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

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***Abstract*—The introduction of synthetic fertilizers has brought various types of detrimental impacts and people attempt to find out eco-friendly alternatives to chemical compounds for minimizing the dependency on synthetic chemicals. In this context, the exploitation of alternative growth substrates is of great interest like compost-like substrates. Therefore, the study was made to study the effect of compost and different levels of NPK fertilizer on growth and yield performance of three different recommended tomato varieties under different field conditions at *Walimada*, Sri Lanka. Treatment consisted of three tomato varieties (Roma, Thilina, and T 245) and five different fertilizer levels including compost & NPK fertilizers. Treatments were considered as control (without compost and NPK fertilizer), 100 % of compost, 100 % of recommended dosage of NPK fertilizers, 50% of compost with 50% of recommended dosage of NPK fertilizers, and 75 % of compost with 25 % of recommended dosage of NPK fertilizers. Field management practices were practiced according to the recommendations given by Department of Agriculture of Sri Lanka. Effect of different fertilizers on vegetative growth, reproductive growth and yield of three tomato varieties was evaluated. According to results, there was a significant different among control treatment and treatment consisted with 50% of compost with 50% of NPK fertilizer treated Roma and Thilina on days to attained 50% of flowering. There were no significant differences between treatments consisted with 100% of NPK fertilizer with 50% of compost and 50% of NPK fertilizer on days to attained 50% of flowering, number of fruit per plant and yield of varieties except the yield of Roma variety (P<0.05). Results showed that all treatments except chemical fertilizer application improved the soil organic C, total N, P and K status. Increase in microbial biomass C and N was observed in soils receiving organic manures only or with the combined application of organic and chemical fertilizers.**

***Index Terms*—compost, growth, NPK fertilizers, tomato, yield**

I. Introduction

Conventional farming relies heavily on the application of a range of and external inputs in particular pesticides and fertilizers to achieve high yields. A consequence of this has been the increasing levels of inorganic fertilizer usage together with increased environmental impacts and health hazards like Chronic Kidney Diseases (CKD) in Sri Lanka [1]. Therefore, people attempt to find out eco-friendly alternatives to chemical compounds for minimizing the dependency on synthetic fertilizers. Further, the cost of inorganic fertilizers is increasing enormously to an extent that they are out of reach of small and marginal farmers [2]. Also, the current global scenario firmly emphasizes the need to adopt eco-friendly agricultural practices for sustainable food production. Therefore, in order to reduce costs and adopt more environmentally-friendly practices, research on alternative growth substrates is of great interest, and several alternatives have been proposed. The considerable increasing concern in waste recycling has led to the proposal of some organic materials such compost-like substrates [3].

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 [4]. In Sri Lanka, tomato is cultivated in more than 7137 ha, producing nearly 73917 t/year [5]. Walimada 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 [5] (Table I). In up country, especially in Nuwara Eliya and Walimada, farmers use large quantities of fertilizer for their tomato cultivation. Continuous application of excessive amount of fertilizer increases 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.

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The probability increases with rising levels of fertilizer use. Long term applications of inorganic fertilizer, 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 and compost under field conditions.

In spite that several studies have addressed the effect of different types of compost [6]-[8] and/or vermicompost [9] as potting or soil amendments on tomato growth and yield, there are no studies concerning the effects of compost and inorganic fertilizers at same time in the field level. Understanding the value of this cost-effective product of compost, the overall objective of this study was made to study the effect of compost and different levels of NPK fertilizer on growth and yield performance of three different recommended tomato varieties under different field conditions at Walimada, Sri Lanka.

II. Materials and Methods

The experiments were conducted from May to August, 2016 in fields at Walimada (IU3e) (6.904 ºN, 80.904 ºE; 1085 m amsl) in Sri Lanka aiming to establish the effects of compost and different levels of NPK fertilizers on growth and yield of three varieties of tomato. Treatment consisted of three tomato varieties (Roma, Thilina, and T 245) and five different fertilizer levels including compost & NPK fertilizers. Treatments were considered as control (without compost and NPK fertilizer),100 % of compost, 100 % of recommended dosage of NPK fertilizers, 50% of compost with 50% of recommended dosage of NPK fertilizers, and 75 % of compost with 25 % of recommended dosage of NPK fertilizers.

TABLE I. Recommended Fertilizer Mixture for Tomato

Time of application	Source			Quantity		
	Source and Quantity kg/ha			Nutrient and Quantity kg/ha		
	Urea	TSP	MOP	N	P_2O_5	K_2O
3 weeks before planting	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 II. Treatments Combination of Tomato Varieties and Levels of NPK Fertilizer Used in the Experiment

Fertilizer Level	Tomato Varieties		
	Roma	T245	Thilina
Control (without compost and NPK fertilizers)	T1	T6	T11
100% of compost	T2	T7	T12
100% of recommended dosage of NPK	T3	T8	T13
50% of compost with 50 % of recommended dosage of NPK	T4	T9	T14
75 % of compost with 25 % of recommended dosage of NPK	T5	T10	T15

Nursery management was initiated on 20th May 2016, and transplanting was done 21 days later at 40 cm × 50 cm spacing. Tomato seeds of three different varieties were sown in cell plug trays within a cultivation chamber at 24 ℃. At the two-leaf stage, tomato seedlings were transplanted into plots. Treatments were laid in a split-plot in complete randomized block design with five replications as mentioned in Table II. A factorial combination of compost, NPK fertilizer and tomato varieties were assigned to the main plot treatment with gross plot size measured 50 m^2.

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). Fertilization was done before transplanting and weeding was practiced at 3 and 6 WAP. In addition, 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) and 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/m2) were recorded to study the flowering behavior and fruit production under different treatments. Data analysis was done using SAS (statistical analysis system) and MS Excel software.

III. Results and Discussion

Effect of different levels of compost and NPK fertilizers on vegetative growth, reproductive growth and yield of three tomato varieties was evaluated (Table III). According to the Table III, there was a significant difference between controls of each variety on plant height at three weeks after planting. But there was no significant difference between all controls on survival rate, plant height and number of leaves per plant at six weeks after planting.

TABLE III. EFFECT OF COMPOST AND 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: Control+Roma	68.2^{c}	18^{bc}	48^{a}	11.4^{b}	27.2^{a}
T2: 100% Compost+Roma	80^{ab}	14.1^{a}	55.1^{a}	8.3^{a}	34.6^{b}
T3:100% NPK+ Roma	86.3^{a}	10^{a}	50.2^{a}	5.1^{a}	29.4^{a}
T4:50% Compost+50%NPK+Roma	77.4^{bc}	22.3^{c}	70.2^{c}	12.3^{b}	40.4^{c}
T5: 75% Compost+25%NPK+Roma	80^{bc}	13^{a}	63.2^{bc}	8.7^{a}	25.5^{a}
T6: Control+T245	75.3^{bc}	14^{a}	58^{a}	10.1^{ab}	28.2^{a}
T7:100% Compost+T245	83.4^{ab}	17.1^{a}	68.3^{bc}	11.3^{b}	33.2^{b}
T8:100% NPK+T245	82^{ab}	16.5^{a}	49.3^{a}	9.5^{ab}	31.1^{b}
T9: 50% Compost+50%NPK+T245	86.5^{a}	17.4^{bc}	58^{a}	13.3^{b}	38.4^{bc}
T10: 75% Compost+25%NPK+T245	81^{bc}	15.3^{a}	60^{abc}	10.1^{ab}	25.3^{a}
T11:Control+Thilina	76^{bc}	15.3^{a}	60^{abc}	8.3^{a}	27.5^{a}
T12: 100% Compost+Thilina	75^{bc}	14.8^{a}	50.3^{a}	9.3^{ab}	32.5^{b}
T13: 100% NPK+Thilina	85.6^{ab}	18^{bc}	50^{a}	10.2^{ab}	28.2^{a}
T14: 50% Compost+50%NPK+Thilina	84.4^{bc}	18^{bc}	58.5^{a}	10.1^{ab}	32.3^{b}
T15: 75% Compost+25%NPK+Thilina	76^{bc}	15.3^{a}	60^{abc}	8.3^{a}	27.5^{a}
LSD		0.66	0.83	0.3	0.51
SE+		0.21	0.11	0.34	0.25
CV%		25	15	8	13

There was a significant different between 100 % of compost applied Roma tomato plants and control. Also to the 100 % NPK fertilizer applied Roma tomato plants on survival rate, plant height and number of leaves after three weeks of planting. Significantly, survival rate, plant height and number of leaves per plant of 100% of NPK applied Roma tomato plants varied from all control treatments and other treatments of T2, T4, T5, T10, T11, T14 and T15 on survival rate of particular variety. All three tomato varieties were shown favorable response to increase their survival rate, plant height and number of leaves per plant with the application of compost and NPK fertilizer in a ratio of 1:1 than the response shown for plants for that of 100% of NPK fertilizer applied plants. Most of the cases, there was a significant difference between plants treated with mixture of compost and NPK fertilizer in 1:1 and 3:1 ratios. Among all the treatments, selected three tomato varieties were shown higher vegetative growth in a condition where those treated with 50% of compost and 50% of NPK fertilizers together.

TABLE IV. EFFECT OF COMPOST AND NPK FERTILIZERS ON VARIATION OF REPRODUCTIVE AND YIELD OF SELECTED TOMATO VARIETIES

Treatment	Days to attained 50% flowering	Number of fruits/plant	Yield (g/m^2)
T1: Control+Roma	30.3^{b}	13.5a	1^{cde}
T2: 100%compost+Roma	32.1^{ab}	15.6^{ab}	0.7^{de}
T3:100% NPK+ Roma	34.5^{ab}	18.3^{ab}	2^{bc}
T4:50% Compost+50%NPK+Roma	36.2^{a}	22^{bc}	2.1^{bc}
T5: 75% Compost+25%NPK+Roma	33^{ab}	20^{bc}	1^{cde}
T6: Control+T245	28.7^{abc}	17^{abc}	0.9^{de}
T7:100% Compost+T245	29.9^{b}	20.3^{bc}	1^{cde}
T8:100% NPK+T245	31^{ab}	22.2^{bc}	0.6^{e}
T9: 50% Compost+50%NPK+T245	34.5^{ab}	20.7^{bc}	2^{bc}
T10: 75% Compost+25%NPK+T245	29.2^{b}	24^{c}	1.8^{bc}
T11:Control+Thilina	27^{c}	15.9^{bc}	0.5^{e}
T12: 100%Compost+Thilina	27.5^{abc}	20^{bc}	0.8^{cde}
T13: 100%NPK+Thilina	31.2^{ab}	20.5^{bc}	1^{cde}
T14: 50% Compost+50%NPK+Thilina	34.4^{a}	18^{abc}	1.2^{cde}
T15: 75% Compost+25%NPK+Thilina	28^{abc}	19.3^{ab}	1.1^{cde}
LSD	0.22	0.41	0.42
SE+	0.16	0.24	0.45
CV%	23	17	11

According to experimental results, there was a significant different among control treatment and treatment consisted with 50% of compost with 50% of NPK fertilizer treated Roma and Thilina on days to attained 50% of flowering. There were no significant differences between treatments consisted with 100% of NPK fertilizer with 50% of compost and 50% of NPK fertilizer on days to attained 50% of flowering, number of fruit per plant and yield of varieties except the yield of Roma variety (Table IV).

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 [10]. 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 [11]. Potassium (K) is an important macronutrient and the most abundant cation in higher plants. K has been the target of some

researchers mainly because it is essential for enzyme activation [12]. As per the previous results vegetative characteristics of all three varieties were increased with increase in NPK levels [13], [14].

This, however, contradicts with growth performances of three tomato varieties with the increased inorganic fertilizer levels as there was no significant difference among treatment consist higher levels of NPK ($P>0.05$).

Results indicated that integrated supply of plant nutrients through compost and fertilizer NPK, played a significant role in sustaining soil fertility and crop productivity in terms of vegetative and reproductive growth. Several researchers have demonstrated the beneficial effect of combined use of chemical and organic fertilizers to mitigate the deficiency of many secondary and micronutrients in fields that continuously received only N, P and K fertilizers for a few years, without any micronutrient or organic fertilizer.

Previous studies also reported that the use of organic fertilizers together with chemical fertilizers, compared to the addition of organic fertilizers alone, had a higher positive effect on microbial biomass and hence soil health [15]. Application of organic manure in combination with chemical fertilizer has been reported to increase absorption of N, P and K in sugarcane leaf tissue in the plant, compared to chemical fertilizer alone [16]. The change of chemical and biological properties in soils receiving FYM, poultry manure and sugarcane filter cake alone or in combination with chemical fertilizers for seven years under a cropping sequence of pearl millet and wheat [17].

Results showed that all treatments except chemical fertilizer application improved the soil organic C, total N, P and K status. Increase in microbial biomass C and N was observed in soils receiving organic manures only or with the combined application of organic manures and chemical fertilizers compared to soils receiving chemical fertilizers.

This study showed that balanced fertilization using both organic and chemical fertilizers is important for maintenance of soil organic matter (OM) content and long-term soil productivity in the tropics where soil OM content is low. Also in some studies, it was found that manure in combination with small fertilizer applications improved the soil as opposed to heavy fertilizer doses alone or mere application of crop residues [18]. Palm (1995) also obtained significant increase in crop yields when a combination of organic and mineral fertilizers was applied compared with sole application of organic or mineral fertilizer [19]. The effects of organic fertilization and combined use of chemical and organic fertilizer on crop growth and soil fertility depends on the application rates and the nature of fertilizers used.

Tomato growth increases as expressed by the increases observed in vegetative and reproductive measures. Use of compost can be beneficial to improve organic matter status. Compost is rich source of nutrients with high organic matter content. Physical and chemical properties of soil can be improved by using compost, which may ultimately increase crop yields. So use of compost is the need of the time. Physical properties like bulk density, porosity, void ratio, water permeability and hydraulic conductivity were significantly improved when compost was applied in combination with chemical amendments, resulting in enhanced yields of tomato [20].

A combination of compost and chemical fertilizer proved further helpful in increasing the organic matter level of the soil. Similar results were also obtained by earlier workers [21]. The reason for the increase in organic matter status is very clear. Application of compost resulted in overall increase of the soil organic matter level. The status of organic matter in the soil had a relationship with the quantity applied. Comparatively more biomass production in different treatments also contributed towards the improvement of organic matter status of the soil [22].

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 [23].

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. But, they can obtain similar yield as they incorporate synthetic fertilizer with compost while reducing cost of production and adverse environmental impacts. The composts prepared will not only supplement the chemical fertilizers but also reduce the environmental pollution. In this strategy, the cost of production is also reduced. Hence, higher yield with resultantly more income is expected for the farming community in this farming system. The fertility and productivity of the soil can be improved on sustainable basis.

IV. Conclusions

It was evident that increased levels of NPK levels resulted higher growth performance in all three tomato varieties than that of other treatment having none of inorganic or organic fertilizers. Similarly, the same output can be obtained by applying compost and NPK fertilizer 1:1 ratio while reducing cost of production and environmental hazards. It is found that farmers can apply inorganic fertilizer application rate half of the amount and add another half amount of compost fertilizer which can be a substitute and replaced the inorganic fertilizer while they can save their money and environment.

New incentives and findings of this research will ensure the sustainability of crop production system and it will be crucial if we are to meet the demands of improving tomato yields without applying inorganic fertilizer to conserve the environmental integrity and public health.

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