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Effect of Phosphorus Management and Drought Mitigating Strategies on Yield and Economics of Rainfed Chickpea

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted to find out the Phosphorous and drought mitigating strategies on yield and economics of Chickpea (*var.* RVG-202) with the different levels of Phosphorus (40, 50, 60 P_2O_5 kg/ha) and with the application of Drought mitigating strategies applied at pre-flowering and pod formation stage) respectively, at Crop Research Farm, Department of Agronomy, Faculty of Agriculture, SHUATS, Prayagraj, Uttar Pradesh, India. The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.28%), available N (225 kg/ha), available P (19.50 kg/ha) and available K (92.00 kg/ha). The experiment was laid out in Randomized Block Design, with ten treatments and replicated thrice. Results obtained that there was a significant increase in yield attributes *viz*., Seed yield (2332.00 kg/ha), Straw yield (4571.33 kg/ha) and Harvest index (33.51%) were recorded with the application of P_2O_5 60kg/ha + 25kg $ZnSO_4$/ha + 1%KCl +0.5%sodium selenite spray. However, Maximum Gross return (124481.70 INR/ha), net return (89064.67 INR/ha) and B: C ratio (2.51) was recorded with the application of P_2O_5 60 kg /ha+ 25 kg $ZnSO_4$/ ha + 1 % KCl + 0.5 % sodium selenite spray. Therefore, it is concluded that the application of P_2O_5 60 kg /ha+ 25 kg $ZnSO_4$/ ha + 1 % KCl + 0.5 % sodium selenite spray was more productive and economically feasible.

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1. INTRODUCTION

"Chickpea (*Cicer arietinum L.*) is the world`s third most important winter (*rabi*) food legume with 96% cultivation in the developing countries. In India, it occupies 9.18 million ha area, with a production of 8.22 million tons registering 900kg/ha productivity. Chickpea is the fourth largest grain legume crop globally, In India with a total output of 11.09 million tons from an area of 14.56 million ha and a productivity of 1.31t/ha. Major producing countries include India, Pakistan and Iran" (FAO, 2019) [1]. "In India, Chickpea is the premier pulse crop occupying 8.32 million hectares and contributing 7.5 million tons to the national pulse basket with a productivity of 912 kg ha-1 in 2011-12. Uttar Pradesh produced 0.72 million tons of Chickpea with a productivity of 1248 kg ha-1 in 2011-12" [2].

"Phosphorus (P) is one of the macronutrients for the growth and development of plants, and it`s the second in importance next to nitrogen (N). The P plays a vital role in the metabolism of plants. It is also a structural component of nucleic acid, co-enzymes, phosphor-proteins and phosphor-lipids present in plants. Foliar application of N at particular stage may solve the slow growth, nodule senescence, and low seed yield of pulse without root absorption at the critical stage" [3]; [4]. "Under the situation of terminal drought, the photosynthetic activity of leaves is rampant. The foliar nutrition with nitrogenous fertilizer *i.e.* 2% urea spray is essential as roots fails to absorb nitrogen from the dry soil profile. Zinc is the only metal that is required in all six enzyme classes (oxidoreductases, transferase, hydrolases, lyases, isomerase and ligases). The zinc requirement for the function of a wide range of enzymes indicates that the metabolism of proteins, carbohydrates, auxin, and reproductive processes is hampered under zinc deficiency" [5].

"The KCl (1%) sprays affected root and shoot growth, recording maximum seedling root length and shoot length, fresh weight, dry weight, and vigour index". [6] "Selenium (Se) is a trace element; it can exert beneficial effects at low concentrations. It can increase the tolerance of plants to UV-induced oxidative stress, delay senescence, and promote the growth of ageing seedlings. Recently it has been shown that Se can regulate the water status of plants under drought conditions. It has also been reported that Selenium (Se) has an antioxidant effect and can increase the anti-oxidative capacity and stress tolerance of plants" [7]; [8]. "There is growing evidence that Selenium has a positively affects on crop growth and stress tolerance at low concentrations" [9]; [10]. "Selenium can regulate the water status of plants under conditions of water deficiency and there by performs its protective effect" [11]. By keeping these points in mind, present research carried out in the title, "Effect of Phosphorous management and drought mitigating strategies on yield and economics of rainfed Chickpea (*Cicer arietinum* L.)".

2. MATERIALS AND METHODS

A field trial was conducted during *Rabi,* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) which is located at 25°39"42" N latitude, 81°67"56" E longitude, and 98m altitude above the mean sea level (MSL). The soil was sandy loam in texture, low in organic carbon and medium in available nitrogen, Phosphorus, and low in potassium. Nutrient sources were Urea, Single Super Phosphate, and Murate of potash to fulfill the requirement of Nitrogen, Phosphorus, and Potassium. The experiment was laid out in Randomized Block Design with ten treatments each replicated thrice. The treatments which are with 1: Control(RDF) 2: P_2O_5 40 kg / ha + 1 % KCl spray 3: P_2O_5 40kg/ha + 0.5% sodium selenite spray 4: P_2O_5 40 kg/ha+1% KCl + 0.5% sodium selenite spray 5: P_2O_5 50 kg / ha+1 % KCl spray 6: P_2O_5 50kg/ha+2% Urea + 0.5% sodium selenite spray 7: P_2O_5 50 kg/ha + 2% Urea + 1% KCl +0.5% sodium selenite spray 8: P_2O_5 60kg/ha + 25kg $ZnSO_4$/ha + 1% KCl spray 9: P_2O_5 60kg/ha + 25kg $ZnSO_4$/ha + 0.5% sodium selenite spray10: P_2O_5 60kg/ha+25kg $ZnSO_4$/ha + 1%KCl +0.5% sodium selenite spray. Blanket application of a recommended dose of Nitrogen and Potassium (20:0:20 NPK kg/ha). The sowing date was 28th November 2021 with the seed rate of 20kg/ha. The foliar application of 1% Potassium chloride, 0.5% Sodium selenite, and 1% Potassium chloride along with 0.5% Sodium selenite is applied during pre-flowering and pod formation stage., The yield parameters were recorded after harvest and economic analysis of the overall trial. The yield

parameters such as number of pods per plant, number of seeds per pod, test weight, seed yield, stover yield, and harvest index were recorded. These parameters were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design [12]. Economic analysis is also calculated according to valid data.

3. RESULTS AND DISCUSSION

3.1 Effect on the Yield of Chickpea

As can be seen in Table 1, yield parameters are summarized statistically. A Significantly higher number of pods/plant was observed with the P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl and 0.5 % sodium selenite spray (59.10). However, P_2O_5 60 kg/ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl spray (58.66), P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$ and 0.5 % sodium selenite spray (58.00) statistically at par P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl + 0.5 % sodium selenite spray. The maximum number of seeds/pod was observed with the P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl and 0.5 % sodium selenite spray (1.66). However, P_2O_5 60 kg /ha + 25 kg $ZnSO_4$/ ha + 1 % KCl spray (1.58), P_2O_5 60 kg /ha + 25 kg $ZnSO_4$/ ha +0.5 % sodium selenite spray (1.54) statistically at par P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl + 0.5 % sodium selenite spray. The highest Test weight was observed with P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl and 0.5 % sodium selenite spray (23.48). However, P_2O_5 60 kg /ha + 25 kg $ZnSO_4$/ ha +1 % KCl spray (23.37), P_2O_5 60 kg /ha + 25 kg $ZnSO_4$/ ha + 0.5 % sodium selenite spray (23.18) statistically at par P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl + 0.5 % sodium selenite spray. Maximum seed yield was observed with P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl and 0.5 % sodium selenite spray (2332.00 kg/ha). However, P_2O_5 60 kg /ha + 25 kg $ZnSO_4$/ ha +1 % KCl spray (2246.33 kg/ha), P_2O_5 60 kg /ha + 25 kg $ZnSO_4$/ ha + 0.5 % sodium selenite spray (2169.33 kg/ha) statistically at par P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl + 0.5 % sodium selenite spray. Maximum stover yield was observed with P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl and 0.5 % sodium selenite spray (4571.33 kg/ha). However, P_2O_5 60 kg /ha + 25 kg $ZnSO_4$/ ha +1 % KCl spray (4510.00 kg/ha), P_2O_5 60 kg /ha + 25 kg $ZnSO_4$/ ha + 0.5 % sodium selenite spray (4448.67 kg/ha) statistically at par P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl + 0.5 % sodium selenite spray. A higher harvest index was observed with P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl and 0.5 % sodium selenite spray (33.51). However, P_2O_5 60 kg /ha + 25 kg $ZnSO_4$/ ha +1 % KCl spray (33.01), P_2O_5 60 kg /ha + 25 kg $ZnSO_4$/ ha + 0.5 % sodium selenite spray (32.50) statistically at par P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl + 0.5 % sodium selenite spray. The results demonstrate that [13]. Foliar spray of 2% KCl + 0.4% Sodium selenite was significantly superior to rest of the treatments. The second treatment in order of magnitude was 2% KCl which proved significantly superior to the rest of the three treatments regarding yield attributes number of pods/plants. [14] stated that “the seed yield of Chickpea improved in each increase with P_2O_5 levels. Similar improvement in yield attributes like no. of pods plant^{-}1 and the seed yield plant also observed with increase in P_2O_5 levels”. The Highest seed yield was recorded in 60 kg P_2O_5 ha^{-}1. All P_2O_5 levels were significantly superior over control [15] On pooling of data, the number of pods per plant, seeds/pod, 100-seed weight and seed yield increased significantly with 100% RDF + 2% urea spray during both the years. [16] stated that “increasing levels of phosphorus increased seed yield plant'1 of Chickpea and mustard both significantly up to 60 kg$P_2 0_5$ha^{-}1”. [17] observed that “the foliar application of urea apart from the basal application of recommended a dose of fertilizers increased grain yield and yield attributes were recorded with 2 % urea spray at 75 days after sowing (DAS)”. [18] found that application of 25 kg $ZnSO_4$ ha^{-}1 increased grain yield significantly over no application of zinc sulphate [19] observed that application of Phosphorus at 60 kg P_2O_5/ha significantly increased yield attributes. The increasing above value was progressively related to P doses from 0-60 kg P_2O_5/ha.

3.2 Economic Analysis of Chickpea

As shown in Table 2, all the economic parameters *viz.*, gross return, net return, and B: C ratio are summarized. Maximum gross return (INR 1,24,481.70 /ha) recorded in P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl and 0.5 % sodium selenite spray. Minimum gross return (INR 89,538.50 /ha) was recorded in control plot with recommended dose of fertilizer. Maximum net return (INR 89,064.67 /ha) recorded in P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl and 0.5 % sodium selenite spray. The minimum net return

Table 1. Effect of phosphorous management and mitigating drought strategies on yield of Chickpea

Treatment combination	Number of pods per plant	Number of seeds per pod	Test weight (g)	Seed yield (Kg/ha)	Stover yield (Kg/ha)	Harvest Index (%)
1	53.80	1.34	21.21	1716.33	4011.00	29.79
2	54.50	1.38	21.89	1814.00	4134.33	30.13
3	54.16	1.36	21.55	1742.67	4071.66	29.66
4	54.70	1.42	22.13	1887.33	4196.67	30.61
5	55.50	1.48	22.72	2037.33	4324.33	31.74
6	55.30	1.46	22.61	1960.00	4260.00	31.22
7	55.66	1.51	22.93	2104.67	4387.00	32.12
8	58.66	1.58	23.37	2246.33	4510.00	33.01
9	58.00	1.54	23.18	2169.33	4448.67	32.50
10	59.10	1.66	23.48	2332.00	4571.33	33.51
F-test	S	S	S	S	S	S
SEm(±)	2.97	0.18	1.31	319.50	298.09	2.19
CD 5%	1.00	0.06	0.44	107.53	100.33	0.74

Table 2. Effect of Phosphorous management and mitigating drought strategies on the economics of Chickpea

Treatment combination	Gross Return (INR/ha)	Net Return (INR/ha)	B: C ratio
1	89538.5	58631.5	1.89
2	94581.17	63464.17	2.03
3	90911.83	57004.83	1.68
4	98352.33	64235.33	1.88
5	106066.20	74741.67	2.38
6	102090.00	67975.50	1.99
7	109531.50	75207.00	2.19
8	114353.00	81936.00	2.50
9	112860.30	77653.33	2.20
10	124481.70	89064.67	2.51

(INR 58,631.50 /ha) recorded in Control plot with recommended dose of fertilizer. Higher B: C ratio (2.51) recorded in P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1 % KCl and 0.5 % sodium selenite spray. Minimum B:C ratio (1.89) was recorded in control plot with recommended dose of fertilize. [20]. "The higher dose of 40 kg/ha phosphorus along with seaweed extract had given higher gross return, net return, and B: C ratio in blackgram crop at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P)" [21]. It is evident from the pooled analysis data that the application of various treatments markedly increased gross return, net return and B: C ratio of the cropping system over control.

4. CONCLUSION

Phosphorus (P) is a macronutrient required for plant growth and development. The element P is essential for plant metabolism. Based on my research trial, the treatment combination of P_2O_5 60 kg /ha + 25 kg $ZnSO_4$/ ha and 1 % KCl and 0.5 % sodium selenite spray was more productive and economically feasible.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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