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Influence of stage of harvesting and zinc application on yield and zinc uptake in cluster bean [*Cyamopsis tetragonoloba* (L.) TAUB]

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ABSTRACT

The field experiment entitled, "Influence of stage of harvesting and zinc application on yield and zinc uptake in cluster bean (*Cyamopsis tetragonoloba* L.)" was conducted during *Kharif* 2016 at Forage Research Farm, Agronomy Section, ICAR-National Dairy Research Institute, Karnal, Haryana. The experiment was laid out in split plot design with three replications. The main plot treatments comprised of four stages of harvesting [50, 60, 70 and 80 DAS] and under sub plot treatments four levels of Zinc application (Control, 10 kg $ZnSO_4$, 20 kg $ZnSO_4$ and 0.5 % Zinc spray at 30 DAS) were taken. The soil of the experimental field was sandy clay loam in texture with neutral pH, low in available nitrogen and zinc, medium in available phosphorus and higher in available potassium. The growth parameters *viz.* plant height, leaf length, number of leaves, stem girth and leaf: stem ratio were significantly higher at 80 DAS over other harvesting stages. In sub plot treatments application of zinc through zinc sulphate @ 20 $kgha^{-1}$ significantly improved all growth parameters except stem girth over other treatments. Positive interaction effect was recorded between Stage of harvesting and zinc application for stem girth and plant height. Highest plant height was recorded under treatment combination of 80 DAS and zinc application @ 20 kg ha^{-1}over other harvesting date and zinc level combinations. A significant increase in green fodder yield (GFY) and dry matter yield (DMY) was obtainedup to harvest at 80 DAS and zinc application @ 20 kg ha^{-1}whereas significantly highest OM content was recorded at 50 DAS (Day after sowing). Maximum zinc uptake was noticed at 80 DAS stage and application rate of 20 kg $ZnSO_4ha^{-1}$ among other treatments.

Key words: Guar fodder, Stage of harvesting, Zinc application, Zinc content, Uptake.

INTRODUCTION

Cluster bean is a robust annual herb having long tap root and well developed laterals. Guar is mainly grown in the semi-arid areas of North and North-West part of India (mainly in Rajasthan) and South-East Pakistan (Whistler and Hymowitz, 1979). It is an erect and bushy herbaceous legume having trifoliate leaves up to 10 cm long and grows up to 3 m height. Rajasthan having the largest cultivatedarea under this crop (82.1%) followed by Haryana Gujarat and Punjab. This plant is also used as a cover crop, green manure and green fodder yield up to 450 q/ha, 60-90 q/ha of green pods. (Ecoport, 2010). It plays important role in recycling of nutrients from deeper soil layers, enhancing soil organic matter, reducing soil compaction, harmful allelopathic effects and breaking weed and pest cycles (Yadav *et al.*, 2003). The productivity is far away from its potential yield in many of the states due to unbalance nutrient management under limited moisture (Shubhra *et al.*, 2004).

Stage of harvesting is one of the important factors which determine the higher fodder production level with higher quality. Nutritive value of green fodder is recorded highest at 50% flowering stage and further decreased after flowering stage in most of the other fodder crops. Stage of harvesting in guar also determines the potential of the crop in term of yield and quality which may be adversely affected by later stage of harvesting for green fodder.

Crop yield and quality are often limited by lower level of mineral micronutrients such as zinc (Zn). Zinc is one of the most important factors for the low productivity of cluster bean in western part of India. Zinc deficiency is widely spread in India in different type of soils. The deficiency of Zn in soil may lead to poor yield and quality along with Zn uptake by this fodder crops. Zinc acts as channel of photosynthesis during the reproductive stage of plant because it is involved in electron transfer (Baker *et al.*, 1982). Zinc have play important role for carbohydrate andprotein metabolism, maintenance of biological membrane, pollen formation andprovide resistanceto infection by certain pathogens (Alloway, 2008). It also has co-factor of over 300 enzymes and proteins involved in cell division, nucleic acid metabolism (Marschner 1986).Response of zinc has been significantly reported in different pulses *e.g.* Lentil shows significant response when zinc applied in soil as well as foliar application (Sakal *et al.*, 1998). Based on over fifteen thousand on station field trial all over India, the overall crop response to zinc for fodder and pulses are 90-4620 kg/ha

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(5-34%) and 170-460 kg/ha (7.3-28.2%) respectively (Singh, 2008). In dry areas, the availability and uptake of zinc is affected with crop growth environment. Farmers are not much aware about proper stage of harvesting and Zn application in Guar fodder crop. A little information is available with the application of Zn and its effect on fodder quality. Hence, it was undertaken to study the performance of Guar with application of Zn under different harvesting stages on yield and quality of guar fodder.

MATERIALS AND METHODS

The Field experiment was conducted at Agronomy Section, ICAR-National Dairy Research Institute, Karnal during *Kharif* 2016. Karnal situated at an elevation of 245 meters above mean sea level with a latitude of 29°43' North and longitude of 76°58' East in the sub-tropical zone. The average maximum temperature recorded 45°C during summer and minimum temperature reaches near freezing point in peak winter months of December and January. Based on an average meteorological data 2016 (July to September), the highest rainfall of 14.5 mm was recorded in 35th (26 August -02 September, 2016) standard week, and there was no rainfall in 38th and 39th standard week of the crop period. The highest relative humidity of 92.7% was recorded in 33th standard week (12-18 August, 2016) and lowest relative humidity of 58% in 39th standard week (24-30 September, 2016). The lowest temperature (23.1°C) during crop growth period occurred on 39th week (24-30 September 2016) and highest temperature (34.5°C) was recorded in 38th week (17-23 September, 2016). The soil of the experimental field was sandy clay loam in texture with low in available nitrogen and zinc, medium in available phosphorus and potassium with neutral pH. The experiment was laid out in the split plot design with three replications. The main plots contains four different stage of harvesting (at 50, 60, 70 and 80 days after sowing) while sub plot contains four levels of Zn application (Control, 10kg $ZnSO_4$, 20kg $ZnSO_4$ as basal application and 0.5 % foliar spray at 30 DAS). The N applied 25 Kg/ha, (half dose as basal) in the form of urea, P_2O_5@ 60 kg/ha as SSP and 20 kg/ha K_2O as MOP in all plots as basal doses. The rest half dose of N was applied at 20 DAS (days after sowing). Dual purpose variety of Guar RGC-986 was used seed rate @ of 25 kg/ha with spacing of 30 cm row to row. All recommended agronomical practices were followed during growing periods. The yields obtained from net plot area and calculated on per hectare basis. The plant samples collected and dried in hot air oven and proximate analysis were done as per standard procedures (AOAC, 2005). Cell wall constituents were determined by Van Soest *et al.* (1991). Data were analyzed by using analysis of variance (ANOVA) as described by Chandel (1984) by using MS-Excel.

RESULTS AND DISCUSSION

Growth parameters

Plant height: Plant height is a reliable index of growth of the plant especially in case of fodder crops, which represents the canopy, builds up in plants over a period. The plant height at 30 DAS was showed non-significant while at harvesting it was positively influenced by both harvesting management and zinc application. (Table 1) Plant height of the guar fodder at 30 DAS showed non-significant difference with stage of harvesting and zinc application over control. Harvesting at 80 DAS significantly increased the plant height, over different stages of 50, 60 and 70 DAS. At 30 DAS the effect of treatments on plant growth was not so much effective. Plant initially develops on stored food materials. Similar finding was observed by Singh *et al.*, (2016) that plant height of barley fodder increased significantly at 65 DAS over 45 and 55 DAS harvest stage.

Non-significant effect on plant height was observed at 30 DAS with zinc application, while plant height affected significantly up to 20 kg $ZnSO_4$ at harvest. Similar finding was observed by Kumar *et al.*, (2016) that application of 20 kg $ZnSO_4$ recorded non-significant improvement in plant height at both stages i.e. at 30 DAS and at harvest.

Leaf length: Leaf length is a basic parameter for determination of green fodder yield and quality. Data at harvest showed significant differences in leaf length due to stage of harvesting but non-significant at 30 DAS.Application of 20 kg $ZnSO_4$ per ha increased the leaf length significantly over controland in both stages of observation. However, difference between 10 kg $ZnSO_4$ and 0.5 % spray of $ZnSO_4$ were at par with each other at harvest.

Number of leaves: Number of leaves per plant considered as an important parameter of plant growth and development which act as source to trap solar energy for photosynthesis. Although, number of leaves are controlled by genetic factors but to some extent it can be modified by agronomic manipulations. The observations indicated that stage of harvesting has non-significant effect on no of leaves at 30 DAS observation, while in further advancement of harvesting increased the number of leaves significantly up to 80 DAS. Zinc application significantly influenced the number of leaves up to 20 kg $ZnSO_4$ as basal at 30 DAS observation over control, 10 kg and 0.5 % spray.However, difference between 10 kg $ZnSO_4$ and 0.5 % spray of $ZnSO_4$ were at par with each other at different harvesting stages.

Stem girth: With the successive stage of harvesting increased, the stem girth increases. However, significant improvement was reflected up to stage of 70 DAS. The difference between 70 DAS and 80 DAS were at par with each other (Table 1). Effect of $ZnSO_4$ also significantly affected the stem girth at harvest with application of 0.5 % spray of $ZnSO_4$ over control and 10 kg $ZnSO_4$ recorded at par with 20 kg $ZnSO_4$.

Leaf stem ratio: Leaf stem ratio is an important factor to determine the palatability of any fodder crops. Fodder having

high leaf to stem ratio is considered as good fodder for the animals. Data in Table 1 showed that stage of harvesting from 50 DAS to 80DAS; significantly (p= 0.05) increased the leaf stem ratio of guar fodder. However, differences between 70 DAS and 80 DAS reported at par with each other. Application of $ZnSO_4$ up to 20 kg/ha significantly increased the leaf: stem ratio of guar over control and 10 kg $ZnSO_4$ per ha. Kumar *et al.,* (2014) also observed that the application of zinc 10 kg /ha observed significantly higher values of all growth parameters. The increase in growth parameters may be due to the involvement of zinc as a precursor of tryptophan, which led to in auxin metabolism, higher hormonal and growth metabolic activity.

Green fodder yield: Green fodder yield is one of the most important factors for determination of the efficacy of agronomic management practices. There was significant effect of stage of harvesting and zinc application recorded on green fodder yield of guar (Table 1). Different stages of harvesting management from 50 DAS to 80 DAS significantly increased the green fodder yield of guar due to significance performance of growth attributes. Maximum green fodder yield was observed at harvesting management at 80 DAS (255.33 q/ha), which was statistically significant (p= 0.05) with other harvesting management practices, while minimum yield was obtained in 50 DAS (135.37 q/ha). It may be attributed due to availability of more time duration for photosynthesis which led to growth and yield of 80 days old crop than 50, 60 and 70 days crop. Similar finding was in agreement of Abdullah *et al.,* (2000) and Singh *et. al.,* (2016). Green fodder yield mainly depends on different growth attributes, like plant height, leaf length, number of leaves and stem girth, the individual improvement in particular attribute had cumulative effect on total green fodder yield of guar.

Zinc application up to 20 kg $ZnSO_4$/ha significantly increased the green fodder yield over 0, 10 kg $ZnSO_4$/ha and at 0.5 % zinc spray. However, 10 kg $ZnSO_4$ and 0.5 % zinc spray were at par with each other. The increase in green fodder yield in this trend can be explained as zinc is an essential mineral nutrient and a co-factor of over 300 enzymes and also an important element in nucleic acid metabolism (Marschner 1986). Carbohydrate metabolism at various levels and biosynthesis of tryptophan, which is a precursor of the auxin-indole-3-acetic acid (Oosterhuis *et al.,* 1991). Yield improvement due to zinc application was also reported by Pandya *et al.,* (2007) in cowpea, Mohan and Singh (2014) inteosinte and Bhoya *et al.,* (2013) and Sutaria *et al.,* (2013) in sorghum.

Dry matter yield: There was significant effect of Stage of harvesting and zinc application on dry matter yield of guar fodder (Table 1).Different stages of harvesting management from 50 DAS to 80 DAS, significantly increased the dry matter yield. Maximum dry matter yield was obtained at harvesting management at 80 DAS (68.5 q/ha), while lowest dry matter yield was recorded in 50 DAS (29.2 q/ha). It may be attributed due to availability of more time duration for photosynthesis which led to growth and yield of 80 days old crop due to more growth period than 50, 60 and 70 days old crop. These results were found in conformity with findings of Singh *et al.,* (2016) and Kaur *et al.,* (2013). Zinc application up to 20 kg $ZnSO_4$/ha has significantly increased the yield of guar fodder in term of DM yield over control, 10 kg $ZnSO_4$/ha and with 0.5 % zinc spray. However, 10 kg $ZnSO_4$ and 0.5 % zinc spray were statistically differing from each other.

Zinc content in plant: Stage of harvesting management showed non significant effect of zinc concentration in guar up to 70 DAS, while the highest zinc content was recorded at 60 DAS stage of harvesting and further decrease in zinc content was observed at 80 DAS stage of harvesting. The zinc content in guar plant significantly affected with the zinc

Table 1: Effect of stage of harvesting and zinc application on growth and yield of clusterbean.

Treatments	Plant height (cm)		Leaf length (cm)		Leaves/ plant (Nos)		Leaf stem ratio	Stem girth (cm)	Green fodder yield	Dry matter yield
	30 DAS	harvest	30 DAS	harvest	30 DAS	harvest	harvest	harvest	(q/ha)	(q/ha)
Stage of harvesting (DAS)										
H_1 (50 DAS)	24.28	48.92^d	3.83	5.42^c	31.4	88.9^c	0.38^b	4.7^c	135.3^d	29.2^d
H_2 (60 DAS)	24.32	54.84^c	3.85	6.43^c	31.1	120.2^b	0.74^a	6.3^b	177.5^c	39.7^c
H3(70 DAS)	24.2	78.22^b	3.82	8.14^b	31.5	143.8^b	0.79^a	7.2^a	217.2^b	52.3^b
H_4 (80 DAS)	24.22	96.92^a	3.83	9.93^a	31.4	203.7^a	0.82^a	7.9^a	255.3^a	68.5^a
SEm ±	0.74	1.96	0.34	0.48	1.5	11.4	0.1	0.6	9.2	3.5
CD (*P*=0.05)	NS	4.8	NS	1.18	NS	27.9	0.25	1.4	22.6	8.6
Zinc application										
Zn_1 (control)	23.63	59.14^c	3.17^c	5.9^c	28.36^b	115.9^c	0.62^b	5.1^c	142.5^c	32.3^d
Zn_2 (10 Kg $ZnSO_4$ /ha)	24.38	68.23^b	4.15^b	7.61^b	33.17^a	142.2^b	0.65^b	6.4^b	196.2^b	46.6^c
Zn_3 (20 kg $ZnSO_4$ /ha)	25.4	81.82^a	4.93^a	8.94^a	35.20^a	169.5^a	0.75^a	7.0^a	232.1^a	58.5^a
Zn_4 (0.5 % Zinc spray)	23.6	69.70^b	3.10^c	7.40^b	28.73^b	129.0^b	0.70^a	7.4^a	214.5^b	52.3^b
SEm ±	0.73	1.84	0.28	0.41	2.1	8.4	0.04	0.3	9	2.8
CD (*P*=0.05)	NS	3.79	0.58	0.85	4.34	17.3	0.08	0.7	18.5	5.7

Table 2: Effect of stage of harvesting and zinc application on Zinc content (plant and soil) and total uptake by guar fodder.

Treatments	Zinc content in plant (ppm)	Zinc uptake (g /ha)	Zinc content in soil (ppm)
Stage of harvesting (DAS)			
H_1 (50 DAS)	38.9[a]	116.9[c]	44.97[b]
H_2 (60 DAS)	41.8[a]	169.9[b]	73.24[a]
H_3(70 DAS)	39.2[a]	208.2[a]	62.29[a]
H_4 (80 DAS)	32.6[b]	228.2[a]	52.30[b]
SEm ±	1.91	13.43	6.53
CD (*P*=0.05)	4.67	32.87	15.97
Zinc application			
Zn_1 (control)	33.50[c]	104.75[c]	38.33[c]
Zn_2 (10 Kg/ha)	38.06[b]	175.54[b]	54.68[b]
Zn_3 (20 kg/ha)	44.88[a]	259.15[a]	96.51[a]
Zn_4(0.5 %spray)	36.04[b]	183.83[b]	43.28[b]
SEm ±	1.35	13.71	6.28
CD (*P*=0.05)	2.78	28.3	12.97

application. The higher zinc content was observed in 20 kg $ZnSO_4$ application while10 kg $ZnSO_4$/ha and 0.5 % zinc spray were statistically at par with each other.The minimum zinc content was observed (33.5ppm) in control (Table 2).

Zinc uptake: Zinc uptake in guar fodder increased significantly with advance stage of harvesting up to 80 DAS. However, 70 and 80 DAS were statistically at par with each other. Highest zinc uptake was recorded at 80 DAS (228.23g /ha) while, lowest at 50 DAS (116.87g /ha).With increasing levels of $ZnSO_4$ application zinc uptake increased significantly highest zinc uptake was found with 20 kg $ZnSO_4$/ha (259.15 g /ha) and lowest in control (104.75 g / ha). The zinc uptake at 10 kg $ZnSO_4$/ha over control and 0.5 % zinc spray is 175.54g /ha and 183.83g /ha respectively (Table 2).

Soil zinc status at harvesting: Soil zinc status was improved from the initial status because guar is leguminous crop (Table 2). Soil zinc content was found in 3rd harvesting plot which is at par with 2nd harvesting plot. The advance in harvesting initially zinc status of soil increases at 60 DAS, further decrease was observed in 70 and 80 days harvesting. Application of zinc significantly enhanced the zinc status in soil. The highest soil zinc content was found in 20 kg $ZnSO_4$ treated plot, while10 kg $ZnSO_4$/ha and 0.5 % zinc spray treated plot were found statistically at par with each other.

CONCLUSION

From the findings of present research it has concluded that at 80DAS various growth parameters *viz*; plant height, leaf length, number of leaves, stem girth and leaf: stem ratio were significantly higher and also recorded highest green and dry fodder yield with an Zn application @ 20 kg ha^{-1}. Maximum zinc uptake was noticed at 80 DAS stage and application rate of 20 kg $ZnSO_4 ha^{-1}$ among other treatments.

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