An Evaluation of different Forms of Granulated Compound Fertilisers and Micronutrients on Solanum lycopersicum var. Swaraksha

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Abstract— *An open field experiment was conducted at the University of Mauritius Farm to evaluate the effects of different forms of compound fertilisers and the response of incorporating micronutrients along with the compound fertilisers on the vegetative growth and yield of Solanum lycopersicum, var. 'Swaraksha'. Nitrogen, phosphorus and potassium being three essential plant nutrient components, play important roles in the production of Solanum lycopersicum. Besides, micronutrients in minute amounts are also indispensable for proper plant development. The treatments were randomly arranged in block design (RBD) with four replicates. These were: control (T1), 13-13-20-2 complex (T2), 13-13-20-2 complex with micronutrients (T3), 13-13-20-2 blended form with micronutrient (T4) and 13-13-20-2 in compacted form (T5). The results showed that treatment T4 had the most significant upsurge in growth and yield of Solanum lycopersicum with respect to the control block and compared to the other forms of fertilisers. The yields were found to be 47.83 t/ha under T4 followed by 35.52 t/ha under T3. The highest number of flowers and fruits per plant were also observed in T4. Hence, it is essential to employ these nutritive components for satisfactory growth and yield of Solanum lycopersicum while taking into consideration the costs of inputs.*

Keywords— blended, compacted, complex, costs, growth, yield.

I. INTRODUCTION

Tomato (*Solanum lycopersicum)* belonging to the Solanaceae family, is one of the utmost importance crop cultivated in Mauritius. It is a highly consumed crop both locally and around the World making a global production of up to 182,256,458 tonnes for the year 2018 (FAO, 2018). With regards to its nutritive value, 95% of S.lycopersicum content comprises of water and the other 5 % is carbohydrates and fibre (Bjarnadottir, 2015). The production of crop is the outcome of how well resources such as soil, water and nutrients are being used. A rise in the world's population has led to an increase in the food production to be able to cater for the demands of the population which clearly comes from the amplification of agricultural production. The amount of fertilisers consumed is estimated to rise by 40 % between 2002 and 2030 (FAO, 2000).

In the current experiment, the method of conventional farming is being put into practice which makes use of chemically manufactured fertilisers to monitor the health, growth and development of the plant for optimum yield. Fertilisers are crucial for the plant growth and development at their initial stage (Loks *et al*., 2014). In conventional agriculture, large amount of inorganic fertilisers is added to the soil to increase the quantity and the quality of the plant.

Agro-climatic conditions such as temperature, light and wind speed are also determining factors for a good plant performance. A day temperature of 25 ºC to 30 ºC and a night air temperature of 15 ºC to 20 ºC and a root zone temperature of 25.4 ºC to 26.3 ºC (Diaz-Perez & Batal, 2002). Below 10 ºC, the plants suffer from chilling injury and can cause fruit suppression (Naika *et al*., 2005). Light intensity has a powerful impact on the quality of the product and at the same time on the nutritional quality (Savvas and Passam, 2002). For photosynthesis, visible light is the source of energy (Xiong and Bauer, 2002). As the concentration of carbon dioxide increases in the atmosphere, the net photosynthesis also increases (Thongbai *et al*., 2010) and also when the stomata are opened and the plants are not in severe water stress (Kitaya *et al*., 2004).

Fertilisers are categorised mainly under macronutrients and micronutrients. In the farming context, nitrogen is the first primary macronutrient for plant growth and is needed in great amounts. It is absorbed as nitrate and ammonium ions (Forde and Clarkson, 1999). Nitrogen is important for the formation of amino acids, proteins and vitamins. The deficiency of nitrogen in plants causes poor growth and development of and causes young leaf blades to turn yellow or light green, die back on older leaves (Bianco *et al*., 2015).

De Groot *et al*., (2002) proclaimed that the rate of growth of S.lycopersicum expand rapidly with a high level of phosphorus. It promotes early root formation, growth and increase water-use efficiency (Grant *et al*., 2011). Deficiency of phosphorus include purple and red discoloration of leaf tips and margins, slender leaves, thin stalks, poor or no tillering and short internodes and finally poor growth (Kuo and Chiou, 2011). Potassium is the third macronutrient which is useful in carbohydrate breakdown and protein synthesis (Kadam *et al*., 2011) and also increases rate of photosynthesis (Battie-Laclau *et al*., 2014). A need in potassium can result in leaf wilt, distorted spindles, slim and short shoots. Gap analysis in the historical use of fertilisers revealed that no studies were conducted on the possible effects of different forms of compound fertilisers on a specific plant and the interest of incorporating microelements in the granules. Hence, it was hypothesized that the different forms of granulated compound fertiliers (13-13-20-2) would have no differences in plant development and yield of S.lycopersicum. The objectives of the experiment were to assess soil chemical parameters before and after experiment and to evaluate the effects of the different forms of compound fertilisers including micronutrients on S.lycopersicum

II. MATERIALS AND METHODS

2.1 Site Description

The field experiment was conducted on the University of Mauritius Farm (20°14'08.1"S, 57°29'26.6"E) located at Reduit during the summer season from October to January (2018-2019). The soil was prepared mechanically at a depth of 30 cm. Water was fed through sprinkler irrigation on a uniform basis.

2.2 Experimental design and data analysis

The trial was carried out to evaluate the different forms of granulated compound fertilisers and micronutrients on *Solanum lycopersicum* var. *Swaraksha* on 20 sub-plots of land giving an area of 500 m^2. The experiment was laid out on a completely randomised block design (RBD) with 5 replicates for each treatment and 4 blocks. The unit plot was 5.0 m by 2.8 m and would contain 20 *S.lycopersicum* plants. Statistical analysis was completed using Minitab 18® Statistical Software for Windows at 5% significance level by means of Tukey’s Pairwise Comparisons. Plant height, leaf area and root dry matter content was modeled by using Microsoft Excel ® 2016.

2.3 Planting material

A spacing of 1.0 m was maintained between two plants horizontally and 0.6 m vertically between seedling to seedling. About 4 weeks of age of the ‘*Swaraksha*’ variety from Maxiplex Ltd were collected and were transplanted to the field at a planting density of 33,333 plants/ha followed by sprinkler irrigation. Cultural practices for weeding, fertiliser and pesticide application were followed as stated in Le Guide Agricole (2010) of the Food and Agricultural Research and Extension Institute (FAREI).

2.4 Treatments

There were 20 plots (4 blocks and 5 treatments) comprising of NPK fertilisers as follows:

TABLE 1
TREATMENT ALLOCATIONS

T1 = Control (No fertiliser)
T2 = 13-13-20-2 (complex)
T3 = 13-13-20-2(complex + micronutrients)
T4 = 13-13-20-2(blended + micronutrients)
T5 = 13-13-20-2(compacted)

The fertilisers were applied at 3 stages throughout the crop cycle namely at the date of transplantation, 3 weeks after transplantation and at the flowering stage. Composted cow manure was applied only at the transplanting stage.

TABLE 2
AMOUNT OF FERTILIZER AND MANURE USED AT DIFFERENT STAGES

Fertiliser used (13-13-20-2)	Amount (g) - per hole	Amount (kg) - total
At transplantation	24	67.2
3 weeks after transplantation	9	3.6
At flowering	9	3.6
Manure	900	360

TABLE 3
RATE OF APPLICATION OF 13-13-20-2 AT DIFFERENT STAGES OF THE GROWTH

Stages	Nutrients (Kg/ha)		
	N	P_2O_5	K_20
At transplantation	52	52	80
3 weeks after transplantation	39	-	-
At flowering	20	20	30

2.5 Soil parameters analysis

Soil sample at a depth of 30 cm were collected before conducting the experiment from the experimental field using W-method as illustrated by Mungla and Chooneea (2016). Soil pH, electrical conductivity, total nitrogen, total potassium and total phosphorus before and after the experiment were analysed.

2.6 Plant parameters analysis

Physical plant analysis such as plant height, shoot and root dry matter content, root length, leaf area, harvestable and non-harvestable yield were recorded. Plant chemical analysis was also done by tagging the plants. Plant height was being monitored each week throughout the vegetative, flowering and fruiting stage to assess plant growth. The fruits were harvested when matured and ripened. The number of fruits per plant, weight per plant and yield were registered during harvest. Root length and leaf area were measured at the same time. Shoot and root dry matter content, root length and leaf area were also being supervised throughout the 3 stages upon uprooting, washed thoroughly with tap water first to remove the adhering soil and dust. They were dried first, oven dried at 70ºC to constant weight.

III. RESULTS AND DISCUSSION

3.1 NPK concentrations in soil

After the experiment, an increase in total nitrogen, total phosphorus, total potassium and electrical conductivity was noted.

The nitrogen content heightened from 3.55 ± 0.127 mg/kg before plantation to 8.56 ± 0.173 mg/kg after plantation. This increment can be justified by the administration of inorganic fertilisers as well as manure which was rich in organic matter; that is nitrogen. As the plant grows in size from the juvenile phase till the ageing phase, nitrogen in form of inorganic fertiliser is added at different phases namely at the transplantation day, three (3) weeks after transplantation week and lastly at the flowering stage in recommended doses which adds to the level of nitrogen in the soil. Nitrogen promotes rapid development, enhances fruit quality, and improves the foliage for photosynthesis. When the plant is mature enough, its roots' is far down the soil which boots up the uptake of Nitrogen (Leghari *et al*., 2016). This was similar to Afghan *et al*., (2005) who indicated that by making use of blended fertilisers has caused NPK levels to rise in sugarcane.

The amount of phosphorus level increased from 74.98 mg/kg at transplanting stage to 94.01 mg/kg post-transplanting. Phosphorus exhibits a noteworthy impact on the growth of the plant as a primary macronutrient (Radin and Eidenbock, 1984). To explain this increase in phosphorus level, it was related to its mobility in the soil, that is, phosphorus is relatively immobile in the soil. Very little amount inorganic phosphate travel through mass flow to the roots of plants and it provides in minute quantity as 1 to 5 % of the plant phosphorus requirement (Oliveira *et al*., 2010), hence more phosphorus remains in the soil for a longer time compared to nitrogen.

Total potassium level in the soil improved by 4.86 mg/kg. In an experiment conducted by Hariprakash and Subramanian in 1991, higher amounts of potassium increased the yield of tomatoes and it was also noted that the quality of fruits was affected by potassium supply (Lester *et al.*, 2005). By comparing soil-applied fetiliser with foliar potassium application, the foliar application is a better point of view according to Jifon and Lester (2009) who claimed that productivity and quality of fruits can be upgraded. It is similar to the actual field experiment in a sense that blended, compacted and NPK granular coated with micronutrients fertilisers were used and the potassium level was augmented. It was somewhat contradictory to Fufa (2018) stating that high amount of potassium inorganic fertilisers did not show any changes to it's' growth and changes in fruit weight in chillies.

3.2 Plant height

Plant height is one of the most important characteristics of tomato plant. The plant height of the tomato was measured 30 and 45 days after transplantation (DAT) of the tomato seedlings throughout the crop cycle and the results are presented in the histogram below

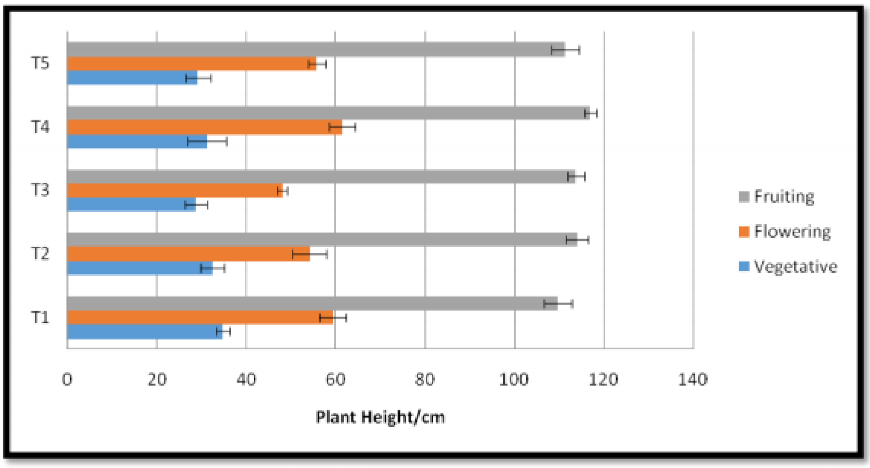

FIGURE 1: Plant height at the different stages of growth.

The mean plant height at the vegetative stage for T1, T2, T3, T4 and T5 was 34.69, 32.35, 28.68, 31.06 and 29.18 cm.

The mean plant height at the flowering stage for T1, T2, T3, T4 and T5 was 59.31, 54.14, 47.95, 61.48 and 55.71 cm.

The mean plant height for the fruiting stage for T1, T2, T3, T4 and T5 was 95.21, 86.70, 91.93, 97.15 AND 103.1 cm respectively.

Regarding the effect of different complex fertilisers on tomato plant height, the results of this experiment is in line with those obtained by Majumdar *et al.*, (2000) stating that potassium in the complex fertiliser strengthened the plant canopy and widened photosynthetic activity and therefore led to the growth of the plant.

3.3 Shoot and root dry matter content

Shoot dry matter content of tomato plants at fruiting stage revealed that plants treated with the blended, compacted and with micronutrients form of fertiliser had the highest shoot and root dry matter content. For the shoot biomass; at the vegetative stage it was optimum, 23.65 cm for the compacted form (T5), at the flowering stage, it was the highest for the control (T1), 35.53 cm and at the fruiting stage, it was the maximum for the blended form (T4), 50.83 cm. The increase in shoot biomass content from vegetative to the fruiting stage can be explained by Isitekhale *et al.*, (2013) stating that manure can be considered as a reservoir of the main macro elements and trace minerals. The General Linear Model revealed that the blocks did not differed statistically ($p>0.05$); while there was significant difference among the treatments ($p<0.05$) for the shoot biomass.

For the root biomass; at the vegetative stage and the flowering stage, it was optimum with the compacted form (T5), and at the fruiting stage, it was maximum with the control (T1). This increase can be related to the level of phosphorus in the soil. The movement of phosphorus to the root system occurs by diffusion with soil particles (Rahmatullah *et al.*, 1994). The root morphology of plants is such that it is crucial for absorbing dormant minerals such as Phosphorus (Zhu *et al.*, 2005). The diameter of the roots, root hairs affect the movement of Phosphorus in the soil (Aziz *et al.*, 2011). Root hairs improve the potential of the roots to look for rhizosphere (small zones found in soil) for Phosphorus because of its high surface area of absorption (Hill *et al.*, 2010). There is statistically no difference between root dry matter content and treatment ($p>0.05$) and block ($p>0.05$).

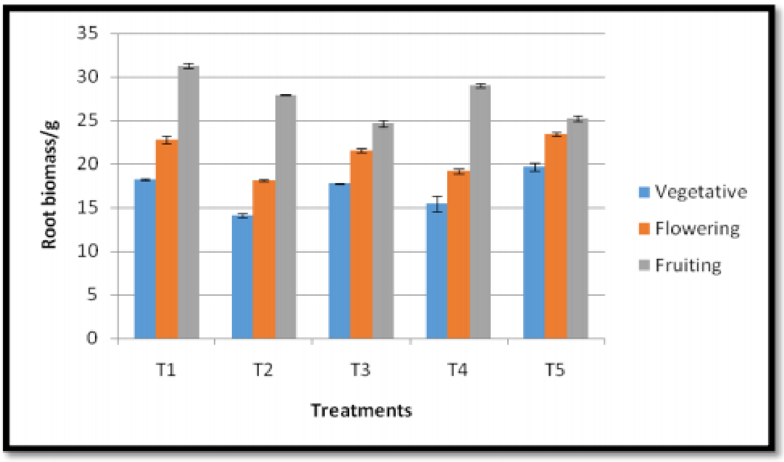

FIGURE 2: Root biomass at different stage of crop cycle

3.4 Root length

At the vegetative stage, the compacted form (T5) showed an increase in the root length with 24.25 cm. At the flowering and fruiting stage, the root length was the highest with the blended form of fertiliser (T4). There was no statistical difference in the length of the root for the five (5) treatments at the three consecutive phases of the growth cycle ($p>0.05$); in the same way there was no statistically significant differences between the blocks ($p>0.05$).

T3 contained micronutrients. It demonstrated that in the vegetative stage, the trace element Zinc favored the production of the auxin precisely Indole Acetic Acid (IAA) (Marschner, 1995) to achieve its maximum length. Indole Acetic Acid is the predominant common auxin found in most of the plants and is allowed for all developmental practices like it initiates roots (Phillips *et al.*, 2011) and literally forms lateral roots in dicotyledonous plants such as tomatoes (McSteen, 2010).

3.5 Leaf area

At the vegetative stage, plants treated with the 13-13-20-2 complex, T2 had the maximum leaf area. At the flowering and fruiting stage, the plants treated with the compacted form (T5) has the maximum leaf area. For the flowering stage, there was no significant difference among the block ($p>0.05$).

The maximum leaf area noted in this study was in Treatment 5. This finding agrees with the findings of Tabitha (2013) who studied on the effect of organic and inorganic fertilisers on growth and yield of amaranths who declared that basic ammonia or synthetic urea fertilisers has the tendency to initiate profuse growing of the plant that results in leaves of considerable size.

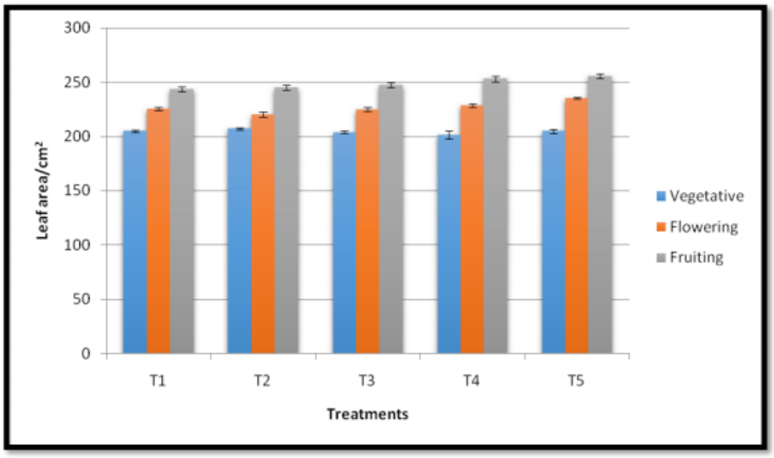

FIGURE 3: Leaf area of tomato crop throughout crop cycle

3.6 Yield

Number of fruits per plant is the most important yield attributing character of tomato plant and therefore, yield is the most important characteristics for the justification of the evaluation of different forms of complex fertilisers (13-13-20-2) on tomatoes. It was observed that the harvestable yield of tomatoes varied from 29.90 t/ha (T1) to 47.83 t/ha (T4) (Table 4).

TABLE 4
YIELD ATTRIBUTES OF DIFFERENT TREATMENTS

Treatments	Number of flowers per plant	Number of fruits per plant	Average fruit weight/g	Harvestable Yield(t/ha)	Non-marketable yield (t/ha)
T1	29	20	28.57	29.90	2.28
T2	18	18	29.52	29.96	1.88
T3	19	16	29.97	35.52	1.06
T4	25	23	30.11	47.83	2.33
T5	19	19	28.15	33.36	1.55

The yield with blended form of fertiliser could be linked due to sulfur presence (Fufa, 2018). As stated by Fufa (2018) applying NPK granular fertilisers, it could improve the growing characteristics which might be due to improved photosynthesis and other chemical reactions which consequently raises the plant biomass and is also accountable for cell differentiation.

Fayera *et al.,* (2014) claimed that the use of trace elements together with blended fertiliser can refine the concentration of the nutrient, nutrient uptake and therefore a better yield. It was advocated probably boron is crucial at the flowering stage and during the formation of tomato fruits (Naz *et al.,* 2012).

As blended fertiliser (T4) is a mixture of 13 % nitrogen as urea, 13 % phosphorus as TSP and 20 % potassium as muriate of potash, it might have helped to achieve the highest yield. Three (3) sources of N, P and K were mixed together but in separated granules, the solubility of these granules at different stages could have made the proper nutrients available to the plants as compared to compacted and complexed granules, which might require more water to dissolve the nitrogen and other elements. This actual statement is further supported by the fact that a higher plant height was measured under same treatment and foliage which is directly linked with supply of nitrogen for foliage development.

In addition, the use of blended form of fertiliser applied, coupled with the benefits of micronutrients might have resulted in uneven and excessive granules of potassium in the form of MOP to the plants, which in turn led to higher amount of potassium available to the plants, hence increasing the yield.

IV. CONCLUSION

This work shows that inorganic complex fertiliser (13-13-20-2) under all its forms significantly affected the parameters like plant height, shoot and root biomass, root length, leaf area and leaf area. Moreover after the experiment, an increase in the NPK content was observed as compared with the untreated plots. Throughout the years, fertilisers have been changing in terms of structure, formulations. Although it was often refuted for it unevenness, blended fertiliser, could reduce the fertiliser cost and at the same time increase productivity to match the use of compacted and complexes. Moreover, trace elements also played an important role and have cause to have a yield of 35.52 t/ha and 47.83 t/ha. Farmers should consider well before purchasing fertilisers since it constitute quite a reasonable expenditure in the cost of production. Blended synthetic nutrients are primordial as it has a high degree of fertiliser use efficiency. Therefore, by this experiment, it can be concluded that if different forms of granular NPK fertilisers are to be used for a crop production, the blended mode one will function better than any other granular NPK fertilisers and will yield will be higher.

COMPETING INTEREST

The author has declared that no competing interest exists.

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