

Crop, water productivity and economics in chickpea as influenced by application of hydrogel and foliar nutrition

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ABSTRACT

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A field experiment was carried out during two consecutive winter seasons of 2018-19 and 2019-20 to enhance crop and water productivity in chickpea RSG 973 through hydrogel and foliar nutrition under deficit soil moisture conditions. Ten treatments combinations consisting of two hydrogel levels (control versus hydrogel at 5 kg/ha applied at last plough or sowing in rows) in main plots and five foliar nutrition levels (water spray i.e., control, urea 2%, thiourea 500 ppm, salicylic acid 100 ppm and NPK at 0.5% (with complex fertilizer having N:P:K 19:19:19 kg/ha) applied at flowering and pod development stages) in sub plots were carried out in trice replicated split plot. Results revealed that application of hydrogel @5 kg/ha significantly increased growth, yield attributes and yield of chickpea during both the year. The mean increases in grain yield and water productivity due to application of hydrogel were 17.54 per cent and 0.24 kg/m³ respectively over control. Similarly, foliar nutrition significantly influence pods/per plant, 100-seed weight, grain, straw, biological yield, harvest index and water productivity during both year of experimentation. Further, foliar application of salicylic acid @ 100 ppm recorded significantly higher pods/plants (63.87, 67.40), 100-seed weight (15.67, 15.85 g), grain yield (15.48, 16.27 qha⁻¹) and water productivity being at par with NPK 19:19:19 @0.5 per cent, thiourea @ 500ppm but significantly superior over water spray and urea@ 2 per cent.

Key words: Chickpea, Foliar Nutrition, Hydrogel, water productivity, Yield

INTRODUCTION

Chickpea (*Cicer arietinum* L.), an important constituent of Indian vegetarian diet, is considered as one of the most important pulses in India. In Rajasthan, it is grown in an acreage of 2.46 million hectares (mha) producing about 2.66 million tonnes (mt) with the productivity of 1080 kg/ha (Anonymous 2020). This crop is also an integral part of diverse and intensive cropping systems for sustainable agricultural production. In spite of its multifarious advantages, its productivity is low due to several biotic and abiotic factors. Insufficient soil moisture is the major environmental stress in dryland areas of several countries of the world (Kalhapure *et al.* 2016) and often affects the crop along with heat stress and perplexing effects on crop productivity (Erskine *et al.* 2011; Singh *et al.* 2016). In Rajasthan, chickpea is mostly grown as rainfed crop on conserved soil moisture as there is little scope for supplementary irrigation as this Indian state falls under semiarid region. Thus, water scarcity is one of the major constraints in increasing/sustaining chickpea productivity under this agro-ecosystem (Prahara *et al.* 2018). Under these sorts of

abiotic stress (moisture) conditions, the heat and temperature extremities especially during flowering and pod development are also major impediment affecting development of the crop and its productivity resulting in flower drop and improper seed filling. Therefore, we needed a substance which could be used in the field to retain (excess) moisture in the time of its availability and released the same in case crop needed it (removal/uptake by the crop in case of water stress). Thus, hydrogel used in the experiment were granular insoluble materials with hydrophilic in nature which could absorb large quantities of water. In areas where opportunity for irrigation is very limited, hydrogels have great potential and can increase the water availability during crop growth period. This can also absorb and retain water as much as 80–180 times of its original volume (Singh *et al.* 2016) while on weight basis it can absorb as high as 400 times its original weight (Subbarao *et al.* 1995). Application of hydrogel delays the permanent wilting point, thereby minimizing the irrigation requirement of the crop (Shooshtarian *et al.* 2012). The various physical properties of soil like infiltration rates, density, soil

structure and compaction etc. can also be modified by application of hydrogel. Agriculture production may be stabilized by soil application of polymer (Khadem *et al.* 2010), through mitigating the effect of drought stress (Ali *et al.* 2014; Praharaj *et al.* 2018). For an improved production in dryland/rainfed ecosystems, a larger percentage of the precipitation must be stored in soil and the stored water must be used more efficiently to exploit its full potential (Singh *et al.* 2016, Praharaj *et al.* 2018). The abnormal weather conditions have also posed new generation problems like nutrient management in rainfed areas. Under dry conditions, supply of nutrients through soil application may involve higher costs besides lower absorption capacity by roots (Baldeo Ram *et al.* 2018). Foliar application of nutrients in a lower concentration through bio-regulators enhances physiological and reproductive efficiencies of plants and helps in nutrient absorption by acting as chemical catalyst in plant (Davies *et al.* 2000). Thus efficient nutrient management (macro and micronutrients) through foliar application not only helps in amending the nutrient deficiency, but also helps in reducing the heat stress. Yield of lentil has been reported to increase by drilling hydrogel (2.5 kg/ha) along with foliar application of either NPK (0.5%) or salicylic acid (75 ppm) (Baldeo Ram *et al.* 2018). Keeping this in view, a field experiment was conducted for consecutive two winter seasons during 2018-20 to assess the effect of hydrogel with suitable foliar nutrition at critical stages for enhancing productivity and profitability of chickpea under limited irrigation situation.

MATERIALS AND METHODS

A field experiment was conducted during two consecutive winter seasons of 2018-19 and 2019-20 at research farm of Rajasthan Agricultural Research Institute, Durgapura, Jaipur (26° 51' N, 75° 47' E and 390 m altitude) to enhance the chickpea productivity with higher water productivity through hydrogel and foliar nutrition under limited water conditions. Durgapura, Jaipur falls in the Semi-Arid Eastern Plain Zone of Rajasthan (III-A) having extreme cold winters and hot summers. During winter season, occurrence of frost (below °C) is quite common. The average annual rainfall of zone is 529 mm of which about 90 % is received from South-west monsoon during latter half of June to September with erratic distribution over time and space. The soil of the experimental site was sandy loam with sand (86.8%), silt (5.6%), clay (7.6%), pH 7.9, 0.17 % organic carbon and 139.2, 36.6 and 238.0 kg/ha available N, P, K, respectively. The experiment was laid out in thrice replicated split plot with two

levels of hydrogel (no hydrogel and hydrogel @ 5 kg/ha) and five treatments of foliar nutrition (Control, urea @ 2%, Thiourea @ 500 ppm, salicylic acid @ 500 ppm and NPK 19:19:19 @ 2%). Field preparation included one deep ploughing followed by 2 cross harrowing followed by planking. The chickpea var. RSG 973 were sown during first fortnight of November during both the years of experimentation using crop geometry of 30x10 cm. The experimental crops were fertilized with uniform basal dose of 20 kg N + 40 kg P₂O₅ /ha and whole amount of N and P₂O₅ was drilled at the time of sowing. Crop was raised under limited irrigated condition and a total of two including pre-sowing irrigation were applied. A total of 10 cm water was applied in irrigation. Crop protection measures were followed as and when required. Chickpea crop was harvested in first week of April during both the years, manually at about 10 cm above the ground level and were kept for sun drying for some days in field and after threshing the bundles from each plot, the seeds were cleaned, dried and weighed. The grain and straw yield was expressed in kg ha⁻¹. The water productivity was estimated as per the formula given by Pereira *et al.* (2002). The net returns of each treatment were calculated by deducting the total cost of cultivation from gross returns of respective treatments and the benefit: cost ratio was calculated by dividing the net returns with total cost of cultivation. All data recorded were analyzed with the help of analysis of variance (ANOVA) technique (Gomez and Gomez, 1984) SPD. The least significant test was used to decipher the effects of treatments at 5% level of significance (P<0.05).

RESULTS AND DISCUSSION

Effect of hydrogel:

Results (Table 1 and 2) revealed that drilling of hydrogel @ 5 kg/ha had significant effect on growth, yield attributes and yield of chickpea. Application of hydrogel @ 5 kg/ha resulted in significantly increase in plant height, pods/plant, 100-seed weight, grain and straw yield of chickpea during both the years of experimentation. The mean increase in plant height, pods/plant and 100-seed weight due to hydrogel were 11.65, 12.32 and 5.73 percent respectively over no hydrogel application. Similarly, higher mean chickpea seed, straw and biological yield (15.95, 33.83 and 49.76 q/ha) was recorded under application of hydrogel @ 5 kg/ha compared to no hydrogel. The mean increases in chickpea grain, straw and biological yield due to hydrogel were 17.54, 12.32 and 13.89 percent respectively over no hydrogel application. The significant increases in growth, yield attributes and

Table 1. Effect of hydrogel and foliar nutrition on growth, seed yield and yield attributes of chickpea

Treatments	Plant height (cm)			Pods /plant			100-seed weight (g)			Grain yield (q/ha)			Straw yield (q/ha)		
	18-19	19-20	Mean	18-19	19-20	Mean	18-19	19-20	Mean	18-19	19-20	Mean	18-19	19-20	Mean
Years	18-19	19-20	Mean	18-19	19-20	Mean	18-19	19-20	Mean	18-19	19-20	Mean	18-19	19-20	Mean
No hydrogel	52.27	53.49	52.88	55.56	60.65	58.11	14.90	15.13	15.02	13.21	13.93	13.57	29.40	30.83	30.12
Hydrogel @ 5 kg/ha	58.59	59.49	59.04	63.87	66.67	65.27	15.86	15.90	15.88	15.71	16.19	15.95	33.02	34.64	33.83
SEm±	1.00	0.85	-	1.26	0.79	-	0.14	0.13	-	0.21	0.27	-	0.44	0.56	-
CD 5%	6.11	5.18	-	7.65	4.80	-	0.89	0.56	-	1.29	1.65	-	2.65	3.41	-
Water spray (control)	53.63	54.83	54.23	52.50	55.37	53.94	14.81	14.94	14.88	12.80	12.90	12.85	29.56	29.66	29.61
Urea 2%	55.40	56.73	56.07	56.53	61.23	58.88	15.16	15.23	15.20	13.79	14.29	14.04	30.85	31.35	31.10
Thiourea 500 ppm	55.42	56.40	55.91	62.50	65.63	64.07	15.61	15.81	15.71	14.88	15.77	15.33	31.65	33.63	32.64
Salicylic acid 100 ppm	55.80	56.70	56.25	63.87	67.40	65.64	15.67	15.85	15.76	15.48	16.27	15.88	31.65	34.13	32.89
NPK (19:19:19) @ 0.5%	56.90	57.80	57.35	63.17	68.67	65.92	15.68	15.75	15.72	15.38	16.07	15.73	32.34	34.92	33.63
SEm(±)	1.98	1.91	-	2.20	3.49	-	0.21	0.25	-	0.24	0.38	-	0.66	0.75	-
CD (0.05)	NS	NS	-	6.61	7.39	-	0.63	0.54	-	0.72	1.14	-	NS	2.23	-

Table 1. Cont....

Treatments	Biological yield (q/ha)			Harvest index (%)			WP (Kg/M ³)			
	Years	18-19	19-20	Mean	18-19	19-20	Mean	18-19	19-20	Mean
No hydrogel		42.62	44.76	43.69	30.98	31.07	31.03	1.32	1.39	1.36
Hydrogel @ 5 kg/ha		48.73	50.79	49.76	32.23	31.79	32.01	1.57	1.62	1.60
SEm±		0.65	0.91	-	0.01	0.10	-	0.02	0.03	-
CD 5%		3.94	5.54	-	0.06	0.61	-	0.13	0.16	-
Water spray (control)		42.36	42.56	42.46	30.15	30.28	30.22	1.28	1.29	1.29
Urea 2%		44.64	45.63	45.14	30.84	31.24	31.04	1.38	1.43	1.41
Thiourea 500 ppm		46.53	49.40	47.97	31.95	31.90	31.93	1.49	1.58	1.54
Salicylic acid 100 ppm		47.12	50.30	48.71	32.83	32.24	32.54	1.55	1.63	1.59
NPK (19:19:19) @ 0.5%		47.72	50.99	49.36	32.24	31.48	31.86	1.54	1.61	1.58
SEm(±)		0.86	1.09	-	0.31	0.33	-	0.02	0.04	-
CD (0.05)		2.58	3.28	-	0.92	0.98	-	0.07	0.11	-

yield of chickpea under application of hydrogel might be due to better availability of moisture during the entire crop growth stages which may enhance better uptake of macro and micro nutrients and thus reduced moisture stress and better availability of nutrients plays an important role in improving crop productivity. 8-55% increase in chickpea yield was also observed by Dingre *et al.*, 2017. Similar findings were also reported by Baldeo Ram *et al.*, 2018 who also recorded significantly higher values of plant height pods/plant and grain yield of lentil under application of hydrogel compared to control. Significantly higher values of harvest index and water use efficiencies were also recorded under application of hydrogel during both the years. However, on pooled basis only the WP could prove significantly superior over no hydrogel. The mean increases in WP due to hydrogel were 0.24 kg/m³ compared to no hydrogel. The increase in water use efficiency might be higher grain yield under hydrogel application. Higher water use efficiency under application of hydrogel was also reported by Kumar and Rajkumara (2016). Similarly, higher gross

and net returns were also recorded under application of hydrogel compared to no hydrogel during both years of experimentation. The mean increases in gross and net returns under hydrogel were Rs. 13144 and Rs. 5326/- respectively, over no hydrogel. Halagalimath and Rajkumara (2017) also observed higher gross and net returns were obtained from the irrigation at 0.4 IW/CPE + 2.5 kg ha⁻¹ of hydrogel application.

Effect of foliar nutrition

The yield and yield attributes of chickpea crop was significantly influenced by foliar nutrition during both the years of study except straw yield during 2018-19 compared to control (water spray) presented in Table 1 and 2. Application of urea @ 2% though improved the yield attributing characters like pods/plant and 100-seed weight but failed to attain statistical significance during both the years. However, application of thiourea @ 500 ppm, salicylic acid @ 100 ppm and NPK 19:19:19 @ 2 % significantly improved the studied yield attributing characters during both the years. The mean increases in pod/

Table 2. Effect of hydrogel and foliar nutrition on economics of chickpea

Treatments	Gross returns (Rs/ha)			Net returns (Rs/ha)			B:C Ratio			
	Years	18-19	19-20	Mean	18-19	19-20	Mean	18-19	19-20	Mean
No hydrogel		75752	83318	79535	42256	49822	46039	1.26	1.49	1.38
Hydrogel @5 kg/ha		89108	96250	92679	47794	54936	51365	1.16	1.33	1.25
SEm±		--	--	--	--	--	--	--	--	--
CD 5%		--	--	--	--	--	--	--	--	--
Water spray (control)		73907	77703	75805	37090	40886	38988	1.01	1.12	1.07
Urea 2%		79135	85317	82226	41738	47920	44829	1.12	1.29	1.21
Thiourea 500 ppm		84573	93713	89143	46901	56041	51471	1.25	1.49	1.37
Salicylic acid 100 ppm		87323	96379	91851	49919	58975	54447	1.34	1.59	1.47
NPK(19:19:19)@0.5%		87212	95809	91511	49475	58072	53774	1.32	1.55	1.44
SEm(±)		--	--	-	--	--	-	--	--	-
CD (0.05)		--	--	-	--	--	-	--	--	-

Common cost of cultivation INR 32284/-ha, Thiourea INR 1.34/g, Salicylic acid INR 1.33/g, NPK at INR 160/kg, Hydrogel at 1500/kg

plant and 100-seed weight due to application of thiourea, salicylic acid and NPK were 18.78, 21.69 and 22.21% and 5.58, 5.91 and 5.65%, respectively over control. Application of salicylic acid @100 ppm recorded maximum grain yield of chickpea closely followed by NPK 19:19:19 during both the years and both were statistically at par with thiourea @ 500 ppm and significantly superior over grain yield under urea @ 2% and control. However, straw yield failed to influence significantly during 2018-19 but during 2019-20 foliar nutrition significantly influenced straw yield. The mean increases in grain and straw yield due to application of salicylic acid were 23.58 and 11.08 percent; 13.11 and 5.76 percent, respectively over control and urea @ 2%. Similarly, the mean increases in grain and straw yield due to application of N,P,K 19:19:19 @ 0.5% were 22.41 and 13.58 and 12.04 and 8.14 percent, respectively over control and urea 2%. The increase in yield was due to the increase in the number of pods per plant under the foliar application of nutrient chemicals and plant growth regulators. Similar findings were also reported by Shankarappa *et al.*, 2020 in lentil where significantly highest grain yield was recorded in the NPK spray of 0.5% remained on par with salicylic acid 75 ppm. Chickpea though produces large number of flowers but most of them get abscised without forming pods. The retention of flowers and pods can be increased by either foliar application of nutrients or plant growth regulators as reported by Sharma and Dey (1986). Similarly, the foliar application of thiourea, salicylic acid and NPK 19:19:19 significantly improved harvest index of chickpea compared to control. Further, the harvest index and water use efficiency improved significantly under application of foliar nutrition during both the years. The mean increases in harvest index and water

use efficiency due to application of salicylic acid were 2.32 and 23.26; 1.50 and 12.77; 0.61 and 3.25 percent over control, urea 2% and thiourea 500 ppm, respectively. Similarly, the mean increases in harvest index and water use efficiency due to application of NPK 19:19:19 were 1.64 and 22.48 and 0.82 and 12.06%, respectively over control and urea 2%. Similarly, the mean maximum gross, net returns and B:C ratio (Rs. 91851/-, Rs. 54447/- and 1.47) was obtained under application of salicylic acid @ 100 ppm closely followed by application of N,P,K 19:19:19 @ 0.5% (Rs. 91511, Rs. 53774 and 1.44) while, the least were recorded under control (Rs. 75805/-, Rs. 38988/- and 1.07).

It is inferred from the above that hydrogel (5 kg/ha) application before sowing of chickpea crop and foliar supplementation with salicylic acid at 100 ppm at flowering and pod development stages could be useful in terms of crop and water productivity and profitability under semiarid condition of Rajasthan, India.

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