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Effect of Salicylic Acid and Biochar on Nutrient content and Uptake of chickpea (*Cicer arietinum* L.) under Rainfed condition

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ABSTRACT: A field experiment was conducted at Instructional Agronomy Farm, Rajasthan College of Agriculture, MPUAT, Udaipur (Rajasthan) during *rabi*, 2021–2022 to assess the effect of salicylic acid and biochar on nutrient content and uptake of chickpea (*Cicer arietinum* L.) under rainfed condition. The experiment was comprised of a combination of 4 concentrations of salicylic acid (water spray, 50, 100, 150 ppm) and 3 levels of biochar (control, 1, 2 t ha^{-1}) thereby making 12 treatment combinations replicated thrice in FRBD. The foliar spray of salicylic acid was done at the flower initiation and pod filling stage. The experiment results revealed that with foliar applied salicylic acid at 100 ppm chickpea crop accumulated the highest quantum of nutrients *i.e.*, nitrogen, phosphorus and potassium by seed (64.28, 6.58 and 11.47 kg ha^{-1}), haulm (27.25, 9.21 and 59.49 kg ha^{-1}) and total (91.91, 15.79 and 70.97 kg ha^{-1}). Biochar application at 2 t ha^{-1} recorded significantly higher quantum of nitrogen, phosphorus and potassium uptake by seed (69.47, 7.03 and 12.18 kg ha^{-1}), haulm (29.03, 9.78 and 62.75 kg ha^{-1}) and total (98.50, 16.82 and 74.93 kg ha^{-1}).

Keywords: Salicylic acid, biochar, chickpea, foliar, rainfed.

INTRODUCTION

Our country is predominantly vegetarian and pulses are the main source of quality protein. Chickpea (*Cicer arietinum* L.) known as “king of pulses” is a most important winter (*rabi*) season legume with high acceptability and wider use in nutritional food basket. India is a premier chickpea growing country in the world, accounting for an area of 10.17 m ha and production of 11.35 m t with average productivity of 1116 kg ha^{-1} (DAC&FW, 2020). Chickpea is typically grown in marginal and rainfed regions, and it tends to be sensitive to abiotic stresses such as drought, low and high temperatures (Mantri *et al*., 2010).

In recent years, the use of bioregulators has opened new vistas for enhancing the productivity of several crops under stress conditions. Among these, salicylic acid is one of the plant hormones produced by the plant naturally. It plays an important role in the growth and development of the plant, physiologically it helps in increasing the plant’s response to biotic and abiotic stress conditions (Mohamed *et al*., 2020). Its diverse physiological role in plants includes thermogenesis, flower induction, nutrient uptake, stomatal movement and photosynthesis (Hayat *et al*., 2013). Generally, a high concentration of it reduces tolerance to abiotic stress whereas a low concentration increases drought tolerance (Miura and Tada 2014).

Biochar is a porous, carbon rich material prepared through pyrolysis process from biomass. In absence of oxygen, biomass is subjected to thermo-chemical conversion at a temperature range of 350°C to 500°C (Sakhiya *et al*., 2020). Its application to soil improves soil's physical, chemical and biological properties (Somerville *et al*., 2020) which provides favourable conditions for living microbiota in the soil and increases the soil carbon pool, improves soil tilth (Glaser *et al*., 2002) and nutrient availability (Hossain *et al*., 2020). It can be the solution to the energy, carbon storage, and ecosystem function (Lori *et al*., 2013).

MATERIAL AND METHODS

The field experiment was conducted at Instructional Farm of Agronomy, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur during the *rabi* season of 2021-22. The soil of the experimental field was clay loam in texture, slightly alkaline in reaction (pH 8.1), low in available nitrogen

(261.24 kg ha^{-1}) and medium in available phosphorus (17.48 kg ha^{-1}) while high in available potassium status (296.45 kg ha^{-1}) and the site falls under agro-climatic zone IV a (Sub-Humid Southern Plains and Aravalli hills). The experiment was conducted in a factorial randomized block design (FRBD) with twelve treatments comprising four doses of salicylic acid *viz*., water spray, 50, 100 and 150 ppm and three doses of biochar *viz*., control, 1 and 2 t ha^{-1} and replicated thrice. Chickpea crop variety JAKI-9218 was sown on 1st November 2021 at a seed rate of 80 kg ha^{-1}. There is no irrigation applied during the crop growth duration other than pre-sowing irrigation. Recommended doses of Nitrogen and Phosphorus *i.e*., 20 and 40 kg ha^{-1} were supplied through Urea and SSP. Foliar application of salicylic acid was done at flower initiation and pod filling stage of chickpea while biochar application and incorporation in soil were done before the sowing of the crop.

Nutrient content and uptake estimation. For estimation of nitrogen, phosphorus and potassium content plant samples were collected at the time of harvest of crop and oven dried at 70°C for 72 hours to obtain constant weight. Fully dried samples were grinded to a fine powder and nutrient content in seed and haulm were estimated as per the following method.

S. No.	Nutrient	Method of analysis
1.	Nitrogen	Nessler's reagent colorimeter method (Snell and Snell 1949)
2.	Phosphorus	Ammonium vanadomolybdate yellow color method (Richards, 1968)
3.	Potassium	Flame photometer method (Jackson, 1973)

Uptake of nitrogen, phosphorus and potassium by seed as well as haulm was estimated by using the following formula.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)} \times \text{Seed or haulm yield (kg ha}^{-1}\text{)}}{100}$$

RESULTSAND DISCUSSION

Effect of Salicylic acid. Foliar application of salicylic acid at varying concentrations failed to bring about a significant variation in nitrogen, phosphorus and potassium content in seed and haulm of chickpea but the crop accumulated the highest quantum of nutrients *i.e*., nitrogen, phosphorus and potassium by seed (64.28, 6.58 and 11.47 kg ha^{-1}), haulm (27.25, 9.21 and 59.49 kg ha^{-1}) and total uptake (91.54, 15.79 and 70.97 kg ha^{-1}) by crop with the application of salicylic acid at 100 ppm over application of salicylic acid at 50 ppm and water spray. The magnitude of increase in total nitrogen, phosphorus and potassium uptake by crop was 11.34, 11.28, 11.10 per cent over foliar application of salicylic acid at 50 ppm and 26.75, 25.81, 24.12 per cent over control, respectively. Further, the increase in salicylic acid from 100 to 150 ppm though decreased nutrient uptake but failed to record statistical significance.

The positive influence of the foliar application of salicylic acid on nutrient uptake by seed and haulm seems on account of increased plant growth due to secretion of growth promoting substances which might have maintained an adequate supply of metabolites for enhancing root growth, development and their functional activities (Lian *et al*., 2000; Manoj 2021). The improvement in dry matter production by plants due to salicylic acid application might have promoted root growth and development, which might have resulted in greater secretion of organic acid thus increasing the availability of nutrients (Bowya and Balachandar 2020) thereby, greater extraction of nutrients from the soil and their efficient translocation in the plant system. Thus improvement in total biomass production with the application of salicylic acid results in higher uptake of nitrogen, phosphorus and potassium by seed, haulm and total uptake by the crop. The results obtained are similar to the findings of Kuttimani–and Velayutham (2011). At higher concentrations, salicylic acid seems to induce stomatal closure, decrease chlorophyll and carotenoid contents (Fariduddin *et al*., 2003; Moharekar *et al*., 2003) and may therefore be expected to affect the rate of photosynthesis (Poor and Tari 2012) hence the negative impact of higher rate of salicylic acid leads to lesser nutrient uptake by the crop.

Effect of Biochar. The results showed that biochar application significantly improved the nitrogen status of seed and haulm. It can be attributed to their efficient extraction/translocation due to an increase in root ramification/activities as biochar plays a vital role in maintaining physico-chemical and biological properties of soils. Application of increasing rate of biochar up to 2 t ha^{-1} significantly increased uptake of nitrogen, phosphorus and potassium by seed (69.47, 7.03 and 12.18 kg ha^{-1}), haulm (29.03, 9.78 and 62.75 kg ha^{-1}) and total uptake (98.50, 16.82 and 74.93 kg ha^{-1}) by crop. The magnitude of increase in total nitrogen, phosphorus and potassium uptake with the application of 2 t biochar ha^{-1} was to the tune of 17.10, 15.84, 13.74 and 41.84, 37.64, 34.52 per cent, respectively over application of biochar at 1 t ha^{-1} and control. Biochar increases the nutrient uptake because of mineralization of nutrients *i.e*., increasing nutrient availability (Hossain *et al*., 2020), modification in cation exchange sites and also improving the biological environment of soil. An increase in nitrogen uptake by crop may be attributed to the improvement in soil microbiota that increases biological nitrogen fixation as well as organic forms of nitrogen in soil like amines, amino acids and amino sugars which become bioavailable to plants (Younis *et al*., 2016). The significant improvement in phosphorus uptake with biochar addition seems to be on account of increased solubility of fixed phosphorus due to a higher microbial population (Inal *et al*., 2015).

Table 1: Effect of salicylic acid and biochar on nutrient content of chickpea crop.

Treatments	Nutrient content (%)					
	Nitrogen		Phosphorus		Potassium	
	Seed	Haulm	Seed	Haulm	Seed	Haulm
Salicylic acid (ppm)						
Water spray	3.68	0.74	0.37	0.25	0.64	1.62
50	3.70	0.75	0.38	0.26	0.66	1.64
100	3.75	0.76	0.38	0.26	0.67	1.67
150	3.74	0.76	0.38	0.26	0.67	1.66
S.Em. ±	0.035	0.007	0.004	0.003	0.007	0.019
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Biochar (t ha^{-1})						
Control	3.63	0.73	0.37	0.25	0.65	1.62
1	3.73	0.76	0.38	0.26	0.66	1.66
2	3.80	0.77	0.38	0.26	0.67	1.66
S.Em. ±	0.030	0.006	0.003	0.003	0.006	0.016
C.D. (P=0.05)	0.089	0.017	NS	NS	NS	NS

Table 2: Effect of salicylic acid and biochar on nutrient uptake by chickpea crop.

Treatments	Nutrient uptake (kg ha^{-1})								
	Nitrogen			Phosphorus			Potassium		
	Seed	Haulm	Total	Seed	Haulm	Total	Seed	Haulm	Total
Salicylic acid (ppm)									
Water spray	50.17	22.05	72.22	5.10	7.46	12.55	8.70	48.48	57.18
50	57.55	24.67	82.22	5.84	8.36	14.19	10.17	53.70	63.88
100	64.28	27.25	91.54	6.58	9.21	15.79	11.47	59.49	70.97
150	63.31	26.80	90.11	6.45	9.10	15.54	11.28	58.82	70.00
S.Em. ±	1.77	0.70	1.85	0.18	0.25	0.32	0.27	1.74	1.75
C.D. (P=0.05)	5.18	2.05	5.41	0.54	0.73	0.93	0.79	5.10	5.14
Biochar (t ha^{-1})									
Control	48.15	21.30	69.44	4.94	7.29	12.22	8.59	47.19	55.70
1	58.87	25.25	84.12	6.00	8.52	14.52	10.44	55.43	65.88
2	69.47	29.03	98.50	7.03	9.78	16.82	12.18	62.75	74.93
S.Em. ±	1.53	0.61	1.60	0.16	0.22	0.27	0.23	1.51	1.52
C.D. (P=0.05)	4.49	1.78	4.69	0.47	0.63	0.80	0.69	4.42	4.46

CONCLUSION

Based on the above summarized results, it can be concluded that the foliar application of salicylic acid increases nutrient uptake due to higher extraction of nutrients and their translocation while biochar enhanced nutrient content and uptake of chickpea crop by improving nutrient availability in soil due to its positive impact on soil physcio-chemical and biological properties.

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Conflicts of Interest. None.

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