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EFFECTS OF SOIL TEXTURE AND NUTRIENTS APPLICATION ON SOYBEAN NUTRIENT UPTAKE, GROWTH AND YIELD RESPONSE

Bashir, M.[1]*, Adam, A. M.[1], Shehu, B. M.[2], and Abubakar M. S.[2]

1. *Centre for Dryland Agriculture, Bayero University, Kano-Nigeria.*
2. *Department of Soil Science, Bayero University, Kano-Nigeria*

***Corresponding author email**: mbashir.cda@buk.edu.ng*

ABSTRACT

Soybean is a good source of protein and calories and therefore important for food security. Soybean yields in small scale farmers field stand at less than 1.0 t ha^{-1} against a potential of 3 to 3.6 t ha^{-1}. This has been attributed to low soil fertility. Although a lot of work has been carried out on Soybean nitrogen (N) and phosphorus (P) nutrition, but research findings indicate that yields are still low, raising suspicion that other nutrients could also be limiting. To investigate this, a nutrient omission trial was used in the greenhouse to find out the nutrients that limit soybean production in four distinct soil textures - clay loam, sandy clay loam, sandy clay and sandy loam following the recommended rate of 20:40:20:5:20 Kg/ha for N,P,K,Zn, and S respectively. Similarly we applied 1 ton/ha of poultry manure with thirty six treatments combinations arranged in a completely randomized design. The results revealed that soybean performance and nutrient uptake varied significantly ($p<0.05$) between the soil texture and nutrients application. Sandy clay loam and sandy loam textures respond significantly to nitrogen, phosphorus, potassium and manure application whereas zinc and NPK nutrients limits soybean performance and uptake in sandy clay and clay loam soils. In conclusion, to increase soybean production in sandy loam and clay loam of Sudan savanna of Nigeria, fertilizer formulations containing N, P, K and Zn should be used. Manure may be used to improve soybean production in sandy clay and sandy clay loam together with application of NPK fertilizer.

Key words: Fertility, Fertilizer, Legumes, Greenhouse

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INTRODUCTION

Grain legumes represent an important component of agricultural food crops consumed in developing countries and are considered vital for achieving food and nutritional security among the smallholder farmers. They are also an important source of income for the poor farmers and vital in improving soil fertility. This is because of their ability to fix atmospheric nitrogen into the form that can be utilized by plants, thereby reducing the need for mineral nitrogen fertilizers. It is estimated that one third to one half of the total nitrogen added to agricultural land come from legume-rhizobia symbiosis (Alistair *et al.,* 2009).

Soybean stands out as the most popular grain legume in the world. Its popularity is attributed to a number of factors related to its composition and productivity. Soybean is a source of the most consumed edible oil and livestock feeds (Myaka *et al.,* 2005). Many other soybean products are directly used for human consumption including soymilk, soya sauce, protein extracts and concentrates. Cultivation of soybean is rapidly gaining popularity in Africa following high demand from the expanding livestock feed industry (which consumes about 70 - 80% of soybean produced per year) and need to restore soil nitrogen (Mahasi *et al.,* 2011, Chianu *et al.,* 2009).

Adaptive research campaigns initiated across western Kenya by an N2Africa project team to assess the responses of soybean to the application of phosphorus (P) and Potassium (K) fertilizers and their combination with inoculants recorded yield increase in 60% of the experimental sites (Baijukya *et al.,* 2010). However, the remaining sites were not responding to P and K application and were grouped as non-responsive soils. They included the sandy or the highly weathered - nutrient-depleted soils, majority in farms owned by poor farmers. The low soybean grain yields experienced in the non-responsive soils could be attributed to nutrients limitations, leaching and imbalances (Mburu *et al.,* 2011; Thuita *et al.,* 2012) including chemical, physical and biological factors. The soil chemical degradation, specifically nutrient limitations can be caused by continuous nutrient mining with minimal nutrient replenishment via crop harvests, soil erosion, leaching during heavy rainfall and soil acidity (Verde *et al.,* 2013). The minimal nutrient replenishment can be attributed to minimal fertilizer use in the region due to lack of money to purchase by the farmers. It is imperative therefore to investigate the effect of soil texture and nutrient applications on soybean growth, yield response and nutrient uptake using nutrient omission plots.

MATERIALS AND METHODS

Greenhouse Experiment

Assessment of limiting nutrients was carried out in the greenhouse at the Centre for Dryland Agriculture, Bayero University Kano. The soils that were used in the greenhouse experiment were collected from four (4) distinct locations representing major soil texture in the Nigerian savanna, including sandy loam, sandy clay loam, clay loam, and sandy clay at a depth of 0-20 cm. Before starting the experiment, sub-samples of the soils from each texture were sieved through 2mm sieved and taken to the laboratory for chemical and physical characterization (analysis) in the laboratory (Table 1). The Near-infrared spectrometer was used to analyse the soil chemical properties and hydrometer for particle size analysis. Undisturbed soil samples were collected using core samplers for bulk density determination from each texture.

Nutrient treatments

The nutrients applications included a control ("Control") in which no nutrient was applied, N omitted ("PK") P and K applied, P omitted ("NK") with N and K applied, K omitted ("NP") with N and P applied, NPK treatment ("NPK"), NPK + Zn treatment ("NPK + Zn"), NPK + S treatment ("NPK + S"), NPK + S+ Zn treatment ("NPK + S + Zn"), and NPK + poultry manure treatment ("NPK + PM"). The nutrients were applied according to the general recommendation for soybean in Sudan savanna zone of Nigeria with 20:40:20: 5:20 Kg/ha for N, P, K, Zn, S, and 1 tons/ha for poultry manure respectively. Urea was used as N source, triple super phosphate as P source, muriate of potash as K source, elemental sulphur as S source, and zinc chloride as Zn source. All the nutrients were applied at planting.

Management of experiment and experimental design.

The greenhouse experiment was laid out in a Completely Randomized Design (CRD) with two factors including four distinct soil texture and nine nutrients application in 72 plastic pots. Each pot had a diameter of 27.5 cm and

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height of 45 cm. The pots were filled with seven kilogram of dry soil samples for each soil texture. Soybean variety TGX 1448-2E was used for planting in the experiment. The pots were watered to field capacity and left for 2 days to equilibrate before planting. Two seeds were sown per pot and were thinned to single uniform plants per pot after emergence at one week after planting. Management practices during the experimental period were the same as the local field method.

Data collection

The data collected from the pots experiment included plant heights, normalized difference vegetation index (for chlorophyll content) Initial measurements were taken at eight weeks after planting (WAP) and thereafter repeated at ten weeks after planting. At physiological maturity, the plants were pulled from the pots, weighed, and placed in an envelope for air drying. Stover weight and grain weight were determined after air drying the samples. The samples from the grain and stover were ground and analyzed in the Centre for Dryland Agriculture laboratory. P and K were determined using micro-plasma atomic emission spectroscopy (MP-AES 4200). Nitrogen was analysed by digesting the samples in hot sulphuric acid solution in the presence of Selenium as a catalyst, followed by colorimetric N analysis (Okalebo *et al.,* 2002). Finally, total N, P and K uptake of the grain and stover were calculated for each of the soil texture as the product of nutrient concentration of the sample, and its dry matter content.

Statistical Analysis

Analysis of variance was also done to compare the effects of the treatments on soybean performance and on nutrient uptake using JMP Pro 15 statistical package. The effects of the different treatments were also compared by computing their least significant difference at 5 % probability level.

RESULT

Soil chemical and physical properties

Table 1 shows the chemical and physical properties of the soil used for this experiment. Sandy loam had high sand content (69.52%) and the least clay content (9.04%) compared to other textures. Sandy clay loam had a high bulk density (1.74 gcm^{-3}), while sandy clay has the least bulk density. Sandy loam, sandy clay loam, and clay loam are moderately acid, while sandy clay is significantly different, with a pH of 6.40 (slightly acid). The four texture soils have both low organic matter and total N contents. Clay loam has a medium calcium content of 3.15$cmol_c$/kg, while sandy loam, sandy clay loam, and sandy clay have low calcium content 1.12, 1.44, 1.81$cmol_c$/kg respectively. All the textures with exception of clay loam had magnesium content of 0.77cmol/kg. The results indicate that the overall status of the fertility, clay loam soil is inherently more fertile compared to other textures even though it has the lowest soil organic carbon content with high exchangeable calcium, potassium, magnesium, and effective cation exchange capacity. The high fertility level observed in clay loam texture could be attributed to low sand fraction and the presence of high activity clays. This was in conformity with the finding of Kome *et al*. (2019), who reported that soil clay fraction appears to be one of the most important indicators of soil quality which has significant implications on nutrient management, particularly in tropical soils. Shehu *et al*. (2019) found that soils in the savannah had low clay content justifying the low-level fertility observed across the textures.

Effect of Soil Texture and Nutrients application on growth and yield response of Soybean

Number of Leaves

As illustrated in Table 2, the result of the number of leaves at 8 WAP indicates a significant effect of soil texture, and nutrient applications on number of leaves at 1% and 5% probability levels, respectively. There was no significant interaction effect of the soil texture and nutrient application on the number of leaves. For nutrient, the highest number of leaves was observed in a treatment where Control was applied, then followed by NPK + Zn, NPK + S, NPK + PM, Full NPK, - K, NPK + S + Zn, - P, and the least value was obtained in -N. In contrast to the texture, the highest number of leaves was observed in Sandy clay, followed by Clay loam, sandy loam, and the least value recorded in Sandy clay loam. For the interaction, Clay loam produced the highest number of leaves when NPK + PM has been applied. Sandy clay produced the highest number of leaves when the NPK + S was applied, Sandy clay loam responded the highest number of leaves when Control was applied, and Sandy loam produced the highest number of leaves when the NPK + Zn was applied.

For the number of leaves at 10 WAP (Table 3), there is significant effect of soil texture and nutrient application on number of leaves at 1% and 5% level of significance, respectively. There was no significant interaction effect between soil texture and nutrient application on the number of leaves at 10 WAP. For the highest number of leaves was observed in a treatment where control was applied, then followed by NPK + S, Full NPK, NPK + Zn, NPK + PM, - K, NPK + S Zn, - P, and the least value was obtained in - N. In contrast to the texture, the highest number of leaves was observed in Sandy clay, then followed by Clay loam, sandy loam, and the least value was recorded in Sandy clay loam. For the interaction, Clay loam produced the highest number of leaves when the control has been applied. Sandy clay produced the highest number of leaves when the NPK + S was applied, Sandy clay loam responded the highest number of leaves when control was applied, and Sandy loam produced the highest number of leaves when the NPK + Zn was applied.

Normalized difference vegetation index (NDVI)
The result of NDVI value at 8 WAP (Table 4) indicates a significant effect of soil texture at a 5% level of significance. There was no significant effect on nutrient application and interaction between soil texture and nutrient application. For the nutrient contains, the highest NDVI value was observed in a treatment where NPK + Zn was applied, and the most negligible value was obtained in - P. In contrast to the texture, the highest NDVI value was observed in Sandy clay, then followed by Clay loam, sandy loam, and the least value was recorded in Sandy clay loam. For the interaction, Clay loam produced the highest NDVI value when NPK + PM has been applied, Sandy clay produced NDVI value when NPK + S was applied, Sandy clay loam produced the highest NDVI value when the Control was applied, while Sandy loam produced the highest NDVI value when the NPK + S + Zn was applied.

As shown in (Table 5), the result of NDVI value at 10 WAP indicates a significant effect of soil texture at a 1% level of significance. There was no significant effect on nutrient application and interaction between soil texture and nutrient application. For the nutrient contains, the highest NDVI value was observed in a treatment where Full NPK was applied, and the least value was obtained in - P. In contrast to the texture, the highest NDVI value was observed in Sandy clay, and the least value was observed in Sandy clay loam. For the interaction, Clay loam produced the highest NDVI value when NPK + PM has been applied, Sandy clay produced NDVI value when -K was applied, Sandy clay loam produced the highest NDVI value when the -P was applied, while Sandy loam produced the highest NDVI value when the NPK + S + Zn was applied.

Stover and seeds dry weight

As presented in Table 6, the result of dry seed weight indicates a significant effect of soil texture, nutrient application, and interaction between soil texture and nutrient application at a 1% level of significance, respectively. For the nutrient contains, the highest Seed Dry Weight value was observed in a treatment where Full NPK was applied, and the least value was obtained in Control. In contrast to the texture, the highest Seed Dry Weight value was observed in Sandy clay, and the lowest was observed in Sandy clay loam. For the interaction, Clay loam produced the highest Seed Dry Weight value when NPK + Zn has been applied, Sandy clay produced Seed Dry Weight value when NPK + PM was applied, Sandy clay loam produced the highest Seed Dry Weight value when the NPK + PM was applied, while Sandy loam produced the highest seed dry weight value when the NPK + Zn was applied.

The result of Stover Dry Weight indicates a significant effect of soil texture, nutrient application, and interaction (Table 7) at a 1% level of significance, respectively. For the nutrient contains, the highest Stover Dry Weight value was observed in a treatment where Full NPK was applied, and the least value was obtained in Control. In contrast to the texture, the highest Stover Dry Weight value was observed in Sandy loam, and the lowest was observed in Clay loam. For the interaction, Clay loam produced the highest Stover Dry Weight value when -K has been applied, Sandy clay produced Stover Dry Weight value when NPK + S + Zn was applied, Sandy clay loam produced the highest Stover Dry Weight value when the Full NPK was applied, while Sandy loam produced highest Stover Dry Weight value when the Full NPK was applied.

Effects of Nutrients and Texture on Soybean nutrient uptake

The result of Total N Uptake indicates that there was a significant effect of soil texture, nutrient application, and interaction between soil texture and nutrient application at a 1% level of significance, respectively (Table 8). The highest Total N Uptake value for the nutrient was observed in the treatment of complete NPK, and the least value was obtained in Control. In contrast to the texture, the highest total N Uptake value was observed in Sandy loam and the least in Sandy clay loam. For the interaction, Clay loam produced the highest Total N Uptake value when complete NPK has been applied, and Sandy clay produced Total N Uptake value when NPK + S Sandy clay loam produced the highest Total N Uptake value when the complete NPK was applied, while Sandy loam produced the highest Total N Uptake value when the complete NPK was applied.

As presented in Table 9, the result of Total P Uptake indicates a significant effect of soil texture, nutrient application, and interaction between soil texture and nutrient application at a 1% level of significance, respectively. The highest Total P Uptake value for the nutrient content was observed in a treatment where Full NPK was applied, and the least value was obtained in Control. In contrast to the texture, the highest Total P Uptake value was observed in Sandy clay and the least in Sandy clay loam. For the interaction, Clay loam produced the highest Total P Uptake value when NPK + S has been applied, Sandy clay produced Total P Uptake value when NPK + S was applied, Sandy clay loam produced the highest Total P Uptake value when the Full NPK was applied, while Sandy loam produced the highest Total P Uptake value when the NPK + S + Zn was applied.

Regarding K uptake, the result indicates that there was a significant effect of soil texture and nutrient application at 1% level of significance (Table 10), respectively, while interaction between soil texture and nutrient application was significant at 5%. The highest Total K Uptake value for the nutrient contains was observed in a treatment where Full NPK was applied, and the least value was obtained in Control. In contrast to the texture, the highest Total K Uptake value was observed in Sandy loam and the least in Sandy clay loam. For the interaction, Clay loam produced the highest Total K Uptake value when -K has been applied, Sandy clay produced Total K Uptake value when NPK + S was applied, Sandy clay loam produced the highest Total K Uptake value when the Full NPK was applied, while Sandy loam produced the highest Total K Uptake value when the Full NPK was applied.

DISCUSSION

The results of growth performance showed a positive response of soybean to the nutrient application across the soil texture. For the sandy clay loam and sandy loam, application of full NPK with addition of poultry manure influenced the growth performance of the soybean.This might attributed as result of increased of cation exchange capacity, nutrients nutrients and water holding capacity with addition of the manure. This confirmed the findings of Sanginga, (2003) who reported that application of P and K fertilizer in low fertile soils increased soybean yield but other nutrient deficiencies might be appear depending on the inherent soil fertility status. Likewise, he increased of performance of soybean to supply of nitrogen, phosphorus and potassium had been reported by Tomar *et al*. (2004) and Rani (1999). Bekere *et al*. (2012) showed that phosphorus application significantly increased soybean performance under controlled environment.

The higher uptake of elements like K observed in in K omitted pots (Table 10) can be attributed to K luxury consumption against Ca and Mg (Moore *et al.,* 2014). This occurs because there are a limited number of ion carrier sites on the root plasma membrane and thus the ions of the same ion strength can compete each other for the sites (Marschner, 2011). The poor performance of plants growing in minus K treatments indicated that K is limiting in these soils. It has been reported that relatively large amounts of K are required by high yielding soybean varieties. This is because K is associated with the improvement of nitrogenase activity and thus enhancing BNF and finally the grain yields (Roy *et al.,* 2006; Uchida, 2000). Decrease in yield of soybean were found in absence of K application and thus suggesting the need to apply the fertilizer according to the requirements of the plants (Myint *et al.,* 2009).

This finding agrees with many findings that P is one of the most limiting elements affecting soybean production in soils of Africa and this can be attributed to the widespread occurrence of soils with high P fixation capacity (Vanlauwe *et al.,* 2003).

The poor performance in plants growing in minus micro-nutrients treatments in soils from sandy loam and clay loam indicates that the micronutrients may be among some of the plant nutrients limiting soybean production as observed. Micro-nutrients 70 are very important in soybean nutrition. For instance, Jabbar and Saud (2012) reported that maximum production in leguminous plants can be obtained through effective nodulation and zinc application, and this is well expressed in terms of yield and nitrogen concentration in the plant tissues. This can be seen in the low accumulation of nitrogen in minus micronutrients treatments.

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CONCLUSION

In conclusion, the most limiting nutrients in the soils studied for soybean production are N, P, K, Zn, and manure (organic carbon). NPK are limiting in all the soils texture and Zn is limiting only in sandy clay and clay loam soils. Though, the other two textures respond well to manure, justifying application of manure plus NPK produced higher productivity in these soils.

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APPENDICES

Table 1: Soil physical and chemical characterization by texture

Variables / Texture	Sandy loam	Sandy clay loam	Clay loam	Sandy clay
Sand (%)	69.52	49.52	31.52	55.52
Silt (%)	21.44	19.44	39.44	5.44
Clay (%)	9.04	31.04	29.04	39.04
Bulk density (gcm^{-3})	1.54	1.74	1.66	1.49
pH (1:1)	5.51	5.76	5.53	6.40
EC (DSm^{-1})	0.133	0.076	0.152	0.104
Organic C (gKg^{-1})	5.00	5.80	3.60	7.70
Total N (gKg^{-1})	0.30	0.30	0.50	0.60
Available P ($mgKg^{-1}$)	5.55	1.36	3.71	2.83
Ca (cmol (+) Kg	1.12	1.44	3.15	1.81
Mg (cmol (+) Kg	0.55	0.42	0.77	0.62
K (cmol (+) Kg	0.44	0.50	0.20	0.11
Na (cmol (+) Kg	0.09	0.09	0.12	0.11
EA (cmol (+) Kg	0.02	0.02	0.00	0.02
ECEC (cmol (+) Kg	2.22	2.47	4.24	2.67

Key: EA means exchangeable acidity; EC means electrical conductivity; and ECEC means effective cation exchange capacity.

Table 2: Effects of texture and nutrient applications on soybean number of leaves at 8 WAP

	Soil Texture (T)				
	TI	T2	T3	T4	Mean
Nutrients (N)	Number of Leaves 8 WAP				
Control	34.00	37.50	26.67	21.00	29.79
-N	15.50	18.50	13.50	16.50	16.00
-P	15.00	32.50	12.00	17.00	19.13
-K	31.00	31.50	13.50	15.50	22.88
Full NPK	27.50	32.50	17.00	19.00	24.00
NPK + Zn	27.00	32.50	22.50	23.00	26.25
NPK + S	22.00	44.50	20.50	16.50	25.88
NPK + S + Zn	21.00	35.00	4.00	22.00	20.50
NPK + PM	35.00	28.50	14.50	20.00	24.50
Texture Mean	25.33	32.56	16.02	18.94	
LSD texture	3.69**				
LSD nutrient	5.05*				
LSD texture x nutrient	11.05^{ns}				

Note: T1 (Clay loam), T2 (Sandy Clay), T3 (Sandy Clay Loam) and T4 (Sandy Loam); ns mean not significant at 5 % probability; LSD means least significant difference, * means significant at 5 % probability level; WAP means week after planting.

Table 3: Effects of texture and nutrient applications on soybean number of leaves at 10 WAP

	Soil Texture (T)				
	TI	T2	T3	T4	Mean
Nutrients (N)	Number of Leaves at 10 WAP				
Control	39.50	41.50	37.00	24.00	35.50
-N	23.50	25.50	14.00	22.50	21.38
-P	21.00	37.50	15.50	23.50	24.38
-K	28.50	34.00	16.50	21.50	25.13
Full NPK	33.00	38.00	24.50	22.00	29.38
NPK + Zn	32.50	33.00	25.50	26.50	29.38
NPK + S	28.50	45.50	26.00	21.00	30.25
NPK + S + Zn	26.00	35.00	13.00	25.00	24.75
NPK + PM	28.50	34.00	18.00	24.50	26.25
Texture Mean	29.00	36.00	21.11	23.39	
LSD texture	3.81**				
LSD nutrient	5.72*				
LSD texture x nutrient	11.44^{ns}				

Note: T1 (Clay loam), T2 (Sandy Clay), T3 (Sandy Clay Loam) and T4 (Sandy Loam); ns mean not significant at 5 % probability; LSD means least significant difference, * means significant at 5 % probability level; WAP means week after planting.

Table 4: Effects of texture and nutrient applications on soybean NDVI 8 WAP

	Soil Texture (T)				
	TI	T2	T3	T4	Mean
Nutrients (N)	NDVI at 8 WAP				
Control	0.50	0.48	0.37	0.28	0.41
-N	0.36	0.36	0.23	0.41	0.34
-P	0.23	0.52	0.28	0.29	0.33
-K	0.43	0.61	0.19	0.41	0.41
Full NPK	0.42	0.45	0.31	0.39	0.39
NPK + Zn	0.45	0.60	0.31	0.56	0.48
NPK + S	0.38	0.68	0.29	0.24	0.39
NPK + S + Zn	0.27	0.47	0.21	0.58	0.38
NPK + PM	0.59	0.42	0.26	0.38	0.41
Texture Mean	0.40	0.51	0.27	0.39	
LSD texture	0.06*				
LSD nutrient	0.08^{ns}				
LSD texture x nutrient	0.18^{ns}				

Note: T1 (Clay loam), T2 (Sandy Clay), T3 (Sandy Clay Loam) and T4 (Sandy Loam); ns mean not significant at 5 % probability; LSD means least significant difference, * means significant at 5 % probability level; WAP means week after planting.

Table 5: Effects of texture and nutrient applications on soybean NDVI 10 WAP

	Soil Texture (T)				
	TI	T2	T3	T4	Mean
Nutrients (N)	NDVI at 10 WAP				
Control	0.57	0.44	0.28	0.30	0.40
-N	0.47	0.41	0.31	0.46	0.41
-P	0.35	0.46	0.40	0.34	0.39
-K	0.54	0.70	0.23	0.42	0.47
Full NPK	0.51	0.58	0.39	0.44	0.48
NPK + Zn	0.54	0.62	0.38	0.35	0.47
NPK + S	0.47	0.56	0.36	0.31	0.42
NPK + S + Zn	0.38	0.57	0.26	0.68	0.47
NPK + PM	0.69	0.49	0.36	0.30	0.46
Texture Mean	0.50	0.53	0.33	0.40	
LSD texture	0.07**				
LSD nutrient	0.09^{ns}				
LSD texture x nutrient	0.20^{ns}				

Note: T1 (Clay loam), T2 (Sandy Clay), T3 (Sandy Clay Loam) and T4 (Sandy Loam); ns mean not significant at 5 % probability; LSD means least significant difference, * means significant at 5 % probability level; WAP means week after planting.

Table 6: Effects of texture and nutrient applications on soybean dry seed weight

	Soil Texture (T)				
	TI	T2	T3	T4	Mean
Nutrients (N)	Seed Dry Weight (g/plant)				
Control	0.60	3.50	0.32	1.96	1.60
-N	7.80	1.70	2.20	2.50	3.55
-P	5.40	7.70	1.30	8.90	5.83
-K	4.80	5.30	3.30	9.80	5.80
Full NPK	10.10	8.20	3.10	13.40	8.70
NPK + Zn	2.60	8.40	3.30	8.26	5.64
NPK + S	3.20	13.30	3.30	7.86	6.92
NPK + S + Zn	8.70	7.00	4.00	10.70	7.60
NPK + PM	3.50	15.40	1.60	5.70	6.55
Texture Mean	5.19	7.83	2.49	7.68	
LSD texture	0.64**				
LSD nutrient	0.97**				
LSD texture x nutrient	1.93**				

Note: T1 (Clay loam), T2 (Sandy Clay), T3 (Sandy Clay Loam) and T4 (Sandy Loam); ns mean not significant at 5 % probability; LSD means least significant difference, * means significant at 5 % probability level; WAP means week after planting.

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Table 7: Effects of texture and nutrient applications on soybean dry stover weight

	Soil Texture (T)				
	TI	T2	T3	T4	Mean
Nutrients (N)	Stover Dry Weight (g/plant)				
Control	2.6	10.5	4.85	2.23	5.05
-N	9.8	16.2	4.7	4.2	8.73
-P	8.0	11.6	11.3	18.3	12.30
-K	13.9	7.6	13.2	20.5	13.80
Full NPK	10.4	16.3	16.5	25.7	17.23
NPK + Zn	7.6	13.4	10.2	16.89	12.02
NPK + S	6.5	14.2	12.3	16.26	12.32
NPK + S + Zn	13.5	8.1	12.5	19.3	13.35
NPK + PM	5.00	18.2	9.5	6.8	9.88
Texture Mean	8.59	12.90	10.56	14.46	
LSD texture	1.13**				
LSD nutrient	1.47**				
LSD texture x nutrient	2.33**				

Note: T1 (Clay loam), T2 (Sandy Clay), T3 (Sandy Clay Loam) and T4 (Sandy Loam); ns mean not significant at 5 % probability; LSD means least significant difference, * means significant at 5 % probability level; WAP means week after planting.

Table 8: Effects of texture and nutrient applications on soybean N Uptake

	Soil Texture (T)				
	TI	T2	T3	T4	Mean
Nutrients (N)	Total N Uptake (g/plant)				
Control	0.17	0.65	0.106667	0.1	0.26
-N	0.84	0.63	0.17	0.18	0.46
-P	0.66	0.77	0.485	1.25	0.79
-K	0.97	0.645	0.525	1.265	0.85
Full NPK	1.13	1.245	0.84	1.71	1.23
NPK + Zn	0.645	1.13	0.55	0.91	0.81
NPK + S	0.51	1.31	0.55	1.145	0.88
NPK + S + Zn	1.025	0.725	0.475	1.54	0.94
NPK + PM	0.535	1.255	0.365	0.45	0.65
Texture Mean	0.72	0.93	0.45	0.95	
LSD texture	0.08**				
LSD nutrient	0.12**				
LSD texture x nutrient	0.26**				

Note: T1 (Clay loam), T2 (Sandy Clay), T3 (Sandy Clay Loam) and T4 (Sandy Loam); ns mean not significant at 5 % probability; LSD means least significant difference, * means significant at 5 % probability level; WAP means week after planting

Table 9: Effects of texture and nutrient applications on soybean P Uptake

	Soil Texture (T)				
	TI	T2	T3	T4	Mean
Nutrients (N)	Total P Uptake (g/plant)				
Control	0.08	0.29	0.07	0.05	0.12
-N	0.26	0.31	0.05	0.15	0.19
-P	0.07	0.51	0.16	0.53	0.32
-K	0.40	0.39	0.04	0.64	0.37
Full NPK	0.40	0.65	0.24	0.82	0.53
NPK + Zn	0.22	0.63	0.21	0.68	0.43
NPK + S	0.17	0.85	0.16	0.42	0.40
NPK + S + Zn	0.26	0.27	0.08	0.87	0.37
NPK + PM	0.24	0.67	0.15	0.33	0.35
Texture Mean	0.23	0.51	0.13	0.50	
LSD texture	0.08**				
LSD nutrient	0.10**				
LSD texture x nutrient	0.23**				

Note: T1 (Clay loam), T2 (Sandy Clay), T3 (Sandy Clay Loam) and T4 (Sandy Loam); ns mean not significant at 5 % probability; LSD means least significant difference, * means significant at 5 % probability level; WAP means week after planting.

Table 10: Effects of texture and nutrient applications on soybean K Uptake

	Soil Texture (T)				
	TI	T2	T3	T4	Mean
Nutrients (N)	Total K Uptake (g/plant)				
Control	0.08	0.39	0.08	0.05	0.15
-N	0.30	0.39	0.06	0.20	0.23
-P	0.13	0.63	0.20	0.72	0.42
-K	0.46	0.48	0.10	0.84	0.47
Full NPK	0.44	0.78	0.32	1.01	0.63
NPK + Zn	0.26	0.76	0.31	0.84	0.54
NPK + S	0.19	1.01	0.19	0.61	0.50
NPK + S + Zn	0.32	0.33	0.15	1.08	0.47
NPK + PM	0.24	0.71	0.21	0.41	0.39
Texture Mean	0.27	0.61	0.18	0.64	
LSD texture	0.10**				
LSD nutrient	0.11**				
LSD texture x nutrient	0.24*				

Note: T1 (Clay loam), T2 (Sandy Clay), T3 (Sandy Clay Loam) and T4 (Sandy Loam); ns mean not significant at 5 % probability; LSD means least significant difference, * means significant at 5 % probability level; WAP means week after planting.