{-1})	Protein (%)		Protein yield (kg ha^{-1})
IW : CPE ratio								
0.4	32.2	64.6	14.45	-	17.88	21.12	7.87	305.2
0.6	41.4	76.4	18.10	25.2	21.81	20.43	7.62	360.8
0.8	47.5	91.8	22.55	56.0	26.95	18.06	7.12	407.2
CD (P=0.05)	1.17	2.75	2.37	-	2.70	NS	NS	36.0
Fertility level								
Control	31.1	58.1	13.07	-	18.04	17.50	6.75	228.7
50% NPK	41.0	80.0	18.72	43.2	22.10	18.93	7.56	454.4
100% NPK	49.1	94.8	23.61	80.6	26.48	19.37	8.25	457.3
CD (P=0.05)	1.17	2.75	2.37	-	2.70	0.42	0.24	36.0

Yield

The improvement in irriation schedule had a pronounced effect on the yield of chickpea. The mean yield of seed of chickpea increased by 25.2 and 56.0 per cent, respectively due to 0.6 and 8 IW:CPE over 0.4 IW:CPE ratio. Thus, higher level of irrigation is beneficial for higher production of chickpea. Similar response to irrigation schedule was reporte by Bhunia *et al.* (2005). The straw yield of chickpea also increased with irrigation schedule, which may be ascribed to better development of growth character of the crop (Bhunia 2005) and Mehta *et al.* (2010). The higher yield with higher levels of irrigation might be due to its key role in root development, higher transpiration, greater uptake of nutrients and more synthesis due to better metabolic activities due to better metabolic activities in plant. Application of fertilizers brought about significant improvement in the seed and straw yield of

chickpea over control. The yields of chickpea seed and straw increased by 80.6 and 46.7 per cent over control with 100% NPK, respectively. Application of 50% NPK increased seed yield of chickpea increased by 43.2% over control. The higher yield with fertilizer application may be ascribed to better growth due to adequate and balanced supply of nutrients as per crop demand. Similar results were reported by Singh (2017), Bonde and Gawande (2017) and Singh *et al.* (2017).

Quality

Protein content in chickpea, decreased under 0.8 IW : CPE ratio over 0.4 IW:CPE ratio which may be attributed to the better plant growth, hence more dry matter production resulting dilution of nitrogen under increased moisture supply. Mehta *et al.* (2010) also reported similar results. The increased levels of fertility boosted the protein content in chickpea up to the highest fertility level. The maximum values of protein content in chickpea seed (19.37%) and straw (8.25%) were recorded under 100% NPK. This increase in protein content may be attributed to increased concentration of nitrogen in seed and straw of chickpea due to application of NPK fertilizers. Similar results were reported by Singh (2017), Bonde and Gawande (2017) and Singh and Singh (2017).A further study of Table 1 reveals that there was a significant increase in the protein production in chickpea seed with irrigation schedule. The maximum values of protein production were noted at higher levels of irrigation (0.6 and 0.8 IW: CPE ratio). This increase may be attributed to increased seed yield of chickpea seeds. There was a significant increase in protein production in chickpea with increasing levels of soil fertility. The maximum protein yield (457.3 kg ha^{-1}) of chickpea seed was recorded at 100% NPK dose. This increase in protein production may be attributed to increased seed yield and protein content in seeds. Similar results were reported by Bonde and Gawande (1917) and Singh and Singh (2017).

Table 2: Effect of various treatments on uptake of nutrients (kg ha^{-1}) by chickpea seed and straw (mean of 2 year)

Treatment	Nitrogen		Phosphorus		Potassium		Water use efficiency (kg/mm/ha)
	Seed	Straw	Seed	Straw	Seed	Straw	
IW : CPE							
0.4	48.8	22.5	6.2	5.0	8.2	33.4	8.4
0.6	59.2	26.6	7.6	5.7	9.2	40.1	8.8
0.8	65.2	30.7	9.2	6.5	10.6	47.7	9.8
CD (P=0.05)	7.52	3.18	0.83	0.48	1.49	5.49	-
Fertility level							
Control	36.96	19.5	5.3	4.3	5.5	31.4	7.0
50% NPK	56.7	26.7	7.9	5.7	8.2	40.9	10.0
100% NPK	68.2	34.9	10.2	7.4	10.3	49.8	11.1
CD(P=0.05)	7.52	3.18	0.83	0.48	1.49	5.48	-

Uptake studies

Nitrogen uptake by seed and straw of chickpea was significantly affected by IW:CPE ratio and the maximum uptake values were recorded under irrigation at 0.8 IW: CPE ratio. Higher irrigation frequency increased the availability of nutrients and thus enhanced the uptake of nitrogen by the crop. The results confirmed the findings those of Yadav *et al.* (2009). The uptake of N increased significantly with increasing levels of soil fertility. Higher values of N uptake with higher soil fertility level are apparently the result of favourable effect of these treatments on N absorption coupled with greater yields (Singh 2017, Singh and Singh 2017). The phosphorus uptake by grain and straw of chickpea increased with IW:CPE ratio and lowest values were recorded under 0.4 IW:CPE ratio. It is therefore, obvious that minimum water supply not only reduced the absorption of P but also did not permit normal distribution of P from the vegetative parts to the reproductive parts (Yadav *et al.* 2009). The uptake of P by seed and straw increased significantly with the application of fertilizers.

Phosphorus uptake by seed and straw of chickpea increased with 100% NPK from 7.5 to 12.7 and 6.2 to 8.8 kg ha^{-1}, respectively. This may be due to the fact that P fertilization results in a better growth and deeper ramification of roots causing higher upake of phosphorus. Chauhan *et al.* (2017) also reported increased P uptake in chickpea crop with NPK fertilizer application. The uptake of K by chickpea crop appreciably increased with every level of irrigation and the highest values of K uptake by seed and steaw were recorded at 0.8 IW:CPE ratio. Higher K uptake at higher levels of irrigation might be attributed to greater root growth and availability of more nutrients along with higher transpiration ratio. Bhunia *et al.* (2005) also reported similar results. Addition of fertilizer to the soil proved beneficial for K uptake by chickpea seed and straw. The 100% NPK removed maximum amounts of K from the soil by seed and straw. Application 50% NPK also helped in removing significantly more K through seed and straw over control, (Bonde and Gawande 2017). Moreover, higher amount of K was received in straw than seed, it was mrely because of higher content of K in straw of the crop.

Moisture Studies

Treatment 0.8 IW:CPE ratio had its superiority in respect of water use over 0.6 and 0.4 IW : CPE ratio treatments. This may be attributed to more and easy availability of water for absorption by the plant roots (Bhunia 2005). Similarly water use efficiency increased with irrigation schedule. Here, it may be recalled that the yields increased under higher irrigation levels and total consumptive use also increased in the same ratio. The consumptive use of water by the crop increased with increasing levels of fertilizer. Water use efficiency was noted to increase up to full recommended dose of NPK fertilizers. This pattern of water use efficiency, thus, indicates that full RD of NPK for chickpea is suitable rate in Gird zone of Madhya Pradesh. This is because higher rate of fertilizer results in higher grain yield which is proportionately more than the increase in water thereby resulting in to higher WUE (Yadav *et al.* 2009).

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