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INFLUENCE OF FOLIAR APPLICATION OF COBALT ON GROWTH, YIELD AND BIOCHEMICAL PARAMETERS IN CHICKPEA (*CICER ARIETINUM* L.)

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ABSTRACT

Cobalt has been categorized as a beneficial element for plants growth and development and it has been proved essential for nodulating bacteria and fixing atmospheric nitrogen in legumes. Cobalt is the constituent of cyanocobalamin (vitamin B_{12}), which is constituent of leghemoglobin synthesized in the rhizobium. Chickpea (*Cicer arietinum* L.) is an important grain legume, ranked second after common bean in consumption globally. Since, cobalt's role as a beneficial nutrient for legume growth, nodulation and nitrogen fixation is vital for maintaining healthy legume crops. Ensuring an adequate supply of cobalt in soil and plant is crucial for promoting optimal performance and yield in leguminous crops. The present study is conducted to examine the effect of cobalt foliar application on growth, yield and biochemical parameters in chickpea crop.

An experiment was conducted during the *Rabi* season of 2022-2023 at Zonal Agricultural and Horticultural Research Station, Babur farm, Hiriyur. The study utilized the Jaki-9218 chickpea variety and the experiment was laid out in RCBD with nine treatments and three replications which consists of varying levels of cobalt foliar application (0, 25, 50, 75, 100, 125, 150, 175 and 200 ppm) as cobalt sulphate at 30 and 60 DAS along with RDF (13: 25: 25 kg N: P_2O_5: K_2O ha^{-1} + FYM @ 10 t ha^{-1}).

Among the varying levels of cobalt foliar application, 150 ppm has recorded significantly higher plant height (36.25 cm), number of branches (13.90) per plant, dry matter accumulation per plant (19.84 g), number of nodules (31.41) and effective nodules (23.87) per plant. The better values of these indices in the treatment resulted in higher yield parameters like number of pods per plant (44.93), pod yield per plant (13.79 g), seed (18.43 q ha^{-1}) and haulm yield (26.57 q ha^{-1}) which was on par with 125 and 100 ppm of cobalt spray. Crude protein (22.65%) and catalase activity (144.83 µmol min^{-1}) were observed significantly higher with 150 ppm of cobalt foliar spray.

Key words : Cobalt, Chickpea, Growth, Yield, Crude protein, Catalase activity.

Introduction

Chickpea (*Cicer arietinum* L.) is an important grain legume, ranked second after common bean in consumption. India is the largest producer of Chickpea, contributing 65 per cent of World's annual production. Chickpea is grown on 12-13Mha, with annual production of 10440 thousand tonnes and productivity of 1059 kg ha^{-1} (Anonymous, 2022). Chickpea is rich in protein, folate, vitamins and some minerals like Ca, P, Zn, Fe and Mg. It's inclusion in cropping system significantly improves soil fertility by fixing the atmospheric nitrogen.

Cobalt has been categorized as a beneficial element for plants. It has been proved essential for plant growth, nodulating bacteria and fixing atmospheric nitrogen in legumes. Cobalt is crucial for the growth of *Rhizobium* bacteria involved in legume nodulation and atmospheric nitrogen fixation. It is also a constituent of cyanocobalamin (vitamin B_{12}), which is required for leghaemoglobin synthesis by *Rhizobium*. Leghaemoglobin content in nodules directly relates to nitrogen fixation. Cobaltinduced changes in cobalamin-dependent enzyme activities are responsible for nodulation and nitrogen fixation in legumes (Dilworth *et al*., 1979).

The primary effects of cobalt in plants are related to its involvement in two key processes. They are, it affects cyanocobalamin-dependent ribonucleoside triphosphate reductase, an enzyme crucial for DNA synthesis and acts as a cofactor in the nitrogenase enzyme activity, which is essential for nitrogen fixation in leguminous plants. The significance of cobalt in plants became of agronomic interest following the recognition of its essentiality for various legume crops like soybeans, alfalfa and clover. Cobalt plays a crucial role in plant metabolism due to its ability to change its valence state, which enables it to efficiently participate in oxidation-reduction reactions. Furthermore, cobalt significantly contributes to processes like respiration and energy metabolism (Yagodin, 1970). Furthermore, cobalt serves as a valuable asset in mitigating various forms of stress in plants, including salinity, cadmium exposure and osmotic stress.

Materials and Methods

Location of the study area

The field experiment was conducted at ZAHRS, Babbur farm, Hiriyur during *Rabi* 2022-2023 situated at 13º 96' 01" North latitude and 76º 64' 94" East longitude, with an altitude of 613 meters above mean sea level. The experimental site had clay loam texture, moderately alkaline (8.18) in reaction with a normal electrical conductivity (0.46 dS m^{-1}) and low in organic carbon (4.20 g kg^{-1}). Further, the soil was medium in available nitrogen, phosphorus and potassium status (305.60, 48.70 and 321.50 kg ha^{-1}, respectively).

Experimental design

The experiment was carried out by adopting RCBD with nine treatments replicated thrice with plot size 5 m × 2.1m. The recommended doses of NPK at 13:25:25 (kg ha^{-1}) were applied in combination with different levels of Co (0, 25, 50, 75, 100, 125, 150, 175 and 200 ppm) as cobalt sulfate through foliar spray at 30 and 60 DAS in all treatments. Variety used is JAKI-9218, it is medium tall, semi-spreading type with profuse branching.

Collection of experimental data

Five plants were selected at random in each treatment in the net plot area and they were labeled with tags for recording various observations on growth parameters *viz*., plant height, number of branches per plant, at 30, 60 DAS and at harvest and yield parameters like number of pods per plant, pod weight per plant, 100 seed weight, seed yield and haulm yield were recorded at harvest. Another five plants were removed at each stage (rotational sampling procedure) from the area outside the net plot for recording the number of nodules per plant and dry matter production. The crude protein content was worked out by multiplying the nitrogen percentage with a factor 6.25 and expressed in per cent (Doubetz and Wells, 1968). Catalase activity was measured according the method of Chandlee and Scandalios (1984) with small modification.

Statistical analysis

The data collected from the experiment at different growth stages and at harvest was subjected to statistical analysis as per the analysis of variance technique described by Gomez and Gomez (1984). The level of significance used for 'F' tests was at 5%.

Results and Discussion

Growth parameters : The data presented in Table 1 clearly demonstrated that the foliar application of varying cobalt concentrations led to a significant influence in both plant height, number of branches and dry matter accumulation at 60 DAS and at harvest except at 30 DAS. Among the different levels of cobalt, the application of cobalt at 150 ppm (T_7) recorded significantly higher plant height at 60 DAS (32.92 cm) and at harvest stage (36.25 cm) and also recorded significantly higher number of branches at 60 DAS (10.73) and at harvest stage (13.90) compared to control, which recorded significantly lower plant height (23.08 cm at 60 DAS and 25.79 cm at harvest) and lower number of branches (7.10 at 60 DAS and 10.77 at harvest). Significantly higher dry matter accumulation of 6.30 and 19.84 grams per plant at 60 DAS and at harvest stage, respectively, compared to control which recorded significantly lower dry matter accumulation per plant of 5.17 and 13.99 g at 60 DAS and at harvest, respectively. These growth parameters were statistically on par with the foliar application of cobalt at 125 ppm (T_6) and 100 ppm (T_5) for at 60 DAS and at harvest. The significant increase in plant height and number of branches may be attributed to the enhancement of endogenous auxin and gibberellin concentrations through cobalt supplementation, as proposed by Gad (2012). Cobalt, a component of vitamin B_{12}, plays a crucial role in cellular synthesis and also exhibits a synergistic effect on root nodules. This phenomenon results in increased nitrogen fixation, helps in growth and development of plants. This, in turn, promotes higher production of photosynthates within the plant, leading to increased production of dry matter per plant. Similar findings were reported by Younis (2011) and Ali *et al*. (2010) in chickpea.

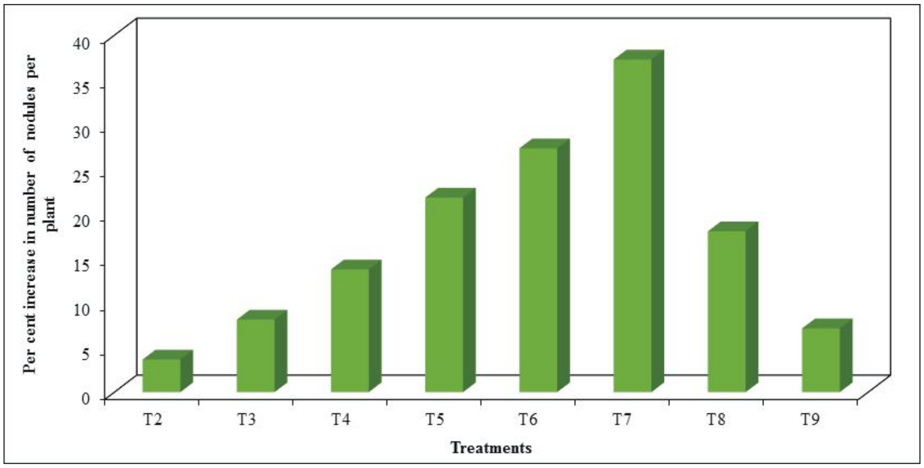
Table 1 : Effect of foliar application of varying concentration of cobalt on growth parameters of chickpea.

Treatment details	Plant height (cm)			No. of branches per plant			Dry matter accumulation per plant(g $plant^{-1}$)		
	30 DAS	60 DAS	At harvest	30 DAS	60DAS	At harvest	30 DAS	60 DAS	At harvest
T_1: RDF (13:25:25 kg N:P_2O_5:K_2O ha^{-1}+ FYM @ 10 t ha^{-1})	16.42	23.08	25.79	2.13	7.10	10.77	1.32	5.17	13.99
T_2: RDF + Foliar application of Co @ 25 ppm	16.79	23.81	26.73	2.37	7.73	11.00	1.38	5.27	14.44
T_3: RDF + Foliar application of Co @ 50 ppm	17.04	25.27	28.11	2.47	7.90	11.27	1.42	5.36	15.54
T_4: RDF + Foliar application of Co @ 75 ppm	17.52	27.09	30.40	2.60	8.73	11.40	1.43	5.58	16.93
T_5: RDF + Foliar application of Co @ 100 ppm	18.19	29.49	32.96	2.53	9.33	12.47	1.42	5.69	18.11
T_6: RDF + Foliar application of Co @ 125 ppm	18.37	31.83	34.83	2.60	9.67	13.00	1.53	5.81	19.58
T_7: RDF + Foliar application of Co @ 150 ppm	19.39	32.92	36.25	2.47	10.73	13.90	1.54	6.30	19.84
T_8: RDF + Foliar application of Co @ 175 ppm	18.57	28.56	30.30	2.40	8.60	11.93	1.52	5.62	17.44
T_9: RDF + Foliar application of Co @ 200 ppm	17.16	24.20	29.54	2.20	7.80	11.53	1.50	5.46	15.78
S.Em. ±	**1.04**	**1.20**	**1.93**	**0.23**	**0.61**	**0.65**	**0.06**	**0.20**	**0.77**
C.D. @ 5%	**NS**	**3.6**	**5.76**	**NS**	**1.84**	**1.95**	**NS**	**0.62**	**2.31**

Foliar application of varying concentration of cobalt significantly influenced on number of nodules and effective nodules per plant at 45 DAS (Table 2 and Fig. 1). Among the different levels of cobalt, the application of cobalt at 150 ppm (T_7) recorded significantly higher number of nodules and effective nodules per plant (31.41 and 23.87 $plant^{-1}$, respectively) at 45 DAS. This performance was on par with the foliar application of cobalt at 125 ppm (T_6) and 100 ppm (T_5). Cobalt element plays a pivotal role in regulating both the quantity and size of nodules. Moreover, cobalt application increases the formation of leghaemoglobin required for nitrogen fixation, thereby improves the nodules activity. Similar observations were made by Jain and Nainawatee (2000) in mung bean and by Akbar *et al.* (2013) in field grown pea.

Yield : Significantly higher yield related parameters such as number of pods per plant (44.93), pod yield per plant (13.79 g $plant^{-1}$), seed yield (18.43 q ha^{-1}) and stover yield (26.57 q ha^{-1}) were recorded with the foliar cobalt application at a concentration of 150 ppm (T_7), which was statistically on par with the foliar application of cobalt at 125 ppm (T_6) and 100 ppm (T_5). Whereas, maximum 100 seed weight (23.89 g) (Table 3) was also found with foliar application of cobalt at 150 ppm (T_7). Enhanced development of various growth parameters such as plant height, number of branches per plant (primary and secondary) and dry matter accumulation was observed with the application of cobalt (T_7). This ultimately translated into significantly higher yield parameters such as number of pods per plant, pod yield per plant and seed yield per plant under this treatment. The combined effect of improvements in growth and yield related characteristics due to cobalt application potentially contributed to the amplified seed and haulm yields. These findings are consistent with studies conducted by Awomi *et al.* (2012) and Jaleel *et al.* (2009) on mungbean. The lower cobalt dosage supported improved nodulation, thereby fostering enhanced growth and yield. However, at cobalt levels exceeding 150 ppm, adverse effects on the bacterial population in the rhizosphere were observed leading to hindered nodulation, diminished growth and reduced crop yield (Basu and Bhadoria, 2008).

Biochemical parameters : Crude protein content of chickpea seeds was found to be significantly influenced due to the foliar application of varying levels of cobalt (Table 4). Application of cobalt at 150 ppm (T_7) recorded maximum crude protein content of 22.65 per cent which was on par with the treatment that received foliar application of cobalt at 125 ppm (T_6) and 100 ppm (T_5). The remarkable increase in protein content in seed due



Treatment details:

T_1: RDF (13:25:25 kg $N:P_2O_5:K_2O$ ha^{-1} + FYM @ 10 t ha^{-1})
T_2: RDF + Foliar application of Co @ 25 ppm
T_3: RDF + Foliar application of Co @ 50 ppm
T_4: RDF + Foliar application of Co @ 75 ppm
T_5: RDF + Foliar application of Co @ 100 ppm
T_6: RDF + Foliar application of Co @ 125 ppm
T_7: RDF + Foliar application of Co @ 150 ppm
T_8: RDF + Foliar application of Co @ 175 ppm
T_9: RDF + Foliar application of Co @ 200 ppm

Fig. 1 : Per cent increase in number of nodules per plant at 45 DAS as influenced by varying levels of cobalt application.

Table 2 : Effect of foliar application of varying concentration of cobalt on number of nodules and effective nodules per plant at 45 DAS of chickpea.

Treatment details	No. of nodules per plant	No. of effective nodules per plant
T_1: RDF (13:25:25 kg $N:P_2O_5:K_2O$ ha^{-1} + FYM @ 10 t ha^{-1})	22.89	18.43
T_2: RDF + Foliar application of Co @ 25 ppm	23.72	19.10
T_3: RDF + Foliar application of Co @ 50 ppm	24.74	19.87
T_4: RDF + Foliar application of Co @ 75 ppm	26.03	20.37
T_5: RDF + Foliar application of Co @ 100 ppm	27.87	22.40
T_6: RDF + Foliar application of Co @ 125 ppm	29.13	23.23
T_7: RDF + Foliar application of Co @ 150 ppm	31.41	23.87
T_8: RDF + Foliar application of Co @ 175 ppm	27.01	23.13
T_9: RDF + Foliar application of Co @ 200 ppm	24.52	19.73
S. Em. ±	**1.38**	**0.69**
C.D. @ 5%	**4.14**	**2.09**

to cobalt application method observed in present study could be attributed to increasing nitrogen fixation capacity of the nodule bacteria. As a result of this, more nitrogen available to plant and that consequently increased the protein synthesis. An increase in the protein synthesis in seed due to cobalt application was also reported by Gad *et al*. (2012) in groundnut, Bhattacharjee *et al*. (2013) in soyabean and Arora *et al.* (2012).

Catalase activity in leaves of chickpea at 60 DAS was found to be significant due to the foliar application of varying levels of cobalt (Table 4). Application of cobalt at 150 ppm (T_7) recorded maximum catalase activity of 144.83 µmol min^{-1}, which was significantly superior over the treatment without cobalt application which recorded catalase activity of 96.33 µmol min^{-1}. The heightened hydrogen peroxide should be reduced or scavenged by other antioxidant enzymes to protect plants against oxidative stress (Lopez-Moreno *et al*., 2016). In this study, catalase activity was decreased at the highest co of treatment. This reduction might be due to decline in protein content at higher doses of cobalt. Comparable findings were noted in the study by Jahani *et al.* (2020) and Jayakumar *et al.* (2009).

Table 3 : Effect of foliar application of varying concentration of cobalt on yield parameters and yield of chickpea.

Treatment details	No. of pods per plant	Pods yield per plant(g)	100 seed weight (g)	Seed yield	Haulm yield
T_1: RDF (13:25:25 kg $N:P_2O_5:K_2O$ ha^{-1} + FYM @ 10 t ha^{-1})	37.13	8.44	20.33	15.30	18.73
T_2: RDF + Foliar application of Co @ 25 ppm	38.37	9.42	21.13	15.85	19.82
T_3: RDF + Foliar application of Co @ 50 ppm	39.67	10.66	22.06	16.13	20.99
T_4: RDF + Foliar application of Co @ 75 ppm	40.63	11.41	22.63	16.57	21.24
T_5: RDF + Foliar application of Co @ 100 ppm	42.40	12.30	23.03	16.95	24.17
T_6: RDF + Foliar application of Co @ 125 ppm	43.80	12.68	23.62	17.33	26.26
T_7: RDF + Foliar application of Co @ 150 ppm	44.93	13.79	23.89	18.43	26.57
T_8: RDF + Foliar application of Co @ 175 ppm	40.20	10.59	21.96	16.43	22.64
T_9: RDF + Foliar application of Co @ 200 ppm	38.00	10.13	20.56	15.33	20.57
S. Em. ±	**1.32**	**0.68**	**1.26**	**0.57**	**0.93**
C.D. @ 5%	**3.95**	**2.07**	**NS**	**1.69**	**2.78**

Table 4 : Effect of foliar application of varying concentration of cobalt on biochemical parameters of chickpea.

Treatment details	Crude protein content (%)	Catalase activity (μmol min^{-1})
T_1: RDF (13:25:25 kg $N:P_2O_5:K_2O$ ha^{-1} + FYM @ 10 t ha^{-1})	16.07	96.33
T_2: RDF + Foliar application of Co @ 25 ppm	16.96	100.67
T_3: RDF + Foliar application of Co @ 50 ppm	18.57	107.58
T_4: RDF + Foliar application of Co @ 75 ppm	19.09	116.92
T_5: RDF + Foliar application of Co @ 100 ppm	19.96	126.92
T_6: RDF + Foliar application of Co @ 125 ppm	21.35	138.53
T_7: RDF + Foliar application of Co @ 150 ppm	22.65	144.83
T_8: RDF + Foliar application of Co @ 175 ppm	18.78	112.17
T_9: RDF + Foliar application of Co @ 200 ppm	17.95	98.33
S. Em. ±	**1.23**	**6.35**
C.D. @5%	**3.10**	**19.04**

Conclusion

Among the varying levels of foliar application of cobalt 150 ppm was found to be effective followed by 125 and 100 ppm in terms of increasing plant growth parameters, seed yield, protein content and catalase activity. The higher levels of cobalt at 175 and 200 ppm had a negative impact on growth parameters, yield parameters, yield, protein content and also on catalase activity. So, the foliar application of cobalt up to optimal limit of 150 ppm significantly helps in increasing yield, protein content and catalase activity in chickpea.

References

Akbar, F.M., Zafar M., Hamid A., Ahmed M., Khaliq A., Khan M.R. and Rehman Z.U. (2013). Interactive effect of cobalt and nitrogen on growth, nodulation, yield and protein content of field grown pea. *Horticult. Environ. Biotechnol.*, **54**, 465-474.

Ali, B., Hayat S., Hayat Q. and Ahmad A. (2010). Cobalt stress affects nitrogen metabolism, photosynthesis and antioxidant system in chickpea (*Cicer arietinum* L.). *J. Plant Interactions*, **5**, 223-231.

Anonymous (2022). *Agricultural Statistics at a Glance*. DAC, Government of India.

Arora, P., Bhardwaj R. and Kanwar M.K. (2012). Effect of 24-epibrassinolide on growth, protein content and antioxidative defence system of *Brassica juncea* L. subjected to cobalt ion toxicity. *Acta Physiologiae Plantarum*, **34**, 2007-2017.

Awomi, T.A., Singh A.K., Kumar M. and Bordoloi L.J. (2012). Effect of phosphorus, molybdenum and cobalt nutrition on yield and quality of mungbean (*Vigna radiata* L.) in acidic soil of northeast India. *J. Hill Agricult*., **25**, 22-26.

Basu, M. and Bhadoria P.B.S. (2008). Performance of groundnut (*Arachis hypogaea* L.) under nitrogen fixing and phosphorus solubilizing microbial inoculants with different levels of cobalt in alluvial soils of eastern India. *Agronomy Research*, **6**, 15-25.

Bhattacharjee, S., Singh A.K., Kumar M. and Sharma S.K. (2013). Phosphorus, sulphur and cobalt fertilization effect on yield and quality of soybean (*Glycine max* L.) Merrill in acidic soil of northeast India. *Indian J. Hill Farming*, **26**, 63-66.

Chandlee, J.M. and Scandalios J.G. (1984). Analysis of variants affecting the catalase developmental program in maize scutellum. *Theoret. Appl. Gen*., **69**, 71-77.

Dilworth, M.J., Robson A.D. and Chatel D.L. (1979). Cobalt and nitrogen fixation in *Lupinus angustifolius* L. II. Nodule formation and function. *New Phytologist*, **83**, 63-79.

Doubetz, S. and Wells S.A. (1968). Reaction of barley varieties to nitrogen fertilizer. *Indian J. Agricult. Sci*., **70**, 253-256.

Gad, N. (2012). Role and importance of cobalt nutrition on groundnut (*Arachis hypogaea*) production. *World Appl. Sci. J*., **20**, 359-367.

Gomez, K.A. and Gomez A.A. (1984). *Statistical procedures for agricultural research with emphasis on rice*. John Wiley and Sons, New York. pp. 680.

Jahani, M., Khavari-Nejad R.A., Mahmoodzadeh H. and Saadatmand S. (2020). Effects of cobalt oxide nanoparticles (Co_3O_4 NPs) on ion leakage, total phenol, antioxidant enzymes activities and cobalt accumulation in *Brassica napus*. *Notulaebotanicae Horti Agrobotanici Cluj-Napoca*, **48**, 1260-1275.

Jain, V. and Nainawatee H. (2000). Cobalt reduces nitrate inhibition of nodulation in mungbean (*Vigna radiata*). *Biology and Fertility of Soils*, **31**, 522–524.

Jaleel, C.A., Jayakumar K., Zhao C. and Azooz M.M. (2009). Antioxidant potentials protect *Vignaradiata* (L.) Wilczek plants from soil cobalt stress and improve growth and pigment composition. *Plant Omics*, **2**, 120-126.

Jayakumar, K., Jaleel C.A., Azooz M.M., Vijayarengan P., Gomathinayagam M. and Panneerselvam R. (2009). Effect of different concentrations of cobalt on morphological parameters and yield components of soybean. *Glob. J. Mole. Sci*., **4**, 10-14.

Lopez-Moreno, M.L., Aviles L.L., Perez N.G., Irizarry B.A., Perales O., Cedeno-Mattei Y. and Roman F. (2016). Effect of cobalt ferrite ($CoFe_2O_4$) nanoparticles on the growth and development of *Lycopersicon lycopersicum* (tomato plants). *Sci. Total Environ*., **550**, 45-52.

Yagodin, B.A. (1970). *Cobalt in the living process of plants*. Nauka, Moscow. pp. 343.

Younis, M. (2011). Soil applied cobalt and copper alter the Rhizobium symbiosis and growth status of *Lablab purpureus*. *J. Plant Nutr*., **34**, 1736-1745.