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EFFECTS OF NITROGEN, PHOSPHORUS AND POTASSIUM FERTILIZATION ON THE GROWTH AND YIELD OF RADISH ON A VERTISOL

H. Wilson, S. Persad and N. Persad, University of Trinidad and Tobago, School For Studies In Learning, Cognition and Education, O'Meara Campus via Arima

ABSTRACT: In this agronomic study, the effects of varying levels of NPK fertilizers on the growth and yield of radish [*Raphanus sativus* (*L*)] on Tarouba clay (fine montmorillonite, Aquentic Chromudert), were investigated. Tarouba clays are typical sugar cane Vertisols in South Trinidad allocated for '2-acre' small holder farms as part of the Caroni 1975 diversification programme. Nitrogen fertilization at the rates of 60, 120 and 180 kg/ha in the presence of varying rates of phosphorus (30, 60 and 90 kg/ha) and potassium (180 and 220 kg/ha) fertilizers were applied at planting under field conditions. The application of 120 kg N, 60 kg P and 180 kg K/ha had a significant effect (P = 0.05) on all agronomic characteristics including leaf number, leaf length, root length, root girth, root weight and yield per hectare. Increased levels of nitrogen to 180 kg/ha had a significant impact on plant characteristics, with lower root length, root girth and yield per hectare, although the vegetative characteristics were also significantly lower. The response to levels of phosphorus and potassium were less pronounced, with significant effect at 60 kg P/ha and no effect of potassium fertilizer. The yield response indicates that radish can be introduced as a niche crop on Southern Vertisols.

Keywords: Radish yields, NPK fertilization, Vertisol

INTRODUCTION

Restructuring of Caroni (1975) Limited, a state owned, sugar based, agro industrial company in Trinidad and Tobago, and the subsequent decision to terminate sugar cane cultivation in 2003, have released 25,000 hectares of former sugar cane lands for diversified agricultural production. A significant challenge is the formulation of crops and soil management programmes, research based, and the provision of land use recommendation especially for the 7,500 farmers provided with 2-acre farms.

A large acreage, estimated at approximately 50,000 hectares of former sugar cane soils on the Naparima peneplain, South Trinidad are classified as Vertisols (Smith, 1983) and are responsive. Three principal soil series, namely 177 Talparo, 278/L Tarouba and 474/L Princes Town clay occupy approximately 20,801 hectares or 50% (Persad et al., 2001). These series are derived from Pliocene to Eocene clay shale to Miocene marl and Miocene clay shale as parent materials, and their properties are dominated by high levels (>51%) of montmorillonite clays (Brown and Bally, 1968).

Vertisols, according to the FAO-UNESCO legend, are soils having 30% or more clay in all horizons to a depth of at least 50 cm, and they develop cracks from soil surface downwards (FAO, 1990). Nitrogen and phosphorus are the two important elements which are relatively low in Vertisols; with phosphorus, the problem is more unavailability than total phosphorus present in the soil (Dudal,1965). Vertisols in South Trinidad are inherently fertile soils, but their fertility has been depreciated by continuous sugar cane cultivation, soil erosion and unbalanced fertilizer application (Georges,1979).

The chemical properties of 278/L Tarouba clay (soil on experimental site) analyzed in 2008 are presented in Table 1. Nutrient levels, especially those of nitrogen, phosphorus and cation exchange capacity are acceptable for the cultivation of a wide range of crop plants. The soil physical properties are dominated by typical Vertisol properties, including shrink swell properties, high water holding capacity, restricted internal drainage, low aggregate stability and gilgai micro relief (FAO, 1990). South Vertisols exist on slopes of 5° to 20° with significant soil erosion, soil movement and slumping. Therefore, agriculture is adversely influenced by technical constraints identified as inadequate drainage and irrigation infrastructure, tillage and soil management, crop selection and adaptation challenges.

The objective of this agronomic study was to determine the optimum fertilizer recommendations for the cultivation of radish [*Raphanus sativus* (L)] on the Tarouba clay. The use of radish, which is a non traditional vegetable crop with an excellent niche market in Trinidad and Tobago, can provide positive attributes as to the suitability of the crop with the potential for cultivation on '2-acre Vertisol farms' either as a monocrop or as an intercrop. The agronomic advantages include a short growing period of six to eight weeks and an ability to utilize stored soil moisture effectively. However, radish has a very high nutrient requirement and has demonstrated responses to NPK fertilizers and micronutrients in Indian soils. Joshi and Patil (1992) reported that there was significant increase in weight of foliage with increasing inter- and intra-row spacing and nitrogen and phosphorus levels.

MATERIALS AND METHODS

Field experiments were conducted at the Agricultural Experimental Station, Corinth Campus of the University of Trinidad and Tobago in 2008 and 2009. The soil type was 278/L Tarouba clay (fine montmorillonite Aquentic Chromudert). The soil physical and chemical properties are presented in Table 1. Forty-day-old radish seedlings cultivar White Chinese were transplanted on disced and cultivated seedbeds. A factorial arrangement of treatments in a randomized complete block design with four replicates was employed. Individual plot size was 3 m x 2 m with 18 plots per block. The fertilizer treatment levels were nitrogen (60,120, 180 kg/ha), phosphorus (30, 60, 90 kg/ha) and potassium (180, 220 kg/ha). Seven days after planting, the fertilizer treatments were applied as calcium nitrate (15.5% N), potassium polyphosphate (52% P_2O_5, 34% K_2O) and potassium sulphate (50% K_2O). High rates of phosphorus were applied as recommended by Shialaga and Sahrawat (1990) as phosphorus availability is low and soils are capable of fixing applied phosphorus as calcium phosphate because of the high base saturation of these soils. All plants received standard agronomic practices especially manual weed control and moulding.

Four plants from each plot were sampled at random for evaluation of agronomic characteristics. Number and length of leaves, and length, girth and fresh weight of radish roots were recorded. Data were statistically analyzed by using General Linear Models (SAS Institute, Inc., NC). Significance was determined at the 0.05 probability level and means were separated by Fisher's Least Significance Difference (FLSD).

Table 1: Selected Physical and Chemical Properties of 278/L Tarouba clay (0-30cm)*

PHYSICAL PROPERTIES

Texture Sand %	Texture Silt %	Texture Clay %	Bulk Density g/cm	Available Water/mm	Infiltration Cm/h
8	13	78	1.45	0.214	0.85-1.24

CHEMICAL PROPERTIES

pH	Phosphorus Mg/kg	Nitrogen g/kg	Organic Carbon g/kg	Calcium cmol/kg	Magnesium cmol/kg	Potash cmol/kg	CEC cmol/kg
6.8	11	2.6	32	35.6	5.2	1.3	45.2

*National Soil Testing Service, Centeno, Trinidad (2008)

Table 2: Effects of different levels of N, P and K fertilizers on leaf and root parameters.

Nutrient Levels kg /ha	Number of Leaves	Leaf Length (cm)	Root Length (cm)	Root Girth (cm)	Root Yield (tonne/ha)	Root Weight (g)
Nitrogen						
60	16.0	15.5	14.2	13.9	14.7	0.27
120	19.0	18.7	15.9	15.0	33.3	0.50
180	14.0	15.4	15.4	14.6	10.0	0.18
Phosphorus						
30	16.0	17.5	17.3	15.4	21.3	0.34
60	17.0	18.0	15.8	14.7	20.8	0.39
90	17.0	14.1	13.0	13.0	16.0	0.30
Potassium						
180	17.0	17.8	15.7	15.1	21.0	0.33
220	15.0	14.5	14.6	13.8	22.0	0.31
LSD 5%	3.0	2.3	2.2	2.4	3.9	0.09

RESULTS

Foliage Growth

Application of fertilizers significantly affected the foliage growth of the radish (average number and length of leaves). The result revealed that increase in the level of nitrogen fertilizer from 60 to 120 kg/ha in the presence of phosphorus and potassium fertilizers caused an increase in the number of leaves produced by the plant. The highest number of leaves per plant (19) was obtained with the treatment of 120 kg N/ha. However, with increasing levels of nitrogen fertilizers (180 kg/ha), the number of leaves produced decreased. On the other hand, no significant effect on the number of leaves per plant produced was obtained in the presence of phosphorus and potassium treatments (Table 2). Significant increases in leaf length were obtained also with the increase in nitrogen fertilizer rate from 60 to 120 kg/ha, and with phosphorus fertilizer increased rate from 30 to 60 kg/ha. In the case of potassium fertilizer, an increased rate of the fertilizer from 180 to 220 kg/ha caused a decrease in leaf length. These findings indicated that moderate levels of nitrogen fertilizers (120 kg/ha) in the presence of 60 kg P/ha and 180 kg K/ha fertilizers improved foliage growth of radish. However, high levels of nitrogen fertilizer (180 kg/ha) or high levels of potassium (220 kg/ha) fertilizers had a retarding effect on foliage growth of radish.

Root Characters

The results of the root characters of radish, that is root length, root girth and root weight, are presented in Table 2. With increasing nitrogen levels from 60 to 180 kg N/ha, no significant effect on root length and root girth was obtained. Likewise, no significant effect on root length or root girth was obtained with increased application of potassium fertilizers from 180 to 220 kg/ha. Increased application of phosphorus from 30 to 60 kg/ha showed no significant increase on root length or root girth; however, when the rates were increased to 90 kg P/ha both root length and root girth decreased.

Furthermore, as to root weight, an increase in nitrogen fertilizer from 60 to 120 kg/ha, significantly increased root weight. Similar results were obtained when phosphorus fertilizer was increased from 30 to 60 kg/ha. However, with further increase of phosphorus fertilizer application, no significant increase in root weight was obtained.

Root Yield

Nitrogen fertilization had marked influence on root yield of radish (Table 2). Increase of nitrogen fertilizers from 60 kg/ha to 120 kg/ha in the presence of phosphorus and potassium significantly increased yield of radish from 14.7 tonnes to 33.3 tonnes per hectare. Further increase of nitrogen fertilizer to 180 kg/ha caused significant reduction in yield. Such an increase is expected since these soils are low in nitrogen as indicated earlier. The yield increase obtained with NPK fertilization was mainly due to increase in some of the growth components and yield components such as root length, root girth and root weight. Increased application of phosphorus fertilizer from 30 to 60 kg/ha had no significant effect on root yield; however, with increased rates of phosphorus fertilizer there was a decrease in root yield. Finally, increasing application of potassium fertilizer had negligible effect on root yield.

Fertilizer treatments of 120 kg N, 60 kg P and 180 kg K/ha gave the best yield of root tubers; however, these yields were lower than those of other researchers (Srinivas and Naik, 1990), who recorded receiving higher yields of radish than were obtained in this trial with similar treatments.

CONCLUSIONS

Radish cultivar White Chinese exhibited superior plant growth and yield during the two-year field trials as a result of fertilization on Tarouba clay. Increases in the levels in nitrogen fertilizers from 60 to 120 kg/ha significantly increased the leaf length, number of leaves and root characteristics. However, nitrogen fertilizer application increased to 180 kg/ha in the presence of phosphorus and potassium fertilizers significantly decreased root length, root girth and radish yield per hectare. Therefore, application of 120 kg N/ha in the presence of 60 kg P/ha and 180 kg K/ha produced the highest tuber yield. Chatterjee and Som (1991) reported from the findings of Roorda Van Eysinga and Meijs (1981), who concluded that for radish no nitrogen fertilizers or too much nitrogen fertilizers were both detrimental to yields. These authors authenticated that increases in nitrogen (90 kg/ha) and potassium (120 kg/ha) levels considerably reduced the gross weight of the root of the radish (Chatterjee and Som, 1991).

The variable responses regarding added nitrogen in these soils are due to the fact that nitrogen fertilizers are considered a limiting factor affecting growth, yield and quality of radish, and increased levels of nitrogen fertilizers increased the vegetative growth which facilitated more scope for photosynthesis, finally resulting in larger quantities of stored food in radish plants. Also the response of nitrogen fertilizer on Tarouba clay is positive because these Vertisols are deficient in total nitrogen, the result of cropping history, rapid nitrification as fertilizer ammonium and further loss of applied nitrogen due to dinitrification.

Finally, the results of the trial indicate that radish can be successfully introduced for cultivation on '2-acre farms' either as a monocrop or as an intercrop. However, additional studies on nutrient use efficiency and uptake are recommended.

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