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Effect of NPK and Minjingu mazao fertilizers on the performance of Sweetpepper in Morogoro, Tanzania

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Research Paper

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ABSTRACT

This study assessed the effect of NPK (23:10:5) and Minjingu mazao (10:20:15) fertilizers on the performance of sweetpepper (*Capsicum annuum* L.) *cv. California Wonder*. The plant growth parameters collected were: plant height, number of leaves per plant, stem girth, and number of branches per plant. The parameters related to yield were fruit grade, fruit shape index (FSI), number of fruits per plant, weight of fruits per plant, and fruit yield. The NPK fertilizer resulted into significantly (*P*=0.03) highest average fruit yield (25 t ha^{-1}). Minjingu mazao fertilizer recorded fruit yield (15.6 t ha^{-1}) which was also significantly higher (*P*= 0.03) than the corresponding control. Fruit yields increase due to NPK fertilizer as opposed to the control and Minjingu mazao fertilizer were 166% and 66%, respectively. This was the same as 66% increase in fruit yield when Minjingu mazao fertilizer was used compared with the control. The Pearson matrix correlation indicated that the fruits length, fruits grade, weight of individual fruits and fruit yield had the strongest relationship (r ≥ 0.90*; *P*<0.001).**

Key words: Growth and yield parameters, sweetpepper *cv. California Wonder.*

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INTRODUCTION

Sweetpepper belongs to the solanaceous family and can be grown throughout the year (Kabura et al., 2008). The crop is ranked third most important vegetable crop after tomato and onion in the world (Islam et al., 2011; Belel et al., 2011). Juroszek and Tsai (2009) reported that sweetpepper fruits are good sources of many essential nutrients, including vitamins A, C, and E, carotenoids, minerals (e.g., calcium and iron), and other secondary plant compounds. Studies conducted by Chellemi and Rosskopf (2004) and Delate et al. (2008, 2003) concluded that yields of sweetpepper were similar in organic and conventional production systems. A study conducted by Murmu et al. (2013) revealed similar observation in intercrop system. However, these consistent outcomes were attributed to mostly controlled environment of crop production. Juroszek and Tsai (2009) obtained high total (44.6-55.7 t ha^{-1}) and marketable yields (36.9 - 45.6 t ha^{-1}) under organic farming conditions in the open field and this was similar to yields of sweetpepper obtained from field experiments for the on-station under tropical climatic conditions. These existing facts do not warrant optimum crop yields without replenishment of depleted nutrients because of increased nutrient transformations in tropical soils (Kisetu et al., 2014; Shaaban and Kisetu, 2014). The outdoor trials on the use of inorganic fertilizers such as NPK and Minjingu mazao for their potentials in sweetpepper in Tanzania remain to be undertaken.

In addition, there exists no documented information on the rates of NPK and Minjingu mazao fertilizers to be applied economically for sweetpepper production under acid Tanzanian soils.

Therefore, the specific objectives of this study were to: (i) assess the growth traits and yield potentials of sweetpepper under different rates of NPK and Minjingu mazao fertilizers, and (ii) evaluate the strength and association of growth traits and yield components in influencing yield of sweetpepper.

MATERIALS AND METHODS

Description of the study area

This experiment was conducted at the Crop Museum at

Sokoine University of Agriculture, Farm. The field is located between latitude 6° 85' and longitude 37° 64' and at an elevation of 568 m above mean sea level and the slope of the area is 4%. The soil of the field where this study was conducted is characteristically acid (pH <7.0) and poor in most of the essential plant nutrients. The area also receives marginally unreliable rains between February and May which range from 800 to 950 mm although it was over optimum during 2014 cropping season (Kisetu et al., 2014). These conditions are ideal for sweetpepper (Khan et al., 2005; Sezen et al., 2007).

Experimental design and treatments

The fertilizer materials used in the present study had different elemental and oxides composition as shown here under (Table 1). The treatments were randomized in a complete block design (RCBD) with three replications. The treatment factors of the experiment were the absolute control, and NPK (23:10:5) fertilizer at 250 kg ha^{-1}equivalent to 80, 15 and15kg N, P and K ha^{-1}, respectively. On the other hand, Minjingu mazao (10:20:15) fertilizer was applied at 375 kg ha^{-1} equivalent to 37.5, 32.25 and 46.7 kg N, P and K ha^{-1}, respectively. Sweetpepper *cv. California Wonder* was used as a test crop and the fertilizers were administered to the experimental plots by banding, an exercise which was done one week after transplanting.

Table 1. Composition of NPK and Minjingu mazao fertilizers used in the experiment.

Fertilizer	N	P_2O_5	K_2O	S	ZnO	CaO	MgO
NPK	23	10	5	5	-	-	-
Minjingu mazao	10	20	15	5	0.5	25	1.5

Seedlings establishment and transplanting

Sweetpepper seedlings were raised in the nursery beds at the Horticultural Unit and transplanted into the experimental field at 1 seedling per stand and at a spacing of 60 cm × 30 cm. Transplanting was done at 4 weeks after seed sowing to the nursery. Each experimental plot was 2 m x 16 m (32 m^2) and constituted 3 rows each with 50 plants henceforth total of 150 plants. All treatments were in three replications hence 9 sub-plots and the measurement between each sub-plot was 1 m.

Data collection

Five (5) plants were systematically identified in each sub-plot after every six (6) plants then tagged for data collection on growth and yield characteristics during the growth periods of plants and at harvesting time of the crop. The vegetative growth parameters collected at the 6^{th} week (42 days) after transplanting were the plant height, number of branches per plant, number of leaves per plant and stem girth. On the other hand, the yield parameters collected included fruit length, fruit grade, number of fruits per plant, individual fruit weight, and yield converted to yield in t ha^{-1} as described by Shaaban and Kisetu (2014).

Data related to fruit shape index (FSI) and grading were collected as described by Navarro et al. (2002). All data depending on the plant growth stage were collected after every three weeks.

Statistical data analysis

The data obtained related to different plant characters were analysed statistically in one-way analysis of variance using GenStat software. The analysis of variance was performed by F-test, while the comparison of the significance pairs of treatment means was by least significance difference at 5% level of minimum error. The strength of the relationship between some growth and yield components with fruit yield was assessed by the standard Pearson matrix correlations.

RESULTS

Results of the effects of NPK and Minjingu mazao fertilizers on the growth parameters of the sweetpepper including number of branches and leaves per plant, plant height, and stem girth are presented in Table 2.The tallest plant (24.36 cm) was recorded from sweetpepper plants which were treated with NPK fertilizer followed closely by the plants which were treated with Minjingu mazao fertilizer (22.33 cm) but the two plants did not differ significantly. However, these plants differed significantly (P=0.004) from the plants which did not receive any fertilizer (control = 18.3 cm) for the measurements recorded at the same plant age. In addition, results showed that the number of leaves per plant differed significantly (P=0.002) across all treatments.

The highest average number of leaves (29.9) was recorded from the plants which were treated with NPK fertilizer followed by Minjingu mazao (19.9) fertilizer and lastly by the absolute control (14.3). On the other hand, the highest but insignificant plant girths were recorded in the NPK (0.8 cm) and Minjingu mazao (0.7 cm) fertilizers. These observations of girth differed significantly (P=0.01) from the measurements obtained in the absolute control (0.6 cm). Furthermore, it was observed from the results that the number of branches from all treatments was insignificantly (P=0.99) different.

Table 2. Effect of NPK and Minjingu mazao fertilizer on sweetpepper growth parameters at 42 days after transplanting.

Treatments	Response variables			
	Plant height (cm)	Number of leaves	Stem girth (cm)	Branches
Control	18.3[a]	14.3[a]	0.6[a]	3.4[a]
NPK	24.4[b]	29.9[c]	0.8[b]	3.5[a]
Minjingu mazao	22.3[b]	19.9[b]	0.7[b]	3.4[a]
LSD (0.05)	2.2**	4.7**	0.1*	3.3
CV (%)	4.5	9.7	0.07	42.3
p-value	0.004	0.002	0.01	0.9

Tests: *P*> 0.05 NS Not Significant; **P* = 0.05; ***P*< 0.01; ****P*<0.001.The means in the same column bearing different letter(s) differ significantly at 5% level of minimum error based on Duncan's New Multiple Range Test (DNMRT).

Table 3. Yield and yield parameters of sweetpepper with an application of NPK and Minjingu mazao fertilizers.

Treatments	Fruits response variables							
	Number per plant	Length (cm)	Grade (mm)	FSI (cm)	Weight per plant (g)	Weight per plot (kg)	Yield (t ha^{-1})	Yield increase (%)
Control	0.7[a]	3.7[a]	87[a]	2.46[a]	28.6[a]	0.03[a]	9.4[a]	N/A
NPK	1.5[b]	5.6[a]	138[a]	2.49[a]	78.9[b]	0.08[b]	25[c]	166
Minjingu mazao	1.3[b]	5.0[a]	141[a]	2.48[a]	52.8[ab]	0.05[b]	15.6[b]	66
LSD (0.05)	0.5*	5.9	133	0.34	28.6*	0.03*	2.7*	
CV (%)	18.4	52.3	48.1	7	23.6	25.3	26.4	
p-value	0.02	0.6	0.5	0.9	0.02	0.02	0.03	

Key: N/A – Not Applicable; FSI – Fruit Shape Index; p-value: *P*> 0.05 NS Not Significant; **P* = 0.05; ***P*< 0.01; ****P*<0.001.The means in the same column bearing different letter(s) differ significantly at 5% level of minimum error based on Duncan's New Multiple Range Test (DNMRT).

Table 4. The relationship between yield and yield components of sweetpepper.

Variables	1	2	3	4	5	6	7
1 Fruit grade	1						
2 Fruit Shape Index	0.51	1					
3 Number of fruits per plant	0.43	0.65*	1				
4 Fruit length	0.98***	0.48	0.42	1			
5 Fruit weight(kg/plot)	0.39	0.52	0.90***	0.36	1		
6 Yield (t/ha)	0.34	0.53	0.88***	0.34	0.97***	1	
7 Fruit weight (g/plant)	0.36	0.55	0.93***	0.34	0.99***	0.99***	1
p-value	<0.001	0.03	<0.001		<0.001	<0.001	

One-sided test of correlations greater than zero.

Yield and yield components of sweetpepper

The results of the effects of NPK and Minjingu mazao fertilizers on fruit yield and yield components of the studied sweetpepper are presented in Table 3. Results indicated that the number of fruits per plant was significantly (*P*= 0.02) affected by type of fertilizer used. The highest mean number of fruits per plant (1.5) was produced by plants which were treated with NPK which do not differ significantly from Minjingu mazao (1.3); however these fruits were significantly different (*P*= 0.02) from the absolute control (0.71) which did not receive any fertilizer. On the other hand, the length of a fruit, grade and FSI were not significantly (*P*>0.05) different between the fertilizers used and the absolute control. However, the difference was obtained the weights of fruits per plant and per plot (*P*=0.02) and yield (*P*=0.03). The weight of fruits per plant was highest in NPK (78.9 g) followed by Minjingu mazao (52.8 g) and then the absolute control (28.6 g). The yields also followed similar trends whereby the order was NPK (25 t ha^{-1}), Minjingu mazao (15.6 t ha^{-1}) and the absolute control (9.4 t ha^{-1}).

Relationship between yield and yield components of sweetpepper

Results of the Pearson matrix correlations showing therelationships among yield components and fruit yield are presented in Table 4.Results showed that there was a strongly positive correlation (r = 0.98***; *P*<0.001) between the length of fruits and the fruit grade. Similarly, a significantly positive correlation (r = 0.65*; *P*=0.03) was observed between the number of fruits per plant and the fruit shape index. Furthermore, results indicated a very significantly (*P*<0.001) positive relationship which existed between number of fruits per plant and weight of fruits per plot (r = 0.90***; p<0.001), weight of individual fruits per plant (r = 0.88***; *P*<0.001) and fruit yield (r = 0.93***; *P*<0.001).

DISCUSSION

The findings of the present study revealed an inconsistent variation in sweetpepper plant height, number of leaves and branches per plant, and stem girth among NPK and Minjingu mazao fertilizers and with the control. Of these parameters, plant height, number of leaves, stem girth and number of branches were positively favoured and increased by the treatments in the order of NPK > Minjingu mazao> control but the two fertilizer sources were superior to the control. However, the number of branches recorded per plant in plants which were treated with Minjingu mazao fertilizer and those in the absolute control were statistically at par but outperformed by the NPK fertilizer. Awodun et al. (2007) found that NPK 15-15-15 fertilizer applied at 250 kg ha^{-1} increased soil N, P and K status, leaf N status and growth and yield parameters such as number of leaves and branches, plant height, stem girth, number and weight of fruits. Sunmola (2007) found that the effect of organic manures and NPK 15-15-15 fertilizer were pronounced on sweetpepper growth, plant height, stem girth, numbers of leaves and changes in soil chemical composition compared with the check.

The highest weights of individual fruits per plant and fruit yields obtained in the NPK fertilizer application over Minjingu mazao fertilizer and the absolute control could be attributed to the solubility potentials of the NPK fertilizer. In addition, the quantities of the same parameters obtained when the two fertilizers were used which were far higher than those in the absolute control signify the importance of fertilizer application in sweetpepper. Ann (2012) conducted a similar study using NPK (12%:12%:17%+2% Mg + trace elements) fertilizer, and organic and foliar (seaweed) fertilizer and the integration of the two fertilizer sources on black pepper. The findings of the present study indicated that at an application of 250 kg ha^{-1} of NPK, the fruit yield of 25 t ha^{1} was obtained but the yield in Minjingu mazao fertilizer was 15.6 t ha^{-1} whereas the absolute control recorded 9.4 tha^{-1}. This observation indicates that NPK fertilizer was 67% and 166% superior to Minjingu mazao fertilizer and the control, respectively and Minjingu mazao fertilizer was superior to control by 66%. Generally, sweetpepper plants which were treated with NPK fertilizer showed vigorous early growth compared with Minjnigu mazao fertilizer and the absolute control and they also produced greater fruit yields. Similar findings were also reported by Hassan et al. (1993) that the reduction in pepper fruit yield was influenced by the effect of N levels on early plant growth and the plants which showed vigorous early growth produced greater yields.

The significantly strong and positive relationships observed between fruit yield and number of fruits per plant, weight of fruits per plot and plant observed in this study indicates the direct contribution of these attributes in the final fruit yield in a given land area. Bozokalfa and Kilic (2010) conducted a study using yield of fruits from sweetpepper as a dependent variable, while fruit length, weight, and, diameter/grade were the independent variables. Their findings revealed a significant relationship ($P \leq 0.01$) between dependent and independent variables. Based on their results, the correlation coefficient describing the relationship between the actual fruit yields and the water displacement techniques model solution was 0.95 and concluded that pepper fruit yield depends on fruit length, weight, and diameter.

The inconsistent variation in the correlations among the response variables observed in the present study suggests that nutrients availability in the soil and their concentrations in plant during early plant growth influenced final fruit production. Further to that, this observation stretches an insight that external sources of essential nutrients which included NPK and Minjingu mazao fertilizers were effective in modifying the internal nutrients in sweetpepper which apparently influenced the fruit yield.

CONCLUSION

Based on the findings of the present study, stakeholders particularly in the farming community should deliberately invest on application of soil amendments including the inorganic fertilizer to improve crop production. Of the industrial fertilizers, the locally available Minjingu mazao fertilizer might be the best option but where capital is not a problem, the highly soluble blended NPK fertilizer would be the viable option.

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