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Soil zinc Status and response of berseem (*Trifolium alexandrinum*) and lentil (*Lens culinaris*) to zinc application

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ABSTRACT

Two hundred soil samples collected from Agra district were analysed for their status of total and available zinc. DTPA-Zn ranged from 0.30 to 1.06 mg kg^{-1} with a mean value of 0.55 mg kg^{-1}. Soil organic carbon, C_aCO_3 and pH were the important soil characteristics that governed the status of Zn in soils. Highly significant positive relationship was noted between total and available zinc of soil. The berseem crop responded significantly to zinc up to 5 kg Zn ha^{-1} and that of lentil up to 7.5 kg Zn ha^{-1}. The magnitude of response was recorded higher (35.5%) in lentil than that of berseem (21.9%). The content and yield of protein in both the crops increased significantly with the addition of zinc and the higher values of protein content were recorded in lentil grain. Nitrogen uptake by berseem and lentil increased from 27.7 to 32.5 kg ha^{-1} and 38.2 to 56.0 kg ha^{-1} (lentil grain) and 11.8 to 22.1 kg ha^{-1} (lentil straw) with the addition of 7.5 and 10.0 kg Zn ha^{-1}, respectively. The uptake of P tended to decrease by both the crops at higher levels of zinc whereas the uptake of zinc increased significantly with its addition. The higher amounts of zinc were utilized by lentil than that of berseem. The potassium and sulphur uptake by both the crops increased up to 7.5 kg Zn ha^{-1} followed by a reduction at 10.0 kg Zn ha^{-1}.

Key words: Zinc status, response, legume crops, zinc

INTRODUCTION

The status of Zn and its interrelationship with soil characteristics is supportive in understanding the natural capacity of soil to supply zinc to plants (Kakar *et al.* 2018). Low productivity of berseem (*Trifolinvm alexandrinum* L.) and lentil (*Lens culinaris*) crops may be ascribed to many reasons but inadrquatr and unbalanced fertilizers is the major factor. Optimum nutrition is required for getting maximum yield and quality of these crops. Balanced fertilization results in the supply of nutrients in a well balanced ratio, leading to their efficient utilization. Presently the application of zinc has become essential as N and P for legume crops. Zinc is essential for promoting certain metabolic reactions, It is necessary for the production of chlorophyll and carbohydrates. Zinc is directly or indirectly required by several enzyme systems, auxin and protein synthesis seed production and rate of maturity. About 40% of the soils of our country are deficient in zinz. Zinc is an important and limiting micronutrient for proper growth of the crops (Singh and Singh 2017). Response to applied Zn for better growth and yield of legumes has been reported by Sharma *et al.* (2014). The response of Zn differed widely among the field crops because of wide variations in sensitivity to zinc stress and soil types. The information regarding the differential behavior of the crops to zinc application under identical soil and weather conditions was considered to be of interest. Not much work has been done in Agra region on the status and the effect of levels of zinc on berseem and lentil. Hence, an attempt was made to assess the status of zinc and response of legume crops to zinc in alluvial soils of Agra.

MATERIALS AND METHODS

Two hundred composite surface soil samples (0-15cm were collected from the cultivated fields of Agra district of Uttar Pradesh. These soil samples were analysed for EC, pH organic carbon and free lime by adopting standard procedures (Jackson 1973). Extraction of total zinc was done through percloric acid digestion of soil (Jackson 1973). Available zinc was determind by shaking the soil with DTPA extractant (Lindsay and Norvell. 1978). The estimation of zinc in both the cases was done on atomic absorption spectrophotometer. A field experiment was conducted during winter season at R. B. S. College Research farm, Bichpuri, Agra (U.P.) with berseem and lentil as the test crops. The soil of the experimental field was sandy loam in texture with pH 8.0, EC 0.19 dSm^{-1}, organic carbon 3.3 g kg^{-1} and available N, P, K, S and zinc 155, 10.0, 110, 16.0 kg ha^{-1} and 0.54 mg kg^{-1}, respectively. Five levels of zinc as zinc sulphate (0, 2.5, 5.0. 7.5 and 10.0 kg ha^{-1} was applied. The experiment was laid out in a randomized block design with four replications. In both the crops, the recommended doses of N, P and K 20, 60 and 40 kg ha^{-1} were applied through diammonium phosphate and muriate of potash, respectively. The berseem and lentil crops were sown in October and November. respectively. These crops were raised by adopting standard package of practices. At harvest, fodder yield of berseem and grain and straw yield of lentil were recorded. The samples of berseem and lentil were analysed for N by Kjeldahl method. Phosphorus, S, K and zinc were determined in diacid (HNO_3 : $HClO_4$) digest by phosphomolybdate yellow colour method, turbidimetric method (Chesnin and Yien 1951) flamephotometer and atomic absorption spectrophotometer, respectively. The uptake of nutrients was worked out by multiplying their content values with corresponding yield data.

RESULTS AND DISCUSSION

Zinc status

A perusal of the data (Table 1) indicated that all the soils under study were alkaline in reaction, the variation in pH being from 7.2 to 8.9. EC ranged between 0.06 and 0.30 dSm^{-1} indicating that these soils did not pose any problem for successful cultivation of crop. Free lime ranged from 5.0 to 25.0 g kg^{-1}. The organic carbon content in the soils varied from 2.8 to 5.6 g kg^{-1}. The variation in the organic carbon content may be attributed to variation in the texture of the soils and differences in the management practices. Total zinc content of the soils studied ranged from 26.0 to 59.0 mg kg^{-1} with a mean value of 37.2 mg kg^{-1} (Table 1). These values are fairly comparable to the results reported by Singh and Singh (2018) and Kakar *et al.* (2018). The amount of available (DTPA-Zn) Zn in these soils varied with the range of 0.30 to 1.06 mg kg^{-1} with a mean value of 0.55 mg kg^{-1}. Available Zn had significant and positive correlation with total zinc. Using 0.60 ppm DTPA- extractable zinc as deficient, 49 per cent samples in the present investigation are classified as deficient. Singh and Singh (2018) also reported similar results. DTPA-Zn had negative (-0.69^{**}) and positive (0.79^{**}) significant correlation with C_aCO_3 and organic carbon, respectively Rai *et al.* (2018).

Table 1: Some physico-chemical properties and zinc status in soil of Agra

Soil Characteristics	Range	Mean
pH (1:2.5)	7.2-8.9	-
EC (dSm^{-1})	0.06-0.30	0.14
Organic carbon (g ha^{-1})	2.8-5.6	4.3
Free lime (g ha^{-1})	5.0-25.0	11.6
Total zinc (mg kg^{-1})	26.0-59.0	37.2
DTPA- Zn (mg kg^{-1})	0.30-1.06	0.55

Yield

Data (Table 2) revealed an increase in forage and dry matter yield of berseem and grain and straw yield of lentil with the application of zinc over control. Application of 5 kg Zn ha^{-1} produced significantly higher forage and dry matter yield of berseem as compared to control. The increases in forage and dry matter yield of berseem due to 5 kg Zn ha^{-1} were 21.9 and 7.1 per cent, respectively over control. On the other hand, the highest grain (14.25 q ha^{-1}) and straw (20.23 q ha^{-1}) yields of lentil were recorded with 7.5 kg Zn ha^{-1}, which were 38.2 and 39.7% higher in comparison to control, respectively. This increase in yields of both the crops due to Zn application may be attributed to the fact that Zn is main yield limiting plant nutrient in arid and semi-arid regions, where the soils are deficient in zinc. Applied zinc is reported to enhance the absorption of native as well as added major nutrients such as N thereby improves overall growth and development of plants and ultimately the yields of the crops. These findings are in agreement with those of Singh and Singh (2018).

Quality

Application of Zn gradually increased the protein content and its yield in berseem and lentil crops (Table 2). The protein content in berseem and lentil crops ranged from 13.7 to 15.3% and 23.4 to 24.6%, respectively with 10 kg Zn ha^{-1}. Zinc functions in plants largely as a metal activators and enzymes like alcohol desulphydrase, carbonic anhydrase. Thus addition of Zn might have activated the enzymes responsible for the production of protein. The higher value of protein was recorded in lentil than that of berseem , irrespective of zinc levels. Similar results were reported by Singh and Singh (2017). The increase in protein yield in berseem due to 7.5 kg Zn ha^{-1} was from 173.2 to 203.3 kg ha^{-1} followed by a reduction at 10 kg Zn ha^{-1}.

Table 2: Effect of zinc levels on yield and quality of leguminous crops

Zn levels (kg ha^{-1})	Berseem				Lentil			
	Yield (t ha^{-1})		Protein content (%)	Protein yield (kg ha^{-1})	Yield (q ha^{-1})		Protein content (%)	Protein yield (kg ha^{-1})
	Forage	Dry matter			Grain	Straw		
0.0	7.83	1.26	13.7	173.2	10.20	14.48	23.4	238.9
2.5	8.37	1.27	14.1	179.3	11.49	16.31	23.7	272.8
5.0	9.55	1.35	14.6	187.9	13.82	19.76	23.8	329.8
7.5	9.17	1.28	15.0	203.3	14.25	20.23	24.3	347.2
10.0	8.25	1.25	15.3	192.1	14.19	20.14	24.6	350.2
SEm±	0.19	0.03	0.20	3.9	0.26	0.36	0.26	2.6
CD (P=0.05)	0.40	0.07	0.43	8.9	0.56	0.77	0.56	5.6

The protein yield in lentil increased from 238.9 kg ha^{-1} at control to 350.2 kg ha^{-1} with 10 kg Zn ha^{-1} The results indicate a beneficial effect of Zn on protein percentage in both the crops. Protein yield is a function of protein content and dry matter yield of berseem and grain yield of lentil and both the parameters increased with Zn application thus resulting in a significant increase in protein yield. The increase in protein yield with Zn application has been reported by Singh and Singh (2017).

Table 3: Effect of zinc on uptake of nutrient in leguminous crops

Zn levels (kg ha^{-1})	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	Berseem	Lentil		Berseem	Lentil		Berseem	Lentil	
		Grain	Straw		Grain	Straw		Grain	Straw
0.0	27.7	38.2	11.8	5.5	4.8	2.3	25.2	6.8	26.6
2.5	28.7	43.6	14.8	5.4	5.2	2.6	25.5	7.7	30.0
5.0	30.0	52.8	19.7	5.1	6.0	2.9	25.8	9.4	36.5
7.5	32.5	55.5	21.4	5.1	5.9	3.0	27.5	9.8	37.6
10	30.7	56.0	22.1	4.6	5.6	2.8	25.6	9.9	37.6
SEm±	0.99	1.14	0.46	0.10	0.18	0.12	0.53	0.42	1.00
CD (P=0.05)	2.13	2.45	1.00	0.21	0.38	0.26	1.13	0.90	2.15

Uptake studies

The nitrogen uptake by berseem crop and lentil grain and straw increased significantly with increasing levels of zinc (Table 3). Nitrogen uptake by berseem crop increased from 27.7 kg ha^{-1} at control to 32.5 kg ha^{-1} with 7.5 kg Zn ha^{-1}. Thereafter, nitrogen uptake by berseem crop tended to decrease at 10 kg Zn ha^{-1}. Nitrogen uptake by lentil grain increased from 38.2 kg ha^{-1} at control to 56.0 kg ha^{-1}. The corresponding increase in N uptake by lentil straw was from 11.8 to 22.1 kg ha^{-1} The higher values of N uptake with Zn addition could be attributed to enhanced vigour of crop growth with increased N utilization and translocation in to the plant resulting in the enhancement of yield. Similar results were reported by Singh *et al.* (2016). The lentil crop utilized the greater amount of nitrogen as compared to berseem crop. Singh and Singh (2017) also reported similar results.

Table 4: Effect of zinc levels on sulphur and zinc uptake by berseem and lentil crop

Zn levels (kg ha^{-1})	Sulphur (kg ha^{-1})			Zinc (g ha^{-1})		
	Berseem	Lentil		Berseem	Lentil	
		Grain	Straw		Grain	Straw
0.0	5.0	4.4	3.1	35.9	30.6	37.6
2.5	5.0	4.9	3.4	37.2	40.4	49.2
5.0	4.8	5.8	3.9	39.6	55.0	69.1
7.5	4.9	6.0	3.8	43.2	61.0	76.6
10	4.3	5.8	3.6	40.8	63.5	79.3
SEm±	0.08	0.14	0.15	1.43	1.21	1.49
CD (P=0.05)	0.18	0.31	0.33	3.07	2.61	3.00

The data (Table 3) indicate that the application of zinc significantly decreased the phosphorus uptake by berseem crop over control and minimum value of P uptake (4.6 kg ha^{-1}) was recorded with 10 kg Zn ha^{-1} Application of lower levels of zinc increased P uptake by lentil grain and straw followed by a reduction at higher levels of zinc. Owing to the antagonistic relationship of zinc and P reduction in P uptake was recorded with the application of zinc. The increased Zn concentration of Zn created hindrance in absorption and translocation of P from the root to the above parts (Singh and Singh 2012, Ali *et al.* 2013). Potassium uptake by both the crops was significantly influenced by Zn levels with maximum uptake values at 7.5 kg Zn ha^{-1} The range of K uptake by berseem crop was from 25.2 to 27.5 kg ha^{-1}. The ranges of K uptake by lentil grain and straw were from 6.8 to 9.9 kg ha^{-1} and 26.6 to 37.6 kg ha^{-1}, respectively. The increase in K uptake may be due to increase in K content and yield of both the crops. Similar results were reported by Singh and Singh (2012) in chickpea. Application of zinc significantly increased sulphur uptake to 5.0 kg Zn ha^{-1} by lentil crop. Thereafter, S uptake tended to decrease by the crop at higher levels of zinc. Zinc levels tended to decrease the S uptake significantly by berseem crop over control and minimum value (4.3 kg ha^{-1}) was recorded at 10 kg Zn ha^{-1}. The decreased S uptake following application of higher levels of zinc might have been contributed by decreased yields of both the crops. Similar results were reported by Ali et al (2013) in fababean. A progressive increase in zinc levels gradually increased the uptake of zinc by both the crops. Highest uptake of zinc by berseem and lentil crop was recorded at 7.5 kg ha^{-1} and 10 kg Zn ha^{-1}, respectively. Highest zinc uptake by these crops was recorded for the treatments giving higher yields. Higher uptake of zinc might be due to higher yields of both the crops as the differences in zinc content were significant. In both the cases, the uptake of zinc under 2.5, 5.0, 7.5 and 10.0 kg Zn ha^{-1} was significantly more than the control. This increase in Zn uptake may be ascribed to the higher yields of both the crops as well as improvement in Zn content with its addition (Singh and Singh 2017).

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