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EFFECT OF PHOSPHORUS AND SULPHUR ON GROWTH, YIELD AND QUALITY OF MUNGBEAN (*Vigna radiata* L. Wilczek)

Evaliesa E. Marbaniang[1], Engrala Ao[2], Sentimenla[3], Yabi Gadi[4] and A. K. Singh[5]

ABSTRACT

A field experiment was conducted during the *kharif* season of 2017 to study the effect of phosphorus and sulphur on the growth, yield and quality of mungbean (*Vigna radiata* L. Wilczek.). The experiment was laid out in Randomised Block Design (RBD) having three replications. The treatments comprised of four levels of phosphorus @ (0,10,20,30 kg ha^{-1}) and three levels of sulphur @ (0,10,20 kg ha^{-1}).The study revealed that combined application of 30 kg phosphorus and 20 kg sulphur ha^{-1} recorded significantly the highest growth parameters (plant height, number of leaves plant^{-1} and nodulation), yield and yield attributes (number of pods plant^{-1}, number of seeds pod^{-1}, seed yield and stover yield), nutrient content (N, P, K and S) in seed and stover and total nutrient uptake(N, P, K and S) by seed and stover.Protein content in seeds were also found to be increased from 19.98% to 23.06%.Except for soil pH, all the soil parameters *viz.*,organic carbon, available N, P, K and S of the soil after crop harvest were found to be increased with the increasing levels of phosphorus and sulphur.

(Key words:Mungbean,protein, phosphorus, sulphur, quality, yield)

INTRODUCTION

India is a major pulse growing country of the world, accounting roughly for one-third of the total world area under pulses and one-fourth of the total world production. The area under pulses in India is around 30.0 mha with a production and productivity of 25.20 metric tons and 841 kg ha^{-1} respectively (Anonymous, 2018). Nearly 8% of this area is occupied by mungbean. It is the third most important pulse crop in South East Asia after chickpea and pigeonpea.

Its low requirement of inputs and its ability to restore soil fertility through symbiotic nitrogen fixation makes it particularly important to resource poor farmers (Ali *et al*., 2012).It is a drought tolerant crop that can withstand adverse environmental conditions and can be successfully grown in rainfed areas (Anjum *et al*., 2006). It fixes 38 kg ha^{-1} year^{-1} of atmospheric nitrogen to the soil through symbiosis.

India is the largest producer and consumer of mungbean with an area of 4.26 M ha (*kharif and rabi*), 2.01 metric tons production and yield level of 472 kg ha^{-1} (Anonymous, 2018). In Nagaland, the area and production under pulse crop stretches to 37490 hectare and 43110 metric tonnes respectively where mungbean contribute 390 hectare of the total pulse area and 400 tonnes of the total pulse production (Anonymous, 2017). Phosphorus is one of the key nutrient that is responsible for increasing the productivity of pulses. Legume crops need phosphorus for rapid and healthy root development. It hastens the maturity and increases the rate of nodulation and pod development. Fixation of atmospheric nitrogen in leguminous crops is an energy intensive process which needs phosphorus supply to meet its ATP requirement. With increasing phosphorus rates, yield of mung bean is also increased (Nirmal *et al*. 1991). Being a rich source of protein, it needs to be judiciously fertilized with S, as this element plays a key role in protein synthesis. With limited sulphur

1. P.G Student, Deptt. of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema-797601
2. Scientist, All India Coordinated Research Project on Soybean, Nagaland University, Medzhiphema-797106
3. Subject Matter Specialist (Soil Science), Krishi Vigyan Kendra, Nagaland University, Lumami-798627
4. Research Scholar, Deptt. of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema-797106
5. Assoc. Professor, Deptt. of Agricultural Chemistry and Soil Science, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema-797106 and Soil Science, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema-797106.

fertilization in legumes, N_2 fixation is reduced as the nodule development and function is affected (Scherer, 2008). It is thus,considered critical for seed yield, protein synthesis and for improvement in the quality of produce in legumes through their enzymatic and metabolic effects.

Cultivation on marginal to sub-marginal lands with minimal supply of nutrients or unjudicious use of fertilizer are thought to be a major cause for low productivity of mungbean in North easthern India. Besides these, the soils of this region are deficient in phosphorus and sulphur and both the elements have direct role in plant metabolism especially in the pulses. The area and production under mungbean is also low in this region.However, mungbean being a drought tolerant crop can counteract the effects of climate change as it can withstand adverse environmental conditions and can be successfully grown in rainfed areas. Hence, the present investigation was undertaken to study the response of phosphorus and sulphur on growth,yield and quality of mungbean (*Vigna radiata* L. Wilczek).

MATERIALS AND METHOD

A field experiment was carried out during *kharif* season of 2017 at the Agricultural Chemistry and Soil Science Experimental Farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema campus, Nagaland to study the effects of phosphorus and sulphur on the growth, yield and quality of mungbean (*Vigna radiata* L. Wilczek). Initial soil samples were collected from experimental site, processed and physio-chemical properties of soils were analysed with prescribed standard procedure (Jackson, 1973). The experimental soil was sandy clay loam in texture, acidic in reaction (5.3) having 14.2 g kg^{-1} organic C, 278 kg ha^{-1} available N, 15.56 kg ha^{-1} available P and 210 kg ha^{-1}available K. Altogether 12 treatments consisting of four levels of phosphorus (0, 10, 20, 30) kg ha^{-1} and three levels of sulphur (0, 10, 20) kg ha^{-1} were laid out in Randomized Block Design with three replications. The recommended dose of nitrogen and potassium were applied through urea and muriate of potash and phosphorus and sulphur levels were applied through di-ammonium phosphate and elemental sulphur. All fertilizers were incorporated into the plot a day before sowing of the crop. Mungbean variety (K-851) was sown in June, 2017. After harvest, the seeds and stover samples were taken from each plot for analysing N (modified kjeldhal method as described by Black, 1965), P (vanado-molybdate yellow colour method as outlined by Jackson, 1973), K (Chapman and Pratt, 1961) and S (turbidimetric method as detailed by Chesnin and Yien, 1950). Seed protein content (%) wasestimated by multiplying percent N content in seed with the factor 6.25. Composite soil samples were also collected plot wiseafter harvest and available N, P, K were analysed as per the method described by Jackson (1973).

RESULTS AND DISCUSSION

Effect of phosphorus and sulphur levels on growth attributes of mungbean

Perusal of the data (Table 1) indicates that increasing levels of phosphorus had significant effect on growth performance at different growth stages (30, 45 and 60 DAS) of mungbean *viz.,* plant height, number of leaves $plant^{-1}$ and nodulation at flowering stage.At all the growth stages, application of phosphorus 30 kg P_2O_5 ha^{-1} recorded significantly the highest plant height (35.93, 63.40 and 72.34 cm) at 30, 45 and 60 DAS respectively and the number of leaves $plant^{-1}$ (13.67, 16.00 and 29.56) was also increased at 30, 45 and 60 DAS respectively over control (P_0). The increase in plant height and number of leaves may be attributed to the application of phosphorus which plays an important role in plant physiological process, as it helps for better root growth to extract nutrients and moisture more efficiently from the deeper soil layer. It was also observed that increasing the application of phosphorus increased the nodule formation in green gram. The highest nodulation (30.11) at flowering stage was observed at 30 kg P_2O_5 $ha^{-1}$and lowest was recorded in control (17.11). This may be attributed to the fact that phosphorus hastens the maturity and increases the rate of nodulation in leguminous crops as it is a constituent of nucleic acid and different forms of proteins, which might have stimulated cell division. Patel *et al*. (2013) also reported that phosphorus is the main element in the process of photosynthesis, root formation and development, growth, yield and crop maturity.

Similarly, increasing levels of sulphur showed significant effect on plant height, number of leaves $plant^{-1}$ and nodulation at flowering (Table 1). Sulphur application of 20 kg ha^{-1} recorded significantly the highest values of plant height (29.77, 49.73, 62.78 cm) at (30, 45 and 60) DAS and number of leaves $plant^{-1}$ (13.42, 15.67, 26.00) at 30, 45 and 60 DAS.Nodulation at flowering stage also recorded the highest value (25.58) with the application of 20 kg S ha^{-1} whereas the lowest (22.50) was recorded in control. Sulphur fertilization increases photosynthetic activity in plant resulting into improvement in plant height, branches, leaves and dry matter accumulation. Favourable effect of sulphur application on growth parameters of green gram has also been reported by Tripathi *et al.*(2011). Combined application of 30 kg P and 20 kg S ha^{-1} also showed significant influence on plant height, number of leaves $plant^{-1}$ and nodulations. Tomar *et al.* (2004) also found the positive interaction effect of P and S on the plant height of soybean.

Effect of phosphorus and sulphur levels on yield, yield attributes and quality of mungbean

The treatment receiving 30 kg $ha^{-1}$of phosphorus recorded the highest number of pods $plant^{-1}$ (17.33), number of seeds pod^{-1} (14.33), seed yield (350 kg ha^{-1}) and stover yield (472.23 kg ha^{-1}) as compared to control (Table 2).Mungbean responds well to P fertilization since P influences enzymatic activities which control flowering, fruiting and seed formation. Phosphorus application may mobilize the photosynthesis from growing organs to grains, consequently increasing their number, size and yield. Singh *et al.* (2015) also reported that application of phosphorus upto 40 kg P_2O_5 ha^{-1} gave significantly higher number of pods $plant^{-1}$,number of seeds pod^{-1},seed yield and stover yield in mungbean under rainfed condition. The number of pods $plant^{-1}$, seeds pod^{-1} and seed yield were increased at the increasing levels of phosphorus.

Increasing levels of sulphur application improved the number of pods $plant^{-1}$, number of seeds pod^{-1}, seed and stover yield. The highest number of pods (14.92), number of seeds pod^{-1} (12.92), seed yield (286.11 kg ha^{-1}) and stover yield (396.95 kg ha^{-1}) were recorded with the application of 20 kg S ha^{-1}over control. The increase in yield attributing characters might be due to the supply of sulphur in adequate and appropriate amounts which helps in flower primordial initiation for its reproductive part, which govern number of pods $plant^{-1}$, number of seeds pod^{-1}, length of pods (Dey and Basu,2004).It might also be due to the important role of sulphur in energy transformation, activation of a number of enzymes and also in carbohydrate metabolism. Plants well supplied with sulphur are expected to have efficient photosynthetic mechanism and better equipped for efficient translocation to sink site, consequently resulting into improved seed yield.Tripathi *et al.* (2011) and Bainade *et al.* (2018) also recorded significant increase in seed yields of urdbean and linseed due to sulphur fertilization respectively.

Protein content in seeds of mungbean varied from 20.33 to 22.75 %. Application of 30 kg ha^{-1} phosphorus enhanced protein content significantly over control (Table 2). Improvement in protein content may be due to the increase in nitrogen content due to phosphorus application. Increase in protein content in summer greengram due to phosphorus fertilization was also reported by Mitra *et al.* (2006). Further, different levels of sulphur application showed significant effect on the protein content in seeds. With the increasing sulphur levels,the highest protein content of 21.99% was recorded at 30 kg ha^{-1} over control (21.42%). Bainade *et al.* (2019) also found significant increased in protein content in linseed through sulphur application.Punse *et al.* (2018) also observed that the application of 60 kg phosphorus and 30 kg sulphur ha^{-1} improved the protein content and protein yield of greengram.

Effect of phosphorus and sulphur levels on N, P, K and S content in seed and stover and total nutrient uptake

Application of phosphorus @ 30 kg ha^{-1} significantly increased N, P, K and S content in both seed and stover (Table 3). Enhancement in nitrogen content in seed and stover might be due to the better growth of root system and thus increased nitrogen absorption, which resulted in increased nitrogen content. Tanwar and Shaktawat (2003) also observed increase in protein content in soybean seeds with phosphorus application. Increase in phosphorus content in seed and stover might be due to the reason that phosphorus application enhanced the supply of phosphorus in soil solution that resulted in the plant to absorb more phosphorus. Furthermore phosphorus application increased the total volume of roots which provide large root area for phosphorus absorption by plant (Singh *et al.*, 2015).The increase in potassium content in seed and stover with the application of phosphorus might be due to favourable effect of phosphorus on root development of the plants by absorbing more nutrients from the soil (Kumawat *et al.*,2009).The total uptake of NPK and S were also higher with the application of 30 kg P_2O_5 ha^{-1}. Dhage *et al.*(2014) reported increase in phosphorus and sulphur uptake in soybean with phosphorus and sulphur fertilization. Kumawat *et al.*(2009) also reported uptake of N, P and K in mungbean as influenced by organic manures, PSB and phosphorus fertilization.

Sulphur application also enhanced N, P, K and S content significantly over control in both seed and stover (Table 4). Maximum values were recorded @ 20 kg ha^{-1} sulphur. It might be due to the increased availability of sulphur which further increased nitrogen availability.Sulphur also synthesized some sulphur containing amino acids like cystine, cysteine and methionine and thus resulting in increase in the synthesis of protein. Mazel *et al.*(2016) also observed significant increase in NPK and S content in seed and stover of mungbean with sulphur application.There was also significant effect on the total uptake by plant at different levels of sulphur. Sulphur application at 20 kg ha^{-1} recorded the highest values. Tripathi *et al.* (2011) also observed significant increase in the uptake of N, K and S both in grain and stover with increasing levels of Sulphur. Combined application of 30 kg P and 20 kg S ha^{-1} produced significant result on total nutrient (NPKS) uptake(Table 6). Das *et al.* (2017) also observed positive interaction of phosphorus and sulphur on total N and P uptake in greengram.

Effect of phosphorus and sulphur levels on pH, organic carbon, N, P, K and S in the soil after harvest

The increase in total P and S uptake in urdbean due to phosphorus and sulphur interaction was also reported by Tripathi *et al.* (2011).

Application of different levels of phosphorus and sulphur did not have any significant effect on the pH of the soil (Table 4).Significantly higher values of soil organic carbon, available N,P,K,S in soil after harvest were observed to increase significantly at 30 kg phosphorus and 20 kg sulphur ha^{-1} individually.The maximum soil organic carbon was observed at combined application of 30 kg P and 20 kg S ha^{-1}. The interaction effect of phosphorus and sulphur on available soil nitrogen was found to be significant at 30 kg P and 20 kg S ha^{-1} and 30 kg P and 10 kg S ha^{-1}(Table 6). The highest available soil P, K and S were recorded at 30 kg P and 20 kg S ha^{-1}.

From the present study, it was concluded that phosphorus and sulphur application played an important role in improving the growth, yield attributes, yield and quality of green gram. Application of 30 kg P_2O_5 ha^{-1} and 20 kg S ha^{-1} proved to be an optimum dose for getting better yield, quality and nodulation under acidic soils of Nagaland.

Table 1. Effect of phosphorus and sulphur levels on growth attributes of mungbean at different days after sowing

Treatments	Plant height (cm)			Number of leaves plant^{-1}			Nodulation at flowering stage
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	
P_0	20.80	32.51	48.01	12.11	14.00	23.56	17.11
P_{10}	25.11	40.74	54.74	13.22	15.78	24.33	22.56
P_{20}	29.44	50.50	65.41	13.67	15.44	24.56	26.44
P_{30}	35.93	63.40	72.34	13.67	16.00	29.56	30.11
SE(m)±	0.33	0.35	0.37	0.33	0.44	0.39	0.25
CD (p=0.05)	0.97	1.02	1.08	0.97	1.28	1.16	0.72
S_0	25.73	44.14	57.36	13.08	14.58	24.50	22.58
S_{10}	27.97	46.49	60.25	13.00	15.67	26.00	24.08
S_{20}	29.77	49.73	62.78	13.42	15.67	26.00	25.50
SE(m)±	0.29	0.30	0.32	0.29	0.38	0.34	0.21
CD (p=0.05)	0.84	0.88	0.93	-	-	1.00	0.62

Table 2. Effect of phosphorus and sulphur levels on yield and yield attributes of mungbean

Treatments	No. of pods plant^{-1}	No. of seeds pod^{-1}	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Protein content (%)
P_0	11.11	9.56	183.34	286.30	20.33
P_{10}	13.11	11.89	242.60	341.49	21.54
P_{20}	15.00	13.44	290.00	412.67	22.15
P_{30}	17.33	14.33	350.00	472.23	22.75
SE(m)±	0.17	0.17	1.78	1.87	0.02
CD (p=0.05)	0.49	0.49	5.23	5.49	0.06
S_0	13.33	11.75	248.89	363.67	21.42
S_{10}	14.17	12.25	264.45	373.89	21.67
S_{20}	14.92	12.92	286.11	396.95	21.99
SE(m)±	0.15	0.15	1.54	1.62	0.02
CD (p=0.05)	0.43	0.43	4.53	4.75	0.05

Table 3. Effect of phosphorus and sulphur levels on N, P, K and S content in seed and stover at harvest and total nutrient uptake

Treatments	N			P			K			S		
	Seed (%)	Stover (%)	Total uptake (kg ha^{-1})	Seed (%)	Stover (%)	Total uptake (kg ha^{-1})	Seed (%)	Stover (%)	Total uptake (kg ha^{-1})	Seed (%)	Stover (%)	Total uptake (kg ha^{-1})
P_0	3.25	1.14	9.18	0.23	0.13	0.80	1.14	1.39	6.02	0.24	0.19	1.00
P_{10}	3.45	1.26	12.52	0.30	0.15	1.24	1.20	1.44	7.75	0.26	0.21	1.34
P_{20}	3.55	1.31	15.67	0.35	0.18	1.71	1.24	1.45	9.57	0.28	0.21	1.65
P_{30}	3.64	1.40	19.34	0.39	0.20	2.29	1.30	1.47	11.48	0.29	0.22	2.02
SE(m)±	0.003	0.004	0.08	0.002	0.002	0.009	0.002	0.002	0.04	0.003	0.002	0.02
CD (p=0.05)	0.010	0.011	0.24	0.005	0.005	0.025	0.005	0.006	0.11	0.009	0.005	0.05
S_0	3.43	1.25	13.14	0.30	0.15	1.37	1.20	1.43	8.18	0.25	0.20	1.33
S_{10}	3.47	1.27	14.07	0.32	0.16	1.49	1.22	1.44	8.66	0.27	0.21	1.49
S_{20}	3.52	1.31	15.32	0.33	0.17	1.67	1.24	1.45	9.29	0.29	0.22	1.69
SE(m)±	0.003	0.003	0.07	0.001	0.002	0.007	0.002	0.002	0.04	0.003	0.002	0.02
CD (p=0.05)	0.009	0.009	0.20	0.004	0.005	0.022	0.005	0.005	0.11	0.008	0.005	0.05

Table 4. Effect of phosphorus and sulphur levels on pH, organic carbon, N, P, K and S in the soil after harvest

Treatments	pH	Organic carbon (g kg^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})
P_0	5.31	14.60	224.40	16.68	216.31	24.27
P_{10}	5.33	13.92	281.54	18.83	295.89	25.46
P_{20}	5.37	15.21	263.42	24.12	315.76	25.99
P_{30}	5.40	16.01	313.60	26.84	340.57	26.66
SE(m)±	0.04	0.22	3.37	0.44	8.66	0.11
CD (p=0.05)	-	0.64	9.89	1.30	25.41	0.32
S_0	5.37	14.42	265.51	20.41	282.01	24.70
S_{10}	5.33	15.14	277.01	21.06	289.79	25.81
S_{20}	5.36	15.25	269.70	23.38	304.60	26.27
SE(m)±	0.04	0.19	2.92	0.38	7.50	0.09
CD (p=0.05)	-	0.55	8.56	1.13	-	0.27

Table 5. Interaction effect of phosphorus and sulphur levels on growth attributes, yield and yield attributes of mungbean.

Phosphorus x Sulphur	Plant Height (cm)	Number of leaves plant^{-1}	No. of nodules	No. of pods plant^{-1}	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
P_0S_0	46.10	23.67	14.67	10.00	168.89	272.22
P_0S_{10}	48.20	23.67	17.33	11.67	180.01	282.23
P_0S_{20}	49.73	23.33	19.33	11.67	201.11	304.45
$P_{10}S_0$	51.30	23.33	21.00	12.33	216.67	334.45
$P_{10}S_{10}$	55.83	25.67	23.00	13.33	241.11	330.00
$P_{10}S_{20}$	57.10	25.00	23.67	13.67	270.00	360.00
$P_{20}S_0$	61.73	25.00	25.67	14.67	277.78	395.78
$P_{20}S_{10}$	65.53	24.33	26.00	14.67	287.78	411.12
$P_{20}S_{20}$	68.97	24.33	27.67	15.67	304.45	431.11
$P_{30}S_0$	70.30	27.00	29.00	16.33	332.23	452.23
$P_{30}S_{10}$	71.43	30.33	30.00	17.00	348.89	472.23
$P_{30}S_{20}$	75.30	31.33	31.33	18.67	368.89	492.23
SE(m)±	0.64	0.68	0.43	0.29	3.09	3.24
CD (p=0.05)	1.87	2.00	1.25	0.86	9.06	9.50

Table 6. Interaction effect of phosphorus and sulphur levels on nutrient uptake (seed and stover) and soil fertility status.

Phosphorus x Sulphur	Nutrient uptake (seed+stover) (kg ha^{-1})				Soil fertility status (kg ha^{-1})					
	N	P	K	S	pH	Organic carbon (g kg^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (kg ha^{-1})
P_0S_0	8.36	0.71	5.68	0.89	5.30	14.17	188.16	14.08	202.56	23.17
P_0S_{10}	9.03	0.77	5.95	0.98	5.30	14.23	242.52	16.22	235.36	24.32
P_0S2_0	10.13	0.92	6.44	1.12	5.33	15.40	242.52	19.74	211.01	25.32
$P_{10}S_0$	11.20	1.09	7.11	1.21	5.37	13.83	292.69	18.82	278.24	24.51
$P_{10}S_{10}$	12.45	1.20	7.65	1.30	5.27	14.37	288.51	17.07	281.15	26.06
$P_{10}S_{20}$	13.93	1.43	8.50	1.52	5.37	13.57	263.42	20.59	328.29	25.80
$P_{20}S_0$	14.79	1.58	9.12	1.44	5.47	14.53	301.06	22.11	291.16	25.04
$P_{20}S_{10}$	15.58	1.69	9.51	1.66	5.23	16.27	246.70	24.44	344.69	26.06
$P_{20}S_{20}$	16.65	1.88	10.09	1.84	5.40	14.83	242.52	25.82	311.44	26.86
$P_{30}S_0$	18.21	2.12	10.80	1.76	5.33	15.13	280.15	26.63	356.08	26.08
$P_{30}S_{10}$	19.22	2.29	11.52	2.03	5.53	15.70	330.33	26.51	297.96	26.79
$P_{30}S_{20}$	20.58	2.47	12.11	2.26	5.33	17.20	330.33	27.38	367.67	27.10
SE(m)±	0.14	0.015	0.08	0.03	0.07	0.38	5.84	0.77	15.00	0.19
CD (p=0.05)	0.41	0.044	0.23	0.09	NS	1.11	17.12	2.26	44.00	0.55

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