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Effect of phosphorus management and drought mitigating strategies on growth and yield of rainfed chickpea (*Cicer arietinum* L.)

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Abstract
A field experiment was conducted to find out the Phosphorous and drought mitigating strategies on growth and yield of Chickpea (*var.* RVG-202) with the different levels of Phosphorous (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 The soil of 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 consists of *viz*., 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 spray8: $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%sodiumselenitespray in the *rabi*2021. Results obtained that there was significant increase in growth parameters *viz*., Plant height (60.36cm), Number of Nodules/Plant (38.60 at 60DAS), Dry weight (26.56g)and 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. 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.

Keywords: Phosphorus, management, mitigating, strategies, chickpea, *Cicer arietinum* L.

Introduction
The Green Revolution in agriculture has been one of the most successful achievements of this century. This revolution resulted in global food security and played an important role in transforming developing countries, such as India, from being food deficient to having a food surplus. Chickpea (*Cicer arietinum* L.) is the world's third most important winter (*rabi*) food legume with 96% cultivation in the developing countries and in India, it occupies 9.18 million ha area, with a production of 8.22 million tonnes registering the productivity of 900kg/ha.
In many soil types, Phosphorus is the most limiting nutrient for the production of crops, especially legumes like Chickpea which generally having higher P requirement because the process of symbiotic nitrogen fixation consumes a lot of energy. Therefore, to achieve better crop productivity under such conditions, proper nutrients management as well as suitable drought mitigating practices like 1% KCl(Potassium chloride) and 0.5% sodium selenite applied at pre-flowering and pod formation stage, matching with the crop requirement may play an important role. The limited and erratic rainfall in the rainfed area makes Chickpea vulnerable to experience moisture stress conditions during the later part of its growth, resulting in severe yield reduction. Foliar application of N at particular stage may solve the slow growth, nodule senescence and low seed yield of pulse without involving root absorption at critical stage [1, 2]. 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 required in small amount to allow the normal function of several key plant physiological pathways as well as to ensure the structural and functional integrity of membranes. The requirement of zinc for the function of a wide range of enzymes indicates that the metabolism of proteins, carbohydrates and auxin as well as reproductive processes are hampered under zinc deficiency [3].

The KCl (1%) sprays had a positive effect on root and shoot growth recording maximum seedling root length and shoot length, fresh weight, dry weight and vigour index [4]. 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 is able to regulate the water status of plants under conditions of drought. It has also been reported that Selenium (Se) has an antioxidant effect and can increase the anti-oxidative capacity and stress tolerance of plants [5, 6]. There is increasing evidence that Selenium has a positive effect on crop growth and stress tolerance at low concentrations [7, 8]. Selenium can regulate the water status of plants under conditions of water deficiency and there by performs its protective effect [9]. By keeping these points in mind, present research carried out in title, "Effect of Phosphorous management and drought mitigating strategies on growth and yield of rainfed Chickpea (*Cicer arietinum* L.)".

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 spray8: $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 date of sowing was 28th November 2021with 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 are applied during pre-flowering and pod formation stage., the yield parameters were recorded after harvest and also, economic analysis of overall trial. The growth parameters reading such as plant height, number of branches, number of nodules, plant dry weight and also, yield parameters such as number of pods per plant, number of seeds per pod, test weight, seed yield, stover yield, and harvest index. These parameters were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design [10].

Results and Discussion

Effect on the growth of Chickpea. As can be seen in Table 1, growth parameters are summarized statistically. At Harvest, the highest plant height (60.36cm) was recorded with the P_2O_5 60 kg /ha and 25 kg $ZnSO_4$/ ha along with 1% KCl and 0.5% sodium selenite spray. However, $P_2O_5$60 kg /ha + 25 kg $ZnSO_4$/ ha +1% KCl spray (59.03cm) and P_2O_5 60 kg /ha+ 25 kg $ZnSO_4$/ ha +0.5% sodium selenite spray (58.55cm) statistically at parP_2O_5 60 kg /ha and 25 kg $ZnSO_4$/ ha along with 1% KCl and 0.5% sodium selenite spray. At Harvest, the highest number of nodules/plants (9.36) was recorded with the P_2O_5 60 kg /ha and 25 kg $ZnSO_4$/ ha along with 1% KCl and 0.5% sodium selenite spray. However,$P_2O_5$60 kg/ha + 25 kg $ZnSO_4$/ ha +1% KCl spray (9.23) and P_2O_5 60 kg /ha+ 25 kg $ZnSO_4$/ ha +0.5% sodium selenite spray (9.06) statistically at parP_2O_5 60 kg /ha and 25 kg $ZnSO_4$/ ha along with 1% KCl and 0.5% sodium selenite spray. At Harvest, the highest dry weight/plant (26.56g) was recorded with the P_2O_5 60 kg /ha and 25 kg $ZnSO_4$/ ha along with 1% KCl and 0.5% sodium selenite spray. However,$P_2O_5$60 kg/ha + 25 kg $ZnSO_4$/ ha +1% KCl spray (26.40g) and P_2O_5 60 kg /ha+ 25 kg $ZnSO_4$/ ha +0.5% sodium selenite spray (26.10) statistically at parP_2O_5 60 kg /ha and 25 kg $ZnSO_4$/ ha along with 1% KCl and 0.5% sodium selenite spray. The results demonstrate that [11] Significantly, the maximum plant height and no. of pods/plant were recorded in 60 kgP_2O_5/ha + NPK consortia which was statistically at with 60 kg P_2O_5/ha + PSB I, 60 kg P_2O_5/ha + PSB II and 60 kg P_2O_5/ha as compared to control [12]. stated that increasing levels of phosphorus increased plant height, no. of branches per plant and dry matter per plant- of Chickpea significantly up to 60 kg P_2O_5/ha. Dry weight of root nodules in Chickpea also increased significantly up to 60 kg P_2O_5/ha. It might be due to increased availability of phosphorus to plant at higher rate of application [13]. The increase in nodulation was highest with 60 kg P_2O_5/ha when applied with AM [14]. stated that dry matter accumulation increased significantly with P2Os levels at all the growth levels except at 50 DAS in both the years. Dry matter production increased significantly with each increase in phosphorus levels and highest dry matter was recorded with 60 kg P_2O_5 ha^{-1}.

Table 1: Effect of Phosphorous management and drought mitigating strategies on growth of Chickpea

Treatment combination	Plant height (cm)	Number of nodules per plant	Plant dry weight (g)
1	54.26	7.23	23.36
2	56.20	7.6	24.06
3	55.73	7.46	23.80
4	56.43	7.83	24.53
5	57.76	8.5	25.06
6	56.76	8.33	24.90
7	58.26	8.73	25.66
8	59.03	9.23	26.40
9	58.50	9.06	26.10
10	60.36	9.36	26.56
F-test	S	S	S
S.Em(±)	3.08	1.27	2.05
CD 5%	1.04	0.43	0.69

Table 2: Effect of Phosphorous management and drought mitigating strategies on yieldof 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
S.Em(±)	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

Effect on the yield of Chickpea: As can be seen in Table 2, yield parameters are summarized statistically.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. 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. 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 rest of the three treatments in respect of yield attributes number of pods/plants [14]. Stated that the seed yield of Chickpea improved with 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. Highest seed yield was recorded with 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]. Observed that the foliar application of urea apart from basal application of recommended dose of fertilizers increased grain yield and yield attributes were recorded with 2% urea spray at 75 days after sowing (DAS) [17]. Found that application of 25 kg $ZnSO_4$ ha^{-1} increased grain yield significantly over no application of zinc sulphate.

Conclusion

In conclusion, the treatment combination of P_2O_5 60 kg /ha along with 25 kg $ZnSO_4$/ ha and 1% KCl and 0.5% sodium selenite spray was found to be more productive and also economically feasible.

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