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Effect of phosphorous and zinc nutrition on growth and fodder yield of cowpea (*Vigna unguiculata* L. Walp)

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Abstract
The field experiment was conducted during *Zaid* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, (U.P). The soil of the experiment plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.21), low in organic carbon (0.536%), available N (163.42 kg/ha), available P (21.96 kg/ha), available K (256.48 kg/ha). The treatments consists of three levels of phosphorus (50 kg/ha, 60 kg/ha and 70 kg/ha) and zinc (15 kg/ha, 20 kg/ha and 25 kg/ha). The experiment was laid out in Randomized Block Design which consist of 9 treatments which are replicated thrice.The results revealed that maximum plant height was recorded significantly higher *viz*., plant height (90.18 cm), number of branches/plant (5.04), dry weight (17.19 g), Crop Growth Rate (6.53 g/m^2/day),Green fodder yield (351.72 q/ha) and Dry matter yield (74.14 q/ha) were recorded with application of 70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$.

Keywords: Phosphorus, zinc, cowpea, green fodder yield, dry matter yield and economics

Introduction
Cowpea (*Vigna unguiculata* Walp.) is one of the most important vegetable crops grown as pulse, vegetable and fodder. It is poor man's protein source and considered one of the most ancient human food sources and has probably been used as a crop plant since Neolithic times (Ng and Marechal 1985) [12]. Cowpea is an important multipurpose grain legume extensively cultivated in arid and semiarid tropics. It is an important source of nutrients and provides high quality, inexpensive protein to diet based on cereal grains and starchy foods. Cowpea is a good source of food, fodder, vegetables and certain snacks (Singh *et al*. 2012) [14]. It is a crop that can be used as catch crop, mulch crop, intercrop, mixed crop and green crop. It has ability to fix atmospheric N_2 in the soil @ 56 kg ha-1 in association with symbiotic bacteria under favourable conditions (Mandal *et al*. 2009) [9]. The protein concentration ranges from about 3 to 4% in green leaves, 4 to 5% in immature pod and 25 to 30% in mature seeds. The amino acid profile reveals that lysine, leusine and phenylanine contents are relatively high in cowpea. Trends in the production of pulse is adversely affected the per capita availability of pulses. In India per capita/day availability of pulses had decreased from 69 g during sixties to 35g as against the FAO/WHO's current recommendation of 80 g per day (Ali and Gupta 2012) [1]. India ranks first in terms of milk production (137.7 million tonnes), however the productivity is quite low mainly because of scarcity of feeds and fodders. Recent reports clearly indicated that India faces as high as 64% dry crop residues by 21.9% and for feeds as high as 64% (Anonymous, 2016-17a) [2]. Wide spread deficiency of micronutrient has become major constraint for achieving higher genetic potential yield along with quality of crop. Among the micronutrients, the deficiency of Zinc and boron has become wide spread in recent years all over the country. In India next to nitrogen, phosphorus, potassium and sulphur 5th important yield limiting nutrient is Zinc which accounts for 48 per cent of Indian soils (Vinod Kumar *et al*., 2020) [15]. Phosphorus as a constituent of cell nucleus is essential for cell division and development of meristematic tissue. Phosphorus deficiencies lead to reduction in the rate of leaf expansion and photosynthesis per unit leaf area hence reduction in fodder yield. The adequate supply of phosphorus to legumes is more important than that of Phosphorus because it has beneficial effect on nodulation, growth and yield. Phosphorus is of paramount importance for increasing yield. Phosphorous plays important role in energy transfer in the living cells by means of high energy phosphate bond of ATP (Tisdale *et al*., 1984). Thus, it plays an important role in formation and translocation of carbohydrates, fatty acids, glyceroids and other essential intermediate compounds.

Therefore, there is need to work out the optimum dose of phosphorus fertilizers for cowpea under the prevailing agro-climatic condition. It also improves the crop quality and resistance to diseases. Zinc is one of the seventh plant micronutrient, involved in many enzymatic activities of the plant. It functions generally as a metal activator of enzymes. It is reported that, Zinc improves crop productivity almost as much as major nutrients. Besides increasing crop yield, it increases the crude protein content, amino acids, energy value and total lipid in chickpea, soybean, blackgram, etc. Zn deficiency can also adversely affect the quality of harvested products, plants susceptibility to injury by high light or temperature intensity and infection by fungal diseases can also increase. Zinc seems to affect the capacity for water uptake and transport in plants and also reduce the adverse effects of short periods of heat and salt stress. (Chalak *et al*., 2018) [6].

Materials and Methods

This experimental trial was carried out during Zaid 2021 at Crop Research Farm (CRF), Department of Agronomy, Sam Higginbottom University of Agriculture, Technology & Sciences (SHUATS), Prayagraj (U. P) located at 25˚39"42" North latitude, 81˚67"56" East longitude and 98 m altitude above the mean sea level. The experiment laid out in Randomized Block Design consisting of nine treatments which T1: P_2O_5 - 50 kg/ha + Zinc 15 kg/ha, T2: P_2O_5 - 50 kg/ha + Zinc 20 kg/ha, T3: P_2O_5 - 50 kg/ha + Zinc 25 kg/ha, T4: P_2O_5 - 60 kg/ha + Zinc 15 kg/ha, T5: P_2O_5 - 60 kg/ha + Zinc 20 kg/ha, T6: P_2O_5 - 60 kg/ha + Zinc 25 kg/ha, T7: P_2O_5 - 70 kg/ha + Zinc 15 kg/ha, T8: P_2O_5 - 70 kg/ha + Zinc 20 kg/ha, T9: P_2O_5 - 70 kg/ha + Zinc 25 kg/hareplicated thrice to determine the effect of potassium and zinc nutrition on growth and fodder yield of cowpea. The soil of trial plot was sandy loam in texture nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha).The nutrient sources used in the research plot were urea and MOP to fulfill the requirements of nitrogen and potassium. SSP and $ZnSO_4$were applied as per the treatment combinations to fulfill the requirements of phosphorous and zinc. Several plant growth parameters were recorded at harvest *viz*., plant height (cm), number of branches/plant and plant dry weight (g) plant were recorded and green fodder yield (q/ha) and Dry matter yield (q/ha) were recorded. and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez, K. A. and Gomez, A. A. 1984).

Results and Discussion

Effect on growth of fodder Cowpea: The statistical data regarding growth parameters is presented in Table 1.

Plant height (cm)

Significantly maximum plant height (90.18 cm) was observed in the treatment with 70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$ over all the other treatments. However, the treatments with application of 70 kg/ha P_2O_5 + 20 kg/ha $ZnSO_4$ (88.65 cm) and 60 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$ (87.32 cm) were found to be statistically at par with treatment 70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$ as compared to all the treatments. Higher levels of Phosphorus encourage formation of new cells, promote plant vigour and hastens leaf development, which help in harvesting more solar energy and better utilization of nitrogen, which help towards higher growth attributes like plant height. The results were in accordance to Namakka *et al*. (2017) [11]. Increase in plant height might be the involvement of zinc in different physiological processes like enzyme activation, electron transport, chlorophyll formation, stomatal regulation, etc. With the increase in levels of zinc the plant height gradually increased, which might be attributable to greater photosynthetic activity and chlorophyll synthesis due to zinc fertilization resulting into better vegetative growth. Similar results were reported by Kumar *et al*. (2016) [8].

Number of branches/plant

Highest number of branches per plant (5.04) was observed in the treatment with application of 70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$, which was significantly higher over rest of the treatments. However, the treatments with 70 kg/ha P_2O_5 + 20 kg/ha $ZnSO_4$ (4.89), 60 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$ (4.76) and 70 kg/ha P_2O_5 + 15 kg/ha $ZnSO_4$ (4.47) which were found to be statistically at par with 70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$. The application of Zinc on an enhanced branching in pulses mainly attributed to promotion of bud and branch development by the auxin whereas Zn application ultimately increased the availability of other nutrients and accelerated the translocation of photo assimilates. The results were found to be similar with Masih *et al*. (2020) [10].

Plant dry weight (g)

Treatment with 70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$ was recorded with significantly maximum dry weight (17.19 g/plant) over all the treatments. However, the treatments with 70 kg/ha P_2O_5 + 20 kg/ha $ZnSO_4$ (16.87 g/plant) and 60 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$ (16.28 g/plant) which were found to be statistically at par with 70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$. The plants attained more vigour with phosphorus, due to adequate supply and availability of nitrogen, phosphorus, potassium and spacing in balanced combination, resulting in increased dry weight of the plant. The application of Phosphorus 70 kg/ha to cowpea significantly increased biomass accumulation and dry matter production. Bhilare (2003) [4] reported the similar results. Application of Higher levels of zinc to cowpea leads to increase in the higher auxin activity in plant which promoted growth attributes and higher biomass accumulation in plants. This resulted in higher plant dry matter. The results were in resonance with Kumar and Bohra (2014) [7].

Table 1: Effect of Phosphorous and Zinc nutrition on Growth parameters of fodder Cowpea.

	Treatment combinations	Plant height (cm)	Number of branches /plant	Plant dry weight (g/plant)	Crop growth rate	Relative growth Rate
1.	50 kg/ha P_2O_5 + 15 kg/ha $ZnSO_4$	75.39	3.07	13.19	21.62	0.150
2.	50 kg/ha P_2O_5 + 20 kg/ha $ZnSO_4$	78.53	3.21	13.60	21.90	0.145
3.	50 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$	82.64	3.87	14.82	22.42	0.134
4.	60 kg/ha P_2O_5 + 15 kg/ha $ZnSO_4$	80.71	3.42	14.19	22.04	0.138

5.	60 kg/ha P_2O_5 + 20 kg/ha $ZnSO_4$	84.53	4.27	15.24	23.12	0.133
6.	60 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$	87.32	4.76	16.28	25.17	0.129
7.	70 kg/ha P_2O_5 + 15 kg/ha $ZnSO_4$	85.90	4.47	15.76	23.77	0.130
8.	70 kg/ha P_2O_5 + 20 kg/ha $ZnSO_4$	88.65	4.89	16.87	25.85	0.127
9.	70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$	90.18	5.04	17.19	26.77	0.125
	S. EM (±)	1.01	0.21	0.39	0.77	0.00
	CD (5%)	3.03	0.62	1.17	2.30	-

Effect on Green fodder yield and Dry matter yield of Cowpea: The statistical data is presented in Table 2.

Green fodder yield (q/ha)

Significantly highest green fodder yield (351.72 q/ha) was recorded with the treatment with 70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$. However, the treatments 70 kg/ha P_2O_5 + 20 kg/ha $ZnSO_4$ (347.89 q/ha) and 60 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$ (342.31 q/ha) were found to be statistically at par with 70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$ as compared to all other treatments. The significant increase in green fodder yield is due to the favourable effect of phosphorous on yield may be ascribed to its role in the constitution of ribonucleic acid, deoxyribonucleic acid and ATP which regulate the vital metabolic processes in the plant, helping in the root formation, nitrogen fixation and finally the crop yield. Bhavya *et al*. (2014) [3] recorded the similar results. Application of zinc helped in enzyme activation, membrane integrity, chlorophyll formation, stomatal balance and starch utilization at early stages which enhanced accumulation of assimilate in the vegetative parts resulting in higher green fodder yield. These results are in agreement with the findings of Rana *et al*. (2014).

Dry matter yield (q/ha)

Maximum dry matter yield (74.14 q/ha) was recorded with the treatment with 70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$. However, the treatments 70 kg/ha P_2O_5 + 20 kg/ha $ZnSO_4$ (70.80 q/ha) and 60 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$ (67.70 q/ha) were found to be statistically at par with 70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$.The increase in dry matter yield due to phosphorus application is attributed to source and sink relationship. It appears that greater translocation of photosynthates from source to sink might have increased dry matter yield. Phosphorus increases yield due to its well-developed root system, increased N fixation and its availability to the plants and favourable environments in the rhizosphere.) The results were similar with the findings of Bhilare and Patil (2002) [5].

Table 2: Effect of Phosphorous and Zinc nutrition on fodder Yield (q/ha) of Cowpea.

Treatment combinations	Green fodder yield (q/ha)	Dry matter yield (q/ha)
50 kg/ha P_2O_5 + 15 kg/ha $ZnSO_4$	261.33	44.74
50 kg/ha P_2O_5 + 20 kg/ha $ZnSO_4$	280.63	49.15
50 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$	298.10	58.53
60 kg/ha P_2O_5 + 15 kg/ha $ZnSO_4$	282.17	53.37
60 kg/ha P_2O_5 + 20 kg/ha $ZnSO_4$	302.17	61.93
60 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$	338.20	67.70
70 kg/ha P_2O_5 + 15 kg/ha $ZnSO_4$	305.03	64.87
70 kg/ha P_2O_5 + 20 kg/ha $ZnSO_4$	338.70	70.80
70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$	365.13	74.14
S. EM (±)	4.12	2.33
CD (P = 0.05)	12.35	6.99

Conclusion

It can be concluded that 70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$ performed exceptionally in obtaining maximum green fodder (365.13 q/ha) and dry matter yield (74.14 q/ha) of cowpea. Hence, 70 kg/ha P_2O_5 + 25 kg/ha $ZnSO_4$ is beneficial under eastern Uttar Pradesh Conditions.

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