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Application of Biochar, Leaf Compost, and Spent Mushroom Compost for Tomato Growth in Alternative to Chemical Fertilizer

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ABSTRACT

Tomato *(Solanum lycopersicon* L.) is one of the most popular vegetables on the earth and produced in bulk quantities. Over the years non-judicious use of chemicals has reduced the soil fertility resulting decrease in the production of tomato and qualities. Here an attempted has been made to find alternatives for chemicals fertilizer, in this study we have use biochar, leaf compost, and SMC (Spent Mushroom Compost) the results indicates that out of these three, SMC yield better results in plant growth and productivity, followed by biochar than leaf compost and comparative lesser growth was observed in field soil, which was taken as control. Field soil was combined with different percentages of Biochar, Leaf compost, and SMC to obtain the following combinations T_1 (control), T_2, T_3 and T_4). The concentrations of Biochar, Leaf compost, and SMC promoted vegetative growth (plant height, leaf area, number of leaves, and axillary branches) of the test plants (tomato plant). Tomato seedlings were grown in pots under different treatments, the experimental setup was visited regularly to record data viz. plant height, number of floral buds, and flowers. The study shows that SMC provides favorable soil conditioners for the cultivation of tomatoes as it improved growth and yield of tomato seedlings in the experiment.

Key words: Tomato, Biochar, SMC, Leaf compost, Growth performance

Tomato contributes to a healthy and well-balanced diet. They are rich in minerals, vitamins, essential amino acids, sugars, and dietary fiber, tomato has an appreciable protein as well as vitamins A, C, and D content (Nasir *et al*. 2015, Oboulbiga *et al*. 2017, Raiola *et al*. 2015). Tomato is consumed in diverse ways including raw in salads or cooked in sauces, soup, meat, or fish dishes (Domínguez *et al*. 2020). It can be processed into purees, juices, ketchup, and drinks or sliced and sundry. Tomato fruit contains lycopene which has various good health effects and several nutrients (Hedges and Lister 2005, Nasir *et al*. 2015). For a higher yield of tomatoes, it requires nutrients like N, P, K, Mg, Ca, Na, and S, and farmers had relied on inorganic fertilizer to meet the nutritional requirement for yield (Kinoshita and Masuda 2011, Kochakinezhad *et al*. 2012). In our country (India), ever since, the green revolution has taken place farmers have used chemical fertilizers, non-judiciously resulting degradation of agric soil field. In a study, it has been found that the overuse of chemical fertilizers reduces the protein and carbohydrates content in the crops (Marzouk and Kassem 2011). Toor *et al*. (2006) reported that chemical fertilizer that content excess of potassium decreases vitamin C, carotene content, and antioxidant compounds of the vegetables, and also chemically grown vegetables are more prone to the attack by insects and disease (Karungi *et al*. 2006). It has been seen that the rising human population compels deforestation to increase agricultural land. Now the time has come to search alternative eco-friendly substances that enable to enrich agric land by improving fertility resulting to get a higher yield of the crop. Our rising society is facing many challenges and struggling with soil degradation due to the overuse of inorganic fertilizer and environmental changes (Chandini *et al*. 2019, Massah and Azadegan 2016). Therefore, copying the ancient technique of biochar, leaf compost, and spent mushroom compost

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would be a potential tool for both alternative to chemical fertilizers and a sustainable agriculture. So, this study aims to evaluate the tomato growth using the three different soil amendments (biochar, leaf compost, spent mushroom compost) based on physical parameters.

MATERIALS AND METHODS

This study was carried out in the greenhouse at the Department of Botany, Dr. Harisingh Gour Central University, Sagar, using pot experiments (Pot of dimensions 25 cm and 22 cm diameter). The test seedlings of tomato seeds were obtained from the local market of Sagar. A pot experiment was conducted with three treatments i.e. Biochar, Leaf compost, and Spent mushroom compost with field soil as a control for comparing the efficacy of all these organic treatments over the field soil.

Preparation of biochar

Biochar is a stable solid, rich in carbon, and can endure in soil for thousands of years, these solid materials obtained from the thermochemical conversion of biomass in an oxygen-limited environment (Kavitha *et al*. 2018, USBI, n.d.). It is defined as carbonized biomass obtained from sustainable sources and sequestered in soil sustainably enhance their agricultural and environmental values under present and future management (Arbestain *et al*. 2015). Biochar can be prepared using any biomass such as a dry leaf, agric residue, dry cattle cake, properties of biochar vary with both the feedstock from which it is produced and the method of production (Nair *et al*. 2017). The indigenous method, "Top Lit Up Draft" (TLUD) made up of the barrel is used to prepare the biochar. The biomass used to prepare biochar are dry leaf and small pruned branches from the Botanical Garden (Department of Botany, Dr. Harisingh Gour Vishwavidyalaya, Sagar).

Activation of biochar

Adding freshly made Biochar into the soil will deplete nutrient that is being sucked into the pores of biochar giving negative effects on crop production. Therefore, before adding biochar to the soil, it must be activated. There are different ways to activate biochar but we have charged with the @ 1 part of the flour, 8 part of Biochar, 2 parts animal manure mix, and kept damp for 2 weeks.

Preparation of leaf compost

The leaf Compost unit has been set up in the department of Botany in Net house. The dry leaf was collected in leaf falling season and was bagged in a black polypyrene bag and sprinkled with water to mist the leaved and then after the bag was closed tightly using a rope. Kept aside in a net house. The bag containing the leaves was opened in a month to check the moisture, and if required water was sprinkled and closed, after 5-6 months each bag of the leaves was composted to give a silver-grey or black like organic matter sometimes called leaf mold (Fig 1).

Fig 1 Showing Leaf mold formation progressively: A (Initial stage), B (Silver grey stage) and C (Black and mature stage)

Collection of spent mushroom compost

There are generally two methods or formulas used for substrate preparation that employed in mushroom cultivation which is optimized depending on the species to be cultivated viz. Composted materials and non-composted materials are derived from agricultural residues such as cereals straw, plant fiber/husk, manure, or sawdust (Carrasco *et al*. 2018, Dehariya and Vyas 2020). The left out of substrate material after mushroom harvesting called spent mushroom compost or spent mushroom substrate depending upon the type of substrate used for cultivation. We have used Spent mushroom compost generated from the mushroom cultivation Lab of the Botany department Dr. Harisingh Gour Vishwavidayalya, Sagar.

Experimental setup

Tomato seeds purchased from a local vendor (desi variety) and seeds were raised to seedling on-field soil when the seedling becomes 4-6 cm height bearing 3-4 leaves, pots were filled with the 100% of field soil, 30% Biochar, 30% Leaf compost, and 30% SMC (in three replicates). 100% Soil treated as control with the treatment, the concentration of these treatments has been set based on existing literature. Only physical Parameters; Plant height, Number of leaves, buds and flowers, fruits, and auxiliary branches have been undertaken in the study.

Treatments

T_1- 100% Soil (control)

T_2- 30% Activated Biochar (30% Activated Biochar and 70% Soil)
T_3- 30% Leaf compost (30% Leaf compost and 70% Soil)
T_4- 30% SMC (30% SMC and 70% Soil)

After the cultivation of the seedlings to pots, the experimental setup was monitored daily and the pots were watered in an interval of two days using normal tap water, and required data were collected.

RESULTS AND DISCUSSION

Plant height

Plant height was estimated by using a meter rule placed firmly on the surface of the substrate to determine the height of the plant in centimeters. The height of the plants in different treatments is measured in a week interval of time from the date of transplantation to the pots. It has been observed that field soil amended with the 30% SMC (T_4) showed the highest growth in plant height (Fig 2) followed by 30% Biochar amended soil (T_2) & then by field soil (T_1) while T_3 showed very poor growth even less than field soil.

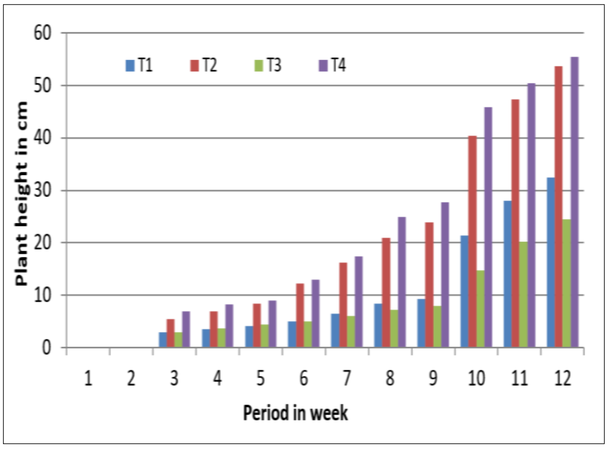

Fig 2 Showing plant height on different treatments

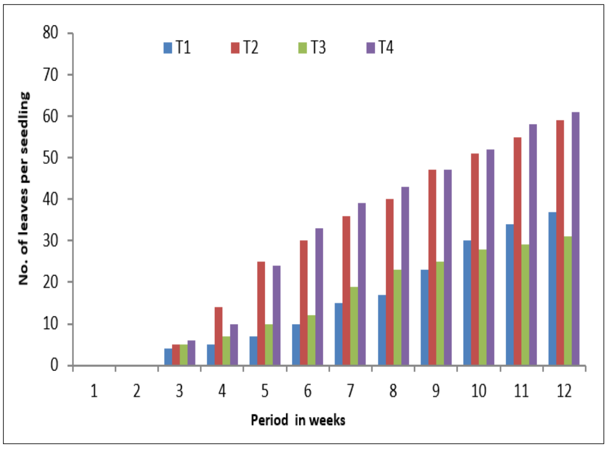

Fig 3 Showing the number of leaves on each treatment

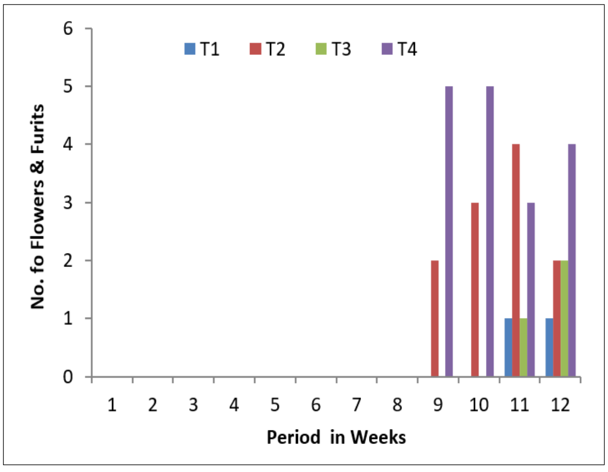

Fig 4 Numbers of flowers and fruit in different treatment of tomato plants

Numbers of leaves

The numbers of leaves were counted when new leaf comes after the cultivation of seedlings in pots. The leaves of each seedling were counted in a week interval, according to the data obtained and interpreted it was found that the number of leaves was highest in the treatment of T_2 (30% Biochar) initially from 3rd to 5th week followed by the treatment T_4 (30% SMC) and then by treatment T_3 (30% leaf compost) as compared to control, but it was interesting to note that the numbers of leaves were found to exceed in treatment of T_4 from 6th week onward then to the treatment of T_2 gradually, while the control exceeds the leaf numbers to T_3 (Fig 3). The reason for the gradual increase of leaf number in T_4 treatments might be due to the slow release of nutrients available in the SMC for the tomato growth (Jordan *et al*. 2008). For not surprise T_3 treatment showed poor performance, it may be attributed to fact that the leaf compost nutrient depends on the type of leaf taken for composting and nutrient available in the leaf during the leaf fall (Flannery, n.d.), however, more study needed to be carried out to investigate the nutrient content of the leaf compost.

Numbers of flowers and fruits

The appearance of the first flowers was noticed in T_4 and T_2 treatments on the 9th week of cultivation, meanwhile the numbers of flowers were highest in T_4 compared to control followed by T_2 treatment while the first flowers appear in T_1 treatments and T_3 in the 11th week and the treatment which shows highest flowers count will have the highest number of fruits (Fig 4).

It has been seen with the comparative study that the concentrations of Biochar, Leaf compost, and SMC promoted vegetative growth (plant height, leaf area, number of leaves, and axillary branches) of the tomato plants and reproductive growth as well. With this study, it can be concluded that the SMC and biochar could be a good soil conditioner for tomato production and improvement of the quality and could be a more sustainable approach to be adopted for organic cultivation to restore the degraded soil and reduce the cost input in the cultivation. SMC has a wide range of application on different cultivars and had shown positive effects (Castro 2008, Sagar *et al*. 2009) apart from being a good source of nutrient SMC has great potential in disease suppression and soil management (Frutos *et al*. 2017, Marín-Benito *et al*. 2016, Singh *et al*. 2020). Biochar application to the soil helps to maintain the physical and chemical properties of soil (Bista *et al*. 2019, Jien 2018) and has reported enriching the soil with microflora by providing a suitable niche (Gorovtsov *et al*. 2019) and helps to prevent nutrient leaching, moreover, it is a good way to sequestrate carbon in the soil (Joseph *et al*. 2020) while enriching the soil.

With the outcomes of the result, it can be suggested that SMC and Biochar could be a good means of alternative fertilizer in mitigating chemical hazards and degrading agricultural lands. However, research must be focused on obtaining the best combination and ratio of SMC, Biochar, and leaf compost for the different cultivar.

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