Annals of Plant and Soil Research 22(3): 281-284 (2020)

Soil zinc status and response of barley (*Hordeum vulgare*) to zinc application in alluvial soil

U.N. SINGH AND TAHIR MOHD. CHAUHAN[2]

Department of Agricultural Chemistry and Soil Science, Raja Balwant Singh College, Bichpuri, Agra (U.P.) – 283 105

Received: April, 2020, Revised accepted: June, 2020

ABSTRACT

One hundred soil samples collected from Agra district of Uttar Pradesh were analyzed for their physico-chemical properties and zinc status. The total and available (DTPA- extractable) Zn ranged from 29 to 66 mg kg^{-1} and 0.35 to 1.20 mg kg^{-1}, respectively. Highly significant positive relationship was recorded between total and available Zn. About 48 % of the soil samples were found to be deficient in plant available zinc. A filed experiment was also conducted to study the effect of zinc on barley (Hordeum vulgare) yield and uptake of nutrients. Results revealed that the grain and straw yields of barley were significantly improved with the increase in the levels of Zn and maximum grain (5.85t ha^{-1}) and straw (9.71t ha^{-1}) yields were recorded with 4 kg Zn ha^{-1}. However, the grain yield obtained with 6 kg Zn ha^{-1} was statistically at par with kg Zn ha^{-1}. Zinc application significantly increased the content and yield of protein in barley grain over control and maximum valves were recorded with8 and 6 kg Zn ha^{-1}, respectively. Such beneficial effect of Zn was also found in increasing the uptake of nutrients by barley crop. The highest uptake of Zn by the crop was recorded with 8 kg Zn ha^{-1}. The minimum yield and uptake of nutrients were recorded under control.

Keywords: Zinc status, nutrient uptake, quality, yield, barley

INTRODUCTION

Barley (Hordeum vulgare) ranks next only wheat, rice and maize among cereals. Imbalanced fertilization has aggravated the deficiencies of available nutrients, leading to deterioration in soil fertility and crop productivity. Widespread deficiency of zinc has been reported in light textured soils (Singh, 2017). Soil is the primary source of micronutrients, which are essential for plants. Thus, the knowledge of status of zinc is essential in improving the nutrition of 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 enzymes, auxin and protein syntheses. Zinc is believed to promote RNA synthesis which is turn is needed for protein synthesis. At several places, normal yield of crops could not be achieved despite judicious use of NPK fertilizers due to zinc deficiency. Chaudhary *et al.* (2014) and Kaini Kumari (2017) reported significant improvement in productivity and zinc uptake by various crops. Keeping this in view, the present study was conducted to assess soil available zinc status and response of barley to application of zinc in alluvial soils of Agra region, Uttar Pradesh.

MATERIALS AND METHODS

In order to delineate zinc status of Agra soils, 100 surface (0-15 cm) soil samples were collected from the farmers' fields. The soil samples after preparation were analyzed for pH and EC (1: 2.5 soil: water suspension) as described by Jackson (1973). Organic Carbon and $CaCO_3$ were determined by standard procedures. The total and available Zn were extracted with perchloric acid and DTPA extractant (Lindsay and Norvell, 1978), respectively and the concentration of Zn in both extracts was determined on atomic absorption spectrophotometer.A field experiment was conducted on barley at farmer field during rabi seaon of 2016-17. The experimental soil was sandy loam in texture. It had pH 8.1, organic carbon 3.1 g kg^{-1}, available N 167 kg ha^{-1}, available P 9.5 kg ha^{-1}, available K 115 kg ha^{-1} and DTPA extractable Zn 0.53 mg kg^{-1}. Treatments comprised of five levels of zinc (0, 2, 4, 6 and 8 kg Zn ha^{-1}) were evaluated in randomized block design with four replications. Barley (BH 946) was sown on November 10, 2016. Recommended dose of N, P and K fertilizers were 100 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1}. A basal dose of P and K and half dose of N were applied as the time of sowing through

[1]*Department of Agricultural Statistics, R.B.S. College, Bichpuri, Agra*
[2]*Faculty of Agriculture, A.M.U. Aligarh*

diammonium phosphate, muriate of potash and urea, respectively. Half dose of N was applied at first irrigation. The doses of Zn were applied through zinc sulphate (21% Zn) before sowing of barley along with basal dose of N, P and K fertilizers. The crop was irrigated as and when required. The grain and straw yields were recorded at maturity. The grain and straw samples were analyzed for their N, P, K, S and Zn content by adopting standard procedures. Nutrient uptake was calculated by multiplying nutrient concentration in grain and straw with their respective yields. The data collected from the study were subjected to statistical analysis as suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Zinc Status

Some of the important physico-chemical properties of the soils are presented in Table 1. The soils of Agra district were alkaline in reaction, the variation in pH being from 7.3 to 8.8. Electrical conductively values of these, soils ranged from 0.21to 0.45 dSm^{-1}. Organic carbon content ranged from 2.5 to 6.2 g kg^{-1} with a mean value of 4.9 g kg^{-1}. The amount of free lime also varied widely (5 to 45 g kg^{-1}). The total Zn content in these soils ranged between 29 and 66 mg kg^{-1} with a mean value of 46.5 mg kg^{-1}. The low values of total zinc in these soils might be associated with lower amount of organic carbon. Rai *et al.* (2018) also reported similar results. Total Zn content was positively and significantly correlated with organic carbon (r = 0.62) and negatively with pH (r = 0.55). The significant positive correlation of total Zn with organic carbon has also been reported by Rai *et al.* (2018). The available Zn content in these soils ranged between 0.35 and 1.20 mg kg^{-1} with a mean value of 0.64 mg kg^{-1}. Considering critical value of 0.6 mg kg^{-1}, the deficiency of Zn was rated up to 48 per cent. Widespread Zn deficiency has also been reported by Singh (2017) in Allahabad soils. The Zn deficiency in these soils might be attributed due to continuous mining of native zinc, imbalanced fertilization and no external addition of Zn through organic and inorganic sources. Available Zn was positively and significantly correlated with total Zn (r = 0.82), organic Carbon (r = 0.59) and negatively with soil pH (r = - 0.49). These results are in accordance with those of Rai *et al.* (2018).

Table 1: Physico-Chemical properties and Zinc status of Agra soils

Soil Parameters	Range	Mean
Soil pH (1 : 2.5)	7.3-8.8	-
EC (dSm^{-1})	0.21-0.45	0.36
Organic Carbon (g kg^{-1})	2.5-6.2	4.9
$CaCO_3$ (g kg^{-1})	5.0-45.0	28.5
Total Zn (mg kg^{-1})	29-66	46.5
DTPA – Zn (mg kg^{-1})	0.35-1.20	0.64

Yield

The data (Table 2) revealed that the maximum grain (5.85t ha^{-1}) and straw (9.71t ha^{-1}) yields were observed with 4 kg Zn ha^{-1} which was significantly higher than the recommended dose of N, P and K fertilizers (T_1). The lowest grain (5.53t ha^{-1}) and straw (8.64t ha^{-1}) yields were recorded in recommended dose of N, P and K fertilizers. Further increase in Zn levels depressed the yields of barley. The increase in grain and straw yields might be due to the fact that Zn plays an important role in bio-synthesis of the indole acetic and (IAA) and initiation of primordia for reproductive parts and a result of favourable effect of Zn on the metabolic reactions with the plants. The results are in close conformity with the findings of Chaudhary *et al.* (2014) and Singh and Pandey (2018).

Quality

The protein in barley grain increased from 10.9 to 12.1% with 8 kg Zn ha^{-1}. The corresponding range of protein content in barley straw was from 3.5 to 4.0 per cent (Table 2). This increase in protein content with Zn addition may be attributed to its involvement in N metabolism. Similar results were reported by Chaudhary *et al.* (2014) in wheat. There was a consistent and significant increase in protein yield of barley grain with increasing levels of Zn and maximum value (686 kg ha^{-1}) was recorded at 6 kg Zn ha^{-1}. This increase in protein yield due to Zn levels may be attributed to increased yield of grain and protein content in grain of the crop (Goswami and Pandey 2018).

Table 2: Effect of zinc levels on yield and quality of barley and zinc status in post harvest soil

Zn levels (kg ha^{-1})	Yield t ha^{-1})		Protein (%)		Protein yield (kg ha^{-1})	DTPA-Zn (mg kg^{-1})
	Grain	Straw	Grain	Straw		
0	5.53	8.64	10.9	3.4	602.7	0.50
2	5.68	9.10	11.0	3.5	624.8	0.57
4	5.85	9.71	11.5	3.7	672.7	0.62
6	5.72	9.41	12.0	4.0	686.0	0.69
8	5.60	8.91	12.1	4.0	674.6	0.74
CD(P=0.05)	0.13	0.25	0.21	0.09	19.8	0.05

Uptake of nutrients

A perusal of data (Table 3) showed that the application of zinc increased N and K uptake by barley grain and straw significantly over RDF alone except P uptake. The maximum uptake of N by grain (109.8 kg ha^{-1}) and straw (60.2 kg ha^{-1}) and K (28.6 and 182.5 Kg ha^{-1}, respectively) was recorded with 6 and 4 kg Zn ha^{-1}, respectively which was significantly higher than the recommended dose of N, P and K fertilizers. The minimum uptake of N (96.2 and 46.6 kg ha^{-1}) and K (23.5 and 159 kg ha^{-1}) by barley grain and straw was recorded in recommended dose of N, P and K fertilizers. The increase in uptake of N and K could be attributed to synergistic effect among N and Zn. Pandey and Kumar (2017) also reported similar results. Phosphorus uptake by barley crop was reduced with higher levels (6 and 8 kg Zn ha^{-1}) of zinc over N, P and K fertilizers alone. It might be due to antagonistic effect of P with Zn. The zinc was found to inhibit the translocation of P from roots to the tops. Similar results were reported by Kamini Kumar (2017). Application of zinc increased uptake of S by barley crop and maximum uptake of S by grain (12.2 kg ha^{-1}) and straw (13.5 kg ha^{-1}) was recorded with 4 kg Zn ha^{-1}. The uptake of Zn by the grain and straw ranged from 101.6 to 182.8 g ha^{-1} and 106.8 to 176.4 g ha^{-1} and maximum values of Zn uptake were recorded with 8 kg Zn ha^{-1}. The lowest values of S and Zn uptake by barley crop were recorded under recommended dose of N, P and K fertilizers. Poor availability of S and Zn in experimental soil with recommended dose of N, P and K fertilizers has resulted in lower S and Zn uptake by barley crop (Singh 2019).

Table 3: Effect of zinc levels on uptake of N, P, K and (kg ha^{-1}) and Zn (g ha^{-1}) by barley

Zinc (kg ha^{-1})	Nitrogen		Phosphorus		Potassium		Sulphur		Zinc	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
0	96.2	46.6	9.4	8.6	26.5	159.0	10.5	10.3	101.6	106.8
2	100.0	51.0	10.2	10.0	27.8	169.2	11.3	10.9	127.6	122.2
4	107.4	57.2	11.1	11.6	28.6	182.5	12.2	13.5	155.5	145.4
6	109.8	60.2	9.7	9.4	28.5	174.0	10.8	11.2	180.2	171.7
8	108.0	57.0	8.4	8.0	26.8	163.0	9.5	8.9	182.8	176.4
CD(P=0.05)	4.70	3.14	1.02	1.14	1.21	7.32	0.60	0.55	3.85	5.29

Available Zn

DTPA-extractable Zn in post harvest soil increased with increasing levels of Zn (Table 2). The Zn content in control plot decreased after taking the barley crop over initial value, indicating an exhaustion of Zn by the crop. DTPA-Zn remained much higher than the original value at higher levels of zinc, thus indicating that further crops could be taken without Zn application. Similar results were reported by Chaudhary *et al.* (2014).

It may be concluded from the present study that zinc deficiencies are widespread in alluvial soils of Agra District. A significant beneficial effect in barley grain and straw production can be achieved by the application of 4 kg Zn ha^{-1}. Application of 4 kg Zn ha^{-1} recorded sub-stantial increase in yield, quality and uptake of nutrients in barley crop.

REFERENCES

Chaudhary, S., Singh, H., Singh, S., and Singh, V. (2014) Zinc requirement of green gram (Vigna radiata)- wheat (Triticum aestivum) crop sequence in alluvial soil. *Indian Journal of Agronomy* **59** (1): 48-52.

Goswami, R.K. and Pandey, M. (2018) Effect of integrated use of nutrients and FYM on yield, quality and uptake of nutrients by barley (Hordeum vulgare).*Annals of Plant and Soil Research* **20**(4): 422-427.

Jackson, M.L. (1973) *Soil Chemical Analysis*.Prentice.Hall of India Private Limited, New Delhi.

Kamini Kumari (2017) Yield, quality and nutrient uptake of rabi fodder crops in response to zinc. *Annals of Plant and Soil Research* **19**(2): 219-222.

Lindsay, W.L. and Norvell, W.A. (1978) Development of DTPA soil test for zinc, iron, manganese and copper.*Soil Science Society of America Journal* **42**: 421-428.

Pandey, M. and Kumar, M. (2017) Effect of sulphur, manganese and zinc on yield, quality and uptake of nutrients by wheat (Triticum aestivum). *Annals of Plant and Soil Research* **19**(4): 403-407.

Panse, V.G. and Sukhatme, P.V. (1985) *Statistical Methods for Agricultural Workers*.Indian Council of Agricultural Research, New Delhi.

Rai, A.P. Mondal, A.K., Kumar, V., Samamta, A. Wali, P., Kumar, M. and Drivedi, M.C. (2018) Status of DTPA – extractable micronutrients in soils of Samba District of Jammu and Kashmir in relation to soil properties. *Annals of Plant and Soil Research* **20**(2) : 139-142.

Singh, R. (2017) status of available sulphur and micronutrients in soils of Allahabad, Uttar Pradesh.*Annals of Plant and Soil Research* **19**(2) : 237-239.

Singh, V. (2019) Effect of site specific nutrient management on yield and nutrient uptake in rice (*Oryza sativa*) wheat (*Triticum aestivum*) cropping system. *Annals of Plant and Soil Research* **27**(2): 135-140.

Singh, V. and Pandey, Mamta (2018) Direct effect of sulphur and Zinc on productivity, quality and nutrient uptake by pearl millet (Pennisetum glaucum) and their residual effect on succeeding wheat (Triticum aestivum) in pearl millet – wheat crop sequence. *Annals of Plant and Soil Research* **18**(3): 233-238.