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Effect of Different NPK Levels on the Growth and Yield of Three Tomato (*Solanum lycopersicum)* Varieties in Sri Lanka

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Authors' contributions

This work was carried out in collaboration between all authors. Authors HASLJ and HKSGG designed the study, wrote the protocol and wrote the first draft of the manuscript. Author HASLJ reviewed the experimental design and all drafts of the manuscript. Authors HASLJ and LMHRA managed the data collection of the study and performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Experiments were conducted from June to August, 2016 in fields at Attampitiya and Walimada in Sri Lanka. The aim was to obtain growth and yield parameters of three tomato varieties under three levels of NPK fertilizers. Treatment consisted of two tomato varieties (Roma, Thilina, and T 245), five levels of NPK fertilizer (recommended dosage of inorganic fertilizers as a control dosage (T1), ½, ¾, 5/4 and 3/2 fold of the control treatment laid in a split-plot design with two replications. T-245 tomato variety proved superior over Roma and Thilina on growth characteristics. It was evident that increased NPK levels resulted in higher growth performance in all three tomato varieties. Elevated NPK level did not respond significantly to yield increase, implying that such additions are not necessary as they increase the cost of production in terms of high cost incurred for fertilizer and pollution.

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1. INTRODUCTION

Tomato (S*olanum lycopersicum*) belongs to the family Solanaceae and is one of the most widely eaten vegetables in the world. This popularity is partly because tomato can be eaten fresh or in multiple of processed forms. Tomato being one of the popular vegetable crops in Sri Lanka is preferred by farmers due to high economic returns, export potentials and nutritive value. Tomato is a rich source of vitamin A, C and minerals like Ca, P and Fe [1]. In Sri Lanka, tomato is cultivated in more than 7137 ha, producing nearly 73917 t/year [2].

Badulla district is one of the major tomato growing districts in Sri Lanka where the environmental conditions are favorable for its cultivations. Correct dosage of fertilizer forms and adopting improved varieties are fundamental and crucial inputs for sustained growth in field production of tomato. Recommended fertilizer levels for tomato cultivation in Up Country are 30 kg/ha N, 100 kg/ha P_2O_5 and 30 kg/ha K_2O at basal dressing stage and 60 kg/ha N, 0 kg/ha P_2O_5 and 60 kg/ha K_2O at top dressing stage [2] (Table 1).

In up country, especially in Nuwara Eliya and Walimada, farmers use large quantities of fertilizer for their tomato cultivation. Levels of fertilizer applied in upcountry were higher than the recommended rates [3,4]. Continuous application of excessive amount of fertilizer increase the cost of production while causing many environmental problems. There is a danger of environmental damage even where applications are below maximum levels, especially if fertilizer is broadcast onto the soil surface in a single application. The probability increases with rising levels of fertilizer use. Unbalanced applications, on the other hand, with an oversupply or deficit of some nutrient elements, can have a detrimental effect on crop performance and yield.

Apparently, numbers of selected tomato varieties are available in the market and seeds of these varieties are expensive. Tomato growers use these selected varieties without having a proper knowledge on the performances under field conditions. Especially, there is an urgent need to evaluate the growth and yield performance of these tomato varieties with varying dosage of NPK fertilizer under field conditions.

Therefore, this research aims to study the effect of different levels of NPK fertilizer on growth and yield performance of three different recommended tomato varieties under different field conditions in Up Country.

2. MATERIALS AND METHODS

The experiments were conducted from May to August, 2016 in fields at Attampitiya (IU3c) (6.938º N, 80.971º E; 1020 m amsl) and Walimada (IU3e) (6.904º N, 80.904º E; 1085 m amsl) in Sri Lanka aiming to establish the effects of five levels of NPK fertilizers on growth and yield of three varieties of tomato. Treatment consisted of three tomato varieties (Roma, Thilina, and T 245), five rates of NPK fertilizer (recommended dosage of NPK fertilizers as a control dosage, ½ fold of the control dosage, ¾ fold of the control dosage, 5/4 of the control dosage and 3/2 of the control dosage laid in a split-plot in complete randomized block design with two replications as mentioned in Table 2. A factorial combination of NPK fertilizer and tomato varieties were assigned to the main plot treatment with gross plot size measured 50 m^2.

Table 1. Recommended fertilizer mixture for tomato

Time of application	Source			Quantity		
	Source and qty kg/ha			Nutrient qty kg/ha		
	Urea	TSP	MOP	N	P_2O_5	K_2O
Before planting (BP)	65	215	50	30	100	30
3 Week after planting (WAP)	65	-	-	30	-	-
6 Week after planting (WAP)	65	-	50	30	-	30
Total	195	215	100	90	100	60

Source: Sri Lanka Department of Agriculture, 2010

Table 2. Treatments combination of tomato varieties and levels of NPK fertilizer used in the experiment

Varieties / NPK fertilizer level	Roma	T 245	Thilina
Recommended dosage of NPK (Control)	T1	T6	T11
½ fold of the control dosage	T2	T7	T12
¾ fold of the control dosage	T3	T8	T13
5/4 of the control dosage	T4	T9	T14
3/2 of the control dosage	T5	T10	T15

Required field management practices (Nursery preparation, land preparation, transplanting, supporting and gap filling, trailing, thinning, watering, weeding, pest and disease control and harvesting) were practiced according to the recommendations given by Department of Agriculture (2010). Nursery management was initiated on 20th May 2016, and transplanting was done 21 days later at 40 cm × 50 cm spacing. Basal dressing was done before transplanting and weeding was practiced at 3 and 6 WAP. Chemical control of pest and diseases were done by application of mancozeb at 4, 6 and 8 WAP. In addition, application of top dressing was done at 3 and 6 WAP as well as regular observation were done.

The germination percentage was determined after 21 days of nursery establishment. Survival rate was estimated by the percentage of plants that showed successful establishment in the field at 3 WAP. Number of leaves per plant, plant height (cm), leaf area (cm^2), Plant dry weight (g) were measured at weekly intervals up to 6 WAP. Time of flowering (days to attain 50% flowering), number of fruits per plant and yield (g/m^2) were recorded to study the flowering behavior and fruit production under different treatments. Data analysis was done using SAS [in full] and MS-Excel software.

3. RESULTS AND DISCUSSION

Effect of different levels of NPK fertilizer on vegetative growth, reproductive growth and yield of three tomato varieties was evaluated. The highest survival rate (86.3%) was recorded in T-245 with the basal dressing including recommended dosage of NPK (T1) while the lowest survival rate was recorded in Thilina tomato variety with 3/2 fold of recommended dosage of NPK (T15) (Table 3).

According to experimental results, there was a significant different among treatments combination on vegetative, reproductive growth and yield of three tomato varieties. In vegetative growth phase, the highest plant height and leaf number per plant after 3 WAP and 6 WAP were recorded in T-245 with the application of 3/2 fold of recommended dosage of NPK (T10).

Plant nutrition is one of the most important factors that increase plant production. Nitrogen (N) is the most recognized in plant for its presence in the structure of the protein molecule. Accordingly, N plays an important role in synthesis of the plant constituents through the action of different enzymes [5]. Phosphorus (P) is required in large quantities in young cells, such as shoots and root tips, where metabolism is high and cell division is rapid. P aids in root development, flower initiation, seed and fruit development. P_2O_5 has been shown to reduce disease incidence in some plants and has been found to improve the quality of certain crops. Potassium (K) is an important macro-nutrient and the most abundant cation in higher plants. K has been the target of some researchers mainly because it is essential for enzyme activation. As per the previous results vegetative characteristics of all three varieties were increased with increase in NPK levels [6,7].

In reproductive phase, Thilina variety with ¾ of recommended dosage of NPK recorded minimum days (27 days) to attain 50% of flowering. There was no significant difference between treatments for the observation of number of fruits per plant. There was a significant effect of NPK levels and varieties on yield. Interestingly, there was no significant difference between yield of three tomato varieties with recommended and increased (5/4 and 3/2 fold) levels of NPK. But with the decreased levels (1/2 and ¾ fold) of NPK levels ($P<0.05$), yield of three tomato varieties were significantly reduced as mentioned in Table 4. This, however, contradicts with growth performances of three tomato varieties with the increased fertilizer levels as there was no significant difference

among treatment consist higher levels and recommended level of NPK (P>0.05).

The results of this study were mostly in agreement with previous studies. Tomato growth increases as expressed by the increases observed in plant height, crop dry weight, crop growth rate, and relative growth rate. The higher response of tomato to the growth might be due to the availability of essential elements from inorganic fertilizer. This observation is in agreement with previous studies [8]. The result of their study demonstrated that highest yields of tomato were obtained from the plots

Table 3. Effect of levels of NPK fertilizers on variation of vegetative growth of tomato varieties

Treatment	Survival rate (%)	Plant height (cm)		Leaf number /Plant	
		3 WAP	6 WAP	3 WAP	6 WAP
T1	86.3^{a}	10 ^{a}	50.2^{a}	5.1^{a}	29.4^{a}
T2	80^{ab}	14.1^{a}	55.1^{a}	8.3^{a}	34.6^{b}
T3	81^{ab}	13.1^{a}	53.4^{a}	7.5^{a}	31.6^{b}
T4	84.4^{bc}	18 ^{bc}	58.5^{a}	10.1^{ab}	32.3^{b}
T5	86.5^{c}	17.4^{bc}	58^{a}	13.3^{b}	38.4^{bc}
T6	76^{bc}	15.3^{a}	60^{abc}	8.3^{a}	27.5^{a}
T7	75.3^{bc}	14^{a}	58^{a}	10.1^{ab}	28.2^{a}
T8	82^{ab}	16.5^{a}	49.3^{a}	9.5^{ab}	31.1^{b}
T9	83.4^{ab}	17.1^{a}	68.3^{bc}	11.3^{b}	33.2^{b}
T10	77.4^{bc}	22.3^{c}	70.2^{c}	12.3^{b}	40.4^{c}
T11	80^{bc}	13^{a}	63.2^{bc}	8.7^{a}	25.5^{a}
T12	81^{bc}	15.3^{a}	60^{abc}	10.1^{ab}	25.3^{a}
T13	85.6^{ab}	18^{bc}	50^{a}	10.2^{ab}	28.2^{a}
T14	75^{bc}	14.8^{a}	50.3^{a}	9.3^{ab}	32.5^{b}
T15	68.2^{c}	18^{bc}	48^{a}	11.4^{b}	27.2^{a}
LSD		0.66	0.83	0.3	0.51
SE+		0.21	0.11	0.34	0.25
CV%		25	15	8	13

Means followed by the same letter are not significantly different at P=0.05

Table 4. Effect of levels of NPK fertilizers on variation of reproductive and yield of tomato varieties

Treatment	Days to attain 50 % flowering	Number of fruits per plant	yield (g/m2)
T1	32.1^{ab}	13.5^{a}	1^{cde}
T2	30.3^{b}	15.6^{ab}	0.7^{de}
T3	34.5^{ab}	20^{bc}	1^{cde}
T4	33^{ab}	18.3^{ab}	2^{bc}
T5	36.2^{a}	22^{bc}	2.1^{bc}
T6	34.5^{ab}	22.2^{bc}	0.6^{e}
T7	29.9^{b}	20.3^{bc}	1^{cde}
T8	31^{ab}	17^{abc}	0.9^{de}
T9	28.7^{abc}	20.7^{bc}	2^{bc}
T10	29.2^{b}	24^{c}	1.8^{bc}
T11	31.2^{ab}	15.9^{bc}	1^{cde}
T12	34.4^{a}	20^{bc}	0.5^{e}
T13	27^{c}	20.5^{bc}	0.8^{cde}
T14	28^{abc}	18^{abc}	1.2^{cde}
T15	27.5^{abc}	19.3^{ab}	1.1^{cde}
LSD	0.23	0.43	0.45
SE+	0.14	0.23	0.44
CV%	22	18	10

Means followed by the same letter are not significantly different at P=0.05

treated with NPK fertilizer compared to the control. The results of previous experiments revealed that the application of NPK fertilizers at highest dose produced significantly the maximum plant height, number of leaves per plant, leaf length, stem thickness and number of flower clusters per plant [9,10].

Also it is evident that the excessive use of synthetic agrochemicals in crop production and in soil fertility management causes detrimental effect on plant growth, make residue toxicity and environmental pollution [11-13].

Although a majority of farmers are aware about fertilizer recommendations made by the Department of Agriculture, they do not consider it as a mandatory requirement when they applying fertilizers to their fields. Because they only consider to obtain high profit within short time period. Maximum yield with maximum affordable inputs is the misunderstood rationale behind this business. The decision of farmers on the rate of fertilizer application is highly subjective. The general practice of a significant population of farmers is to add fertilizer to maintain the greenness of the crop, a sign of getting the maximum yield.

4. CONCLUSIONS

It was evident that increased levels of NPK levels resulted higher growth performance in all three tomato varieties than that of recommended NPK level. Increasing nitrogen from recommended level to 3/2 fold of recommended level not resulted significant difference in yield performances in Roma, Thilina and T-245 varieties. It is essential if farmers will keep increasing fertilizer application rate only up to a point where yield response is evident and which will save their money and environment.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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