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Impact of Zinc and Molybdenum Fertilization on Growth, Yield and Nutrient Uptake by Chickpea (*Cicer arietinum* L.) in Bundelkhand Region

Anushka Mishra [a*], Satyavir Singh Solanki [a], Anil Kumar Sahu [a] and Awanish Kumar [a]

[a] *Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Bundelkhand University, Jhansi, Uttar Pradesh, India.*

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 pot experiment was conducted during rabi season of 2019-20 at the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Bundelkhand University, Jhansi U.P, to find out the suitable doses of Zn and Mo for chickpea crop. The experiment was carried out in CRD with 3 replication having nine treatments as T_0- RDF (20:40: 20 kg ha^{-1}), T_1- Zn 20 kg ha^{-1} + Mo 0 kg ha^{-1}, T_2- Zn 30 kg ha^{-1} + Mo 0 kg ha^{-1}, T_3- Zn 0 kg ha^{-1} + Mo 1 kg ha^{-1}, T_4- Zn 20 kg ha^{-1} + Mo 1 kg ha^{-1}, T_5- Zn 30 kg ha^{-1} + Mo 1 kg ha^{-1}, T_6- Zn 0 kg ha^{-1} + Mo 2 kg ha^{-1}, T_7- Zn 20 kg ha^{-1} +

**Corresponding author: E-mail: anushkamishra442@gmail.com;*

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Mo 2 kg ha^{-1} , T_8- Zn 30 kg ha^{-1} + Mo 2 kg ha^{-1}. The results indicated that growth, yield attributes and yield viz. plant height, branches plant^{-1}, dry weight of plant, No. of pods plant^{-1}, No. of seeds pod^{-1}, grain yield, biological yield and stover yield were increased significantly and found better all treatments, over control, except T_1. The highest values in respect to plant height (33.86cm, 34.09%), branches plant^{-1} (8.00, 60%), dry weight of plant(19.74 g plant^{-1}, 38.52%) , No. of pods plant^{-1} (50.33, 14.39%), No. of seeds pod^{-1} (1.50, 150%) grain yield (32.27 g plant^{-1}, 39.51%), stover yield (72.95 g plant^{-1}, 45.54%) and biological yield (40.68 g plant^{-1}, 42.81%) recorded in T_5 followed by T_3 and T_8. The maximum nutrient concentration and its corresponding uptake of N,P,K content in grain (3.66 %N, 0.59%P, 0.72%K) and in straw (2.20 %N, 0.34%P, 1.57%K) recorded in T_5, followed by T_4 and T_8. The Zinc and molybdenum concentration in grain (58.09 mg kg^{-1} and 1.59 mg kg^{-1}) and in straw (56.56 mg kg^{-1} and 1.02 mg kg^{-1}) were registered in T_8. The highest uptake of NPK and Zn (0.208 g pot^{-1}, 0.033 g pot^{-1},0.087 g pot^{-1} and 4.13 mg pot^{-1}, respectively) in T_5 and Mo uptake (0.086 mg pot^{-1}) in T_8. Maximum protein content in seed (22.88%) was observed in (T_5) followed by T_4 and T8. The T_5 (Zn 30 kg ha^{-1} + Mo 1 kg ha^{-}1) treatment was proved most superior in respect to growth, yield, nutrient concentration and corresponding uptake among treatments. The application of Zn and Mo with different doses enhanced the soil quality and increase the nutrient availability in soil.

Keywords: Biological yield; micronutrient; nutrient concentration and uptake; soil quality; nutrient availability.

1. INTRODUCTION

"Among the pulses, chickpea is a major crop, which is highly nutrition grain legume and one of the cheapest sources of energy and protein. But, the slow growth in pulses production compared to enormous increase in human population let to the progressive decline in per capita availability of pulses. Chickpea is an excellent source of both soluble and insoluble fiber, complex carbohydrate, vitamins, folate and minerals especially Mg, Zn, P and Fe" (Nwokolo & Smartt, 1996).

"Micronutrients act as co-factor in enzyme system and participate in redox reaction and having several other vital functions in plants" (Mengel et al., 2001). "The role of micronutrients is crucial in crop nutrition and thus important for achieving higher yields. Six micronutrients i.e. Mn, Fe, Cu, Zn, B and Mo are known to be required for all higher plants" (Welch et al., 2005). "The main micronutrient that limits chickpea productivity is Zn. Zn is one of the essential plant nutrient that functions in diverse metabolics, regulatory and developmental processes" (Broadly et al., 2007).). "Zn is involved in biosynthesis of plant hormone, indole acetic acid (IAA), auxin metabolism, constituent of enzymes and protein. It is the only metal element present in all the six enzyme classes, oxidoreductases, transferases, hydrolases, lyases, isomerases and ligases" (Auld, 2001). "Zinc increases resistancy to disease in plant and involved in the channelization of photosynthesis during reproductive stage by way of its involvement in electron transfer" (Baker et al., 1982). "In general, each tonne of chickpea grain removes 38g of Zn from the soil" (Ahlawat et al., 2007). "The critical Zn concentration in soils vary from 0.48 to 2.5 mg/kg depending on soil type" (Ahlawat et al., 2007). "It is also playing an important role in nucleic acid and protein synthesis and helps in utilization of P and N in seed formation and development. The second phase of seed development requires adequate amount of Zn. Zinc deficiency decreases crop yield and delays crop maturity also reduces water use and water use efficiency" (Khan et al., 2004), "reduces nodulation and nitrogen fixation" (Ahlawat et al., 2007). "Zinc deficiency in agricultural soils is also a wide-spread constraint for chickpea production in India" (Ahlawat et al., 2007). "Zinc deficiency not only cause of low productivity of the crops but it also results in low Zn concentration in seeds, which leads to poor dietary Zn intake when consumed" (Pathak et al., 2012).

"Molybdenum also plays an crucial role in increasing yield of chickpea. Mo is involved in nitrogen nutrition and its assimilation. In legumes, it helps root nodule bacteria to fix atmospheric nitrogen" (Campo et al., 2000). "In general, each tonne of chickpea grain removes 1.5g of Mo from soil but Mo that is in the soil is largely unavailable, since usually less than 0.2 mg/kg of Mo has been reported to be soluble" (Sillanpaa, 1972). "The availability of Mo increases as the pH of the soil approaches neutrality (pH-7) or is higher than neutral" (Sims, 2000). "Mo deficiency common in acidic soils, especially in crops that are very sensitive to low concentration of Mo such as legume" (Sims, 2000). "In Mo deficient chickpea, the flowers produced are less in number, smaller in size and many of them fail to open or to mature, consequently this leads to lower seed yield" (Ahlawat et al., 2007). "These micronutrients may be supplied to the plants through soil application, foliar spray or seed treatment. Micronutrients application though seed treatments improves the stand establishment, advances phonological events and increase yield and micronutrient grain content in many crops" (Farooq et al., 2012). Zn and Mo application have positive effect on growth parameters, yield attributes and yield. The soil application of Zn and Mo significantly increased the performance in field in respect to yield and seed quality of chickpea. This work was conducted to determine the impact of Zn and Mo applications on growth, yield attributes and yield of chickpea.

2. METHODS AND MATERIALS

A pot experiment was conducted during rabi season 2019-20 at the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Bundelkhand University Jhansi, U.P., to find out the "Impact of Zinc and Molybdenum fertilization on Growth, Yield and Nutrient uptake by Chickpea (*Cicer arietinum* L.) under pot conditions." The experiment was carried out using a CRD with three replication and nine treatments with comprising of 3 levels of Zn (0, 20 and 30 kg ha^{-1}) and 3 levels of Mo (0, 1 and 2kg ha^{-1}) were applied and treatments codes were T_0- RDF (20:40: 20 kg ha^{-1}), T_1- Zn 20 kg ha^{-1} + Mo 0 kg ha^{-1}, T_2- Zn 30 kg ha^{-1} + Mo 0 kg ha^{-1}, T_3- Zn 0 kg ha^{-1} + Mo 1 kg ha^{-1}, T_4- Zn 20 kg ha^{-1} + Mo 1 kg ha^{-1}, T_5- Zn 30 kg ha^{-1} + Mo 1 kg ha^{-1}, T_6- Zn 0 kg ha^{-1} + Mo 2 kg ha^{-1}, T_7- Zn 20 kg ha^{-1} + Mo 2 kg ha^{-1} , T_8- Zn 30 kg ha^{-1} + Mo 2 kg ha^{-1}. Zinc applied through zinc sulphate and Molybdenum through ammonium molybdate.

The eight kg soil is filled in every pot. The experimental soil was having pH 7.24, EC 0.56 dS m^{-1}, OC 0.66%, with available N, P and K as 278 kg ha^{-1},17.72 kg ha^{-1}and 261.52 kg ha^{-1}, respectively. As regards micronutrient, the soil was sufficient in extractable Zn (0.77 mg kg^{-1}) and Mo (0.66 mg kg^{-1}). The experiment is conducted using neutral soils. For each pot, 5 seeds were sown at 3cm depth in each pot on 7th November 2019. One week after emergence, the seedlings were thinned so that there was only one plant per pot left. The treatments were applied at the time of sowing as soil application. Soil moisture was maintained near field capacity by watering the plants as per requirement with tap water.

At maturity, 4th march, 2020, all plants were harvested with the help of reaping hook. The roots, the stems with leaves and pods including seeds were separated and sun dried. At harvest, plant height, branches plant^{-1}, Dry weight of plant, No. of pods plant^{-1}, No. of seeds pod^{-1}, grain yield, biological yield, stover yield, protein content and harvest index were determined. N,P,K, Zn and Mo content and uptake also determined. The study is based on mean data.

Soil pH and available potassium were determined according to Jackson (1973), EC by Bouwer (1986), OC by Walkley and Black (1934), Available Nitrogen Bradstreet, (1954), Available Phosphorus by Olsen et al. (1954), extractable Zn by Lindsay and Norvell (1978) and extractable Mo by Grigg (1953). NPK content in seed and straw were determined according to the method described by A.O.A.C. and protein content in seed calculated by multiplying total nitrogen content in grain by 6.25. Zinc was determined by di-acid mixture extraction using AAS, Dithizone method (Shaw and Dean 1952) and Molybdenum by EDTA with ammonium acetate method described by Lindsay and Norvell (1978). Harvest index (HI) determined by dividing the total grain yield by biological yield and multiply with 100. Nutrient uptake by following formula-

$$\text{Nutrient uptake (g/pot)} = \frac{\text{Nutrient content (\%)} \times \text{dry matter yield (g/pot)}}{1000}$$

3. RESULTS AND DISCUSSION

3.1 Impact of Zn and Mo Application on Growth, Yield Attributes and Yield of Chickpea

A perusal on Table 1 showed that plant height, branches plant^{-1} , dry weight of plant, No. of pods plant^{-1} and No. of seeds pod^{-1} significantly increased in all treatments over control except T_1 with the combined application of Zn + Mo in present study. The application of 30 kg ha^{-1} zinc through zinc sulphate + 2 kg ha^{-1} molybdenum through ammonium molybdate (T_5) registered highest plant height (33.86cm, 34.09%), branches plant^{-1} (8.00, 60%), dry weight of plant(19.74 g plant^{-1}, 38.52%) , No. of pods plant^{-1} (50.33, 14.39%) and No. of seeds pod^{-1} (1.50, 150%) over control, followed by T_3 and T_8, while minimum plant height (24.96 cm), number of branches (5) and dry weight of plant (13.95 g plant^{-1}), number of pods (43.33) and seeds pod^{-1} (0.53) were recorded in T_1 (Zn 20 kg ha^{-1}). The increase in plant height, branches per plant, dry weight of plant, No. of pods plant^{-1} and No. of seeds pod^{-1} might be due to inhanced the nodulation, photosynthesis, metabolism, translocation and assimilation of nitrogen as influenced by Zn and Mo application. Besides it could attribute to improvement and nutritional improvement in crop root zone and alternately resulted in better vegetation growth and finally promoted the yield indirectely. Our findings are partially agreed with Valenciano et al. (2010) reported that the mature plants fertilized with the Zn, B and Mo increased growth, seed yield mainly due to number of pods plant^{-1}and total dry matter production. Sarbandi and Madani (2014) also reported that plant height is significantly affected by foliar application of Zn and Fe, Mn individually the highest plant height was obtained by foliar application of Zn, followed by Fe. Mekkei (2019) reported that the foliar application of micronutrient have significant effect on the number of branches plant^{-1}. Gupta and Gangwar (2012) also stated that the Mo application along with other treatment indicated significant increase in branches plant^{-1}. Gupta and Gangwar (2012) also reported higher dry weight of plant with the application of AM + ferrous sulphate or AM in combination with *Rhizobium* + PSB + RDF. Kumari et al. (2019) observed that application of micronutrient and biofertilizer influenced significantly yield attributes. Deshlahare and Banjara (2019) who reported that the application of $ZnSO_4$ and $FeSO_4$ significantly influence the number of seed pod^{-1}.

3.2 Impact of Zn and Mo Application on Grain Yield, Stover Yield, Biological Yield and Harvest Index of Chickpea

Grain yield, stover yield and biological yield significantly increased in all treatments over control, except T_1 with the combined application of Zn + Mo in present study. The application of 30 kg ha^{-1} zinc through zinc sulphate and 2 kg ha^{-1} molybdenum through ammonium molybdate (T_5) registered highest grain yield (32.27 g plant^{-1}, 39.51%), stover yield (72.95 g plant^{-1}, 45.54%) and biological yield (40.68 g plant^{-1}, 42.81%) over control except T_1, followed by T_3 and T_8. While, the lowest value in respect to grain yield (22.73 g plant^{-1}) in T_1 biological yield (51.08 g plant^{-1}) and stover yield (27.95 g plant^{-1}) in control. Highest harvest index (45.28%) registered with T_0, while lowest (42.08 %) in T_2. The increasement in grain yield, biological yield and stover yield, might be due to enhanced nodulation and BNF (biological nitrogen fixation), Nitrogen and other complementary element assimilation and also due to enhance in nitrogenase activity in nodules and nitrate reductase activity in plant system this resulted in increased grain yield, biological and stover yield. These findings are in close conformity with Singh et al. (2004) who reported that the application of different micronutrient (Fe, Zn and Mo) with or without *Rhizobium* inoculation increased the grain yield by chickpea. Sarbandi and Madani (2014) also reported that micronutrient effect the highest grain yield, biological yield and harvest index was recorded with Zn treated plants and followed by Fe and Mn. Shil et al. (2007) observed that the yield of chickpea was found to increase progressively upto 1.5 and 1.0-1.5 kg Mo ha^{-1} at Jessore and Rahmatpur, rescetively. Kumari et al. (2019) who stated that grain yield and stover yield of chickpea was significantly increased by micronutrient. Das et al. (2016) also reported that straw yield due to both levels of Zn application were numerically higher by with 10 and 25kg $ZnSO_4$ ha^{-1} application over control, respectively.

3.2.1 Protein content

The data in Table (2) revels that protein content significantly increased under combined application of zinc and molybdenum in present study, over control. Highest protein content (22.88%) observed in (T_5) followed by T_4 and T_8. The increasement in protein content might be due to compatible impact of Zn and Mo nutrient on nitrogenase and nitrate reductase activities resulting in increased BNF (biological nitrogen fixation) and Nitrogen assimilation, crop growth, photosynthesis process, respiration and other biochemical and physiological activities. Similar result were reported by Singh et al. (2004) observed significant increase in protein content with the application of sodium molybdate over the control. Gupta and Gangwar (2012) reported that protein content significantly increased in all the AM (ammonium molybdate) treatment over RDF. Habbasha et al. (2013) reported that foliar application of Zn led to an increase in concentration of N and protein content which was mainly due to the vital physiological role of Zn in plant cell.

Table 1. Impact of Zn and Mo application on growth, yield attributes and yield of chickpea

Treatments	Plant height (cm)	Branches plants^{-1}	Dry weight of plant (g)	Number of Pod plant^{-1}	Number of seed pod^{-1}	Grain yield (g plant^{-1})	Biological yield (g plant^{-1})	Stover yield (g plant^{-1})	Harvest index (%)
T_0	25.25	5.00	14.25	44.00	0.60	23.13	51.08	27.95	45.28
T_1	24.96	4.67	13.95	43.33	0.53	22.73	53.54	30.82	42.44
T_2	25.59	5.00	14.42	44.00	0.60	23.17	55.02	31.96	42.08
T_3	30.41	7.67	17.70	48.33	1.10	30.38	68.89	38.51	44.09
T_4	29.25	7.00	17.21	47.33	0.90	28.45	64.77	36.32	43.91
T_5	33.86	8.00	19.74	50.33	1.50	32.27	72.95	40.68	44.24
T_6	27.65	6.00	16.42	46.33	0.77	24.84	57.97	33.13	42.82
T_7	28.98	6.67	16.67	47.00	0.83	27.40	62.82	35.42	43.61
T_8	30.04	7.33	17.63	48.00	0.97	29.79	67.56	37.77	44.08
SEm(±)	1.53	0.59	0.76	0.94	0.18	0.88	1.71	0.94	0.62
CD at 5%	4.58	1.76	2.29	2.80	0.54	2.63	5.13	2.83	1.85

Table 2. Impact of Zn and Mo application on nutrient content in seed + straw and protein content in seed.

Treatment	Nitrogen content (%)		Protein content (%)	P content (%)		K content (%)		Zn content (mg kg^{-1})		Mo content (mg kg^{-1})	
	Seed	**Straw**		**Seed**	**straw**	**Seed**	**straw**	**Seed**	**Straw**	**Seed**	**straw**
T_0	3.20	1.95	20.02	0.410	0.250	0.510	1.147	30.15	28.60	0.48	0.24
T_1	3.39	2.04	21.17	0.417	0.250	0.553	1.320	52.19	50.06	0.47	0.22
T_2	3.31	2.10	20.69	0.510	0.287	0.610	1.443	57.78	55.68	0.47	0.25
T_3	3.35	1.99	20.94	0.493	0.297	0.657	1.427	30.82	29.34	0.80	0.45
T_4	3.41	1.90	21.31	0.420	0.243	0.717	1.370	47.78	45.72	1.04	0.73
T_5	3.66	2.20	22.88	0.590	0.343	0.723	1.573	57.74	55.76	1.13	0.72
T_6	3.22	1.94	20.10	0.453	0.287	0.667	1.420	30.46	29.65	1.49	1.01
T_7	3.40	2.12	21.27	0.447	0.267	0.647	1.363	48.76	46.70	1.51	1.00
T_8	3.60	2.00	22.52	0.517	0.287	0.667	1.537	58.09	56.56	1.59	1.02
SEm (±)	0.06	0.04	0.37	0.017	0.011	0.028	0.045	0.359	0.449	0.066	0.024
CD at 5%	0.18	0.12	1.12	0.052	0.033	0.082	0.134	1.076	1.344	0.197	0.073

3.3 Impact of Zn and Mo Application on Nutrient Content in Seed and Straw by Chickpea

The nitrogen, Phosphorus, Potassium content in grain and straw significantly increased under the soil application of Zn and Mo in all treatments over control. The highest N,P,K content in grain (3.66 %N, 0.59%P, 0.72%K) and in straw (2.20 %N, 0.34%P, 1.57%K) recorded in T_5, followed by T_4 and T_8. While, lowest in grain (3.20 %N, 0.41 %P, 0.51 %K) in control and lowest in straw (1.90 %N) in T_4, (0.25 %P) in T_1, (1.15 %K) in control. Increase in NPK content by plant might be due to favorable effect of Zn and Mo nutrient on nitrogenase and nitrate reductase activities resulting in increased BNF and N assimilation, crop growth, photosynthesis process, respiration and other biochemical and physiological activities. These findings are conformity with Quddus et al. (2020) also reported that Zn, B and Mo had a significant impact on the K and S content in mungbean (seed and straw). Gangwar and Dubey (2012) also reported that N and P content in seed significantly increased due to soil application of ammonium molybdate ha^{-1}.

The Zinc and Molybdenum content in grain and straw significantly affected due to the application Zn and Mo fertilizers in all treatments over control. Treatment T_8 recorded the highest Zn and Mo content in grain (58.09 mg kg^{-1}, 1.59 mg kg^{-1}) and in straw 56.56 mg kg^{-1}, 1.02 mg kg^{-1}, respectively. While, lowest content in grain (30.15, and straw 28.60 mg kg^{-1}, respectively) in control, lowest content of Mo in grain (0.47 mg kg^{-1}) in T_1 and T_2, and in straw (0.22 mg kg^{-1}) in T_1. Increase in Mo and Zn content by plant might be due to favorable effect of Zn and Mo nutrient on nitrogenase and nitrate reductase activities resulting in increased BNF and N assimilation, crop growth, photosynthesis process, respiration and other biochemical and physiological activities. These findings were in agreement with Pal et al. (2019) reported that concentration of Mo increases with increasing doses of sodium molybdate and sulphur with inoculation of *Rhizobium*. Balai et al. (2017) reported that application Zn significantly increased Zn content in grain and straw. Maximum content in seed and straw were recorded with the application of 6 kg Zn ha^{-1}.

3.3.1 Nutrient uptake study

The N,P,K uptake by chickpea crop significantly affected due to the application Zn and Mo fertilizers. The highest uptake of NPK (0.208 g pot^{-1}, 0.033 g pot^{-1},0.087 g pot^{-1}) in T_5 and lowest (0.128 g pot^{-1}, 0.016 g pot^{-1}, 0.044 g pot^{-1}) in control, respectively. Increase in NPK uptake by plant might be due to favorable effect of Zn and Mo nutrient on nitrogenase and nitrate reductase activities resulting in increased BNF and N assimilation, crop growth, photosynthesis process, respiration and other biochemical and physiological activities. Similar result were reported by Singh et al. (2004) that significant increase in nitrogen and P uptake by grain and straw was observed with the application of sodium molybdate over the control. Gupta and Gangwar (2012) reported that N uptake by plant significantly increased with AM application. Hanwate et al. (2018) also observed that potassium uptake by soybean as influenced by foliar application of Zn, Fe with or without seed treatment of Mo.

Table 3. Impact of Zn and Mo application of total nutrient uptake by chickpea

Treatment	Total N uptake (g pot^{-1})	Total P uptake (g pot^{-1})	Total K uptake (g pot^{-1})	Total Zn uptake (mg pot^{-1})	Total Mo uptake (mg pot^{-1})
T_0	0.128	0.016	0.044	1.50	0.018
T_1	0.140	0.017	0.053	2.73	0.017
T_2	0.144	0.021	0.060	3.12	0.019
T_3	0.178	0.026	0.075	2.07	0.042
T_4	0.166	0.021	0.070	3.02	0.056
T_5	0.208	0.033	0.087	4.13	0.065
T_6	0.144	0.021	0.064	1.74	0.071
T_7	0.168	0.022	0.066	2.99	0.077
T_8	0.183	0.026	0.078	3.87	0.086
SEm (±)	0.005	0.001	0.003	0.084	0.003
CD at 5%	0.015	0.004	0.008	0.252	0.008

Table 4. Impact of zinc and molybdenum application on pH, EC, OC and available nutrients

Treatment	pH	EC	OC	N	P	K	Zn	Mo
T_0	7.27	0.66	0.64	268.00	24.87	281.67	0.76	0.65
T_1	7.33	0.56	0.69	294.00	17.64	250.33	1.75	0.64
T_2	7.30	0.47	0.72	286.00	15.75	261.67	2.37	0.70
T_3	7.10	0.64	0.69	288.33	13.83	258.33	0.85	1.42
T_4	7.30	0.53	0.67	291.67	14.49	267.67	1.29	1.48
T_5	7.33	0.49	0.67	292.67	15.53	278.66	2.43	1.93
T_6	7.20	0.47	0.71	285.33	21.27	275.67	0.78	2.12
T_7	7.20	0.50	0.68	284.33	26.97	247.00	1.28	2.18
T_8	7.37	0.56	0.65	285.33	16.77	258.00	2.44	2.36
SEm (±)	0.09	0.04	0.04	4.80	0.89	4.42	0.07	0.08
CD at 5 %	N/A	0.10	N/A	14.40	2.65	13.23	0.22	0.24

Zinc and molybdenum uptake increased significantly with the application of Zn and Mo fertilizers over control. The highest Zn uptake (4.13 mg pot^{-1}) was registered with treatment T_5 and lowest uptake (1.50 mg pot^{-1}) in control. Highest Mo uptake (0.086 mg pot^{-1}) in T_8 and lowest (0.017) in T_1. This might be due to Zn application improved the root growth and prevented nutritional disorders and consequently caused increase the uptake of Zn. The increased uptake of Mo might be due to synergistic effect of Zn and Mo in the metabolic activities in photosynthesis, N metabolism. Mo plays important role in activities of several enzymes. The results are corroborated with Singh et al. (2004) who revealed that the uptake of Mo irrespective of *Rhizobium* increased significantly with the addition of micronutrient individually or in combination over the control. Hanwate et al. (2018) observed that Zn and Mo uptake by soybean as influenced by Zn, Fe with or without seed treatment of Mo.

3.4 Impact of Zinc and Molybdenum Application on pH, EC and OC

The chemical properties such as pH, EC and OC did not differ due to the individual or combined soil application of zinc and molybdenum (Table 4). The pH, EC and OC range varies 7.1-7.37, 0.66-0.47 (slightly reduction trend), 0.64–0.72 (slightly increasement), respectively due to the application of Zn and Mo in present study.

3.5 Impact of Zinc and Molybdenum Application on Available Nutrient Content after Harvest

The available nutrient content after harvest of crop also differed with different treatment the higher available nitrogen (292.67 kg ha^{-1}) recorded in T_5, available phosphorus (36.97 kg ha^{-1}) in T_7 and available potassium (281.67 kg ha^{-1}) in T_0. DTPA extractable micronutrient Zn and Mo (2.44, 2.36 mg kg^{-1}) in T_8, while lowest available N (268 kg ha^{-1}) in T_0, P (13.83 kg ha^{-1}) in T_3 and K (247.00 kg ha^{-1}) in T_7. DTPA extractable micronutrient Zn (0.76 mg kg^{-1}) in T_0 and Mo value (0.64 mg kg^{-1}) in T_1. The available Zn and Mo significantly increased with every increasing levels of zinc and molybdenum individually. The increasing trends were recorded in Zn (1.75, 2.37 mg kg^{-1}) and Mo (1.42, 2.12 mg kg^{-1}) over control in present study.

4. CONCLUSION

It can be concluded from the above result of the present investigation, that application of zinc 30 kg ha^{-1} and molybdenum 1 kg ha^{-1} (T_5) was found superior in respect to plant height, braches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1}, yield, nutrient content and its uptake by chickpea crop, followed by T_8 and T_7 treatments. Chickpea is highly responsible crop to micronutrients fertilizers in general and Zn and Mo in particular and their deficiencies may be one of the important reasons of poor yield and uptake of nutrients.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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