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Response of Liming Materials and Phosphorus on Growth and Yield of Soybean in a Dystrudept of Nagaland

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ABSTRACT

A field experiment was conducted during the rainy (kharif) season of 2018 and 2019 on different liming materials and phosphorus to evaluate the influence of different liming materials and levels of phosphorus on growth attributes, yield attributes and yield of soybean [*Glycine max* (L.) Merr.]. All the liming materials (no lime, WA @ 0.4 LR, PMS @ 0.4 LR and CS @ 0.4 LR and P levels (0, 40, 60 and 80 kg P_2O_5 ha^{-1}) significantly increased plant height, leave $plant^{-1}$,branches $plant^{-1}$, number of root nodules $plant^{-1}$, root length and root dry weight at different crop growth stages at 30, 60 and 90 DAS. Application of liming materials and P levels significantly increased pods $plant^{-1}$, 100 seed weight, grain and stover yield.Interaction effect of liming material and P was also significant for the parameters plant height, number of root nodules $plant^{-1}$, root length, number of pods $plant^{-1}$, stover and grain yield. The highest yield was found with an application of calcium silicate @ 0.4 LR along with 80 kg P_2O_5 ha^{-1}.

KEYWORDS

Dystrudept, Liming materials, Phosphorus, Soybean, Yield

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INTRODUCTION

The acid soil occupies 99.5 per cent of total geographical area in Nagaland. Out this area, about 1.60 m ha of acid soil (pH less than 5.5) is strongly acidic in nature. Another 0.5 m ha of acid soil (pH 5.5-6.5) is moderate to slightly acidic in nature. Soils of the state are acidic and deficient in available P. Low availability of phosphorus in these soils is due to fixation of P by Fe and Al oxides. Liming is the addition of a compound containing calcium or calcium plus magnesium to the acid soils that are capable of reducing the acidity of the soil. Soybean (*Glycine max* (L.) Merrill) is known as 'Golden bean' and miracle crop of 20^{th} century (Naik *et al*, 2018). Soybean is the world's most important legume in terms of production and trade and has been a dominant oilseed since the 1960s (Smith and Huyser, 1987). It contains about 40-42 %protein and 20-22 %oil (Barik and Chandel, 2001). In addition to its nutritional values, Soybean is also used as important nitrogen (N_2)-fixing crop throughout the world for the restoration and maintenance of soil fertility in a sustainable way and consequently the improvement of crop yields (Smaling *et al*, 2008). Soybean has the capacity to fix about 240-250 N ha^{-1} through symbiosis. The nitrogen requirement of soybean is substantially fulfilled through symbiotic nitrogen fixation with rhizobium. In India, it is now the second largest oilseed after groundnut. Total area of soybean in India is 11.67 million ha with production of 8.59 mt during year 2015-16 with an average national yield of 737 kg ha^{-1}. Soybean occupied 42% of India's total oilseeds and 25% of edible oil production (Source - Agricultural Statistic at a Glance 2016, Directorate of Economics & Statistics, Ministry of Agriculture, Govt. of India). In Nagaland, it was estimated that the area, production and productivity of soybean during the year 2015-2016 was 24.68 thousand ha, 31.17 thousand tonne and 1254 kg ha^{-1} respectively (Statistical Handbook of Nagaland, Directorate of Economics & Statistics Govt. of Nagaland, 2017). Low phosphorus in soil is a major constraint for soybean growth and production, which are atmospheric nitrogen (N_2) dependent (Bordeleau and Prévost, 1994) because phosphorus is particularly important for symbiotic N_2 fixation in legumes (Zahran, 1999). When phosphorus rate in soil is low, this process can be strongly undermined and thus becomes a principal yield-limiting nutrient (Pereira and Bliss 1989). Most leguminous plants require a neutral or slightly acidic soil for growth (Brockwell *et al*, 1991). Soybeans thrive in the pH range of 6.0 to 6.8. Soil phosphorus tests provide an indication of the level of soil phosphorus in plant. The test provides an index of phosphorus measurement that can be taken up by plant (Watson and Mullen, 2007). Soybean is emerging as an important crop of Nagaland. Soybean being a leguminous oilseed requires relatively large amounts of phosphorus than other crops (Laltlanmawia *et al*, 2004). Adequate supply of phosphorus in early stage of plant growth is important for development of roots as well as for seed formation and yield. As very little information is available on liming materials and phosphorus in acid soil of Nagaland, the present investigation was conducted to study the individual and interaction effect of liming materials and phosphorus levels on growth attributes, yield attributes and yields of soybean.

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MATERIALS AND METHODS

The field experiment was conducted at the research farm of SASRD, Nagaland University, Medziphema (20°45′43″ N and 93°53′04″ E) during kharif season in 2018 and 2019 with average annual rainfall of 200 - 250 cm and temperature 13°C - 32°C.The experiment was laid out in a split plot design on soybean variety JS-335 with liming materials i.e., no liming material, wood ash @ 0.4 LR, paper mill sludge @ 0.4 LR and calcium silicate @ 0.4 LR (M_0, M_1, M_2 andM_3 respectively) in main plot and phosphorus levels i.e., 0, 40, 60and 80 kg P_2O_5 ha^{-1}as single supper phosphate(P_0, P_{40}, P_{60} and P_{80}respectively) in sub plot with 16 treatments and each treatment replicated three time. The soil of experimental plot was sandy clay loam having pH5.3, organic carbon 0.9 %, available N, P, K and S as 240.69, 10.82, 229.93 and 2.62 kg ha^{-1} and lime requirement 9.88 t $CaCO_3$ ha^{-1}. Initial soil sample were analyzed for different soil properties such as pH with a pH meter in soil:water suspension 1:2.5, Jackson 1973, organic carbon by Walkely and Black rapid titration method, available N by Alkaline $KMnO_4$ method, Subbiah and Asija, 1956 , available P by ascorbic acid method, Bray and Kurtz, 1982, available K by Flame photometer method, Hanway and Heidel, 1952 and available S by Turbidimetric method using $BaCl_2$, Chesin and Yien, 1951**.** A common basal dose of 20 kg N ha^{-1} as urea and 30kg K_2O ha^{-1} as muriate of potash were also applied to all plots. The observations were recorded on randomly selected 5 samples and their mean was taken for analysis at 30, 60 and 90 DAS. Observations to be recorded under growth attributes viz. plant height, number of leaves $plant^{-1}$, number of branches $plant^{-1}$, root length, and number of root nodules $plant^{-1}$ under yield attributes numbers of pods $plant^{-1}$, number of seed pod^{-1}, seed test weight, grain and stover yield. All the observed data were statistically analyzed by method of analysis of variance prescribed by Gomez and Gomez, 1984.

RESULTS AND DISCUSSION

Growth attributes

Improvement in growth characters considered to be prerequisite to increased yield. Liming materials and phosphorus play very important role in enhancing the growth characters which results in improved crop yield. All the growth attributes parameters of soybean increased significantly with different liming materials and increasing levels of P over control at different crop growth stages at 30, 60 and 90 DAS. Among the liming materials, CS @ 0.4 LR recorded the highest plant height (47.30 cm), number of leaves (24.12), number of branches (5.77), root length (26.67 cm) and number of root nodules (23.33) at 90 DAS and (Table 1). Application phosphorus observed significant increased in growth attribute and maximum value were recorded with 80 kg P_2O_5 ha^{-1}.The interaction effect of liming materials and P was significant, there by indicating a more beneficial effect of the two in combination on plant height, root length, and number of root nodules. The highest plant height (63.63 cm), root length (52.33 cm) and number of root nodules (51.67) were recorded in the plot receiving calcium silicate @ 0.4 LR + 80 kg P_2O_5 ha^{-1}.The result is in conformity with the finding of Rakesh *et al* (2014). The increase in crop growth rate with liming may result from better availability of nutrients due to moderation of soil reaction. Okpara *et al* (2007) and Bekere *et al* (2013) also reported that liming significantly increased number of nodules $plant^{-1}$, nodules volume and nodules dry weight also reported that liming increased the weight nodule $plant^{-1}$compared to no limed treatment.

Yield attributes

The number of pods $plant^{-1}$of soybean was significantly increasedwith different liming materials and increasing levels of P over control. Among the limning materials, calcium silicate @ 0.4 LR recorded the highest pods $plant^{-1}$(63.57) and the plot receiving 80 kg P_2O_5 $ha^{-1}$was found the highest pods $plant^{-1}$(77.37) (Table 1). Among the interaction, interaction of calcium silicate @ 0.4 LR and 80 kg P_2O_5 ha^{-1} gave the highest pods $plant^{-1}$(88.50). All the levels of P increased the pods $plant^{-1}$ significantly at each liming materials. The result indicated that the utilization of P for plant growth was associated with a concomitant supply of liming materials. Wijanarko et al. (2016) also reported that liming increased number of pods $plant^{-1}$. The higher value of stover yield at higher level of phosphorus is owing to significantly higher value of dry matter per plant beside the other growth and yield parameters. These finding are in conformity with the results of Sarker *et al* (2014).This might be attributed to significant increase in nodulation, nitrogenase activity, growth and efficient nutrient uptake (Srivastava *et al*, 1998). Seeds pod^{-1} was found non-significant with application liming materials and P levels. Seed test weight was significantly increased with different liming materials and increasing levels of P over control. Calcium silicate @ 0.4 LR recorded the highest seed test weight (12.23 g) and the lowest (12.15 g) with no liming material. The plot receiving 80 kg P_2O_5 $ha^{-1}$was found the highest seed test weight (12.27 g) and lowest with 0 kg P_2O_5 ha^{-1}(12.15 g). Their interaction was not significant effect on seed test weight of soybean. Bhattacharjee *et al* (2013) also reported that yield parameters responded positively to higher dose of P (90 kg P_2O_5 ha_{-1}).

Grain and stover yield

Application of calcium silicate @ 0.4 LR and 80 kg P_2O_5 ha^{-1} produced significantly higher grain and stover yield as compared to control (Table 2). The highest grain yield (2196.44 kg ha^{-1}) was recorded with application of calcium silicate @ 0.4 LR and 80 kg P_2O_5 ha^{-1}.

Table 1: Effect of liming materials and phosphorus on growth attributes of soybean (Pooled mean of 2years)

Plant height at 90 DAS (cm)					
Liming materials	Phosphorus levels				
	P_{0}	P_{40}	P_{60}	P_{80}	
M_0	45.13	49.83	52.13	54.30	50.35
M_1	45.97	52.43	54.47	56.30	52.29
M_2	46.03	53.33	55.27	58.07	53.18
M_3	47.30	55.17	59.07	63.63	56.29
Mean	46.11	52.69	55.24	58.08	
SEm±	M=0.63		P=0.48 MxP=0.96		
CD (P=0.05)	M=1.94		P=1.37 MxP=2.74		
Numbers of leave at 90 DAS					
M_0	21.15	24.65	26.58	27.95	25.08
M_1	22.92	25.75	28.05	30.35	26.77
M_2	23.15	27.52	28.68	31.22	27.64
M_3	24.12	27.68	31.52	33.75	29.27
Mean	22.84	26.40	28.71	30.82	
SEm±	M=0.46		P=0.31 MxP=0.61		
CD (P=0.05)	M=1.42		P=0.87 MxP= NS		
Numbers of branches at 90 DAS					
M_0	5.17	5.67	5.9	6.20	5.74
M_1	5.37	5.98	6.28	6.38	6.00
M_2	5.60	6.13	6.40	6.5	6.16
M_3	5.77	6.53	7.00	7.10	6.60
Mean	5.48	6.08	6.40	6.55	
SEm±	M=0.10		P=0.09 MxP=0.18		
CD (P=0.05)	M=0.32		P=0.25 MxP=NS		
Numbers of root nodules plant^{-1} at 90 DAS					
M_0	6.00	6.83	18.00	25.83	14.17
M_1	22.00	27.33	33.00	46.67	32.25
M_2	15.67	20.33	32.00	43.17	27.79
M_3	23.33	22.00	46.33	51.67	35.83
Mean	16.75	19.12	32.33	41.84	
SEm±	M=0.30		P=0.23 MxP=0.47		
CD (P=0.05)	M=0.92		P=0.66 MxP=1.32		
Root length at 90 DAS (cm					
M_0	19.00	21.67	23.00	23.67	21.84
M_1	20.00	22.00	25.33	31.00	24.58
M_2	22.33	28.00	39.33	49.00	34.67
M_3	26.67	33.33	43.33	52.33	38.92
Mean	22.00	26.25	32.75	39.00	
SEm±	M=0.26		P=0.21 MxP=0.42		
CD (P=0.05)	M=0.79		P=0.59 MxP=1.19		

Table 2: Effect of liming materials and phosphorus on yield and yield attributes of soybean (Pooled mean of 2years)

Liming materials	Phosphorus levels				
	P_0	P_{40}	P_{60}	P_{80}	
Grain yield (kg ha^{-1})					
M_0	1501.59	1711.38	1803.56	1835.79	1713.08
M_1	1598.08	1773.33	1801.22	1913.53	1771.54
M_2	1623.39	1794.05	1965.08	2102.38	1871.23
M_3	1655.88	1826.19	2090.35	2196.44	1942.22
Mean	1594.74	1776.24	1915.05	2012.04	
SEm±	M=18.83		P=13.18 MxP=26.37		
CD (P=0.05)	M=58.04		P=37.49 MxP=74.98		
Stover (kg ha^{-1})					
M_0	1926.75	2246.43	2345.4	2436.03	2238.65
M_1	2033.97	2349.6	2467.54	2651.11	2375.56
M_2	2133.25	2367.54	2570.71	2664.6	2434.03
M_3	2214.06	2422.7	2573.89	2742.62	2488.32
Mean	2077.01	2346.57	2489.39	2623.59	
SEm±	M=15.47		P=18.22 MxP=36.44		
CD (P=0.05)	M=47.67		P=51.81 MxP=103.61		
Number of pod plant^{-1}					
M_0	58.27	68.30	70.93	77.37	68.72
M_1	60.30	69.57	74.77	81.27	71.48
M_2	61.07	72.27	77.37	83.33	73.51
M_3	63.57	74.90	83.33	88.50	77.58
Mean	60.803	71.26	76.6	82.62	
SEm±	M=0.59		P=0.79 MxP=1.09		
CD (P=0.05)	M=1.89		P=1.55 MxP=3.11		
Number of seed pod^{-1}					
M_0	2.73	2.83	2.87	2.87	2.83
M_1	2.77	2.73	2.87	2.87	2.81
M_2	2.83	2.80	2.80	2.87	2.83
M_3	2.93	2.90	2.97	2.97	2.94
Mean	2.82	2.82	2.88	2.90	
SEm±	M=0.03		P= 0.03 MxP=0.05		
CD (P=0.05)	M=NS		P= NSMxP=NS		
100 grain weight (g)					
M_0	12.15	12.18	12.20	12.27	12.20
M_1	12.17	12.22	12.25	12.30	12.24
M_2	12.20	12.25	12.28	12.33	12.27
M_3	12.23	12.30	12.35	12.38	12.32
Mean	12.19	12.24	12.27	12.32	
SEm±	M=0.015		P= 0.017 MxP=0.034		
CD (P=0.05)	M=0.043		P= 0.052MxP=NS		

Application of calcium silicate @ 0.4 LR and 80 kg P_2O_5 ha^{-1} had resulted in highest stover yield of 2742.62 kg ha^{-1} over control yield of 1926.75 kg ha^{-1}.

The positive response of soybean to applied lime and P might be due to the improvement of soil pH in response to lime amendment, which enhanced growth and yield of the plant, as a result of increased availability of P that might have increased intensity of photosynthesis, flowering, seed formation and fruiting (Chalk *et al*, 2010). Ameyu and Asfaw (2020) also reported the similar results. The increase in seed yield might be due to more number of of pods per plant, seeds per pod and hundred seed weight. Ilbas and Sahn (2005), Tapas and Gupta (2005) and Jain (2015) also reported that seed yield of soybean increase with inoculation and applying higher levels of phosphorus.

CONCLUSIONS

The application of liming material with 80 kg P_2O_5 $ha^{-1}$was found to be beneficial for increasing the growth and yield attributes, yield of grain and stover of soybean in a Dystrudept of Nagaland.

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