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Response of Green Gram (*Vigna radiata* L.) to an Application of Minjingu Mazao Fertilizer Grown on Olasiti Soils from Minjingu-manyara, Tanzania

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Abstract: A screen-house pot experiment was conducted to assess the response of green gram (*Vigna radiata* L.) to the application of Minjingu Mazao fertilizer (31% P_2O_5) on Olasiti soil, Manyara Region-Tanzania. This study was prompted by very low or limited use of Minjingu Mazao fertilizer by smallholder farmers in the country while yields turnout of most crops, green gram inclusive, is not promising. The soil was clay with medium pH (pH 5.5-7.0) and neutral reaction (pH 6.6-7.3). The results showed that the number of pods and seeds increased from 3-6 and 7-9, respectively, at 40 to 160 mg per 4 kg soil of fertilizer applied. Similarly, the tissue N and P increased with treatment levels. The number of pods per plant and seeds per pod showed similar increase, signifying the role of these nutrients in protein synthesis in leguminous plants like green gram. Soil properties could be the spearhead to low responses obtained at low (<80 mg per 4 kg soil) and high (>320 mg per 4 kg soil) rates of Minjingu Mazao fertilizer applied. It was concluded that to optimize green gram production in Olasiti soil, Minjingu Mazao fertilizer containing 31% P_2O_5 should be applied at a rate of 160-320 kg ha^{-1} while considering other necessary agronomic practices. However, field studies to confirm the findings of this study and verify the usefulness of this fertilizer brand to green gram in Olasiti soil under field conditions could practically be the viable option before its recommendation to the smallholder farmers.

Key words: Green gram, minjingu mazao, phosphorus, growth traits, yield components

INTRODUCTION

Green gram (*Vigna radiata* L.) is an important conventional pulse crop of Tanzania. The crop is a short duration grain legume with wide adaptability to different tracts, low soil fertility requirements and ability to improve most of the soil properties by fixing atmospheric Nitrogen (N). It is well matched to a large number of cropping systems and constitutes an important source of protein in the cereal-based diets of many people in Tanzania. The densely settled humid and sub-humid areas of Tanzania, Manyara region inclusive, accelerated by the population growth in most urban areas are suffering from increased magnitudes of soil fertility depletion, which has hampered food crops production systems. In addition, the high costs of imported conventional P containing fertilizers have resulted in a declined trend for their use in Tanzania in spite that most Tanzanian soils are deficient in P (Mnkeni *et al*., 2000). The population in these areas suffer from erratic food shortages since the majority of smallholder farmers in the country cannot afford imported fertilizer costs for their cropland. However, the domestically manufactured Minjingu Mazao fertilizer could be used as an alternative P source but appropriate rates to be applied to green gram have not clearly been studied. Therefore, the scope of this study was to assess the response of green gram in terms of its growth traits and yield components to different rates of Minjingu Mazao fertilizer (31% P_2O_5).

MATERIALS AND METHODS

Description of the study: The study soil was collected from Olasiti Village located in Nkaiti Division, Mbungwe Ward, Babati District, Manyara Region. The area is located between latitude 3°7'S and longitude 35°56'E and at an elevation of 1024 m above mean sea level. The soil of the area is predominantly amorphous originating from fresher materials of the Rift Valley. The average annual rainfall in this area is between 800 and 1000 mm.

Soil sampling, lab analysis and set up of the screen-house experiment: The composite soil sample constituted 15 spot samples to the depth of 30 cm. About 100 kg of soil was collected, used for soil characterization (Table 1) following standard lab procedures compiled by

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Table 1: Some physical and chemical properties of the soil from Olasiti village

Parameter	Unit	Value
Textural class		Clay
pH (1:2.5 H_2O)		7.07
Organic carbon	%	2.50
Organic matter	%	4.30
Total nitrogen	%	0.18
C:N ratio		13:1
Olsen extractable P	mg kg^{-1}	3.41
Cation exchange capacity	$cmol_{(+)}$ kg^{-1}	46.20
Calcium	$cmol_{(+)}$ kg^{-1}	21.97
Magnesium	$cmol_{(+)}$ kg^{-1}	6.22
Potassium	$cmol_{(+)}$ kg^{-1}	3.59
Sodium	$cmol_{(+)}$ kg^{-1}	0.11
Base saturation	%	69.03

Table 2: Yield parameters of green gram at applied Minjingu Mazao (MM) fertilizer

MM (mg pot^{-1})	DMY (g pot^{-1})	Tissue %N	Tissue %P	Pods/ plant	Seeds/ pod
0	1.41^{b}	1.94^{ab}	0.25^{a}	4.0^{ab}	8.00^{ab}
20	1.3^{ab}	1.89^{a}	0.33^{a}	3.0^{a}	7.00^{b}
40	1.22^{ab}	1.94^{ab}	0.21^{a}	3.0^{a}	7.00^{a}
80	1.23^{ab}	1.96^{ab}	0.27^{a}	5.0^{ab}	8.00^{a}
160	1.32^{ab}	2.35^{b}	0.34^{a}	6.0^{b}	9.00^{ab}
320	1.16^{a}	2.10^{ab}	0.29^{a}	4.0^{0ab}	8.00^{ab}
LSD	0.21	0.39	0.14	2.4	1.44
CV (%)	9.10	10.40	26.80	31.6	9.80

Means in the same column followed by the similar letter(s) are not statistically different at 5% level of significance

Okalebo *et al.* (2002) and then for the screen-house pot experiment where Minjingu Mazao fertilizer (31% P_2O_5) was used as treatment at different rates (0, 5, 10, 20, 40 and 80 kg P ha^{-1}; equivalent to 0, 2.5, 5, 10, 20 and 40 mg P per 4 kg capacity soil pot) and the green gram (*V. radiata,* L.) as a test crop. The lab analyzed and screen-house used soils were sieved through 2 and 8 mm wire mesh, respectively. The treatment levels were replicated three times in a completely randomized block design.

Collection of the green gram early growth and maturity data: One green gram plant above the soil in each pot was cut at 35 days of growth early before flowering, then oven-dried at 70°C for 48 h for the determination of dry matter yield (DMY) and the tissue percentages N, P concentrations at different levels of treatment applied. The maturity yield data collected were number of pods per plant and number of seeds per pod (Table 2).

Statistical data analysis: The means for the early growth and yield data at maximum maturity were subjected to statistical Analysis of Variance (ANOVA) (Appendix 1) to test the differences among parameters and the significance of the differences among means were separated by employing New Duncan's Multiple Range Test using GenStat Discovery computer software (Wim *et al.*, 2007).

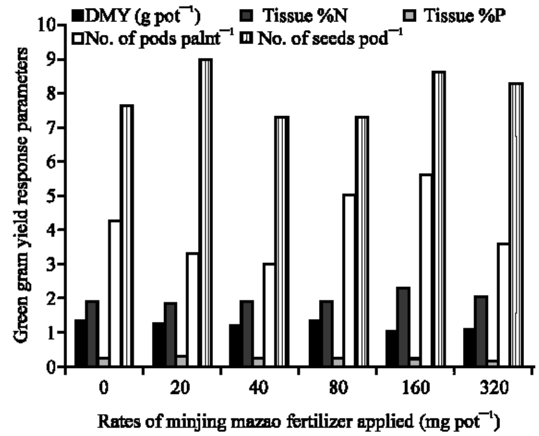

Fig. 1: Trends of yield response of a green gram plant to Minjingu Mazao fertilizer

RESULTS

Physical and chemical characteristics of the study soil: Some of the physical and chemical properties of Olasiti soil are as presented in Table 1.

Response of green gram to the applied Minjingu Mazao fertilizer: The data of the tissue percentage N and P concentrations, dry matter yield (DMY), number of pods per plant and number of seeds per pod are as presented in Table 2 and in Fig. 1.

DISCUSSION

Soil characteristics: The pH of the Olasiti soil was medium (pH 5.5-7.0) and its soil reaction was neutral (pH 6.6-7.3). Most nutrients such as N, P, K, Ca, Mg, S and Mo become readily available for plant uptake at pH 6.0-8.0. However, Olasiti soil is neutral in reaction, which suggests the presence of most macronutrients abundantly but their availability for plant uptake may vary significantly depending on the plant nutrient requirements, growth stage of the plant, soil moisture and temperature and nutrients transformations regimes in the soil. The Total Nitrogen (TN) was low (0.10-0.20%), which was almost in line with its Organic Matter (O.M) content, which was high (4.3-6.0%) and the Organic Carbon (O.C) was medium (1.26-2.50%) as rated by Msanya *et al.* (2003). The low TN of the Olasiti soil could be attributed to the low organic matter content and its soil forming parent materials. The amount of TN of the Olasiti soil confirms the extent of weathering and mineralization of organic and mineral-N (NH_4^+, NO_3^-, NO_2^-) contents in most tropical soils (Msanya *et al.*, 2003). However, the amount O.M of the Olasiti soil confirms the C:N ratio (13:1), which indicates significant process of mineralization exceeding immobilization because it is less than 20:1. Olasiti Village is relatively semi-humid to semi-arid and drier than the upper positions along the Lake Manyara-Tarangire corridor in the lower slopes of Karatu escarpments leading to Mto-wa-Mbu basin, which collects water from the interlocked spurs of the escarpment and fill the lake. Because of this topographic position of the Olasiti Village, probably most of the organic matter has been transported to the adjacent villages through runoff and erosion. These findings are also comparable to those of Kisetu and Mrema (2010) who reported that topographic placement and amorphous Al-clay minerals might hinder decomposition and accumulation of the organic matter in the Haplic Andosols by the formation of stable humus-clay coordination. However, soil O.M in turn influences or modifies many of the soil properties including structure, texture, pH and water and nutrients holding capacity.

Cation Exchange Capacity (CEC) of Olasiti soil was very high (>40 cmol kg^{-1}), which might be related to the nature of its clay fractions, organic matter content and low leaching capacity of the exchangeable bases, especially Ca^{2+}. The CEC of the soil indicates the extent to which a soil can hold and exchange basic cations such as Ca^{2+}, Mg^{2+}, K^+ and Na^+ as well as H^+, Al^{3+}, Fe^{3+} and Mn^{2+}. On the other hand, the percentage base saturation (%BS) of the Olasiti soil was high (ustic) (>50%), which was related to the fresher materials from volcanic ash eruptions since the village is situated in the Rift Valley. The amount of available phosphorus (P) of Olasiti soil was low (<5 mg kg^{-1}), which was related to its origin, primarily the weathering of minerals such as fluoro-apatite ($Ca_5(PO_4)_3F$) and the very high (>20 cmol kg^{-1}) Ca^{2+} contents support this. However, the low content of available P of the Olasiti soil could be attributed to the low dissolution rates of the apatite minerals and a continuous build-up of more apatite minerals through volcanic eruption.

Relationship between growth traits, yield components and the rates of minjingu mazao fertilizer applied: The growth traits assessed were Dry Matter Yield (DMY), tissue percentage N and P concentrations and yield components were number of pods per plant and number of seeds per pod. The findings of the study revealed that an application of Minjingu Mazao fertilizer increased DMY of the green gram plant grown on the Olasiti soil but the increase was only envisaged at a rate exceeding 20 mg P per 4 kg soil (equivalent to 40 kg P ha^{-1}) but at a rate below 40 mg P per 4 kg soil (equivalent to 80 kg P ha^{-1}). However, there was low DMY increase with increase in the levels of fertilizer applied at 5 and 20 mg P per 4 kg soil, which suggested that initially the Olasiti soil was very deficient in plant available P to adjust the nutrient-threshold level (0.1 mg P L^{-1}) for the green gram plant to optimally accumulate dry matter content. These findings suggest that when the fertilizer material was applied to Olasiti soil, part of it was distributed to the soil solution and absorbed by the green gram plant and the rest was precipitated on the soil's complex exchange sites depending on the fractions of the texture constituents. The findings of this study conform to Waqas (2008) who reported that the restricted nutrients movement in soil affects their ionic utilization and efficiently absorption by plant is very low as well as its recovery. In addition, the studied Olasiti soil did not show significant ($p = 0.05$) increase in the overall green gram DMY indicating the possible existence of various complex reactions that reduced most P availability and its uptake by the green gram plant.

The tissue N and P concentrations in the green gram plants generally increased with increased levels of Minjingu Mazao fertilizer applied. However, the results showed that N was increasing relatively higher compared to P. This more increase in N could be attributed to the ability of green gram to fix part of atmospheric N and supplement for the native and applied N through an application of Minjingu Mazao fertilizer. The relatively low increase of P content and to some extent N could be explained by the increase in number of pods per plant and the number of seeds per pod. The findings suggest that most of the N and P nutrients contained in Minjingu Mazao fertilizer were transported to the actively growing parts of the plant for the formation of pods and for seeds production, which might be the reason for insignificancies of these nutrient elements in the green gram plant tissues. These findings conform to Kisetu and Mrema (2011) who reported that the whole plant (above the soil level) as opposed to the actively growing parts harvested could contribute to the percentage tissue nutrient contents below their critical concentrations ranges. In addition, the findings indicated that N and P concentrations in the green gram plants generally increased non-significantly ($p = 0.05$) with increased levels of Minjingu Mazao fertilizer applied, suggesting that the components of the Olasiti soil have higher affinity for the ions of N and P nutrient elements.

The number of pods per plant increased from 4, absolute control, to 6 pods per plant at 20 mg P per 4 kg soil (equivalent to 40 kg P ha^{-1}) applied, which decreased later to 4 pods at 40 mg P per 4 kg soil applied from Minjingu Mazao fertilizer. On the other hand, the number of seeds increased from 8, absolute control, to 9 seeds per pod at 20 mg P per 4 kg soil of fertilizer applied, which decreased later to 7 seeds per pod at 40 mg P per 4 kg soil. The findings indicated that an application of Minjnigu Mazao fertilizer at a rate >320 mg per 4 kg soil (pot) (equivalent to 40 mg P per pot) showed a decrease in both number of pods per plant and their corresponding number of seeds per pod. The increase in the yield parameters (mainly seeds) of green gram because of Minjnigu Mazao fertilizer application was attributed to profound branching, better fruiting, increased number of seeds per pod and the quality of seeds. However, higher doses of Minjnigu Mazao fertilizer beyond 640 kg ha^{-1} (or 40 mg P per 4 kg soil pot) failed to improve the growth and yield while lower than 160 kg ha^{-1}(10 mg P per 4 kg soil pot) was less than the requirement. The favourable climatic conditions (screen-house) during green gram growth period might have resulted in more number of branches, pods and seeds those ultimately increased the overall yield. The reduction in number of pods per plant and then the number of seeds per pod in green gram might have been attributed to the abscission of flowers and pods under hidden moisture stress and partly by the deficiencies in essential plant nutrients. At the flowering stage, green gram is considered more sensitive to water stress than during vegetative stage, because at the former stage even short duration of diurnal fluctuation in plant water content could drastically influence the development and function of its reproductive organs. Similar results were reported by Tomas *et al.* (2004) that green gram is very sensitive to water stress and to the shortages in the essential nutrient elements during flowering and grain formation than vegetative stage and therefore, irrigation increased the number of grains per pod.

The findings of this study on the variation in the number of pods per plant and seeds per pod in the present study conform to the findings of Malik *et al* (2006) who found that the maximum grain yield (1104 kg ha^{-1}) in green gram fertilized at 40 kg P_2O_5 ha^{-1} and it was statistically at par with the same green gram crop fertilized at 60 kg P_2O_5 ha^{-1}.

CONCLUSION

A conclusion was drawn from the study that an application of Minjingu Mazao fertilizer to green gram depicted effects on the dry matter content, tissue N and P concentrations, number of pods per plant and number of seeds per pod during the entire period of growth. The maximum number of pods per plant was recorded for the green gram plant fertilized at 160 kg ha^{-1} (equivalent to 10 mg P per 4 kg soil) of Minjingu Mazao fertilizer applied and it was statistically at par with the results obtained at about 320 kg ha^{-1} (equivalent to 20 mg P per 4 kg soil) of Minjingu Mazao fertilizer applied (Fig. 1). The findings of this study also indicated that the amounts of Minjingu Mazao fertilizer containing 31% P_2O_5 or 13.33% P to be used to optimally obtain promising green gram yield for the Olasiti soil should be applied at rates between 160 to 320 kg ha^{-1}(equivalent to between 20 to 40 kg P ha^{-1}). However, a field study would be a viable option to consolidate and confirm the findings of this study.

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