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EFFECTS OF NPK AND POULTRY MANURE RATES ON GROWTH PERFORMANCE AND YIELD OF SOYBEAN (*Glycine max* L. Merril)

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ABSTRACT

Pot experiments wereconducted in 2021at the screen house to evaluate the effect of nitrogen, phosphorus and potassium (NPK) and poultry manure (PM) rates on the growth and yield of soybean (TGx1835-10E). The treatments consisted of Nitrogen Phosphorus and Potassium (NPK 15:15:15) rates (0g, 0.6g, 1.2g and 2.4g) and Poultry Manure (PM) rates (0g, 3g, 6g and 12g) which were combined in factors to give sixteen treatment combinations and Control with neither fertilizer. The experiment was laid out in a completely randomized design and replicated six times.Soil and PM were analyzed for physico-chemical parameters using standard procedures for pH, O.C, O.M, P, N, Na, Ca, Mg, K, EC and particle size distribution. Data collected includes; growth performance at 64 days after planting (DAP) for; plant height, root length, number of leaves, number of branches, chlorophyll content, leaf area, shoot dry weight) and yield attributes (number of pods/plant, number of seeds/pod, economical yield, biological yield, harvest index) and these data were subjected to analysis of variance (ANOVA) and means were separated using Tukey. Result indicated that the combined application of PM and NPK significantly ($p<0.05$) increased plant height, number of leaves, number of branches, leaf area, chlorophyll content, shoot dry weight, harvest index and economic yield of soybeanthan the sole application of either PM or NPK and the control. No significant difference was however recorded for number of pods, number of seeds and biological yield. The use of balanced doses of inorganic and organic fertilizers improved growth and yield qualities of soybean.

Keywords: Soybean, Poultry manure, NPK fertilizer, Growth attributes, Yield attributes

INTRODUCTION

Soybean (*Glycine max* L. Merr.) belong to the family Leguminosae and subfamily Papilionoidae (Berk, 1992). The crop has opposing, oval, unifoliate primary leaves, alternating, trifoliate secondary leaves, and compound leaves with four or more leaflets present. It also has an upright stalk that bears pods (Sheaffer & Moncada, 2012). It is a self-pollinating diploid plant with 40 chromosomes (2n=40) (Chang & Qiu, 2010) and one of the most significant food plants as well as vital industrial crops that is farmed globally (Afework & Adam, 2018; Shea *et al*., 2020). Poor soil fertility is a generally known issue that serves as a key barrier to optimizing agricultural productivity (Hilhorst *et al*., 2000). Soils of the savannah regions are known to contain low nitrogen that are inadequate to sustain good growth and development of some crop plants (Danmaigoro, 2020**)**. Agricultural lands in Kano state, Northern Nigeria like their counterparts in Sub-Saharan Africa are inherently low in fertility and are subjected to numerous natural challenges imposed by the harsh climatic conditions that ensue in this agro ecological zone (Rabiu, 2015**)**.

Chemical fertilizers are primarily used to maximize crop yield, but their continual use has led to the soil's scarcity of several micronutrients and has also negatively impacted the environment (Kumar, 2008). Due to shortages, high costs, and occasionally a lack of technical knowledge, smallholder farmers in Africa do not adhere to the recommended practices for using inorganic fertilizers (Bationo *et al*., 2006). The challenge of low soil fertility can be addressed in a few different ways, one of which is by supplying the soil with organic and/or inorganic nutrients. Organic food sources boost the availability and quality of food in a distinctive way by combining environmentally friendly techniques with minimal external inputs (Aher *et al*., 2015). A substitute that has proven to be quite effective is integrated nutrient management, which integrates the use of chemical fertilizers with organic resources including crop residue, animal manure, green manure, and composts while minimizing the input of synthetic fertilizers (Chand *et al*., 2006). Also, it has been established that using organic manures coupled with fertilizers can provide soybeans with the micronutrients they require (Joshi *et al*., 2000). Mamia *et al*. (2018) found that when both mineral fertilizers and organic fertilizer are combined in the right proportion, they can stimulate soybean growth and yield more than when applied individually. The effects of organic and inorganic fertilization on soybean production and quality were also examined by Khaim *et al*. (2013). The findings indicate that applying organic and inorganic fertilizers together enhanced greater soybean growth compared to either fertilizer alone. So, this research was initiated to investigate how soybean will respond to the combined application of various rates of PM and NPK fertilizers. The study will further reveal how organic and inorganic fertilizer may co-exist mutually to foster the growth and yield of soybean, further increasing our knowledge of the synergistic effects between them.

MATERIALS AND METHODS

The experiment was conducted at the screen house of the Centre for Dry Land Agriculture (CDA), Bayero University Kano, New Campus, located between latitude 11˚58'N and longitude 8˚25'E. Farm soil was soured and dug out to a depth of 0-30cm from three different point of the farm at Bayero University Kano, New Campus and was thoroughly mixed together to achieve uniformity of constituent. An aliquot of the soil sampled was dried and sieved with a 1.7mm size mesh, then taken to the laboratory and was analyzed for the physicochemical parameters. Bouyoucos hydrometer method (Andres *et al.,* 2014) was used to determine the particle proportions in a soil sample. The pH of the soil was then determined using a 3520pH meter (Mclean, 1962). The electrical conductivity was determined using a glass electrode conductivity meter (ASTM, 2009). Organic carbon content was determined by using the Walkley-Black chromic acid wet oxidation method (Nelson and Sommers, 1982) and the percentage organic matter of soil sample was determined by multiplying the organic carbon content by 1.724 (The Van Bemmelen factor). The total nitrogen content of the soil sample was determined by using the Kjeldahl method (Bremner and Mulvaney, 1982). The amounts of phosphorus in soil sample were determined by using the Bray-1 test method and Bray -1 solution was used to extract phosphorus from soil ample (Jackson, 1958). EDTA titration method was used to assess the Ca and Mg content in soil sample (Moss, 1961) while Potassium and Sodium content in the soil sample were measured using the flame photometer. ECEC was calculated as the sum of exchangeable cations (K, Ca, Mg and Na) and exchangeable acidity (H + Al) (Bascomb, 1964). Poultry manure was sourced from a poultry farm and analyzed for physicochemical parameters. The experiment was a 4 x 4 factorial combination with treatments arranged in a completely randomized design (CRD) replicated six times. The two factors were NPK rates and poultry manure rates. The treatment levels were; 0, 0.6g, 1.2g and 2.4g of NPK with 0, 3g, 6g and 12g of poultry manure respectively. The sixteen treatments combinations were; (0gNPK+0gPM)(0.6gNPK+0gPM), (1.2gNPK+0gPM), (2.4gNPK+0gPM), (3gPM+0gNPK), (0.3gNPK+1.5gPM), (0.6gNPK+1.5gPM), (1.2gNPK+1.5gPM), (6gPM+0gNPK), (0.3gNPK+3gPM), (0.6gNPK+3gPM), (1.2gNPK+3gPM), (12gPM+0gNPK), (0.3gNPK+6gPM), (0.6gNPK+6gPM) and (1.2gNPK+6gPM). Perforated pots of 15L capacity were filled with soil and watered for acclimatization to be achieved. Five soybean seeds were planted and later thinned to three after two weeks and weed was controlled mechanically by hand picking. Fertilizer application was done as per treatment allocation. Harvesting was done when the plant attained physiological maturity. Plants were tagged and data was collected on plant height, root length, number of leaves, number of branches, chlorophyll content, leaf area, shoot dry weight at 64 DAP, number of pods per plant by counting the pods, number of seeds per pod per plant by counting the seeds, economical yield by weighing the grain, biological yield by weighing the grain+pods and harvest index$\frac{Economical\ yield}{Biological\ yield}$. Data was analyzed using one way analysis of variance ANOVA to determine significant differences between means ± standard deviation using MINITAB v18 (Minitab Ltd, UK). Significance difference were all at $p<0.05$ even though this is not repeated in the explanations of results.

RESULTS AND DISCUSSION

Table 1 shows the result of the soil analysis. The soil used was sandy loam in texture, slightly acidic (6.05) and low in organic carbon (0.45). N, P, K, Na, Ca and Mg contents are 0.35%, 14.61mg/kg, 726.69 cmol/kg, 0.05cmol/kg, 2.31 cmol/kg and 1.15cmol/kg respectively. Table 2 shows the physicochemical analysis of the poultry manure used in this experiment. pH is slightly acidic (7.29) and the organic content of 56.85%. N, P, K, Na, Ca and Mg contents are 2.10%, 2804.78 mg/kg, 695.10 mg/kg, 1045.48 mg/kg, 9369.86 mg/kg and 3123.28 mg/kg.

Growth Attributes at 64 Days after Sowing

Table 3 shows the effect of poultry manure and NPK on plant height, number of leaves, number of branches and leaf area at 64 days after sowing. The result showed significant difference ($p<0.05$) among treatments for the assessed parameters.

Table 1. Physico-chemical properties of soil used for the experiment

Soil variable	Composition
Particle size distribution (%)	
Sand	84
Silt	13
Clay	6
Textural class	Loamy sand
pH(H_2O)	6.05
Organic Carbon(%)	0.43
Total Nitrogen(%)	0.35
Available phosphorus(mg/kg)	14.61
Potassium (cmol/kg)	726.69
Sodium(cmol/kg)	0.05
Calcium (cmol/kg)	2.31
Magnesium(cmol/kg)	1.15

Table 2. Physico-chemical properties of poultry manure used for the experiment

Poultry manure variable	Composition
EC (dS/m)	2.10
pH	7.29
Organic Matter(%)	56.85
Total Nitrogen(%)	2.10
Available phosphorus(mg/kg)	2804.78
Potassium (mg/kg)	695.10
Sodium(mg/kg)	1045.48
Calcium (mg/kg)	9369.86
Magnesium(mg/kg)	3123.28

Results indicated that 1.2g NPK + 6g PM recorded the highest plant height (128.67±8.08 cm) and Leaf Area (673.30±83.00cm^2) while 1.2g NPK + 3g PM produced the shortest plant (61.67 cm) and 0.6g NPK + 3g PM with the smallest leaf area (319.40±146.50cm^2). 0.6g NPK + 6g PM recorded the highest number of leaves (69.00±7.94) and the number of branches (23.00±2.65) and the control recorded the lowest values for number of leaves (23.00±9.64) and number of branches (8.33±2.08). Table 4 shows the effects of poultry manure and NPK on chlorophyll content, root length and shoot dry weight. Result shows significant difference ($p<0.05$) among treatments for chlorophyll content, root length and shoot dry weight. 0.6g NPK + 6g PM recorded the highest value for chlorophyll content (47.17±6.75) and 0.3g NPK + 3g PM recorded the highest value (9.873±1.21 g) for shoot dry weight. In terms of all growth characteristics, the results showed that applying both NPK and poultry manure performed better than applying just one of them. When PM and NPK were applied together, the parameters considerably increased compared to when PM and NPK were applied separately and the control. Greater LAI in NPK + PM treatment was attributed to production of new leaves & also increase in size of the existing leaves (Anil *et al*., 2018). Combined application of fertilizers 1.2g NPK + 6g PM produced the highest plant height (128.67±8.08 cm) while 0.6 NPK + 6g PM produced the highest number of leaves (69.00±7.94) and number of branches (20.67±2.52) of soybean.

Table 3: Effect of Effects of Poultry Manure and NPK on Plant Height, Number of Leaves, Number of Branches and Leaf Area at 64 Days after Sowing.

Treatments	PH (cm)	NL	NB	LA (cm^2)
3g PM	117.30±21.20^{ab}	47.00±13.53^{abc}	15.67±4.51^{ab}	613.00±43.30^{abc}
6g PM	90.50±11.30^{ab}	44.67±8.33^{abc}	12.67±6.11^{ab}	507.10±108.50^{abc}
12g PM	97.00±36.20^{ab}	45.00±15.87^{abc}	15.00±5.29^{ab}	597.30±93.40^{abc}
0.6g NPK	102.67±15.37^{ab}	37.00±3.46^{abc}	12.33±1.55^{ab}	553.60±79.20^{abc}
1.2g NPK	76.83±13.60^{ab}	30.00±7.94^{bc}	10.00±2.65^{b}	463.90±47.00^{abc}
2.4g NPK	76.70±26.60^{ab}	43.00±22.50^{abc}	14.33±7.51^{ab}	562.60±45.20^{abc}
0.3g NPK + 1.5g PM	105.70±31.90^{ab}	56.00±12.12^{abc}	18.67±4.04^{ab}	590.00±18.00^{abc}
0.3g NPK + 3g PM	115.00±20.50^{ab}	56.00±13.53^{abc}	18.67±4.51^{ab}	348.00±24.00^{bc}
0.3g NPK + 6g PM	90.00±6.24^{ab}	34.00±6.24^{abc}	11.33±2.08^{ab}	454.30±24.30^{abc}
0.6g NPK + 1.5g PM	114.00±24.30^{ab}	37.00±6.24^{abc}	12.33±2.08^{ab}	605.50±68.80^{abc}
0.6g NPK + 3g PM	79.67±15.95^{ab}	35.00±9.64^{abc}	11.67±3.21^{ab}	319.40±146.50^{c}
0.6g NPK + 6g PM	85.33±8.08^{ab}	69.00±7.94^{a}	23.00±2.65^{a}	614.30±56.80^{abc}
1.2g NPK + 1.5g PM	106.70±32.50^{ab}	48.00±24.60^{abc}	16.00±8.19^{ab}	459.80±28.90^{abc}
1.2g NPK + 3g PM	61.67±11.06^{b}	42.00±6.00^{abc}	14.00±2.00^{ab}	371.60±55.50^{abc}
1.2g NPK + 6g PM	128.67±8.08^{a}	62.00±7.55^{ab}	20.67±2.52^{ab}	673.30±83.00^{a}
Control	70.33±11.15^{ab}	23.00±9.64^{c}	8.33±2.08^{b}	654.70±78.10^{ab}
p-value	0.012	0.006	0.012	0.002

Means with different letters are significantly different
PH=plant height, NL=number of leaves, NB=number of branches, LA=leaf area

This is consistent with the findings of Jagdeesh *et al*. (2018) and Eni *et al*. (2022), who discovered that the application of both organic and inorganic fertilizers significantly increased the number of nodules and other growth aspects (such as plant height, branch count, dry matter output, and nodule count). Ibrahim (2021) reported significant increase in numbers leaves, leaf area index as well as days to 50% flowering in two varieties of peanuts by the application of poultry manure compared to NPK. According to studies by Almaz *et al.* (2017) and Liana *et al.* (2021), manure treatment had a significant influence on plant height and leaf number from 45 to 75 DAP. The internode lengthening and other nutrients the plant obtained from both organic and inorganic sources may be responsible for the considerable rise in plant height seen in plants treated with mixed organic and inorganic fertilizer. Poultry manure had also been shown to increase the growth and yield of non leguminous plants. Abdulbaki (2019) found that 8g of poultry manure in 3kg of soil significantly increased growth and yield of two pepper species (*Capsicum annuum* and *C. frutescens*).

Table 4. Effects of Effects of Poultry Manure and NPK on Chlorophyll Content, Root Length and Shoot Dry Weight

Treatments	CC	RL(cm)	SW(g)
3g PM	36.67±8.99^{ab}	29.47±8.43^{ab}	7.04±2.83^{abc}
6g PM	22.93±4.42^{b}	41.00±13.89^{a}	5.15±2.85^{abc}
12g PM	32.97±5.69^{ab}	26.67±2.36^{ab}	5.113±1.396^{abc}
0.6g NPK	23.57±10.40^{b}	31.80±1.90^{ab}	3.757±1.142^{abc}
1.2g NPK	28.90±7.34^{ab}	20.30±3.40^{b}	2.307±0.366^{c}
2.4g NPK	26.20±7.27^{b}	22.93±7.56^{ab}	3.05±2.03^{bc}
0.3g NPK + 1.5g PM	29.83±5.52^{ab}	28.63±7.32^{ab}	6.88±3.41^{abc}
0.3g NPK + 3g PM	31.17±6.96^{ab}	37.67±3.51^{ab}	9.873±1.210^{a}
0.3g NPK + 6g PM	33.97±10.79^{ab}	27.43±5.05^{ab}	3.600±1.085^{abc}

0.6g NPK + 1.5g PM	28.77±7.13[ab]	27.43±5.36[ab]	6.07±1.94[abc]
0.6g NPK + 3g PM	18.80±3.10[b]	28.97±2.15[ab]	2.6967±0.1012[c]
0.6g NPK + 6g PM	47.17±6.75[a]	26.367±1.320[ab]	9.443±1.207[ab]
1.2g NPK + 1.5g PM	28.57±8.86[ab]	30.77±9.04[ab]	10.067±1.012[a]
1.2g NPK + 3g PM	16.47±1.86[b]	32.07±3.63[ab]	2.127±0.685[c]
1.2g NPK + 6g PM	34.80±3.54[ab]	31.967±0.666[ab]	9.73±4.00[ab]
Control	26.07±2.47[b]	34.77±8.34[ab]	5.76±4.20[abc]
p-value	0.002	0.049	0.0001

Means with different letters are significantly different
CC=chlorophyll content, RL=root length, SW=shoot dry weight

The dry weight of the shoots demonstrated plants' capacity to synthesize carbohydrates. The findings indicated a relationship between organic manure and the NPK dosage applied to soybean plants. This may be due to an adequate and continuous supply of nourishment from organic sources that facilitates improved nutrient absorption, which in turn helps cell division and enhances all growth-promoting properties. These outcomes support the findings of Baghdadi *et al*. (2018), who asserted that chemical fertilizer and organic manure (cow dung) supply essential nutrients during the early establishing stage and produced the best outcomes for the assessed parameters, such as plant height. Poultry manure has the benefit of greatly increasing nutrient availability when combined with inorganic manure, which improves nodule development, energy conversion, metabolic processes, and root growth, increasing the amount of dry matter produced, the number of branches/plants, and the number of nodules (Aher *et al*. 2019).

Yield and Yield Attributes

Table 5 shows the effect of the PM and NPK on the number of pods, number of seeds, harvest index, biological yield and economical yield of soybean. Result showed significant difference ($p<0.05$) among treatments for harvest index and economic yield however no significant difference was observed among treatments for the number of pods, number of seeds and biological yield. 1.2g NPK + 6g PM recorded the highest harvest index and was significantly at par with 0.3g NPK + 6g PM (0.71) and 12g PM recorded the least value for harvest index with (0.07) but was significantly the same as 0.6g NPK + 3g PM (0.13). For economic yield, 0.6g NPK + 1.5g PM (2.74g) produced the highest value for economic yield and was followed by 0.3g NPK + 6g PM (2.31g) and 1.2g NPK (2.30g). The least was however recorded by 12g PM (0.12g). It is thought that a good yield requires improved growth characteristics. Findings showed that applying PM and NPK together substantially increased the harvest index and increased the economic yield compared to applying PM and NPK separately. The combined impact of organic and inorganic fertilizer at various levels led to the larger number of pods and number of seeds, even though there was no significant different between treatments for the number of pods and seeds. The increase in the number of pods, pod weight and yield by the combined application could be due the assertion that organic manure can change physical, chemical and biological characteristics of the soil (Ladan et al, 2021). Another reason could also be due to the fact that organic manure are in their natural state and much more suitable for the release of nutrients and more readily absorbed and utilized by the plants than inorganic fertilizers. Thus, plants showed accelerated growth and organic manure in combination complements this effect at the later stage of growth (Falodun *et al*., 2015). Plants thrive quickly as a result of the quick release of nutrients by inorganic fertilizers, and the application of organic manure in combination at a later stage of growth boosted this impact (Baghdadi *et al*., 2018).

Table 5: Effects of Poultry Manure and NPK on number of pods, number of seeds per pod, harvest index, biological yield and economical yield.

Treatments	NP	NS	HI	BY(g)	EY(g)
3g PM	13.33±7.02	1.10±0.70	0.33±0.26[ab]	3.01±2.91	1.51±2.05[b]
6g PM	8.00±4.58	1.25±0.84	0.283±0.11[ab]	1.24±0.75	0.37±0.30[d]
12g PM	13.33±4.73	0.80±0.36	0.073±0.02[b]	1.58±0.73	0.12±0.08[d]
0.6g NPK	14.33±3.79	1.29±0.34	0.376±0.13[ab]	2.51±0.63	0.99±0.53[c]
1.2g NPK	14.67±5.69	1.79±0.60	0.68±0.09[a]	3.36±0.42	2.30±0.34[a]
2.4g NPK	7.00±3.61	1.50±1.05	0.53±0.28[ab]	1.13±0.46	0.69±0.60[c]
0.3g NPK + 1.5g PM	10.67±6.66	1.30±0.35	0.52±0.02[ab]	1.73±0.11	0.91±0.59[c]
0.3g NPK + 3g PM	6.67±2.08	1.22±1.34	0.36±0.34[ab]	1.65±1.58	0.95±1.20[c]
0.3g NPK + 6g PM	14.67±6.03	1.60±0.31	0.71±0.10[a]	3.12±1.18	2.31±1.12[ab]
0.6g NPK + 1.5g PM	20.33±3.79	1.56±0.26	0.57±0.09[ab]	4.61±1.60	2.74±1.26[a]
0.6g NPK + 3g PM	8.67±10.02	0.88±0.90	0.13±0.18[b]	0.93±0.79	0.16±0.23[d]
0.6g NPK + 6g PM	20.3±12.22	0.86±0.72	0.19±0.09[ab]	2.30±2.75	0.57±0.82[c]
1.2g NPK + 1.5g PM	15.33±2.52	0.74±0.64	0.34±0.30[ab]	1.69±0.65	0.68±0.60[c]
1.2g NPK + 3g PM	15.67±4.04	1.49±0.38	0.50±0.19[ab]	3.01±0.28	1.57±0.72[b]
1.2g NPK + 6g PM	11.33±9.50	2.20±1.16	0.73±0.11[a]	2.79±1.83	1.90±1.10[b]
Control	13.33±2.52	1.91±0.09	0.56±0.04[ab]	3.31±0.84	1.87±0.47[b]
p-value	0.667	0.483	0.001	0.132	0.014

Means with different letters are significantly different
NP=number of pods, NS=number of seeds, HI=harvest index, BY=biological yield, EY=economic yield

The better economic yield may have resulted from sufficient nutrient availability from both organic and inorganic sources at the right moment, which enabled for the optimum dry matter partitioning from the source to sink during the plant's reproductive stage and considerably increased the soybean seed production. Danmaigoro (2020**)** reported that application of poultry manure promoted vegetative growth in sesame consequently resulting in the increase in number of capsules produced, better seed formation and filling which led to the higher seed yield. Falodun *et al.* (2015) reported that the combination of organic and inorganic fertilizers adequately supply nutrient element at the right time from organic and inorganic sources which helped optimum dry matter partitioning from the source to sink during reproductive stage of plant consequently increase the seed yield of soybean. It is possible that the appropriate combination of organic manures and inorganic fertilizers enhanced the yield characteristics and boosted soybean output by enhancing the accessibility of metabolites and photosynthates. The result agrees with those of Baghdadi *et al.* (2018) and Liana *et al* (2021). On the other hand, according to Jagdeesh *et al*. (2018), test weight, pods/plant, and seeds/pod all significantly changed in response to the different integrated fertilizer management methods.

CONCLUSION

Results indicated that a combination of organic and inorganic fertilizer application outperformed a solitary application for all growth characters and the majority of yield characteristics. The growth characters recorded higher readings when organic and inorganic fertilizer were applied together rather than separately, and showed higher values over the control treatment. In general, the use of organic manure raised crop output and enhanced the agronomic performance of soybean. The increased crop performance when organic manures are applied could be attributed to the cumulative impacts on the nutrients available in the soil, increased organic carbon, higher microbial population, increased enzyme activities, as well as the residual effect. . Additionally, the use of balanced doses of inorganic and organic fertilizers improved yield qualities, increasing soybean output. This demonstrates the importance of combining organic manures with inorganic fertilizers to increase nutrient availability for a longer time and in available form, which results in positive effects on crop growth characteristics and promoted a variety of physiological activities in plants that are crucial for healthy growth and development.

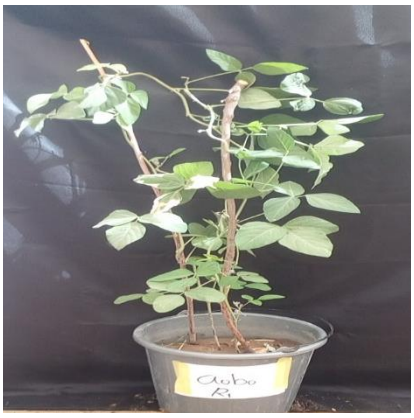

Figure 1: Control at 64DAP

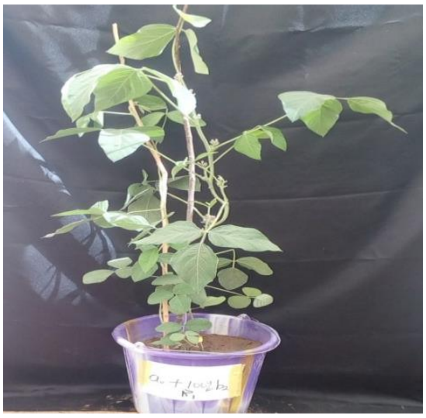

Figure 2: Plant treated with 6g PM at 64DAP

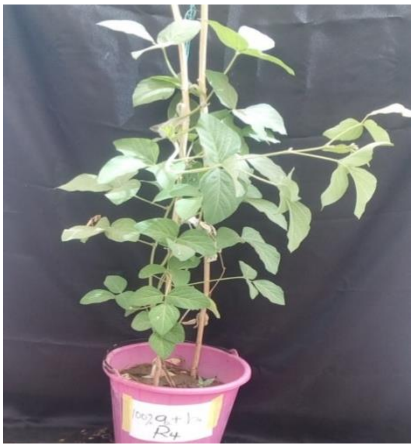

Figure 3 Plant treated with1.2g NPK at 64DAP

Figure 4 Plant treated with1.2g NPK + 6g PM at 64DAP

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