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Yield, quality and nutrient uptake of rabi fodder crops in response to zinc

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ABSTRACT

A field experiment was conducted during winter (rabi) seasons of 2011-12 and 2012-13 to study the response of zinc fertilization on berseem (Trifolium alexandrinun L.) and iucerne (Medicago sativa) on alluvial soil at Pusa, Samastipur (Bihar). The treatments comprised five levels of zinc (0, 2, 4, 6 and 8 kg ha^{-1}) were evaluated in randomized block design with four replications. The results revealed that the application of zinc up to 4 kg ha^{-1} significantly increased the herbage yields and dry matter production of berseem and lucerne fodder crops. The magnitude of mean response to zinc application differed from crop to crop and was recorded as berseem (21.9%) and Lucerne (13.0%) over control. Successive zinc levels had a significant beneficial effect on its uptake by both the fodder crops upto 4 kg Zn ha^{-1}. A phenomenal increase in N, P, K and S uptake was recorded in these crops due to increasing levels of Zn up to 4 kg ha^{-1}. The maximum removal of N, P, K, S and Zn was recorded with Lucerne crop. The higher amounts of protein and protein yield were recorded in Lucerne followed by berseem. Zinc application significantly improved the content and yield of protein in these fodder crops over control and maximum values were recorded at 4 kg Zn ha^{-1}. The apparent recovery of zinc was influenced by Zn levels with maximum at 4 kg Zn ha^{-1} in both crops. Better zinc use efficiency in berseem (430 kg produce/Zn applied) and Lucerne (290 kg produce /Zn applied) was obtained with 4 and 2 kg Zn ha^{-1}, respectively. The zinc use efficiency decreased with its increasing levels and minimum use efficiency was recorded with 8 kg Zn ha^{-1} application.

Keywords: Apparent recovery, berseem, protein yield, lucerne, response, zinc.

INTRODUCTION

India, with 2.2% of the words geographical area, supports nearly 20% of the worlds livestock and 18% human population. Heavy livestock pressure on limited land resources in the country demands increased fodder production for healthy livestock. Therefore, there is a need to increase forage production by adopting improved package of practices of cultivation of forage crop. Berseem (*Trifolium alexandrinum* L) and Lucerne (*Medicago sativa*) are important forage crops and they occupy a sizeable area in Bihar. The high yield and forage quality potential, versatility in utilization, soil improvement and symbiotic N_2 fixation of these crops are among the most important factors in favour of their wider use in agricultural production. 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 synthesis. Zinc is belived 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. In recent years, an increased frequency of zinc deficiency has been observed in crops and Zn may become a factor limiting yield and quality of crops. Zinc deficiency is observed mainly due to high crop yield therefore higher rate of zinc removed by crops and lesser use of zinc containing fertilizers. The response of zinc differed widely among the fodder crops because of wide variations in sensitivity to zinc stress and soil types. The information regarding the differential behavior of these crops to zinc application under identical soil and weather conditions was considered to be of interest. It was felt imperative to find out the relative response of berseem and lucerne crops to zinc application for higher production and quality. However, the information pertaining to relative response of berseem and Lucerne crops to zinc application in light textured soil is limited. Therefore, the present study was planned to compare the response of berseem and Lucerne crops to zinc application in soil of Samastipur, Bihar.

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MATERIALS AND METHOD

The field experiment was conducted during winter season of 2011-12 and 2012-13 at Research farm, R.A.U. Pusa Samastipur (Bihar) The soil was sandy loam in texture having pH (8.6), EC (0.36 dS/m), organic carbon (6.2 g/kg), free C_aCO_3 available N (240 kg/ha), P (19.7 kg/ha) and DTPA – Zn (0.56 mg/kg). The treatments consisting 5 levels of Zn (0, 2, 4, 6 and 8 kg/ha) were tested in randomized block design with four replications. Two fodder crops namely berseem and Lucerne were sown on 25 October in both years. A basal dose of 20 kg N, 60 kg P_2O_5 and 40 kg K_2O ha^{-1} to berseem and Lucerne was applied through di-ammonium phosphate and muriate of potash, respectively. Full dose of phosphorus and potassium were applied at sowing. The crops were raised with recommended agronomic practices. The fodder crops were harvested after 60 days of sowing and green foliage yields were recorded. The fodder crops were cut in to small pieces, dried, ground and digested with di-acid mixture of HNO_3 and $HClO_4$ in 9 : 1 ratio. Phosphorus, K, S and Zn were determined by vanadomolybdophosphoric yellow colour method, flame photometer, turbidimetric method (Chesnin and Yien, 1951) and atomic absorption spectrophotometer, respectively. Nitrogen content was determined following micro Kjeldahl method (Jackson 1973). The protein content was computed from the nitrogen content multiplied by a factor 6.25. The uptake of nutrient was calculated by multiplying the concentration values with respective economic yield data. The following formulae were used to calculate zinc use efficiency and apparent Zn recovery:

Zinc use efficiency (kg produce/kg Zn applied) = Yield (F) – Yield (C)/Fertilizer Zn applied

Apparent Zn Recovery (%) = [Uptake of Zn in treated plot – Uptake of Zn in control plot/applied Zn dose] x 100,

Where, F and C are fertilizer treated and control plot, respectively.

Data obtained from consecutive two years were statistically analyzed as per procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Yield

The results on yield distinctly indicated that both the test crops responded markedly to zinc application. In general, each additional dose of zinc application up to 4 kg Zn/ha increased significantly the yields of both fodder crops. Thereafter, a decreasing trend was observed at higher levels (Table 1). The per cent increases in yields of berseem due to 4 kg Zn ha^{-1} over control were 21.9 and 13.0, respectively. This increase in yields with Zn levels seems to be associated with the increased Zn availability from applied zinc as the experimental soil was low in available Zn. The response to zinc may be attributed to improved nutritional management as a result of increased Zn supply which might have favourable influence on the growth and yield of fodder crops. The favourable influence of Zn application on the yields of fodder crops may be attributed to its role in various enzymic reactions, growth processes, hormone production and protein synthesis and also the translocationof photosynthates to reproductive parts thereby leading to higher yield of the crops. Sahay *et al.* (2009), Chaudhary *et al.* (2014), Singh *et al.* (2016) & Singh and Singh (2017) also reported significant response of fodder crops to zinc application. It was also apparent that fodder crops differed significantly between them in their magnitude of response to zinc application. The mean per cent yield response of berseem and Lucerne was 12.8 and 6.6 over control, respectively indicating higher response of Zn in berseem than lucerne. Singh *et al.* (2016) reported similar results in fodder crops to zinc application. Increasing levels of zinc significantly increased dry matter production in berseem from 1.26 to 1.53 tonnes ha^{-1} and Lucerne from 1.75 to 1.98 tonnes ha^{-1} with 4kg Zn ha^{-1}, respectively (Table 1). The average dry matter yields of fodder crops exhibited practically no difference at higher levels of Zn. Hence, 4 kg Zn ha^{-1} can be regarded as suitable dose for these two fodder crops. Increase in dry matter production due to zinc addition was largely a function of improved growth, translocation of more photosynthate towards sink and consequent accumulation of more dry matter in foliage of berseem and lucerne (Singh and Singh 2017). The lowest dry matter production in both crops was noted in control. Singh *et al.* (2017) & Joshi *et al.* (2007) also reported significant response of the fodder crops to zinc application.

Table 1: Effect of zinc fertilization on yield and quality of berseem and lucerne (mean of 2 years)

Zinc (kg/ha)	Berseem					Lucerne				
	Herbage yield (t ha^{-1})	% response	Dry matter yield (t ha^{-1})	Protein content (%)	Protein yield (kg ha^{-1})	Herbage yield (t ha^{-1})	% respo-nse	Dry matter yield (t ha^{-1})	Protein content (%)	Protein yield (kg ha^{-1})
0	7.83	-	1.26	13.75	173.2	8.67	-	1.75	18.5	323.7
2	8.37	6.9	1.35	14.12	190.3	9.25	6.7	1.88	19.3	362.8
4	9.55	21.9	1.55	14.68	227.9	9.80	13.0	1.98	19.4	384.0
6	9.17	17.1	1.48	15.06	223.0	9.05	4.4	1.84	19.6	368.8
8	8.25	5.3	1.35	15.37	207.1	7.86	2.2	1.80	19.7	354.3
SEm ±	0.44		0.05	0.12	4.04	0.15		0.06	0.14	3.8
CD (P=0.05)	0.95		0.12	0.28	9.69	0.49		0.15	0.31	12.6

Quality

Increasing levels of zinc significantly increased the protein content in fodder of berseem and Lucerne from 13.75 to 15.37 and 18.5 to 19.7%, respectively with 8 kg Zn/ha (Table 1). This may be attributed to significant role of zinc in protein synthesis and nitrogen metabolism in the plants (Singh *et al.* 2016). The relatively lower vaues of protein content were recorded in berseem as compared tolucerne. The increasing zinc levels upto 4 kg Zn ha^{-1} resulted in higher protein yield in both fodder crops over lower levels of zinc and control. Since, protein yield is mainly the function of dry matter yields and their respective protein content in the roots, protein yield increased with increase in zinc levels. The maximum value of protein yield was recorded in fodder of Lucerne (3.84 kg ha^{-1}) followed by berseem (227.9 kg ha^{-1}) at 4 kg Zn/ha. The increase in protein yield with zinc application has been also reported by Chaudhary *et al.* (2014). Lowest protein content and yield in both fodder crops were recorded in control.

Table 2: Uptake of N, P, K, S (kg ha^{-1}) and Zn (g ha^{-1}) in berseem and lucerne as influenced by zinc fertilization (mean of two years)

Zinc (kg/ha	Berseem					Lucerne				
	N	P	K	S	Zn	N	P	K	S	Zn
0	27.2	5.5	25.2	5.0	35.9	36.0	6.8	33.6	8.5	46.0
2	30.7	5.8	27.1	5.4	39.5	39.2	7.0	35.2	10.2	49.8
4	36.6	6.1	31.3	5.8	48.0	43.0	7.2	36.3	13.0	57.6
6	35.5	5.6	30.5	5.4	47.2	38.0	6.2	31.7	12.2	56.0
8	33.0	4.9	27.6	4.7	44.0	36.2	5.1	29.7	11.0	53.8
SEm ±	1.03	0.10	0.64	0.08	1.43	1.20	0.11	0.86	0.72	1.04
CD (P=0.05)	2.14	0.21	1.35	0.18	3.07	2.53	0.24	1.81	1.51	2.19

Uptake of nutrients

Nitrogen uptake by berseem and lucerne increased significantly with increasing levels of zinc and the highest N uptake was observed with 4 kg Zn ha^{-1} i.e. 36.6 and 43.0 kg ha^{-1} and the lowest in the control i.e. 27.2 and 36.0 kg ha^{-1} (Table 2). Thus, the beneficial effect of Zn on N uptake by these crops seems to be associated with promoted nitrogen availability with a concomitant increase in crop yields. The berseem crop accumulated relatively lower amount of P in its plants as compared tolucerne. The differences in P uptake by these crops may be attributed to their genetic makeup that controls the capability to utilize soil P. The significant increase in P uptake by these fodder crops was noticed with the application of Zn and maximum values were recorded at 4 kg Zn/ha. Thus, zinc application increased the efficiency of fodder crops to utilize the phosphorus (Joshi *et al.* 2007). The Lucerne crop utilized the higher amounts of K at all the levels of Zn as compared to berseemt. A progressive increase in Zn levels up to 4 kg ha^{-1} gradually increased K uptake by these fodder crops. Higher uptake of K might be due to higher yield and K content in these fodder crops (Singh *et al.*2016). It was observed that berseem removed lower amounts of zinc thanlucerne. Application of 4 kg Zn ha^{-1} increased S uptake in berseem and Lucerne from 5.0 to 5.8 and 8.5 to 130.0 kg ha^{-1}, respectively. Since, the uptake of nutrient is a function of dry matter and nutrient content, the

increased dry matter yields of fodder crops with higher Zn content resulted in greater uptake of this element (Chaudhary *et al.* 2014). The relatively higher amounts of zinc were utilized by lucernt than that of berseem. The zinc uptake increased from 35.9 to 48.0 and 46.0 to 57.6 g ha^{-1} with 4 kg Zn ha^{-1}. Thereafter, zinc uptake decreased higher levels of Zn. (Verma *et al.* 2005).

Table 3: Effect of zinc levels on economics and efficiency indices in carrot and radish (mean of two years)

Zinc (kg ha^{-1})	Berseem		Lucerne	
	Apparent Zn recovery (%)	Zn UE (kg produce/kg Zn supplied)	Apparent Zn recovery (%)	Zn UE (kg produce/kg Zn supplied)
0	-	-	-	-
2	1.8	270.0	1.9	290.0
4	3.0	430.0	2.9	282.5
6	1.9	233.0	1.7	63.3
8	1.0	52.5	0.9	23.5

Efficiency indices

The maximum values of apparent recovery of zinc by berseem and lucerne were 3.0 and 2.9%, respectively at 4 kg Zn/ha (Table 3). The minimum values of apparent recovery of zinc in both the crops were noted at 8 kg Zn ha^{-1} level. The yield improvement over unit quantity of Zn addition was calculated as Zn use efficiency. Critical examination of the data (Table 3) showed that the different levels of Zn tried had influenced the Zn use efficiency. Zinc use efficiency (kg produce increase/kg zinc) increased with an increase in the rates of zinc up to the level of 4 kg Zn ha^{-1} in both the fodder crops. Better zinc use efficiency was obtained with 4 kg Zn ha^{-1} and recorded 430 kg in berseem fodder and 290 kg produce in lucerne per kg zinc applied. The Zn SUE in these fodder crops decreased at 8 kg Zn ha^{-1}. This may be due to the fact that input-output relationship follows the law of diminishing return as far as the relationship between zinc and yield is concerned. Similar findings have been reported by Chaudhary *et al.* (2014).

Based on two years of field study, it may be concluded that application of 4 kg Zn ha^{-1} to berseem and lucern is sufficient dose for increased productivity and quality of produce under zinc deficient soils. Berseem crop is more responsive to zinc application as compared to lucern. Berseem was also found to have superior utilization of zinc in terms of Zn SUE and apparent Zn recovery compared with lucerne. This indicated the differential behavior of these crops with respect to their zinc requirement.

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