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RESPONSE OF SOYBEAN TO DIFFERENT LEVELS OF PHOSPHORUS AND SULPHUR ON GROWTH, YIELD AND QUALITY

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ABSTRACT

A pot experiment was conducted to study the "Response of soybean (*Glycine max*. L. Merrill) to different levels of phosphorus and sulphur on growth, yield and quality" at the Department of Agricultural Chemistry and Soil Science of SASRD, Medziphema, Nagaland University during the year 2018. The investigation was done in Completely Randomized Design (CRD) with sixteen treatments and three replications. The treatments comprised four levels of phosphorus (0, 20, 40, 60 kg ha^{-1}) and four levels of sulphur (0, 10, 20, 30 kg ha^{-1}) from SSP and elemental sulphur respectively. The data revealed that number of pods, seed and stover yield increased significantly with increase in the rate of application of phosphorus @ 60 kg ha^{-1} and sulphur @ 30 kg ha^{-1} individually. The maximum number of pods pot^{-1}(51.09), seed yield pot^{-1}(13.26 g) and stover yield pot^{-1} (18.61 g) were found at combined application of 60 kg P_2O_5 and 30 kg ha^{-1}. Interaction effect of phosphorus and sulphur increased both seed and stover yield as well as oil content. With higher levels of phosphorus and sulphur increased nutrient content as well as uptake (NPKS) in both seed and stover. Based on the results of this investigation, it is observed that the combined application of 60 kg P_2O_5 and 30 kg S ha^{-1} is recommended for optimum growth, yield and quality of soybean under acidic soils of Nagaland.

(Key words: Soybean, phosphorus, sulphur, growth, yield, quality)

INTRODUCTION

Soybean (*Glycine max* L. Merrill) is considered as one of the dominant protein and oil containing crops of the world also named as the *"Golden Bean"* of the twentieth century due to its high nutritional value and myriad form of its application and uses. It contents oil (18-20%), quality protein (40-42%) and different nutrients like iron, calcium and glycine (Devi *et al.,* 2012). Besides these, as a legume crop, it is also an optimal component of a sound agricultural system which also serves as a means for improving the soil through their capacity to fix atmospheric nitrogen within the soil. Generally, in India the optimum productivity of soybean crop is lesser as compared to other advanced or developing countries.

The north-eastern regions of the country are one of the assuring soybean growing regions, where the crops are grown mostly on terraces, *jhum* lands, slopes, and plains. Soybean is often consumed as a fermented food in the state of Nagaland. Soybean covers an area of 11.3 million hectares and contributes 0.96 metric tons hectare^{-1} (Anonymous, 2019). The main drawback to crop growth and production are those caused by deficiency of plant nutrients. Therefore, interaction of nutrients is one of the important factors for balanced nutrition for a successful crop production.

Soybean is a sulphur loving plant. Sulphur is a significant secondary nutrient which helps in the synthesis of various amino acids such as methionine, cysteine and cystine, vitamins such as biotin, thiamine and chlorophyll. The availability of phosphorus is quite low in the acidic soils and has become a limiting factor for plant and root growth (Okada *et al*., 2011 and Zafar *et al.,* 2004). Phosphorus plays a very crucial role as a plant nutrient from the very young stages of growth for optimum growth and higher crop production (Grant *et al*., 2001). It has a positive effects on root growth, nodule formation, pod development, increase maturity and nitrogen fixation in leguminous crops. Hence, these nutrients are imperative for good field performance.

However, very meagre information is available on response of soybean to phosphorus and sulphur nutrition

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in the foothill of Nagaland. Therefore, there is a great possibility to increase its production by adequate supply of nutrients especially phosphorus and sulphur to the crop.

MATERIALS AND METHODS

The pot experiment was performed in the Department of Agricultural Chemistry and Soil Science, School of Agricultural Science and Rural Development, Nagaland University, Medziphema Campus in Nagaland at an altitude of 310 m above mean sea level with the geographical area of 25045'43" North latitude and 93053'04" East longitude. The location has a tropical sub-humid climate zone of relatively high humidity with a mean temperature ranges from 21^0C to 32^0C during summer and rarely goes below 8^0C in winter season. The average rainfall ranges from 2000-2500 mm annum^{-1}. The soil type of Medziphema is mainly deep sandy loam, having good amount of organic carbon content and good water holding capacity with mean pH of 4.8. The pot experiment was done in Completely Randomized Design (CRD) and conducted in "factorial experiment". Each pot was filled with 10 kg of soil. FYM @ 500 g is mixed thoroughly with the soil in each pot before sowing. Recommended dose of nitrogen @ 20 kg N ha^{-1} and potassium @ 30 kg K_2O ha^{-1}, in the form of Urea and Muriate of Potash (MOP) respectively were applied uniformly in all pots at the time of sowing. Different levels of phosphorus (0, 20, 40, 60 kg ha^{-1}) and Sulphur (0, 10, 20, 30 kg ha^{-1}) as SSP and elemental sulphur respectively were given in combination. The growth attributes were recorded. After harvesting seed yield and stover yield were taken. Protein content was calculated by multiplying the N content with a factor of 6.25. The per cent oil content was estimated by Soxhlet extraction method. Organic carbon was determined by Walkley and Black's rapid titration method (Black, 1934). Available phosphorus determined by spectrophotometer method (Jackson, 1973). Available potassium and potassium content was determined by flame photometer (Chapman and Pratt, 1961). Available sulphur and sulphur content was determined by "Turbidemetric method" (Chesnin and Yien, 1950). The total nitrogen content for both seed and stover was determined by digestion and Kjeldahl distillation procedure. Ammonium molybdate vanadate method (Chapman and Pratt, 1962) was followed for the determination of phosphorus in the plant extract. The nutrient uptake was obtained from nutrient concentration of stover and seed yield. Statistical analysis of data was done as per procedure of Cochran and Cox (1957).

RESULTS AND DISCUSSION

Growth and yield attributes

The effect of various levels of phosphorus on soybean has significantly influenced the plant height at 60 DAS (Table 1). The maximum plant height shown (Table 1) was 56.95 cm and 57.28 cm applied with 40 kg ha^{-1} P_2O_5 and 30 kg sulphur ha^{-1}. The significant increase in plant height might be due to vigorous root growth and formation of chlorophyll resulting in higher photosynthesis which led to higher plant height (Meshram *et al.,* 2017). The number of pods plant^{-1} increased with the increased levels of phosphorus and sulphur (Table 2). The effect of phosphorus and sulphur application showed a positive impact on number of pods in soybean as reported by Deshmukh *et al*. (1994) and Kumar *et al*. (2001). At 60 kg P_2O_5 ha^{-1}, the number of filled pods were recorded the highest (36.91). Among the sulphur levels, application of 30 kg S ha^{-1} gave the highest number of filled pods of 38.95. The application of different levels of phosphorus and sulphur in soybean had no significant impact in the number of seeds pod^{-1}. The maximum seed yield of 11.26 g pot^{-1} was obtain at 60 kg P_2O_5 ha^{-1} and the maximum seed yield of 11.9 g pot^{-1} was obtain through combined interaction of 40 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1} . The increase in seed yield might be due to the favourable effects of better plant nutrition on growth attributes, which affected the yield attributes like higher pods plant^{-1} and finally on seed yield. Application of phosphorus and sulphur individually increased stover yield significantly upto 17.37 and 17.88 g pot^{-1} as compared to control. Ram *et al.* (2014) also reported that the stover yield were found to be highest with the application of 40 kg S ha^{-1}. This might be due to the increase in synthesis of amino acids, fatty acids and meristematic activity which enhances the accumulation of higher dry matter (Bainade *et al*., 2019).

Quality

Data regarding the nutrient content in seed and stover due to phosphorus and sulphur are shown in table 3 and 4 .It was observed that the highest protein content (35.21%) was recorded at 60 kg P_2O_5 ha^{-1}. The highest protein content of 36.99% was also obtained at 30 kg S ha^{-1}. Sharma *et al*. (2014) and Gokila *et al*. (2017) also reported that application of 20 kg S ha^{-1} improved the protein content in soybean. The observations regarding effect of phosphorus and sulphur on oil content of soybean was found to be significant. From the observation it was recorded that the plants treated with 60 kg P_2O_5 ha^{-1} had the highest oil content (18.76 %) as compared to control (18.31 %). The oil content was also found to be highest at 18.90% with the application of 30 kg S ha^{-1}. The results confirmed the findings of Gurjar *et al*. (2014) that the application of 60 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1} produced the maximum oil content. This observation may be due to the fact that sulphur plays a key role in the formation of glucosides which on hydrolysis produces higher oil content and oil yield (Bainade *et al.,* 2019).

Nutrient uptake

The data in table 5 and 6 indicated that the higher levels of phosphorus application significantly enhanced the content of N, P, K and S content in both seed and stover. The uptake of nitrogen in both seed and stover is greatly influenced by the higher levels of phosphorus application. The phosphorus application @ 60 kg ha^{-1} increased significantly the uptake of nitrogen in both seeds and stover *i.e.* 611.20 and 229.79 mg pot^{-1}. These findings are also in agreement with those of Niraj and Prakash (2014) where nitrogen uptake significantly increased with the increase in the level of phosphorus and sulphur. The application of 60 kg P_2O_5 ha^{-1} significantly increased the phosphorus uptake in seeds and stover by 46.76 and 51.23 mg pot^{-1}. Application of sulphur significantly increased the phosphorus uptake by 50.30 and 57.27 mg pot^{-1} in seeds and stover over control. There was a synergistic effect among the interactions. The application of 60 kg P_2O_5 ha^{-1} significantly increased the potassium uptake in seeds and stover. The highest potassium uptake in seeds and stover with the application of 30 kg S ha^{-1} were recorded at 161.78 and 76.91. The combined application of phosphorus and sulphur also showed significant effect on the potassium uptake. The higher levels of sulphur also showed significant response to sulphur uptake in both seeds and stover. Combined application of phosphorus and sulphur significantly increased the sulphur uptake in seeds and stover.

Soil properties

Application of phosphorus and sulphur did not have significant effect on the pH of the soil (Table 7). The pH at post experimentation was found out to be slightly increased with phosphorus and sulphur application. There was no significant effect in the organic carbon by the application of phosphorus and sulphur application. The study revealed that the organic carbon in the soil after crop harvest gave the higher result *i.e.* 1.25% by the combined application of phosphorus and sulphur as compared to the initial. Phosphorus application significantly increased the available N in soil. The maximum available nitrogen of 245.13 kg ha^{-1} was obtained with the application of 60 kg P_2O_5 ha^{-1}. Sulphur application @ 30 kg ha^{-1} showed significant response to available nitrogen. The highest available nitrogen was recorded at 240.74 kg ha^{-1}. The combined application of phosphorus and sulphur favourably responded to build up available of P and S. The application of 60 kg P_2O_5 was found to be the best treatment in maintaining the available phosphorus in the soil followed by 40 kg P_2O_5. Gowda *et al.* (2001) also explained that the increase in available P in soil on addition of sulphur might be due to the release of more soil phosphorus from the adsorption site because of ion exchange with sulphate-S ion.

Combined application of phosphorus and sulphur showed the significant response of available phosphorus in soil. The application of 60 kg P_2O_5 and 30 kg sulphur ha^{-1} individually obtained the highest (285.61 and 302.74 kg ha^{-1}) available potassium in the soil. The application of phosphorus significantly increased the available sulphur in the soil. Phosphorus application had an adverse effect on sulphur content in the soil. This might be due to synergistic effect of applied phosphorus and sulphur (Pandey *et al.,* 2003). In case of sulphur application, the highest available sulphur (17.47 kg ha^{-1}) was recorded with the application of 30 kg S ha^{-1}. It was found that combined application of 60 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1} recorded the maximum available sulphur as compared to other treatments.

It was concluded that phosphorus and sulphur application played a significant role in increasing growth and yield attributes and quality of soybean crop. Combined application of 60 kg P_2O_5 and 30 kg S ha^{-1} were found to be the best treatment in respect of overall performance and hence, recommended to improve growth and yield attributes of soybean. Application of phosphorus with sulphur not only improved growth and yield attributes but also enhanced nutrients (N, P, K and S) content, protein and oil content in seeds. The application of phosphorus and sulphur also enhanced the available NPKS in soil after harvest. It is therefore, advisable to use the optimum dose of phosphorus and sulphur for sustaining higher yield of soybean in Nagaland.

Table 1. Response of soybean on growth attributes to phosphorus and sulphur at different intervals

Phosphorus	Sulphur (kg ha^{-1})				
(kg ha^{-1})	0	10	20	30	Mean
		Plant height (cm)			
0	52.77	54.27	54.68	54.91	54.16
20	54.20	55.16	55.73	57.05	55.53
40	54.88	56.31	56.38	57.84	56.35
60	54.87	56.08	57.55	59.32	56.95
Mean	54.18	55.45	56.08	57.28	
CD (P=0.05), P= 0.50, S= 0.508, PxS= 1.01					
		No of leaves plant^{-1}			
0	22.63	22.95	23.72	23.62	23.23
20	22.90	22.72	24.34	24.19	23.54
40	24.22	23.97	23.87	23.18	23.81
60	24.25	24.49	25.03	25.72	24.87
Mean	23.50	23.53	24.24	24.18	
CD (P=0.05), P= 0.26, S= 0.26, PxS= 0.52					

Table 2. Response of soybean on yield attributes to phosphorus and sulphur at different intervals

Phosphorus (kg ha^{-1})	Sulphur (kg ha^{-1}) 0	10	20	30	Mean
		No of pods plant^{-1}			
0	43.58	45.45	46.69	48.23	45.99
20	43.71	46.00	46.87	48.71	46.32
40	43.91	46.43	46.86	48.86	46.51
60	43.95	46.94	47.22	51.09	47.30
Mean	43.79	46.20	46.91	49.22	
CD (P=0.05), P= 0.52, S= 0.52, PxS= 1.04					
		No of filled pods plant^{-1}			
0	30.12	33.01	36.31	37.83	34.32
20	30.71	32.65	35.00	37.94	34.07
40	31.23	33.48	35.42	38.71	34.71
60	31.67	35.22	39.46	41.32	36.91
Mean	30.93	33.59	36.55	38.95	
CD (P=0.05), P= 0.72, S= 0.72, PxS= 1.45					
		No of seeds pod^{-1}			
0	2.30	2.63	2.63	3.06	2.65
20	2.50	2.73	2.63	2.96	2.70
40	2.73	3.30	3.06	2.96	3.01
60	3.20	2.60	2.83	3.16	2.95
Mean	2.68	2.81	2.79	3.04	
CD (P=0.05), P=0.42, S=0.42, PxS=0.85					
		Seed yield (g pot^{-1})			
0	9.40	10.11	10.85	11.15	10.37
20	9.49	*10.17*	*10.92*	*11.61*	*10.55*
40	*10.19*	*10.89*	*11.16*	*11.82*	*11.01*
60	*10.10*	*10.66*	*11.04*	*13.26*	*11.26*
Mean	*9.79*	*10.46*	*10.99*	*11.90*	
CD (P=0.05), P= 0.38, S= 0.38, PxS= 0.77					
		Stover yield (g pot^{-1})			
0	*15.22*	*16.13*	*16.45*	*16.90*	*16.17*
20	*15.26*	*16.35*	*16.53*	*17.22*	*16.34*
40	*15.35*	*16.44*	*16.70*	*17.50*	*16.50*
60	*15.38*	*16.80*	*16.97*	*17.88*	*16.76*
Mean	*15.30*	*16.43*	*16.66*	*17.37*	
CD (P=0.05), P= 0.05, S= 0.05, PxS= 0.11					
		Protein content (%)			
0	*31.93*	*34.54*	*35.20*	*36.62*	*34.57*
20	*32.26*	*34.68*	*35.37*	*36.74*	*34.76*
40	*32.54*	*34.79*	*35.43*	*37.00*	*34.94*
60	*32.72*	*34.9*	*35.56*	*37.62*	*35.21*
Mean	*32.36*	*34.73*	*35.3*	*36.99*	
CD (P=0.05), P= 0.11, S= 0.11, PxS= 0.22					
		Oil content (%)			
0	*18.13*	*18.23*	*18.33*	*18.57*	*18.31*
20	*18.15*	*18.27*	*18.49*	*18.66*	*18.39*
40	*18.19*	*18.50*	*18.57*	*18.89*	*18.53*
60	*18.22*	*18.59*	*18.77*	*19.47*	*18.76*
Mean	*18.22*	*18.39*	*18.54*	*18.90*	
CD (P=0.05), P= 0.49, S= 0.49, PxS= 0.09					

Table 3. Response of soybean on nutrient content in seed to phosphorus and sulphur at different intervals

Phosphorus (kg ha^{-1})	Sulphur (kg ha^{-1}) 0	10	20	30	Mean
		Nitrogen content (%)			
0	5.11	5.52	5.64	5.66	5.48
20	5.16	5.55	5.66	5.68	5.51
40	5.20	5.56	5.67	5.70	5.53
60	5.22	5.59	5.69	5.72	5.55
Mean	5.17	5.55	5.66	5.69	
CD (P=0.05), P= 0.007, S= 0.007, PxS= 0.014					
		Phophorus content (%)			
0	0.33	0.37	0.30	0.41	0.37
20	0.35	0.30	0.30	0.42	0.39
40	0.35	0.39	0.40	0.44	0.39
60	0.35	0.40	0.41	0.46	0.40
Mean	0.34	0.38	0.40	0.43	
CD (P=0.05), P= 0.005, S= 0.005, PxS= 0.010					
		Potassium content (%)			
0	1.10	1.25	1.3	1.36	1.25
20	1.14	1.29	1.37	1.41	1.30
40	1.15	1.32	1.38	1.42	1.31
60	1.17	1.33	1.43	1.48	1.35
Mean	1.143	1.29	1.37	1.41	
CD (P=0.05), P= 0.007, S= 0.007, PxS= 0.014					
		Sulphur content (%)			
0	0.26	0.32	0.35	0.36	0.32
20	0.28	0.33	0.36	0.38	0.34
40	0.33	0.34	0.36	0.38	0.35
60	0.33	0.34	0.37	0.4	0.36
Mean	0.30	0.33	0.36	0.38	
CD (P=0.05), P= 0.006, S= 0.006, PxS= 0.013					

Table 4. Response of soybean on nutrient content in stover to phosphorus and sulphur at different intervals

Phosphorus (kg ha^{-1})	Sulphur (kg ha^{-1}) 0	10	20	30	Mean
		Nitrogen content (%)			
0	1.25	1.32	1.35	1.38	1.32
20	1.27	1.33	1.36	1.4	1.34
40	1.27	1.35	1.37	1.41	1.35
60	1.27	1.36	1.40	1.45	1.37
Mean	1.26	1.34	1.37	1.41	
CD (P=0.05), P= 0.006, S= 0.006, PxS= 0.013					
		Phophorus content (%)			
0	0.22	0.26	0.27	0.30	0.26
20	0.23	0.27	0.31	0.32	0.28
40	0.24	0.29	0.33	0.34	0.30
60	0.23	0.29	0.34	0.36	0.30
Mean	0.23	0.28	0.31	0.33	
CD (P=0.05), P= 0.005, S= 0.005, PxS= 0.011					
		Potassium content (%)			
0	0.28	0.38	0.4	0.42	0.37
20	0.30	0.39	0.40	0.43	0.38
40	0.31	0.39	0.42	0.45	0.39
60	0.32	0.41	0.43	0.48	0.41
Mean	0.30	0.39	0.41	0.44	
CD (P=0.05), P= 0.006, S= 0.06, PxS= 0.013					
		Sulphur content (%)			
0	0.22	0.25	0.28	0.29	0.26
20	0.22	0.26	0.29	0.31	0.27
40	0.22	0.27	0.33	0.32	0.27
60	0.23	0.27	0.32	0.34	0.29
Mean	0.22	0.26	0.29	0.31	
CD (P=0.05), P= 0.007, S= 0.007, PxS= 0.015					

Table 5. Response of soybean on nutrient uptake in seed to phosphorus and sulphur at different intervals

Phosphorus (kg ha^{-1})	Sulphur (kg ha^{-1}) 0	10	20	30	Mean
		Nitrogen uptake (mg pot^{-1})			
0	480.17	558.7	593.29	615.79	561.99
20	490.03	564.81	614.92	625.37	573.85
40	527.56	606.37	632.73	637.99	601.16
60	540.13	605.57	633.11	666.01	611.21
Mean	509.54	583.86	618.51	636.29	
CD (P=0.05), P= 7.68, S= 7.68, PxS= 15.36					
		Phophorus uptake (mg pot^{-1})			
0	31.35	38.08	41.02	47.40	39.46
20	33.83	39.68	43.33	48.92	41.44
40	35.68	42.47	45.39	50.32	43.46
60	37.00	44.31	51.14	54.58	46.76
Mean	34.46	41.13	45.22	50.30	
CD (P=0.05), P= 0.99, S= 0.99, PxS=1.99					
		Potassium uptake (mg pot^{-1})			
0	104.05	126.38	136.76	152.56	129.4
20	114.49	131.62	149.68	161.35	139.29
40	117.6	142.39	153.42	163.15	144.14
60	119.87	141.87	160.4	170.06	148.05
Mean	114.00	135.57	150.06	161.78	
CD (P=0.05), P= 1.83, S= 1.83, PxS= 3.67					
		Sulphur uptake (mg pot^{-1})			
0	25.07	32.35	36.82	41.25	33.87
20	26.87	34.25	39.69	42.04	35.71
40	32.28	37.04	40.91	43.65	38.47
60	34.91	38.12	41.25	46.49	40.19
Mean	29.78	35.44	39.67	43.36	
CD (P=0.05), P= 1.10, S= 1.10, PxS= 2.21					

Table 6. Response of soybean on nutrient uptake in stover to phosphorus and sulphur at different intervals

Phosphorus (kg ha^{-1})	Sulphur (kg ha^{-1}) 0	10	20	30	Mean
	Nitrogen uptake (mg pot^{-1})				
0	190.87	212.99	222.62	234.39	215.21
20	193.84	218.63	225.39	241.07	219.73
40	195.53	223.12	229.38	248.84	223.72
60	194.68	228.57	237.63	258.29	229.79
Mean	193.72	220.08	228.75	245.15	
CD (P=0.05), P= 1.52, S= 1.52, PxS= 3.04					
	Phophorus uptake (mg pot^{-1})				
0	31.49	41.95	45.50	51.27	43.05
20	36.12	45.25	52.35	55.67	47.34
40	37.37	48.24	55.11	60.10	50.20
60	35.88	48.73	58.27	62.05	51.23
Mean	35.71	46.04	52.81	57.27	
CD (P=0.05), P= 0.90, S= 0.90, PxS= 1.81					
	Potassium uptake (mg pot^{-1})				
0	43.64	61.31	65.79	70.99	60.43
20	46.88	63.78	67.23	74.61	63.12
40	48.06	65.23	70.15	79.35	65.69
60	49.21	68.90	73.54	82.69	68.58
Mean	46.94	64.81	69.18	76.91	
CD (P=0.05), P= 1.19, S= 1.19, PxS= 2.38					
	Sulphur uptake (mg pot^{-1})				
0	33.49	40.33	46.05	50.15	42.51
20	34.08	42.52	47.94	55.09	44.91
40	34.29	41.07	49.36	57.18	45.47
60	35.37	46.49	56.00	62.34	50.05
Mean	34.31	42.60	49.84	56.19	
CD (P=0.05), P= 1.16, S= 1.16, PxS= 3.23					

Table 7. Response of soybean on soil properties to phosphorus and sulphur at different intervals

Phosphorus (kg ha^{-1})	Sulphur (kg ha^{-1}) 0	10	20	30	Mean
	Soil pH				
0	5.17	5.08	5.09	5.07	5.10
20	5.08	5.13	5.13	5.09	5.11
40	5.08	5.08	5.17	5.10	5.11
60	5.01	5.11	5.01	5.16	5.07
Mean	5.09	5.10	5.10	5.10	
CD (P=0.05), P= 0.06, S= 0.06, PxS= 0.13					
	Organic carbon (%)				
0	0.97	1.07	1.18	1.29	1.13
20	1.04	1.19	1.26	1.35	1.21
40	1.04	1.24	1.33	1.40	1.25
60	1.07	1.24	1.41	1.59	1.33
Mean	1.03	1.18	1.29	1.41	
CD (P=0.05), P= 0.04, S= 0.04, PxS= 0.08					
	Available N (kg ha^{-1})				
0	211.57	216.17	215.33	219.93	215.75
20	214.92	217.84	219.93	224.54	219.31
40	217.01	223.28	227.46	236.24	226.00
60	218.26	231.22	248.78	282.24	245.13
Mean	215.44	222.13	227.88	240.74	
CD (P=0.05), P= 3.67, S= 3.67, PxS= 7.35					
	Available P (kg ha^{-1})				
0	30.12	33.01	36.31	37.83	34.32
20	30.71	32.65	35.00	37.94	34.07
40	31.23	33.48	35.42	38.71	34.71
60	31.67	35.22	39.46	41.32	36.91
Mean	30.93	33.59	36.55	38.95	
CD (P=0.05), P= 1.38, S= 1.38, PxS= 2.77					
	Available K (kg ha^{-1})				
0	227.36	250.13	274.02	288.59	260.02
20	229.94	257.23	278.92	295.07	265.29
40	233.94	269.88	287.86	300.09	272.94
60	234.22	284.19	296.85	327.21	285.61
Mean	231.36	265.36	284.41	302.74	
CD (P=0.05), P= 6.19, S= 6.19, PxS= 12.39					
	Available S (kg ha^{-1})				
0	15.52	16.18	16.41	17.08	16.30
20	15.60	16.31	16.51	17.28	16.43
40	15.73	16.48	16.78	17.48	16.62
60	15.82	16.58	16.98	18.06	16.84
Mean	15.67	16.39	16.67	17.47	
CD (P=0.05), P= 0.11, S= 0.11, PxS= 0.23					

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