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Influence of Zinc Fortification on Yields and Quality of Fodder Maize

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Abstract: An experiment was conducted to study the effect of fortification of fodder maize var. African Tall with micronutrient zinc through $ZnSO_4$ fertilizer application. The study involved fortification at different doses through soil application and foliar sprays at different stages of crop. Green fodder yields were highest at 50 kg $ZnSO_4$ $ha^{-1.}$ Zinc content increased with increasing crop growth from knee high (18.9 mg kg^{-1}) to fodder harvest (37.9 mg kg^{-1}) with highest concentration at soil application of 50 $ZnSO_4$ ha^{-1}. Zinc fortification of 23% was observed when 50 kg of $ZnSO_4$ was added through soil application while soil application of 25 kg $ZnSO_4$ ha^{-1} along with two foliar sprays at knee high and tasseling showed on par yields. Foliar sprays complemented soil application but foliar application alone excluding soil application failed to show impact on yields. No significant effect of zinc was observed on quality parameters *viz.*, crude protein, acid detergent fiber or neutral detergent fiber. The crude protein content though did not vary significantly, highest was observed when 50 kg $ZnSO_4$ was applied as soil application. Zinc application significantly influenced Neutral detergent fiber at fodder harvest, on the contrary, acid detergent fiber was not effected at any stage of crop.

Key words: *Fodder maize, zinc fortification, green fodder yields, crude protein, neutral detergent fiber, acid detergent fiber*

Introduction

Zinc is very important micronutrient for human health. Zinc regulates metabolism and influence multifaceted development of body. It also influences human immune system as evident by its deficiency which marks susceptibility to various pathogenic infections and diseases. International Zinc Nutrition Consultative Group (IZiNCG 2004) of WHO indicated that zinc deficiency in children <5 years age increased the risk of diarrhea disease, pneumonia as well as malaria and supplements with zinc would hasten recovery (WHO 2014). Wessells and Brown (2012) indicated that more than 25% population in South Asian countries including India would be an elevated public health concern due to deficiency of zinc. Micronutrient deficiencies of Zn and Fe are more prevalent in countries like India, Pakistan, China, Iran and Turkey. Zinc ranks 5th among the most important factors that affect life in developing countries (Cakmak 2008). The present adversaries of zinc

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deficiencies are result of consumption of nutritionally deficient food like milk and cereal which form vital food component in developing countries. Singh and Behara (2011) analysed three lakh soil samples of India and reported that nearly 49 per cent soils found to be deficit in zinc. Besides, several nutritional surveys conducted for forage quality evaluation by IGFRI, Jhansi clearly indicated deficiency of Ca, P, Cu and Zn in lactating cows due to the feed and forage being served to the animals. The symptoms of deficiency in animals include loss of appetite, reduced growth and reproduction, and impaired health of bone and skin tissues. Forages do not provide all the minerals that are required for growth and development of animals (Vargas and McDowell 1997). Flaring up the situation, use of high analysis fertilizers, limited recycling of plant residues and gap between removal and supplementation of secondary and micro-nutrients have resulted in wide spread Zn deficiency. Fodders do not get sufficient quantities of nutrients like Cu, Zn, Se and Ca from soils, despite the fact that soils are well provided with these nutrients (Marijanusic *et al.* 2017). Grazing animals invariably exhibit Zn deficiency when soils and forages contain limited concentrations of Zn (Hill and Shannon 2019). This deficiency scenario needs to be alleviated with additional zinc to the plant either directly or through soil.

In combating the situation, two options are available to improve the zinc concentration in body tissue, *viz.,* food fortification and pharmaceutical supplementation; while the later comes with a higher cost compared to the former. Biofortification is largely in vogue in present day scenario with studies concentrated on genetic fortification as well as agronomic fortification of cereals and other food grains. The present investigation was emphasized on biofortification of zinc in fodder maize one of the most important for the crops grown throughout the country. It is a popular fodder crop that has vast preference from dairying community owing to its photo insensitive nature, animal preference, adaptability, and forage quality. Besides, being supplied at a subsidized rate by the Department of Animal Husbandry of the State, it is most preferred and widely grown fodder amongst dairying community.

Materials and Methods

A field experiment was conducted on the farm of All India coordinated research project on Forage Crops and Utilization at Rajendranagar, Hyderabad. The geographical details were 17°32' N latitude and 78°39' E longitude, at an altitude of 578 m above mean sea level during first year of experimentation and at 17°32' N latitude and 78°39' E longitude, at an altitude of 573 m above mean sea level during second year of study. Fodder maize was raised during *rabi* season for two consecutive years. The soil of the experimental site was well drained and moderately deep sandy loam in texture with pH of 7.8 and the electrical conductivity 0.38 to 0.56 dS m^{-1}. The soil was low in organic carbon and available nitrogen but high in phosphorus and potassium status with mean of values ranging between 152 and 168 kg of N ha^{-1}, 33 and 36 kg of P ha^{-1}, 344 and 448 kg of K ha^{-1}, respectively. The initial status of soil zinc was 0.45 mg kg^{-1} in both the fields. A total of 13 treatments, in a simple randomized block design were imposed in 3 replications in the field experiments. The treatments included different doses of zinc sulfate, different methods of application at different stages of crop growth. Zinc was applied in the form of zinc sulfate ($ZnSO_4.7H_2O$) @ 12.5, 25 and 50 kg ha^{-1} during the last ploughing as basal application. Treatments included application of zinc sulphate as foliar spray @ 0.2 per cent concentration at knee high stage, tasseling stage or both. Water spray was done to other treatments which did not receive foliar zinc. The detail of treatments is given in table 1.

The state recommended fertilizer dose of N, P, K for fodder maize *i.e.,* 120 : 60 : 40 kg ha^{-1} was adopted. Nitrogen was applied in 2 equal splits, the first split including 50% of N was applied at last ploughing and second half at knee high stage of the crop. The entire dose of phosphorus and potash were applied during the last ploughing. Urea, single superphosphate and muriate of potash were used as sources of N, P & K, respectively. Zinc sulphate (21% zinc) was used as source of zinc. Care is taken that zinc was not applied with phosphorus fertilizer. The spacing adopted was 30 cm between rows and 10 cm between the plants in a row. All the package of practices that recommended for fodder maize was

Table 1. Details of treatments

Sr. No	Treatments
1	T_1- Control
2	T_2- 25 kg $ZnSO_4$ soil
3	T_3-T_2+$ZnSO_4$ spray at knee high
4	T_4-T_2+$ZnSO_4$ at tasselling
5	T_5-T_2+Two sprays at knee high and tasselling
6	T_6- 12.5 kg $ZnSO_4$ soil
7	T_7-T_6+ spray at knee high
8	T_8- T_6+ one spray at tasselling
9	T_9- T_6+ two sprays at knee high and tasselling
10	T_{10}- Spray at knee high
11	T_{11}- Spray at tasselling
12	T_{12}- Two sprays at knee high and tasselling
13	T_{13}- 50 kg soil application of $ZnSO_4$

implemented. The crop was harvested at early dough stage as recommended for fodder maize.

Representative samples of crop were drawn at knee high, tasseling and at harvest stages. Green fodder yields were taken at early dough stage of crop as recommended for forage maize. Plant samples were shade dried before shifting then to ovens at 65^{0}C for further drying to constant weight which took nearly 2-3 days. The samples were pounded in a wiley mill and processed for analysis of zinc and other quality parameters following standard procedures. Zinc in initial soil was estimated by procedure described by Lindsay and Norwell (1978). In plants it was estimated in diacid mixture by instrument atomic absorption spectrophotometer (model Hitachi 170-30). Crude protein was estimated by estimating nitrogen content in sample (Piper 1966) and multiplying with 6.25. Other quality parameters *viz*., neutral detergent fiber and acid detergent fiber were analyzed as per procedure described by Van Soest (1963).

The concentration of zinc was studied at knee high, tasseling and at harvest stages and the percent zinc fortification and sustainability indices were calculated as below.

$$\text{Per cent fortification} = \frac{\text{Content of nutrient in treated plot} - \text{Content of nutrient in control plot}}{\text{Content of nutrient in control plot}} \times 100$$

$$\text{Sustainability index} = \frac{\text{Mean Yield} - \text{Standard Deviation}}{\text{Maximum Yield}}$$

Statistical analysis of the data was done by applying the technique of analysis of variance for simple RBD (Panse and Sukhatme 1989). Critical difference for examining treatment means and their significance was calculated at five per cent level of significance.

Results and Discussion

Yields

The two year data showed a significant response of zinc application on green fodder yields (GFY) of fodder maize (Table 2). There were significant differences in GFY between treatments with highest yields in treatment receiving 50 kg $ZnSO_4$ ha^{-1}. The treatments receiving 25 kg $ZnSO_4$ (with or without foliar sprays), 12.5 kg $ZnSO_4$ and exclusive foliar treatments recorded mean green fodder yields of 45.3, 42.1 and 38.9 t ha^{-1} while highest yields of 53.1 t ha^{-1} were recorded when 50 kg $ZnSO_4$ ha^{-1} was applied. This indicates that soil application performed better than foliar sprays and better performance was evident with increasing application of zinc to soil up to 50 kg ha^{-1}. Though foliar sprays complemented soil application but exclusive foliar application failed to show impact on yields. The best treatment showed an increment of 346 kg of fodder yield for every kilogram of $ZnSO_4$ applied. A sustainability index of 0.70 was obtained which is derived from mean and maximum yields and standard deviation. These results are in conformity to those reported by Muzaffar *et al.* (2014). Mahdi *et al.* (2011); Sheraz *et al.* (2012); Jamil *et al.* (2015) also reported increased GFY with increasing Zn application. Increase in green fodder yields with application of 10 and 20 kg application of $ZnSO_4$ ha^{-1} to soil was also reported by Kumar *et al.* (2015 and 2017), respectively. Maximum accumulation of 13 kg ha^{-1} of zinc was reported by Wenger *et al.* (2002) in maize when grown on artificially zinc enriched soil. Highest green fodder yields at 50 kg $ZnSO_4$ ha^{-1} along with foliar application at 30 and 45 DAS was observed in African Tall (Sulthana 2015), while Kumar *et al.* (2014) reported yield improvement at 10 kg Zn ha^{-1}. Increased zinc content in maize seed was reported by Pongde and Ghodpade (2014); Olusegun and Meki (2014) (in pot studies); Patil *et al*. (2016), Singh *et al.* (2017), Gajbhiye *et al*. (2018) and Khalid *et al*. (2019) (upto 15 kg $ZnSO_4$ ha^{-1}).

Dry fodder yields were also influenced with the zinc application. The treatment that received 50 kg $ZnSO_4$ ha^{-1} as soil application recorded the highest DFY (8.86 tons per hectare) while rest of the treatments were on par with each other. (Table 2).

The treatments receiving 25 kg of $ZnSO_4$ ha^{-1} was on par with the best treatment indicating that performance with respect to DFY at 25 kg $ZnSO_4$ is commendable. The crude protein yield in treatment receiving 50 kg $ZnSO_4$ ha^{-1} was found to be significantly

Table 2. Effect of different levels of Zn and its mode of application on GFY, DFY, CPY and B:C ratio (pooled over two years)

Sr. No.	Treatments	GFY	DFY	CPY
		(t ha^{-1})		
1	T_1- Control	35.8	5.15	0.40
2	T_2- 25 kg $ZnSO_4$ soil	45.4	6.68	0.56
3	T_3-T_2+Zn SO_4 spray at knee high	43.7	6.18	0.53
4	T_4-T_2+$ZnSO_4$ at tasselling	43.0	6.66	0.59
5	T_5-T_2+Two sprays at knee high and tasselling	49.0	7.12	0.61
6	T_6- 12.5 kg $ZnSO_4$ soil	40.5	6.22	0.52
7	T_7-T_6+ spray at knee high	39.1	5.78	0.45
8	T_8- T_6+ one spray at tasselling	43.9	6.85	0.58
9	T_9- T_6+ two sprays at knee high and tasselling	38.7	5.76	0.46
10	T_{10}- Spray at knee high	37.3	5.52	0.49
11	T_{11}- Spray at tasselling	41.0	5.90	0.50
12	T_{12}- Two sprays at knee high and tasselling	38.5	5.88	0.52
13	T_{13}- 50 kg soil application of $ZnSO_4$	53.1	8.86	0.83
	Mean	42.2	6.35	0.54
	s. d	4.88	0.94	0.11
	S. Em (±)	1.56	0.90	0.07
	CD (P 0.05)	5.1	2.66	0.22

superior over all other treatments. The treatment T_2 (25 kg $ZnSO_4$ ha^{-1} along with two foliar sprays) was found to be on par with all other treatments except T_{13}.

The nutrient use efficiency was, 13.1, 26.8 and 48.3 % when $ZnSO_4$ was applied to soil @ 12.5, 25.0 and 50.0 kg ha^{-1}, respectively, on the contrary the NUE of exclusive foliar treatments varied between 4.2 and 7.5%.

Zinc content

Zinc content of fodder maize varied at different stages of crops growth. At knee-high stage (Table 3), zinc content varied from 17.5 mg kg^{-1} to 20 mg kg^{-1}. The results were non-significant at knee high and tasseling stages.

At harvest (*i.e.,* at early dough stage of fodder maize), these differences were significant, with highest concentration of zinc in T_{13} *i.e.,* the treatment which

Table 3. Effect of zinc application on zinc content and fortification at different stages of fodder maize (pooled over two years)

Sr. No	Treatments	Zn content (mg kg^{-1})			Zn fortification (%)		
		KH	Tass	Har.	KH	Tass.	Har.
1	T_1- Control	17.5	24.2	34.1	0	0	0
2	T_2- 25 kg $ZnSO_4$ soil	19.4	27.0	38.5	10.9	11.6	12.9
3	T_3-T_2+Zn SO_4 spray at knee high	19.4	27.2	39.1	10.9	12.4	14.7
4	T_4-T_2+$ZnSO_4$ at tasselling	19.7	27.7	40.3	12.6	14.5	18.2
5	T_5-T_2+Two sprays at knee high and tasselling	20.0	27.9	41.1	14.3	15.3	20.5
6	T_6- 12.5 kg $ZnSO_4$ soil	18.6	25.5	35.8	6.3	5.4	5.0
7	T_7-T_6+ spray at knee high	18.6	25.7	36.3	6.3	6.2	6.5
8	T_8- T_6+ one spray at tasselling	18.6	26.0	36.7	6.3	7.4	7.6
9	T_9- T_6+ two sprays at knee high and tasselling	18.7	26.2	37.7	6.9	8.3	10.6
10	T_{10}- Spray at knee high	18.3	25.5	36.1	4.6	5.4	5.9
11	T_{11}- Spray at tasselling	18.3	25.6	36.4	4.6	5.8	6.7
12	T_{12}- Two sprays at knee high and tasselling	18.4	27.1	38.8	5.1	12.0	13.8
13	T_{13}- 50 kg soil application of $ZnSO_4$	19.7	28.6	41.7	12.6	18.2	22.3
	Mean	18.9	26.5	37.9	7.8	9.4	11.3
	S.Em(±)	0.68	0.56	0.90	1.68	2.08	2.24
	C.D (0.05)	NS	NS	2.62	3.42	5.76	6.24

KH- knee high stage, Tass.: tasseling stage, Har: harvest of fodder, early dough stage received 50 kg $ZnSO_4$ as basal. The treatments receiving 25 kg of $ZnSO_4$ ha^{-1} were on par with treatments T_3 (25 kg $ZnSO_4$ soil+ Zn SO_4 spray at knee high), T_4 (25 kg $ZnSO_4$ soil + Zn SO_4 spray at tasseling) and T_5 (25 kg $ZnSO_4$ soil+ Zn SO_4 spray at knee high and tasseling), respectively. Those treatments which received 12.5 kg $ZnSO_4$ ha^{-1} as basal recorded on par values with single foliar spray at knee high or at tasseling stage of crop (Table 3). This highlights that the foliar sprays are indeed instrumental in increasing the zinc concentration of tissues. Jahiruddin *et al*. (2001) reported that though no changes were observed in yield parameters, but concentration of zinc increased in plant tissues when corn was raised in zinc fertilized soil. Kumar *et al*. (2017) reported 50.9% higher zinc content when 20 kg of $ZnSO_4$ ha^{-1} was applied over control. Sulthana (2015) reported that the highest content of zinc in tissues at fodder harvest was recorded in all treatments receiving 50 kg $ZnSO_4$ ha^{-1}. The increase in zinc content up to 48 mg kg^{-1} was observed by Salakinkop *et al*. (2019).

Zinc fortification

With respect to the application of zinc, it was observed that zinc fortification at knee high stage ranged between 4.6 to 14.3% and the treatments receiving 25 kg $ZnSO_4$ ha^{-1} through soil and foliar spray (T_2 - 25 kg $ZnSO_4$ to soil, T_3 - 25 kg $ZnSO_4$ ha^{-1} through soil + $ZnSO_4$ spray at knee high, T_4 – 25 kg $ZnSO_4$ ha^{-1} through soil + spray at tasseling and T_5 – 25 kg $ZnSO_4$ ha^{-1} through soil + spray at knee high and tasseling) were at par with each other and also with T_{13}- (50 kg $ZnSO_4$ to soil) with values significantly higher than the rest of the treatments.

Similar trends were observed at tasseling stage of crop where the fortification ranged between 5.4 (single foliar spray at knee high stage) to 18.2% (only soil application @ 50 kg $ZnSO_4$ ha^{-1}). Per cent fortification (means), however, steadily increased from knee high (7.8%) to fodder harvest stage and (11.3%) through tasseling (9.4%). The highest zinc fortification (22.3%) was recorded when zinc was applied through soil @ 50 kg $ZnSO_4$ ha^{-1} which was on par with treatments receiving 25 kg $ZnSO_4$ as basal along with one or two sprays at knee high or tasseling stage. There was a 158% increase in zinc fortification with increase in soil application of $ZnSO_4$ from 12.5 to 25.0 kg ha^{-1} and 72% increase by increasing zinc application from 25 kg ha^{-1} to 50 kg ha^{-1}, respectively.

Fodder quality

Data in respect of quality parameters *viz.*, crude protein content, neutral detergent fiber and acid detergent fiber were analysed at the three stages of crop growth *viz.*, knee high, tasseling and harvest (Table 4).

From the data, it was observed that application of zinc showed non-significant results with respect to crude protein percent at knee high as well as at tasseling stages of crop. However, at harvest stage of crop, application of $ZnSO_4$ recorded highest crude protein content (9.4%) with soil application of 50 kg $ZnSO_4$ which was at par with treatments T_{12}, T_{10}, T_4,T_3,T_5,T_8,T_2 and T_6. Jamil *et al*. (2015) reported that application of Zn @10 kg ha^{-1} increased crude protein content of baby corn fodder. Kumar *et al*. (2017) also reported increased crude protein content up to 20 kg of $ZnSO_4$ ha^{-1}. However contradictory results were reported by Sheraz *et al.* (2012) who indicated that crude protein content was unaffected by Zn application in maize.

Application of zinc did not significantly influence ADF at any stage of crop growth (Fig 2). However, the neutral detergent fiber component was significantly influenced by the zinc application at fodder harvest though no logical trends were observed with regard to treatmental variations (Fig.3). Kumar *et al*. (2015) found that crude fiber was negatively influenced by Zn application, on the contrary, Dadhich and Gupta (2005) found that crude protein and crude fibre of fodder pearl millet increased with increase in zinc application up to 10 kg ha^{-1}.

Economics

Investment on zinc (10 kilograms of $ZnSO_4.7H_2O$, costing Rs.700.00) reaped commendable returns in terms of green fodder yield besides quality of fodder (Table 5). The B:C ratio varied between 2.55 to

Table 4. Effect of different levels and mode of zinc application on quality at harvest of fodder (pooled over two years)

Sr.No.	Treatments	CP%			NDF%			ADF%		
		KH	**Tass.**	**Har.**	**KH**	**Tass.**	**Har.**	**KH**	**Tass.**	**Har.**
1	T_1- Control	15.0	9.8	7.8	35.6	41.5	43.6	26.5	35.9	38.2
2	T_2- 25 kg $ZnSO_4$ soil	15.1	10.2	8.4	35.4	40.4	41.8	25.5	35.5	38.6
3	T_3-T_2+Zn SO_4 spray at knee high	16.2	10.8	8.5	36.3	38.2	40.4	25.6	35.0	38.1
4	T_4-T_2+$ZnSO_4$ at tasselling	15.2	10.9	8.9	34.9	39.7	41.2	24.1	35.0	38.2
5	T_5-T_2+Two sprays at knee high and tasselling	17.5	9.6	8.5	35.8	39.5	44.8	25.2	35.9	39.5
6	T_6- 12.5 kg $ZnSO_4$ soil	15.7	11.2	8.4	34.9	39.7	41.8	27.1	35.7	37.8
7	T_7-T_6+ spray at knee high	18.1	10.3	7.8	36.2	38.7	39.6	27.1	34.6	35.9
8	T_8- T_6+ one spray at tasselling	16.2	11.3	8.5	36.0	40.0	43.3	26.8	36.5	38.8
9	T_9- T_6+ two sprays at knee high and tasselling	15.7	10.9	7.9	37.1	40.9	44.6	28.1	36.0	38.4
10	T_{10}- Spray at knee high	16.7	9.9	8.9	37.8	41.7	45.1	27.3	35.0	38.2
11	T_{11}- Spray at tasselling	17.1	11.1	8.5	36.5	40.7	42.1	27.8	35.1	36.6
12	T_{12}- Two sprays at knee high and tasselling	17.1	9.3	8.9	36.0	41.4	41.0	26.5	36.0	36.1
13	T_{13}- 50 kg soil application of $ZnSO_4$	16.1	10.6	9.4	35.5	40.2	41.2	27.1	35.2	37.0
	Mean	16.3	10.2	8.4	36.0	40.2	42.3	26.5	35.5	37.8
	S.Em (±)	0.64	0.81	0.36	0.38	0.94	0.81	1.10	0.98	1.02
	C.D	NS	NS	1.08	NS	NS	2.24	NS	NS	NS

Table 5. Economics of zinc fortification in fodder maize

Treatments	COC fodder maize ha^{-1}	Expenditure on ZnSO4 ha^{-1}	Cost incurred on labour for foliar sprays	Total expenditure	GFY (t/ha^{-1})	Income from GFY (Rs.)	B:C ratio
T1- Control	35,000.00	0.00	0.00	35,000.00	35.8	89500	2.56
T2- 25 kg $ZnSO_4$ soil	35,000.00	1750	515	37,265.00	45.4	113500	3.05
T3-T2+ $ZnSO_4$ Spray at KH	35,000.00	1750	1030	37,780.00	43.7	109250	2.89
T4-T2+ $ZnSO_4$ at tasseling	35,000.00	1750	1030	37,780.00	43	107500	2.85
T5-T2+Two sprays at KH and tasseling	35,000.00	1750	2060	38,810.00	49	122500	3.16
T6- 12.5 kg $ZnSO_4$ soil	35,000.00	875	515	36,390.00	40.5	101250	2.78
T7-T6+ spray at KH	35,000.00	875	1030	36,905.00	39.1	97750	2.65
T8- T6+ one spray at tasseling	35,000.00	875	1030	36,905.00	43.9	109750	2.97
T9- T6+ two sprays at KH and tasseling	35,000.00	875	2060	37,935.00	38.7	96750	2.55
T10- spray at KH	35,000.00	70	1030	36,100.00	37.3	93250	2.58
T11- spray at tasseling	35,000.00	70	1030	36,100.00	41	102500	2.84
T12- two sprays at KH and tasseling	35,000.00	70	2060	37,130.00	38.5	96250	2.59
T13- 50 kg soil application of $ZnSO_4$	35,000.00	3500	515	39,015.00	53.1	132750	3.40

Note: COC- cost of cultivation as per COC scheme, PJTSAU, fodder sale value is Rs.2.50 per kg of green fodder, labour wages are local rates *i.e.,* Rs.515.00 per day

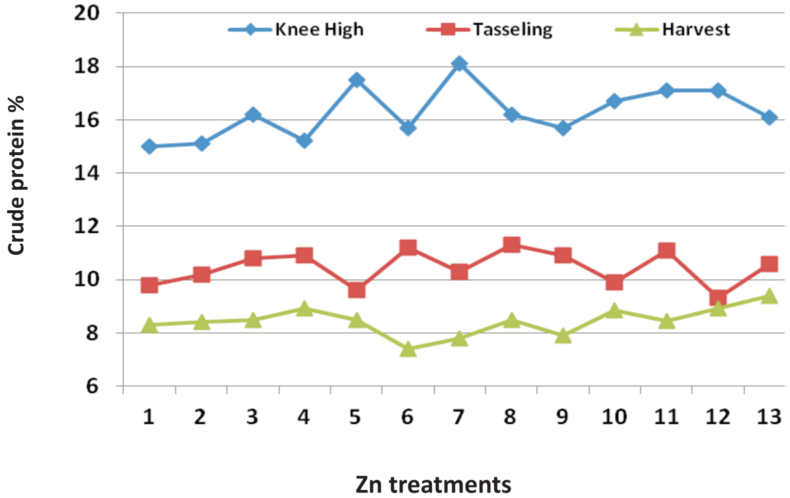

Fig.1. Crude protein % of fodder maize at different stages of crop as influenced by zinc application

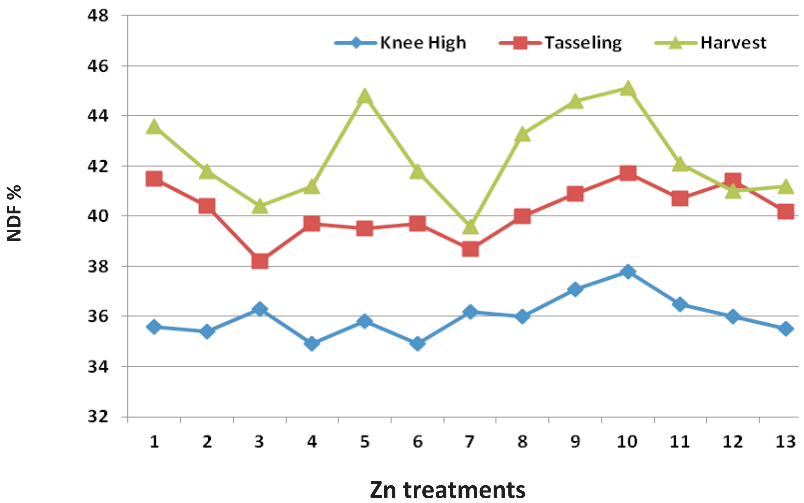

Fig. 2. Neutral detergent fiber % of fodder maize at different stages of crop as influenced by zinc application

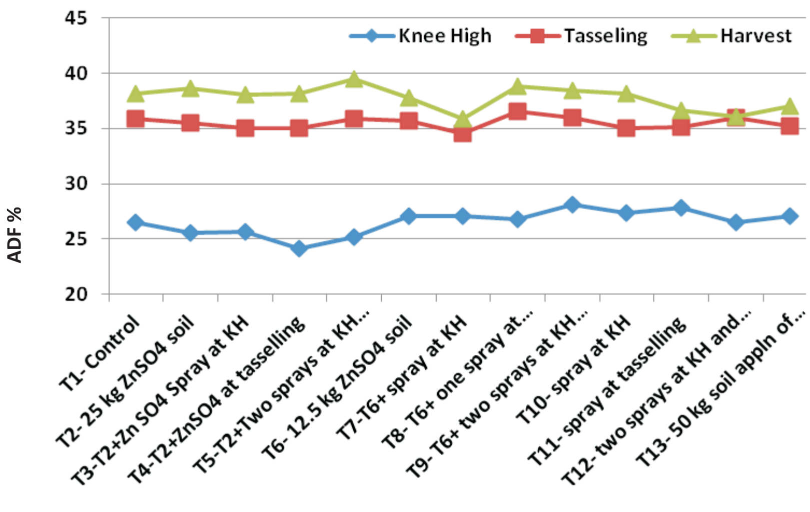

Fig. 3. Acid detergent fiber % of fodder maize at different stages of crops as influenced by zinc application

3.4 with highest values when 50 kg of $ZnSO_4$ was applied as basal, though 25 kg $ZnSO_4$ ha^{-1} to soil along with two foliar sprays also proved on par.

Conclusion

On the basis of forgoing results, it is concluded that application of 50 kg $ZnSO_4$ ha^{-1} as basal or application of 25 kg $ZnSO_4$ ha^{-1} to soil along with two foliar sprays at knee high and tasseling stages in zinc deficient soils increases green fodder yield, quality parameters *viz.*, crude protein and neutral detergent fiber. Thus, fortification of fodder maize would improve milk quality and help in overcoming zinc deficiency especially in children, adolescent girls and lactating mothers for a better country.

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