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Response of sulphur and zinc on yield, quality and nutrient uptake of summer mungbean (*Vigna radiata* L. Wilczek)

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Abstract
An experiment was conducted to study the effect of sulphur and zinc on yield, quality and of summer mungbean for two consecutive seasons i.e. 2008-09 and 2009-10. The experiment with four levels of sulphur (0, 20, 40 and 60 kg S ha^{-1}) and four levels of zinc (0, 5, 7.5 and 10 kg Zn ha^{-1}) was laid down in randomized block design with three replications. The summer mungbean variety “NDM-1” was taken as test crop during both the years. The application of sulphur at 40 kg S ha^{-1} significantly increased the seed yield, stover yield, protein content in seed and uptake of N, P, K over control, 20 kg S ha^{-1} and 60 kg S ha^{-1}. However the sulphur uptake significantly increased by seed and stover of summer mungbean with 60 kg S ha^{-1} and the zinc uptake was higher at 40 kg S ha^{-1} which was at par with 60 kg S ha^{-1}. The application of 10 kg Zn ha^{-1} significantly increased the seed yield, stover yield, protein content in seed and uptake of N, P, K, S and Zn by seed and stover of summer mungbean over control followed by 5.0 kg Zn ha^{-1} and 7.5 kg Zn ha^{-1} during both the years, respectively.

Keywords: Mungbean (*Vigna radiata* L. Wilczek), sulphur, zinc, seed yield, quality and nutrient uptake.

Introduction
Summer mungbean (*Vigna radiata* L.Wilczek) is an important food legume, which is extensively grown in humid to arid and semi-arid regions. But the production of this crop is very low. It is used as whole or split seeds as Dal (Soup) but in other countries sprouted seeds are widely used as vegetables. Mungbean is considered as poor men’s meat containing almost triple amount of protein as compared to rice. The green plants are used as animal feed and the residues as manure. It also plays an important role in maintaining soil fertility by fixing atmospheric nitrogen in the soil by root nodules, which is utilized by the next crops. The roots of such crops on decay add organic matter to the soil which improved its physic-chemical properties. Mungbean also fixed N in soil by 63-342 kg ha^{-1} $season^{-1}$. It roots break the plough pan of puddle rice fields and go deep in search of water and nutrients.

Sulphur has long been recognized as an essential nutrient element for plant and ranks in importance with nitrogen and phosphorus. The legume crops are more susceptible for sulphur deficiency. Since mungbean is a legume crop it is quite likely that it may respond sulphur. Sulphur is a component element of protein, sulpholipids, enzyme etc. (Das and Mishra, 1991) [2]. Zinc also an essential plant nutrient for plant growth and development and it is a constituent of several enzymes such as alcohol dehydrogenase, carbonic anhydrase, proteinase and acts as co-factor for several others. It also plays vital role in the synthesis of protein and nucleic acid and helps in the utilization of nitrogen and phosphorus in plant. It is associated with water uptake and retention in plants. Zinc is also known to stimulate plant resistance to dry and hot weather and also bacterial and fungal diseases. It also promotes nodulation and nitrogen fixation in leguminous crops (Demeterio *et al.* 1972) [3]. The objective of the study was to evaluate the response of doses of sulphur and zinc fertilization on yield, protein content and nutrient uptake by seed of summer mungbean.

Materials and Methods
A field experiment using green gram cv. NDM-1 as a test crop was carried out at Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad during summer season of 2008-09 and 2009-10. The soil was silt loam in texture having pH (8.45 and 8.38), EC (0.26 and 0.24 dSm^{-1}), organic carbon (0.43 and 0.41%), low available N (195.80 and 189.80 kg ha^{-1}), medium P (18.32 and 17.45 kg ha^{-1}), K (233.00 and 221.00 kg ha^{-1}), and deficient in available S (11.20 and 10.80 kg ha^{-1}) and Zn (0.48 and 0.45 ppm) during both the years. The treatments comprising four level each of S (0, 20, 40 and 60 kg ha^{-1}) and Zn (0, 5.0, 7.5 and 10

kg ha^{-1}) which were tested in randomized block design and replicated thrice. A uniform dose of nitrogen, phosphorus and potassium @ 20, 50 and 25 kg ha^{-1} was applied through urea, single super phosphate and mutate of potash, respectively. Treatment wise full dose of S and Zn were applied through elemental sulphur and zinc oxide as basal dressing. At harvest seed and straw yield were recorded. In order to determine protein in seeds Kjeldahl's digestion and distillation procedure was followed to determine nitrogen in seeds. Then the protein content of the seed was determined by multiplying the nitrogen content of seed by 6.25. Nutrients (N, P, K S and Zn) in soil and plants were analyzed following standard usual laboratory procedures (Jackson, 1973) [5].

Results and Discussion

The seed and stover yields increased with increasing levels of sulphur upto 40 kg ha^{-1} and thereafter the yield was decreased (Table-1). The maximum seed and stover yields (11.89, 36.48 and 12.51, 37.86 q ha^{-1}) recorded at 40 kg S ha^{-1} were significantly higher over control (9.21, 28.09 and 9.69, 29.12 q ha^{-1}) as well as 20 kg S ha^{-1} and statistically at par with 60 kg S ha^{-1} during both the years, respectively. The increase in yield was mainly due to enhanced rate of photosynthesis and carbohydrate metabolism as influenced by sulphur application. Decline in yields were observed at higher level of sulphur due to reduced growth of the crop (Sharma and Singh 1997) [8]. Zn application also increased the seed and stover yield. The maximum seed and stover yields (12.02, 36.90 and 12.65, 38.36 q ha^{-1}) observed with 10 kg Zn ha^{-1} application were significantly higher over control (8.92, 27.15 and 9.38, 28.38 q ha^{-1}, respectively) in both the years. The increase in yield might be due to role of zinc in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordial for reproductive parts and partitioning of photosynthesis towards them which resulted in better flowering and fruiting. These results corroborate with the findings of Chaphale *et al.* (1991) [1], Krishna (1995) [7] and Kharche *et al*. (2006) [6].

The highest protein content in seed (23.92 and 24.07%) was obtained with 40 kg S ha^{-1} which was significantly higher over control (18.52 and 18.63%) and 20 kg S ha^{-1} but at par with 60 kg S ha^{-1} during both the season 2008-09 and 2009-10, respectively. This might be attributed to metabolism of protein due to application of S (Singh *et al.*, 1991 and Dey *et al*., 2004) [9, 4]. Zn application also increased the protein content in seed by its application of 10 kg Zn ha^{-1}. The highest protein content in seed (24.17 and 24.32 %) was observed in 10 kg ha^{-1} zinc application treatment which was significantly higher than rest of the other treatments in both the years, respectively (Chaphale *et al.*, 1991 and Srivastava *et al.*, 2006) [1, 10].

Nutrients N (45.87, 48.56 & 23.56, 25.20 kg ha^{-1}), P (6.35,7.06 & 8.73, 9.93 kg ha^{-1}), K (6.96, 7.57 & 52.23, 68.71 kg ha^{-1}) uptake in seed and stover were recorded with 40 kg S ha^{-1} which were significantly higher over control (27.85, 3.90, 4.21 & 29.46, 4.28, 4.45 kg ha^{-1} and 14.20, 5.28, 21.63 & 15.23, 5.95, 41.31 kg ha^{-1} respectively) such as 20 kg S ha^{-1} and 60 kg S ha^{-1} while S (4.49, 5.07 and 7.81, 8.77 kg ha^{-1}) and Zn (23.18, 25.63 and 157.13, 172.43 g ka^{-1}) uptake in seed and stover were recorded with 40 kg S ha^{-1} which were significantly higher over control and 20 kg S ha^{-1} but at par with 60 kg S ha^{-1} (Table-2 & 3) during both the years, respectively. The increase in N, P, K, S and Zn uptake may be due to better availability of these nutrients as a result of S application. Moreover, the uptake followed the yield pattern, as yield was higher, so was the uptake. Nutrients viz. N, P, K, S and Zn uptake in seed and stover were highest in 10 kg ha^{-1} zinc treatment which were significantly higher over control followed by 5.0 and 7.5 kg ha^{-1}, respectively. Similar results were also reported by Chaphale *et al*. (1991) [1] and Kharche *et al*. (2006) [6].

Table 1: Effect of sulphur and zinc levels on seed yield, stover yield and protein content in seed of summer mungbean.

Treatments	Seed yield (q ha^{-1})		Stover yield (q ha^{-1})		Protein content in seed (%)	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
S levels (kg ha^{-1})						
0	9.21	9.69	28.09	29.12	18.52	18.63
20	9.84	10.35	30.13	31.58	19.80	19.89
40	11.89	12.51	36.48	37.86	23.92	24.07
60	11.42	12.01	35.33	36.73	22.97	23.10
SEm±	0.24	0.23	0.64	0.66	0.48	0.43
CD at 5%	0.69	0.65	1.85	1.92	1.39	1.26
Zn levels (kg ha^{-1})						
0	8.92	9.38	27.15	28.38	17.94	18.04
5.0	10.19	10.72	31.55	32.83	20.50	20.61
7.5	11.23	11.82	34.44	35.72	22.60	22.72
10	12.02	12.65	36.90	38.36	24.17	24.32
SEm±	0.24	0.23	0.64	0.66	0.48	0.43
CD at 5%	0.69	0.65	1.85	1.92	1.39	1.26

Table 2: Effect of sulphur and zinc levels on N, P, K, S and Zn uptake by seed of summer mungbean.

Treatments	N uptake by seed (kg ha^{-1})		P uptake by seed (kg ha^{-1})		K uptake by seed (kg ha^{-1})		S uptake by seed (kg ha^{-1})		Zn uptake by seed (g ha^{-1})	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
S levels (kg ha^{-1})										
0	27.85	29.46	3.90	4.28	4.21	4.45	3.20	3.55	16.12	17.86
20	31.98	33.82	4.50	4.94	4.88	5.29	3.51	3.90	17.71	20.41
40	45.87	48.56	6.35	7.06	6.96	7.57	4.49	5.07	23.18	25.63
60	42.35	44.78	5.94	6.51	6.42	6.87	4.40	4.80	22.34	24.90
SEm±	0.89	0.86	0.12	0.13	0.13	0.13	0.09	0.09	0.49	0.49
CD at 5%	2.56	2.49	0.36	0.36	0.39	0.38	0.26	0.26	1.41	1.40
Zn levels (kg ha^{-1})										
0	26.56	28.08	3.73	4.09	4.03	4.25	3.18	3.51	16.03	17.64
5.0	33.63	35.58	4.59	5.18	5.08	5.13	3.62	4.02	18.40	21.04
7.5	40.74	43.12	5.75	6.29	6.20	6.74	4.30	4.76	21.65	24.13
10	47.12	49.84	6.61	7.24	7.16	7.65	4.61	5.10	23.26	25.99
SEm±	0.89	0.86	0.12	0.13	0.13	0.13	0.09	0.09	0.49	0.49
CD at 5%	2.56	2.49	0.36	0.36	0.39	0.38	0.26	0.26	1.41	1.40

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