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RESEARCH ARTICLE

SYNERGETIC EFFECT OF ZINC ON NITROGEN CONTENT IN MUNGBEAN (*VIGNA RADIATA* L. WILCZEK) GENOTYPES

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Abstract: The field experiment was carried out at Instructional Farm, College of Agriculture, Mandor, Jodhpur during *kharif* season of 2019 to study the synergetic effect of zinc on nitrogen content. Under the present investigation, 4 varieties of mungbean and 7 doses of zinc in 28 treatments combinations were taken as experimental factors to study their effect on mungbean. The Field experiment was laid out in factorial randomized block design (RBD). The varieties under experimentation had significant influence on nitrogen content of mungbean at maturity stage. Substantially, highest nitrogen contents were observed in the grain (3.93 %) followed by stover (2.52 %) and pod wall (0.82 %) of mungbean respectively. Further, application of zinc at 6 kg/ha being on par with 5 kg/ha to mungbean fetched significantly highest nitrogen content in grain and stover of mungbean.

Keywords: Mungbean, Nitrogen, Synergism, Zinc

INTRODUCTION

Mungbean belongs to genus *Vigna*, which includes about 150 species. Of them, 22 species are native to India and 16 to South-East Asia. However, largest number of species is native to Africa. Mungbean is a diploid (2n=2x=22) (Somta and Srinives, 2007) and self-pollinated crop and synonymously, known as 'Goldengram or Greengram or Mungbean' and belongs to family leguminosae or fabaceae. Mungbean is being grown in a wide range of climatic conditions. A warm humid climate with temperature ranging from 25-35 °C, 400-550 mm rainfall, well distributed during the growing period is suitable for its cultivation. However, the crop of mungbean is tolerant to both heat and drought and thus can be thriving well under semi-arid environment. Mungbean is responsive to day length. Short days result in early flowering, while the long days result in late flowering. Further, mungbean varieties vary in their photoperiod response (Singh *et al.*, 2017) also. Nitrogen (N) is a key essential macronutrient that affects plant growth and development and is often a major limiting factor in crop yield production. Plants uptake and transport both nitrate (NO_3^-) and ammonium (NH_4^+) through nitrate and ammonium transporters. In plants, nitrate reductase (NR) and nitrite reductase (NiR) reduce NO_3^- to NH_4^+, and NH_4^+ is assimilated into amino acids through the glutamine synthetase (GS) glutamate synthase (GOGAT) cycle (Chenchen Ji *et al.*, 2021). In the last few decades, large amounts of N fertilizers have been applied to arable land in India. Because of the relatively low N use efficiency in crops, excessive N leaching and emissions from farmland cause several environmental problems, such as eutrophication and deterioration of water quality. Increasing crop N use efficiency is still an outstanding issue in India and is meaningful for both agricultural production and environmental protection. Zinc deficiency in soils impacts food and nutritional security, leading to severe health consequences. Application of Zn fertilizers to the field is a simple and easy way for farmers' to avoid Zn deficiency in crops and simultaneously obtain large grains with high Zn content for human nutrition. Both foliar- and soil-applied Zn significantly increased the grain Zn content in mungbean. Application of 6 kg Zn/ha showed significant increment in nitrogen content in pod wall, grain and stover as well as uptake in stover. The increased protein content also improves nitrogen content, as zinc takes part in nitrate conversion to ammonia in plants. The increase in protein content leads to increase in photosynthetic rates and chlorophyll content in leaves of the plants. The role of zinc in increasing the cation exchange capacity of roots might have led to more absorption of nutrients from soil and further more translocation to different vegetative and reproductive parts which ultimately led to higher content in the grain and stover of

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mungbean. Zinc application substantially enhances nitrogen content and uptake under zinc treatment.

It is evidenced under varying physiological studies and strong relationships have been found between different nutrients, and there is indication that changing one or more nutrients in the growth medium may affect the concentrations of many other nutrients in plants. In recent studies, it has been reported that molybdenum (Mo), potassium (K), and phosphorus (P) can interact synergistically with N in plants (Chenchen ji *et al.*, 2021). In this study, we analyzed the mungbean growth and yield production, N and Zn uptake. Our results revealed a clearly synergistic effect between Zn and N mainly on the root-to-shoot translocation in mungbean plants. Zn supply also promoted the N assimilation level in mungbean pod, grain, and stover thereafter increased the biomass and yield production. These results provide a theoretical basis for optimizing the application of Zn and N fertilizers in mungbean cultivation to improve both N use efficiency and Zn nutrition in humans with mungbean-based diets.

MATERIALS AND METHODS

The field experiment was carried out at Instructional Farm, College of Agriculture, Mandor, Jodhpur, Rajasthan, India. Geographically, it is located between 26^o 15' N to 26^o 45' North latitude and 73^o 00' E to 73^o 29' East longitude at an altitude of 231 meter above mean sea level. The region falls under agro-climatic zone Ia (Arid Western Plains Zone) of Rajasthan. Under the present investigation four varieties of mungbean and seven doses of zinc in twenty-eight treatments combinations were taken as experimental factors to study their effect on crop. Total nitrogen content in plant materials (Grain, stover and pod wall) was estimated by the Kjeldahl method following digestion, distillation and titration. Finely ground grain (0.2 g) and stover/leaf/stem/pod wall/root (0.5 g) samples were taken in digestion tube and added 10 ml of concentrated H_2SO_4. For better digestion, added 3 g catalyst mixture (K_2SO_4+$CuSO_4$; 5:1 ratio) was also added prior to H_2SO_4. The digestion tubes were placed on digestion block and set the digestion system to attain a temperature of about 410°C and then attach the digestion tube to the heating unit as per the instructions given in the operation manual. Allowed the digestions continuously till completion (No black or brown colour), it takes about 120-135 minutes. Added 10 ml distilled water in the digestion tubes before distillation. Distillation was done through Automatic Nitrogen Analyser (Kelplus Calssic-DX VA) using 4 per cent boric acid and 40 per cent NaOH. After completion of distillation, the boric acid is titrated against 0.1 N HCl. Blank was also run to the same end point as that of sample (Singh and Praharaj, 2017).

RESULTS AND DISCUSSION

Nitrogen content in pod wall

The varieties under experimentation had significant influence on nitrogen content in pod wall of mungbean (Table 1). Variety 'GAM 5' recorded significantly highest nitrogen content in pod wall (0.81%) which was closely followed by 'GM 6' (0.80%) and 'IPM 02-3' (0.77 %). Variety 'GAM 5' also recorded 10.95 per cent higher nitrogen content in pod wall over 'GM 4' variety. It is observed from the data that application of zinc improved N content in pod wall. However, N content in pod wall of mungbean did not affect significantly by zinc treatments. Application of zinc dose at 6 kg/ha recorded maximum N content in pod wall (0.82%) followed by zinc level applied at 5 kg/ha recorded of 0.80 per cent N content. Thereafter, application of zinc at 4 and 3 kg/ha also caused marked variation and recoded 0.78 and 0.77 per cent N content, respectively during the year of investigation. Lowest N content in pod wall (0.75%) was recorded under 1 kg Zn/ha treatment and control. Moreover, an improvement in N content in pod wall was shown under zinc 6 kg/ha treatment by 9.33 per cent over control.

Nitrogen content in grain

Remarkable variations were observed in nitrogen content in mungbean grains by the varieties (Table 1, 2). Among mungbean genotyps, 'GAM 5' (4.05%) recorded highest nitrogen content in grain which was significantly superior over rest of the varieties. Variety 'IPM 02-3' recorded nitrogen content of 3.73 per cent which was 7.80 and 3.89 per cent higher over 'GM 6' and 'GM 4'. Genotype 'GAM 5' also recorded 17.05 and 12.81 per cent higher nitrogen content over 'GM 6' and 'GM 4'. It is quite evident from the data that increment of nitrogen content was recorded in grain of mungbean with increment in zinc application from control to 6 kg/ha. Substantially highest nitrogen content in grain (3.92%) was observed with the application of 6 kg Zn/ha application. Moreover, a marked improvement in nitrogen content in grains was led by zinc at 6 kg/ha which was 10.82 per cent higher over control. However, it remained statistically on par with zinc at 5 kg/ha (3.87%) and zinc at 4 kg/ha (3.77%). Further, application of 3 kg Zn/ha and 2 kg Zn/ha also recorded improvement in nitrogen content in grains by 3.45 and 2.01 per cent, respectively, over control.

N content (%) in stover

Data revealed that the varieties under experimentation had significant effect on nitrogen content in stover of mungbean (Table 1). Under the investigation, highest nitrogen content in stover was recorded by 'GM 6' (2.61%) which was significantly superior over rest of the varieties. Whileas, variety 'GM 4' recorded 2.44 per cent and 'GAM 5'recorded 2.40 per cent nitrogen content in stover, which was statistically at par with each other. Furthermore, lowest nitrogen content was obtained in stover of 'IPM 02-3' variety (2.04%). 'GM 6' obtained 6.96, 8.75 and 27.94 per cent nitrogen increment in stover over 'GM 4', 'GAM 5' and 'IPM 02-3' varieties, respectively. It is quite evident from the investigated data that gradual increment of nitrogen content in stover of mungbean was noticed up to application of 6 kg Zn/ha to mungbean. Markedly highest zinc content in stover (2.52%) was observed with 6 kg/ha zinc application which was found equally effective with lower doses of zinc at 5 kg/ha (2.46%) and 4 kg/ha (2.40%). Application of zinc at 6 kg/ha recorded 10.45 per cent increase in nitrogen content in stover over control. Though application of zinc at 3, 2 and 1 kg/ha recorded increment in nitrogen content in stover by 3.03, 1.64 and 0.62 per cent over control.

Interaction effect of varieties and zinc levels on nitrogen content in grain

Significant interaction observed amongst treatments on nitrogen content in grain of mungbean (Tabel 2). Application of zinc at 6 kg/ha to 'GAM 5' variety recorded highest nitrogen content in grain (4.57%) which was statistically on par with lower doses of zinc at 5 and 4 kg/ha. Moreover, the variety 'IPM 02-3' also showed positive interaction effect with zinc fertilization at 6 and 5 kg/ha. Further, application of zinc at 6 kg/ha to 'IPM 02-3' variety recorded highest nitrogen content in grain (4.0%), followed by 5 kg/ha zinc application (3.91%).

Nitrogen uptake

The varieties under experimentation had significant influence on nitrogen uptake higher amount of N uptake by grain (45.59 kg/ha), N uptake by stover (78.74 kg/ha) were recorded by 'GM 6' variety of mungbean. Application of zinc at 5 kg/ha observed highest nitrogen uptake by mungbean grain (46.06 kg/ha) and protein yield (287.87 kg/ha). Albeit, highest nitrogen uptake by stover (71.60 kg/ha) was observed with zinc application of 6 kg/ha.

DISCUSSION

Nitrogen content and its uptake are interactively influenced by zinc applied to the crop. Soil pH and biological properties are also responsible for making zinc available or unavailable to the plants. It is well known fact that the zinc availability increases with decreasing soil pH (Tisdale *et al*., 2010). An explicit of data revealed that application of 6 kg Zn/ha showed significant increment in nitrogen content in pod wall, grain and stover as well as uptake in stover. (Boorboori *et al*., 2012). The role of zinc in indole acetic acid synthesis results in amino acids which in turn makes protein (Moussavi-Nik and Kiani, 2012). The increase in protein content may also be due to increase in photosynthetic rates and chlorophyll content in leaves of the plants. The role of zinc in increasing the cation exchange capacity of roots might have led to more absorption of nutrients from soil and further more translocation to different vegetative and reproductive parts which ultimately led to higher content in the grain and stover of mungbean. Zinc application significantly increased nitrogen content and uptake in zinc treatment. It was due to increase in grain and stover yields of mungbean under all treatments, since uptake is calculated from their content and yields. Our findings are in agreement with Srivastava *et al*. (2006), Habibullah *et al*. (2014), Tak *et al*. (2014). Significant improvement in protein content in mungbean were observed with soil application of zinc at 6 kg/ha. Enhanced protein content might be due to increased nitrogen content (Srivastava *et al*., 2006). Krishna (1995) also reported a significant positive effect of zinc treatment on crude protein content in the grains of mungbean. Zinc is required as structural and catalytic components of protein and enzymes for normal growth and development (Broadley *et al*., 2007).

Table 1. Effect of varieties and zinc levels on N (%) content in mungbean

Treatments	N content (%) in pod wall	N content (%) in grain	N content (%) in stover
Varieties			
GM 4	0.73	3.59	2.44
GAM 5	0.81	4.05	2.40
GM 6	0.80	3.47	2.61
IPM 02-3	0.77	3.73	2.04
SEm±	0.02	0.04	0.04
CD (P=0.05)	0.05	0.12	0.10
Zinc levels (kg/ha)			
Zn_0	0.75	3.54	2.28
Zn_1	0.75	3.57	2.29
Zn_2	0.76	3.62	2.32
Zn_3	0.77	3.67	2.35

Zn_4	0.78	3.77	2.40
Zn_5	0.80	3.88	2.46
Zn_6	0.82	3.93	2.52
SEm±	0.02	0.06	0.05
CD (P=0.05)	NS	0.16	0.13
Interaction			
SEm±	0.04	0.11	0.09
CD (P=0.05)	NS	0.32	NS

Table 2. Interaction effect of varieties and zinc levels on N content (%) in grain

Treatments	**GM 4**	**GAM 5**	**GM 6**	**IPM 02-3**	**Mean**
Zn_0	3.53	3.65	3.44	3.55	3.54
Zn_1	3.57	3.79	3.37	3.55	3.57
Zn_2	3.61	3.89	3.37	3.59	3.62
Zn_3	3.66	3.94	3.40	3.66	3.67
Zn_4	3.63	4.17	3.43	3.86	3.77
Zn_5	3.72	4.34	3.55	3.91	3.88
Zn_6	3.44	4.57	3.71	4.00	3.93
Mean	3.59	4.05	3.47	3.73	–
SEm±					0.11
CD (P=0.05)					0.32

Table 3. Effect of varieties and zinc levels on N uptake by grain, stover and total uptake by mungbean

Treatments	**N uptake by grain (kg/ha)**	**N uptake by stover (kg/ha)**	**Total N uptake (kg/ha)**
Varieties			
GM 4	40.07	67.56	107.63
GAM 5	41.41	62.87	104.27
GM 6	45.59	78.74	124.33
IPM 02-3	35.33	53.62	88.94
SEm±	0.87	1.25	1.53
CD (P=0.05)	2.48	3.55	4.34
Zinc levels (kg/ha)			
Zn_0	35.21	60.11	95.32
Zn_1	36.86	61.24	98.10
Zn_2	39.34	63.37	102.71
Zn_3	40.62	65.13	105.75
Zn_4	42.07	67.75	109.82
Zn_5	46.06	70.67	116.73
Zn_6	44.03	71.60	115.63
SEm±	1.16	1.66	2.02
CD (P=0.05)	3.28	4.69	5.74
Interaction			
SEm±	2.31	3.31	4.05
CD (P=0.05)	NS	NS	NS

Fig 1: Interaction treatment (Genotype GAM 5 with Zinc 6 kg/ha)

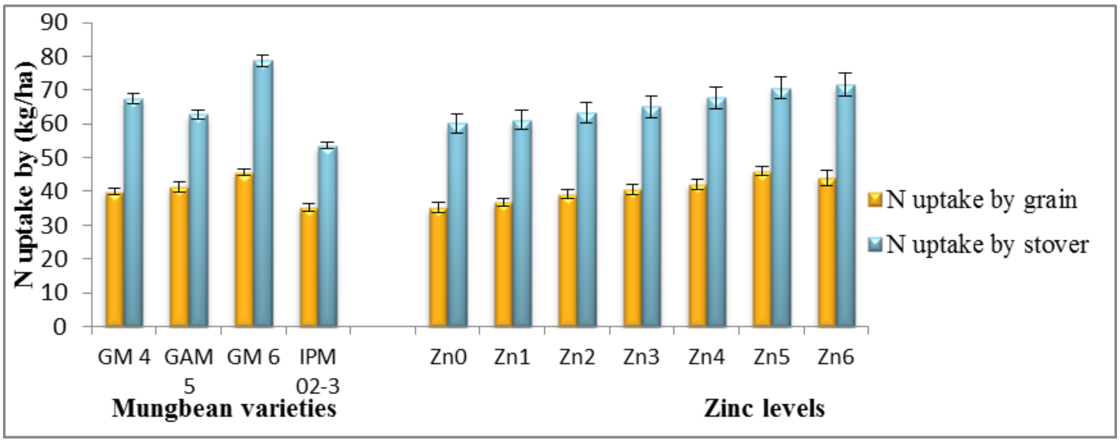

Fig. 2: N uptake by grain and stover in mungbean genotypes

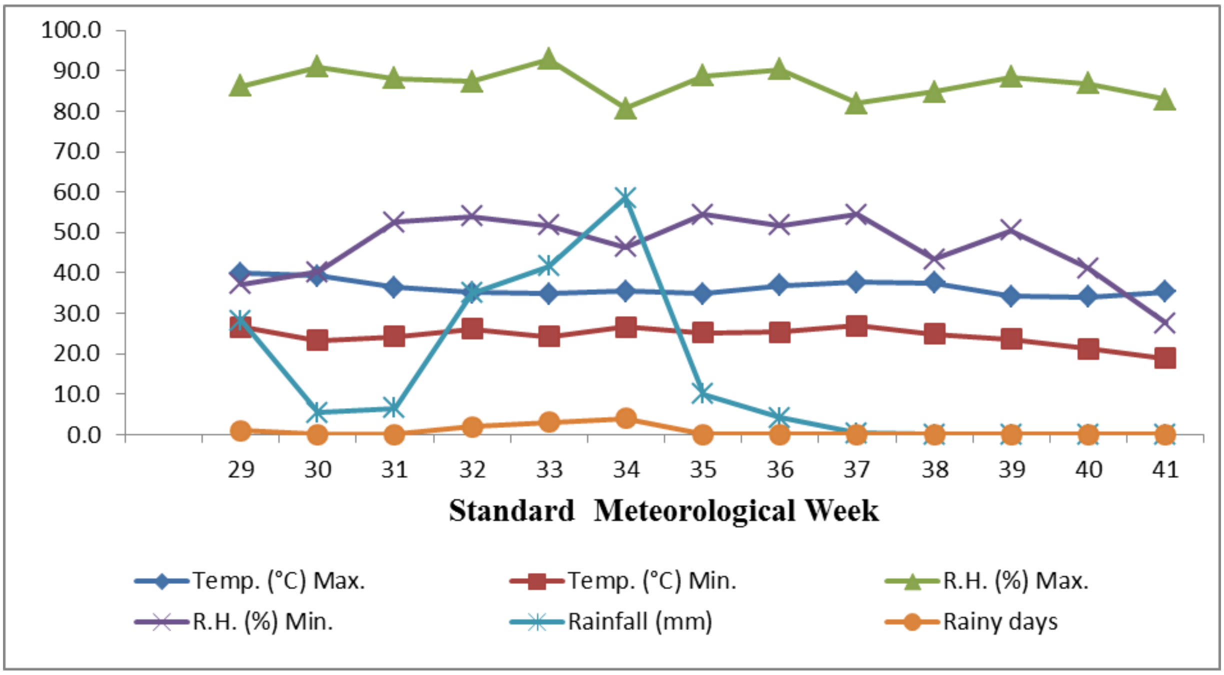

Fig 3: Weather variables during crop season *kharif*

CONCLUSION

Application of zinc at 6 kg/ha and sowing with mungbean genotype 'GAM 5' recorded higher nitrogen content in grain of mungbean.

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