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EFFECT OF SULPHUR AND ZINC ON THE SEED YIELD AND PROTEIN CONTENT OF SUMMER MUNGBEAN UNDER ARID CLIMATE

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ABSTRACT
A field experiment was conducted under Instructional Farm of N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.), to evaluate the influence of sulphur and zinc on mungbean for two consecutive summer 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 "Narendra Moong-1" was sown during both the years. The results revealed that application of 40 Kg S ha^{-1} and 10 Kg Zn ha^{-1} significantly increased the plant height, number of branches plant^{-1}, number of nodules plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, seed yield, protein content (%) and test weight was non-significant. The control (0 Kg Sx0 Kg Zn ha^{-1}) had the poorest performance in respect of yield and protein content of mungbean seed during both the years, respectively. The interaction effect between S x Zn on various parameters of summer mungbean was found significant and test weight was found non-significant during both the years. The interaction effect in seed yield was synergistic. The increasing dose of zinc increased the seed yield with increasing dose of sulphur up to 40 Kg S ha^{-1}. The highest seed yield (13.69 and 14.40 q ha^{-1}) was observed in combination with 40 Kg S ha^{-1} and 10 Kg Zn ha^{-1} which was significantly superior over rest of the combinations except 60 Kg S ha^{-1} and 10 Kg Zn ha^{-1} during 2008-09 and 2009-10, respectively. The minimum seed yield (9.56 and 10.06 q ha^{-1}) was achieved with treatment having 20 Kg S ha^{-1} and 5 Kg Zn ha^{-1} and least was in control during both the years.

KEY WORDS: Mungbean (Vigna radiata), sulphur, zinc, arid, seed yield.

INTRODUCTION
According to the nutritionists, pulses are an excellent source of dietary proteins and can play an important role in fulfilling requirements of rapidly increasing population. Mungbean is an important pulse crop that can be grown twice a year i.e. in spring and autumn season. Among the grain legumes, it is one of the important conventional pulse crops of India. Its ranks second to chickpea *(Cicer arietinum)* amongst grain legumes from production point of view. Its seed is more palatable, nutritive, digestible and non-flatulent than other pulses grown in country. It contains 24.7% protein, 0.6% fat, 0.9% fiber and 3.7% ash. Besides being a rich source of protein, it maintains soil fertility through biological nitrogen fixation in soil and thus plays a vital role in sustainable agriculture (Kannaiyan, 1999). Mungbean fixes 63-342 Kg N ha^{-1} per season in soil by biological nitrogen fixation. In India the area of mungbean was 2.35 m ha in 2009-10 and 1.16 m ha 2010-11 with production of 4.60 m tonnes and 0.98 m tonnes, respectively. Its average productivity was around 361 Kg ha^{-1} (2009-10) and 356 Kg ha^{-1} (2010-11) (Anonymous, 2011). It is a short duration crop therefore has less water requirement as compared to summer crops. Moreover, it is drought resistant that can withstand adverse environmental conditions, and hence successfully be grown in rain fed areas (Anjum *et al*., 2006).Sulphur is one of the essential plant nutrients for all plants and is indispensable for the growth and metabolism. 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 has a number of oxidizing function in soil and plant nutrition. It is a constituent of certain amino acids like methionine, cystine and cysteine and also a constituent of Fe-S proteins called ferrodoxins. The acidity produced by oxidation helps to solubilize plant nutrients and improves alkali soils. Zn is involved in auxin metabolism like, tryptophane synthesis, tryptamine metabolism, protein synthesis, formation of nucleic acid and helps in utilization of nitrogen as well as phosphorus by plants. Zn also stimulates resistance for dry and hot weather, bacterial and fungal diseases and ribosomal fraction in the plants. It also promotes nodulation and nitrogen fixation in leguminous crops (**Demeterio *et al;*** 1972). In view of the above the attempts have been made through the present investigation to study the effect of sulphur and zinc on growth, yield and quality of mungbean (*Vigna radiata* L.).

MATERIALS & METHODS
The field experiment was conducted during summer season of 2008-09 and 2009-10 at Student Instructional Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad, (U.P.). The soil was silty loam in texture having pH (8.45 and 8.38), EC (0.26 and 0.24), organic carbon (0.43 and 0.41), available N (195.80 and 189.80 Kg ha^{-1}), P (18.32 and 17.45 Kg ha^{-1}),

K (233.00 and 221.00 Kg ha^{-1}), S (11.20 and 10.80 Kg ha^{-1}), Zn (0.48 and 0.45 ppm), CEC (12.30 and 13.46 Cmol (p+)/Kg), ESP (15.70 and 14.80) and SAR (12.30 and 11.50) during both the years. The experiment was laid out in factorial randomized block design 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}) with three replications. The summer mungbean variety "Narendra Moong-1" was sown in rows, 30 cm apart using 25 Kg seed ha^{-1} on 8 April in 2008-09 and 10 April in 2009-10. The crop was thinned after complete germination to maintain a plant to plant spacing of 10 cm. A common dose of nitrogen, phosphorus and potassium @ 20, 50 and 25 Kg ha^{-1} was applied through urea, single super phosphate and murate of potash, respectively. The sulphur and zinc was applied through elemental sulphur and zinc oxide as per treatment and incorporated in the soil followed by irrigation to ensure microbial activities to hasten oxidation of sulphur. The seed weight was recorded in Kg ha-^{1} and adjusted at 10% moisture content. The five plants were taken from each plot to measure the growth and yield attributes. In order to determine protein in seeds Kjeldahl's digestion and distillation procedure (Jackson, 1973) was followed to determine nitrogen in seeds. Then the protein content of the grain was determined by multiplying the nitrogen content of grain by 6.25. Year wise data was subjected to statistical analysis separately by using Analysis of Variance Technique. The difference among treatment means was compared by using least significant difference test at 5% probability levels (Steel *et al*., 1980).

RESULTS & DISCUSSION

Effect of sulphur

Growth and yield attributes (plant height, number of branches $plant^{-1}$, number of nodules $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1}) and yield of seed and protein content significantly increased and test weight was non-significant with application of sulphur during both the years (Table-1).

TABLE1: Effect of sulphur and zinc levels on plant height, number of branches, number of nodules and number of pods of summer mungbean.

Treatment Interaction	Plant height (cm)		Number of branches $plant^{-1}$		Number of nodules $plant^{-1}$		Number of pods $plant^{-1}$	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Sulphur Levels (Kg ha^{-1})								
S_0	39.99	40.09	10.15	10.18	26.90	27.24	16.14	16.95
S_1	45.16	45.23	11.46	11.48	28.75	29.09	17.25	18.12
S_2	49.95	50.12	12.68	12.72	34.75	35.25	20.85	21.89
S_3	43.68	43.73	11.09	11.10	33.37	33.74	20.02	21.02
SEm±	1.05	0.92	0.27	0.23	0.70	0.70	0.42	0.40
CD at 5%	3.04	2.66	0.77	0.68	2.02	2.03	1.21	1.14
Zinc levels (Kg ha^{-1})								
Zn_0	40.55	40.62	10.29	10.31	26.06	26.39	15.63	16.41
Zn_1	43.02	43.11	10.92	10.94	29.78	30.14	17.87	18.76
Zn_2	47.29	47.57	11.98	12.01	32.82	33.22	19.69	20.67
Zn_3	47.76	47.88	12.19	12.22	35.12	35.56	21.07	22.13
SEm±	1.05	0.92	0.27	0.23	0.70	0.70	0.42	0.40
CD at 5%	3.04	2.66	0.77	0.68	2.02	2.03	1.21	1.14
Sulphur X Zinc								
S_0 x Zn_0	33.93	33.98	8.61	8.63	20.54	20.77	12.32	12.94
S_0 x Zn_1	39.73	39.83	10.09	10.11	27.26	27.60	16.35	17.17
S_0 x Zn_2	42.85	42.99	11.03	11.05	29.24	29.61	17.54	18.42
S_0 x Zn_3	43.43	43.54	10.88	10.91	30.59	30.99	18.35	19.27
S_1 x Zn_0	41.02	41.08	10.41	10.43	21.51	21.76	12.91	13.55
S_1 x Zn_1	43.39	43.46	11.02	11.03	27.93	28.26	16.76	17.59
S_1 x Zn_2	48.58	48.65	12.10	12.12	33.98	34.38	20.39	21.41
S_1 x Zn_3	47.64	47.73	12.33	12.35	31.59	31.96	18.96	19.90
S_2 x Zn_0	43.25	43.39	10.98	11.01	31.59	32.12	18.96	19.90
S_2 x Zn_1	44.53	44.68	11.31	11.34	33.31	33.75	19.84	20.98
S_2 x Zn_2	55.69	56.53	14.14	14.19	34.11	34.57	20.46	21.49
S_2 x Zn_3	56.32	55.90	14.30	14.35	40.00	40.55	24.00	25.20
S_3 x Zn_0	43.97	44.02	11.16	11.18	30.59	30.92	18.35	19.27
S_3 x Zn_1	44.42	44.47	11.28	11.29	30.62	30.96	18.37	19.29
S_3 x Zn_2	42.02	42.21	10.68	10.69	33.95	34.32	20.37	21.38
S_3 x Zn_3	44.28	44.33	11.24	11.26	38.32	38.75	22.99	24.13
SEm±	2.11	1.85	0.54	0.47	1.40	1.40	0.84	0.79
CD at 5%	6.09	5.33	1.55	1.35	4.04	4.05	2.43	2.28

Increase in S levels from 0 to 40 Kg ha^{-1} significantly increased the plant height, number of branches $plant^{-1}$, number of nodules $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1}, seed yield and protein content and test weight was non-significant during both the years. The maximum plant height (49.95 and 50.12 cm), number of branches plant^{-1} (12.68 and 12.72), number of nodules plant^{-1} (34.75 and 35.25), number of pods plant^{-1} (20.85 and 21.89), number of seeds pod^{-1} (12.49 and 12.99), test weight (37.83 and 38.73) and seed yield (11.89 and 12.51 q ha^{-1}) and protein content (23.92 and 24.07%) was obtained at 40 Kg S ha^{-1}. However, 60 Kg S ha^{-1} was statistically at par with 40 Kg S ha^{-1} in respect of growth and yield attributes, seed yield and protein content. The process of tissue differentiation from somatic to reproductive meristematic activity and development of floral primordial might have increased with increasing sulphur levels resulting in more flowers and pods, longer pods and higher grain yield. Increase in growth and straw yield can be ascribed to cell division, enlargement and elongation resulting in overall improvement in plant organs associated with faster and uniform vegetative growth of the crop under the effect of sulphur application. Similar findings were also reported by Singh *et al.* (1997), Verma and Yadav (2004) and Srivastava *et al.* (2006).

TABLE-2: Effect of sulphur and zinc levels on number of seeds pod^{-1}, test weight and seed yield and protein content of summer mungbean.

Treatment Interaction	Number of seeds pod-1		Test weight (g)		Seed yield (q ha^{-1})		Protein content (%)	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Sulphur Levels (Kg ha^{-1})								
S_0	9.67	10.06	34.51	35.34	9.21	9.69	18.52	18.63
S_1	10.33	10.75	36.45	37.32	9.84	10.35	19.80	19.89
S_2	12.49	12.99	37.83	38.73	11.89	12.51	23.92	24.07
S_3	11.99	12.48	36.52	37.40	11.42	12.01	22.97	23.10
SEm±	0.22	0.23	0.91	0.81	0.24	0.23	0.48	0.43
CD at 5%	0.63	0.66	NS	NS	0.69	0.65	1.39	1.26
Zinc levels (Kg ha^{-1})								
Zn_0	9.36	9.74	34.60	35.43	8.92	9.38	17.94	18.04
Zn_1	10.70	11.13	36.04	36.90	10.19	10.72	20.50	20.61
Zn_2	11.79	12.27	37.18	38.07	11.23	11.82	22.60	22.72
Zn_3	12.62	13.13	37.50	38.39	12.02	12.65	24.17	24.32
SEm±	0.22	0.23	0.91	0.81	0.24	0.23	0.48	0.43
CD at 5%	0.63	0.66	NS	NS	0.69	0.65	1.39	1.26
Sulphur X Zinc								
S_0 x Zn_0	7.38	7.68	32.77	33.55	7.03	7.39	14.13	14.19
S_0 x Zn_1	9.80	10.19	33.15	33.95	9.33	9.81	18.75	18.88
S_0 x Zn_2	10.51	10.93	35.93	36.79	10.01	10.53	20.13	20.25
S_0 x Zn_3	10.99	11.44	36.20	37.06	10.47	11.01	21.06	21.19
S_1 x Zn_0	7.73	8.04	34.22	35.03	7.36	7.74	14.81	18.48
S_1 x Zn_1	10.03	10.44	36.27	37.14	9.56	10.06	19.25	19.31
S_1 x Zn_2	12.21	12.70	37.48	38.37	11.63	12.23	23.38	23.50
S_1 x Zn_3	11.35	11.81	37.83	38.74	10.81	11.37	21.75	21.88
S_2 x Zn_0	11.35	11.81	36.16	37.02	10.81	11.37	21.75	21.88
S_2 x Zn_1	11.97	12.45	37.57	38.47	11.40	11.99	22.94	23.06
S_2 x Zn_2	12.26	12.75	38.78	39.71	11.67	12.28	23.50	23.63
S_2 x Zn_3	14.37	14.96	38.79	39.72	13.69	14.40	27.50	27.69
S_3 x Zn_0	10.99	11.44	35.25	36.09	10.47	11.01	21.06	21.19
S_3 x Zn_1	11.00	11.45	37.15	38.04	10.48	11.02	21.06	21.19
S_3 x Zn_2	12.20	12.69	37.80	38.70	11.62	12.22	23.38	23.50
S_3 x Zn_3	13.77	14.33	35.90	36.76	13.11	13.79	26.38	26.50
SEm±	0.44	0.45	1.81	1.62	0.48	0.45	0.96	0.87
CD at 5%	1.26	1.31	NS	NS	1.38	1.31	2.78	2.51

Effect of zinc

Application of zinc also increased the growth, yield attributes and yields significantly up to 10 Kg Zn ha^{-1} during both the years (Table-1). The magnitude of increase in seed yield was 23.82% in first year and 25.48% in second year by seed, respectively as compared to control. The increase in growth, yield attributes and 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. Similar results were also reported by Krishna, S. (1995), Singh *et al.* (1997) and Srivastava *et al.* (2006).

Interaction effect of sulphur and zinc

The interaction effect between S x Zn on various parameters of summer mungbean was found significant and test weight of seed interaction effect was found non-significant during both the years. The interaction effect in seed yield was synergistic. The increasing dose of zinc increased the seed yield with increasing dose of sulphur up to 40 Kg S ha^{-1}. The highest seed yield (13.69 and 14.40 q ha^{-1}) was observed in combination with 40 Kg S ha^{-1} and 10 Kg Zn ha^{-1} which was significantly superior over rest of the combinations except 60 Kg S ha^{-1} and 10 Kg Zn ha^{-1}

during 2008-09 and 2009-10, respectively. The minimum seed yield (9.56 and 10.06 q ha^{-1}) was achieved with treatment having 20 Kg S ha^{-1} and 5 Kg Zn ha^{-1} and least was in control during both the years. Similar findings were also reported by Krishna, S. (1995), Aulakh *et al.* (1997), Singh *et al.* (1997), Verma and Yadav (2004), Srivastava *et al.* (2006) and Ved Ram *et al.* (2008). Thus, the recommendations of 40 Kg S ha^{-1} and 10 Kg Zn ha^{-1} can be made to the farmers for successful cultivation of summer mungbean under the agro-ecological conditions of arid area.

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