GSC Advanced Research and Reviews

eISSN: 2582-4597 CODEN (USA): GARRC2

Cross Ref DOI: 10.30574/gscarr

Journal homepage: https://gsconlinepress.com/journals/gscarr/

(RESEARCH ARTICLE)

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Impact of soil amendment using indigenous inoculants on tomato growth and yield parameters

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GSC Advanced Research and Reviews, 2023, 17(02), 181–187

Publication history: Received on 13 October 2023; revised on 22 November 2023; accepted on 24 November 2023

Article DOI: https://doi.org/10.30574/gscarr.2023.17.2.0415

Abstract

Tomato (*Lycopersicon esculentum mill*) is one of the most important vegetable crops in the world. It is widely acknowledged that using composts and microbial inoculants as soil amendments, rather than industrialized fertilizer and raw manure, could improve soil nutrients, promote soil health and consequently improve crop yields. Global population increase necessitates increasing crop yields. Improvement and maintenance of soil fertility is essential via bio-augmentation in this economic recovery era. In this work, an open field experiment was conducted in other to study the "Yield Effects of Indigenous Microbial Inoculants on Tomato using autochthonous microbial consortia". The experiment was laid in Randomized complete Block Design (RCBD) with three replicate consisted of six inoculants samples; Indigenous cultures viz; (A) Control, (B)*Bacillus mucilaginosus* (C) *Azospirillum sp*., (D) *Azotobacter sp.* (E) Commercial strains of the inoculants (F) Consortium of B, C and D. The various morphological features/yields parameters measured at intervals includes; no. of leaves, plant height, root length, accumulated dry matter and average fruit weight. The result shows that indigenous inoculants (F) increased tomato overall yield. This research is also of great significance for the development of management strategies for soil maintenance, environmental protection, and resource conservation in Nigeria where soil fertility is on the decrease due to over-use of land in other to achieve food security. From the result of the research, it can be concluded that soil augmentation with indigenous inoculants improves tomato morphological features and yields, hence should be preferred above their exotic commercial strain counterparts because of cost of importation/indigenous product development and GDP growth.

Keywords: Improvement; Inoculants; Yields; Indigenous and Soil

1. Introduction

Tomatoes (*Solanum lycopersicon* L.), like other vegetables are important source of proteins, vitamins, minerals, dietary fibers, micronutrients, antioxidants and phytochemicals that are required by all class of human beings (Kadiri *et al*., 2015). They also contain other phyto-chemicals in different forms that helps the body to either prevent the accumulation of cancerous and anti-oxidants in the body. For instance, flavonoids, glucosinolates and isothyocynates are important composition of many varieties of tomatoes (Erba *et al*., 2013). The world is still in need of tomato production in order to meet the ever-increasing demands because the present production scale is low and are of low quality especially in the sub-Africa continents. The need for improvement is highly needed so as to be able to meet the nutritional requirement of the growing population. Nigeria is blessed with diverse agro-climatic condition with distinct seasons, making it possible to grow wide array of vegetables in like tomatoes all year round where there is water for irrigation (Kane and Piot-Lepetit, 2017). Tomato is one of the few vegetables that due to to its high importance; it is grown all over the world for food nutrients it supplies. It belongs to the family Solanaceae and an originally native to Central and South America but originated in Latin America and has become one of the most widely grown vegetable the world over (Ayinde *et al*., 2014). Its fruit, by chemical composition contains 3-4% total, sugar, 4-7% total solids, 15-30

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mg/100g ascorbic acid, and 20-50 mg/100g fruit weight of lycopene. Also, in 100g of edible part of fruit, it is composed of 93.1 g moisture, protein 1.9 g, fat 0.1 g, minerals 0.6 g, fiber 0.7 g, carbohydrates 3.6 g, sodium 45.8mg, potassium 114 mg, copper 0.19 mg, sulphur 24 mg, chlorine 38 mg, vitamin A, thiamine 0.07 mg, riboflavin 0.1mg, nicotinic acid 0.4mg, vitamin C 31mg, calcium 20mg, magnesium 15mg, oxalic acid 2mg, phosphorus 36mg, and iron 1.8mg. Literature has also revealed some beneficial effects of tomato consumption in the prevention of some major chronic diseases, such as cancer and cardiovascular diseases (Bita and Gerats, 2013). Tomato fruit is also known to contain other important compositions such as vitamin A, B and C and minerals like calcium, iron, and phosphorus and have been implicated in helping the control of liver problems. Increasing global population means there would be need for increasing either the production of this crop on a larger scale than before or increase the quality of the produce (Boansi, 2014). Intensive crop production practices often require extensive use of chemical fertilizers which are often not environmentally friendly. Therefore, there has recently been a renewed interest in the search for alternative to the use of synthetic chemicals for improving yield. Microbial inoculants are agricultural amendments that use beneficial microbes to promote plant health by various mechanisms viz., nitrogen fixation, phosphate solubilization phytohormone production etc. (Huang *et al*. 2020). Several reports have commented on the appropriate and cost- effectiveness, eco-friendly, and renewable nature of the method of soil improvement which could be deployed for improving tomato yield. Therefore, this research was designed to evaluate the effects of some indigenous bacteria inoculants on growth and yield of tomato plant.

2. Materials and Methods

Field experiment was conducted to evaluate the effects of some bacteria inoculants on growth and yield of tomato plant (*Solanum lycopersicon L*). The tomato variety used in the present investigation was *Roma* and the bacteria inoculant was isolated from around the soils where the tomato was later grown.

2.1. Soil Sample Collection

Samples of soils were carefully collected from underneath and around the tomato roots into sterile bottles (Fig. I), labelled and transported to the microbiology laboratory for analysis (Suvo *et al*., 2016).

Figure 1 Soil Sample Collection

2.2. Isolation and Characterization of Soil inoculants

Using the method of Mowa et al., 2017, one gram (1g) of the rhizosphere soil was weighed into 9ml of sterile peptone water and shaken properly. From this, 1ml was used to prepare serial dilution up to 10^{-6}. Aliquot 0.5ml of appropriate dilution was pour plated in molten Nutrient agar and other selective media. The plates were incubated at 35^{0}C for 24-48 hours. After the incubation period, the bacteria inoculants were identified using microbiological techniques including cultural, morphological and biochemical characterization. The respective pure culture isolates were preserved in 10% glycerol and agar plates for subsequent studies and applications.

2.3. Inoculation of Tomato Roots

Using the method of Mengistu *et al*., 2022, pure inoculum was propagated by culturing them respectively in broth media and placed in incu-shaker for both incubation and shaking for 48 hours. Afterwards, the mass-produced biomass was used as inoculants in this study. The roots of tomato seedlings in potted soil previously sterilized using oven were inoculated using standard method. In the procedure, 350 mL of the prepared bacteria cell suspension at 10^8 CFU·mL^{-1} viable cells concentrations were inoculated into the soil around the tomato seedling in the pot. Taking the sterile saline inoculation as a control (uninoculated) treatment. After the inoculation, the required cultural practices were followed and the growth and yield parameters viz., plant height, no. of leaves, root length, dry matter accumulation, average fruit weight, number of fruits were evaluated at various intervals. The performance of each microbial inoculants was evaluated individually and in combination with one other in order to effectively screen for the best microbial inoculants. Five replicates were created for each of the above treatments. The parameters were recorded and after 70 days, the tomato fruits were harvested for analysis.

2.4. Measurement of Tomato Growth and Yield Parameters

2.4.1. Plant Growth Measurement

Plant height was calculated as the distance between the roots and the highest point of the plant, stem thickness was measured at the point where the above-ground and below-ground parts of the plant meet, and both above-ground and below-ground biomass were measured in fresh weight (Polina, *et al*., 2022).

2.4.2. Plant Yield Measurement

The number of tomato fruit was obtained using the counting method. To obtain a yield of the tomatoes, ripe fruits were picked and wiped with sterile cotton (adsorbed with 75% ethanol) and then weighed (Tian *et al.*, 2016).

Figure 2 Determination of Weight Parameters

3. Results and Discussion

The results depicted that the indigenous consortium of the three bacteria strains (Sample F) produced the highest performance followed by sample (D); *Azotobacter sp*. sample (C); *Azospirillum sp*., sample (A); Control, sample (E); Commercial strain, and lastly sample (B); *Bacillus mucilaginosus* strain. (Table 1).

Table 1 The Effects of Microbial Inoculants on Various Growth and Yield Parameters

Treatment	Plant Hgt (cm)	No. of leaves	Root length(cm)	Dry matter(g)	Ave. fruit wt. (g)	No. of fruit	Yield(kg)
Control (A)	29.78	132	20	164	32.9	33	1.74
Bacillus muc. (B)	21.32	122	18	187	33.7	31	1.43
Azospirillum sp. (C)	34.22	201	21	231	37.8	43	1.75
Azotobacter sp. (D)	37.67	187	23	256	45.3	45	1.84
Commercial (E)	31.76	179	18	198	35.3	35	1.65
Consortium (F)	48.20	232	26	272	48.5	48	2.12

The result on the comparativeness improvement of growth quality and yield indicated that maximum plant height was 48.20cm, no. of leave 232, dry matter, 272g, average fruit weight, 48.5g, no. of fruit, 48 and yield was 2.12kg for the plant inoculated with the consortium of bacteria strains. Therefore, the consortium gave the best overall results.

3.1. The Effect on Growth Parameters

There was generally a degree of variation in terms of the performance of the samples. The plant height and all the other parameters increase proportionately from the consortium to *Bacillus mucilaginosus* strain (Fig. I).

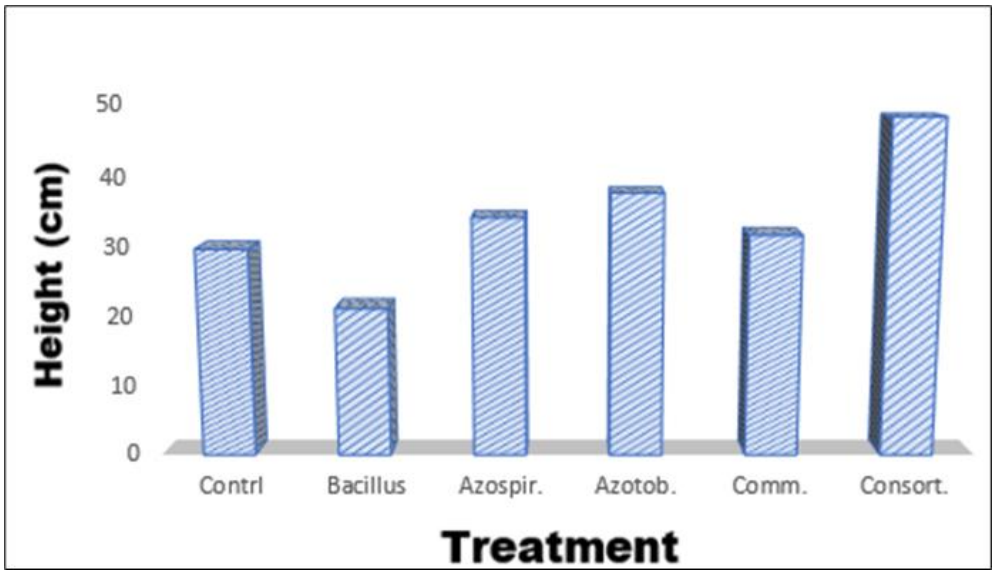

Figure 3 Effects of Inoculants on Plants Height

Therefore, the consortium was found to be superior than any other treatment in all respect. This result conformed with the work of several authors such as Nuti and Giovannetti, 2015 in their work on the "Borderline Products between Bio-fertilizers/ Bio-effectors and Plant Protectants: The Role of Microbial Consortia", that consortium of microbial cultures improves the performance of plant growth more than when single strains are used. This might be due to the fact that the more the bacteria strain in the sample the more benefits the plants are likely to have for their different metabolisms and hence growth and yields (Yakhin *et al*., 2015). Also, the increase in plant height had direct positive effect on other parameters due to the role height plays in the development of leaves which in turn are responsible for photosynthesis, Nitrogen and phosphorus fixation and ultimately on other yield parameters as remarked by Rouphael *et al*., 2018. Plant height increase resulted from the vigour they got from abundant minerals derived from the microbial combination are important for plant yields. This could be as a result of the several interactions among the different microbial content of the consortium (Wilson *et al*., 2918). Several works have observed that the application of Azotobacter increased the

shoot length and the greater number of leaves per plant. This observation was also in line with that of Amirkhani, *et al*., 2016 in the research on the Investigation of Soy Protein—Based Biostimulant Seed Coating for Broccoli Seedling and Plant Growth Enhancement. Also, the result is in accord with those of Sanjay and Asmita (2018) who clearly mentioned that application of Azotobacter resulted increase of shoot length and a greater number of leaves. It is quite possible that the beneficial effect of Azotobacter on tomato plants might be due partly to nitrogen fixation as nitrogen enrichment helps in vegetative growth of tomatoes (Liu *et al*., 2023).

3.2. The Effect of the Treatment on Yields

The tomatoes treated with the consortium of the bacteria recorded the highest amount of accumulated dry matter of 272g. The least is however found in plant with The highest dry matter accumulation (282.2g) was found in plant without any treatment (Table 1). Dry matter and eventually the fruit numbers, fruit weights and yields are the direct results of the activities and numbers of leaves on the given plant. (Heuvelink *et al*., 2004). Nitrogen and other mineral availability in the soil triggers flowering and fruiting of tomatoes (Lufita *et al*., 2023). This was also found out by Rabia *et al*., 2023 who revealed that there is better growth response of Azotobacter inoculated plants as compared to non-inoculated control plants. Better crop growth response ultimately results in better dry matter accumulation and ultimately better yields as could be seen in Table 1. From figure II, the trend of the effects of different treatment on plant leaves that the consortium sample produced higher number of fruits than other treatments.

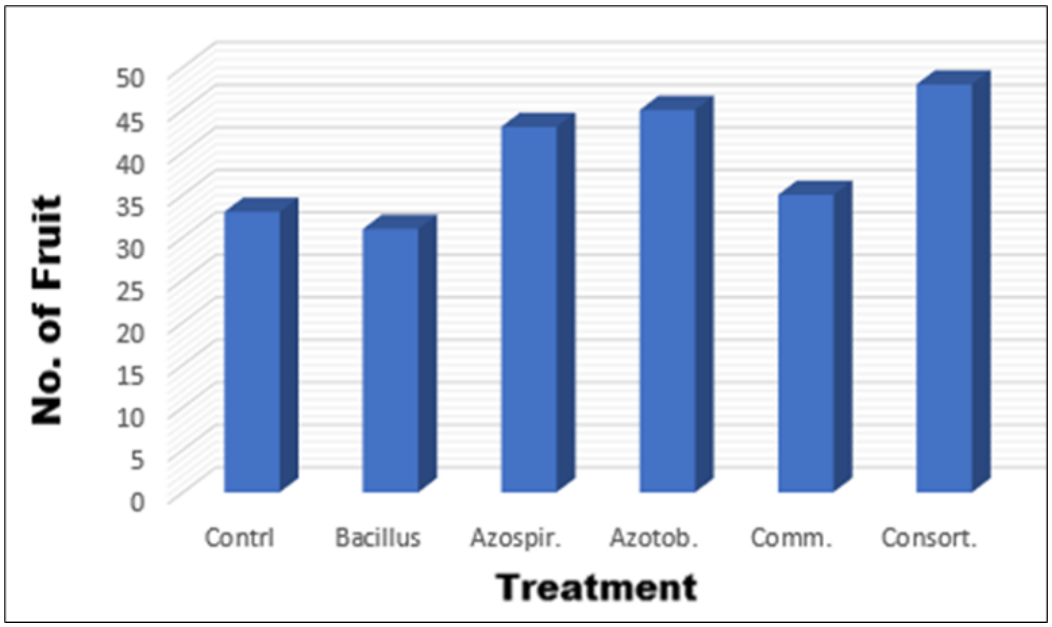

Figure 4 The Effects of Different Treatment on the Number of Fruits

4. Conclusion and Recommendations

The results depicted that among all the microbial inoculants samples, the indigenous consortium made up of *Azotobacter sp*. (D); *Azospirillum sp*., (C) and *Bacillus mucilaginosus strains* (B) recorded the best in terms of improving the respective performance marked by the plant height, dry weight matter accumulation, the number of fruits, the average weight of the fruits and overall yield.

Consequently, this present study can be justified to say that indigenous consortium of microbial cultures permed better than the individual strains. Therefore, treatment of soil meant for tomato cultivation with the right combination of thess indigenous microbial cultures can enhance its performance hence may be the better option to be adopted by farmers and tomato growers in order to achieve optimum yield.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

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