Nig. J. Biotech. Vol. 33 (2017) : 11-15
ISSN: 0189 1731
Available online at
http://www.ajol.info/index.php/njb/index
and www.biotechsocietynigeria.org
DOI: https://dx.doi.org/10.4314/v33i1.2

NIGERIAN JOURNAL OF BIOTECHNOLOGY

Performance of *Glomus clarum* and *Tithonia diversifolia* compost in improving growth and yield of tomato (*Lycopersicum esculentum* Mill)

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(Received: 28:03:2017; Accepted:19 :07:2017)

Abstract

Screen house experiments were conducted at the Institute of Agricultural Research and Training, Ibadan, on a sandy loam soil in two years, to assess the effect of arbuscular mycorrhizal fungus (*Glomus clarum*) and compost (sunflower) on the growth and yield of tomato plants. The experimental design was laid out in a Complete Randomized Design (CRD) with nine treatments replicated three times. Arbuscular mycorrhizal fungi (AMF) and Compost (CMP) were applied into 8 kg soil each at the levels of 2.5, 5.0, 7.5 and 10 tonnes/ha each (2.5 g, 5.0 g, 7.5 g and 10 g respectively), while the control had 0 tonnes /ha (0 g). Results showed that plants treated with 5.0 tonnes/ha AMF produced highest cumulative weight of harvested fruits per plant and number of fruits per plant which were significantly higher ($P<0.05$) than other treatments. Application of 2.5 tonnes/ha CMP significantly ($P<0.05$) produced the highest number of tomato leaves per plant, while the highest number of flowers per plant was significantly higher for 7.5 tonnes/ha CMP. The tallest plants and plants with highest number of branches were also recorded for 5.0 tonnes/ha AMF. This study showed that 5.0 tonnes/ha is the optimum level of AMF required for the cultivation of tomato plant which could have arisen from optimum uptake of phosphorus in the soil.

Keywords: Compost, *Glomus clarum,* fertility, tomato, yield
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Introduction

Tomato (*Lycopersicum esculentum* Mill) is an important edible fruit vegetable widely cultivated in every part of the world including West Africa, particularly Nigeria. It can be eaten raw in salads, cooked into soup and processed to juice, sauce, paste, stew puree, ketchup or as powder in canning industries (Tsado, 2014). Crop production generally depends on many factors which can improve the soil fertility and this is achieved by the application of organic or inorganic fertilizer that aids the improvement of quality of crops on food for man (Rosen and Bierman, 2005; Solutions for sustainable Agriculture and Food Systems, 2013). Optimal growth and yield of tomato production will be enhanced when fertile soil supplies essential plant nutrients such as Nitrogen (N), phosphorus (P), potassium (K), copper (Cu), Iron (Fe) and manganese (Mn) (Janseen, 1993).Tomato requires a deep well-drained loamy soil with pH of 5.0 – 7.5 and thrives well in areas with evenly distributed rainfall of 50 – 125 cm, extended period of sunshine and temperature requirements ranging from 22 – 25°C. Temperature above 29°C tends to inhibit fruitings (Ayres, 2014).

Application of organic fertilizers influences physical, chemical and biological properties in the soil. It produces humus for maintaining soil fertility and improving soil structure, texture, aeration and microbial activities in the soil; thereby enhancing downward movement of water. Animal dung and other metabolic waste products can be utilized effectively as sources of manure as it has been known to release higher nutritional quality needed by plants for successful growth (Hsieh and Hsieh, 1990).

Mexican sunflower, Tithonia diversifolia is a prolific shrub with dark green leaves and bright yellow flowers commonly found on wastelands. It grows naturally, and if its potential is tapped, soil infertility problem would be solved (Obatolu, 1995). Sunflower residues include; green leaves and stem, dry shed leaves, dry stem/stumps and pollen/nectar etc. Recent research has proven that there are considerable nutrients available to farmers who use green foliage of this plant (Udo, 1982; John et al., 1995).

Arbuscular mycorrhizal fungi (AMF) are biological fertilizers which improve plant growth and yield by enhancing water and mineral uptake (Osonubi et al., 1991; Gemma et al., 1997; Olawuyi et al., 2011b; Abiala et al., 2013). They also play important roles in maintaining soil aggregate stability; improve soil structure and porosity which positively influence the growth of plants by promoting aeration (Tisdall, 1991). The AMF, Glomus clarum, had earlier been reported for its growth promoting potentials, as demonstrated by Olawuyi et al. (2012) and Fapohunda et al. (2013). Thus, application of AMF can reduce cost of production in horticultural plants (Douds and Reider, 2003).

In achieving sufficient food production and maximum crop yield potential, concerted efforts are needed to accelerate soil productivity, by adopting soil improvement technique and addition of humus to the soil. These can be achieved through appropriate application of organic raw materials and taking steps to locate, conserve and process all sources of organic materials available in the country in order to sustain agricultural production. The study therefore aimed at assessing the effects of different levels of AMF and Sunflower Compost (CMP) on the growth and yield of tomato.

Materials and Methods

Screen house experiments were conducted between August, 2009 and April, 2010 at the Institute of Agricultural Research and Training, Ibadan, between August, 2009 and April, 2010. Samples of the top soil (0-30 cm depth) were taken from the site and analyzed for their physical and chemical properties (Table 1), while microbial analysis was also done to show the biological properties of the soil (Table 2). In the two experiments, seedlings of tomato (Roma VF) variety were raised for 5 weeks in the nursery beds, before being transplanted into sterilized soil filled into 8kg plastic pots, and were arranged at 50x50cm spacing distance in the screen house using procedure described by Olawuyi et al. (2011a).

The treatments consisted of four AMF (2.5, 5.0, 7.5 and 10.0 tons/ha) and four CMP (2.5, 5.0, 7.5 and 10.0 tons/ha) rates, while the control had 0 tons/ha. The treatments were laid out in a complete randomized design (CRD) with three replications. Glomus clarum and sunflower compost were used as sources of biological and organic fertilizers, respectively.

Transplanting of tomato seedlings was done after 2 weeks of CMP and AMF application. Three tomato plants were randomly selected and tagged within each treatment for data collection on plant height, number of leaves per plant, number of branches per plant, number of flowers per plant, number of fruits per plant and weight of harvested fruit per plant.

Data collected were subjected to analysis of variance (ANOVA) using F-test for significant differences of the treatments using Statistical Analysis System (SAS) version 9.1 (2003). Differences among mean of the treatments were separated using the Least Significant Difference (LSD) at 5% level of probability.

Results and Discussion

Analysis of soil (Table 1) shows that the soil was sandy loam in texture and slightly acidic in nature with mean pH 5.8. Other chemical soil properties were generally low according to Babaji (2002). The mean values of cation exchange capacity, nitrogen and available phosphorus of soil which were found to be low in the experimental plot; shows that the sandy loam nature of the soil was suitable enough for the experiment.

Table 1: Chemical and physical properties of the soil sample of the experimental plot at 0-30cm depths (Mean of two years).

Properties	Value
Ph	5.80
Total nitrogen (%)	0.14
Organic carbon (%)	1.10
Organic matter	1.83
Available phosphorus (mg/kg)	2.80
Exchangeable bases	
Na (c mol/kg)	0.20
K (c mol/kg)	0.43
Mg (c mol/kg)	1.32
Ca (c mol/kg)	2.95
Sand %	75.8
Silt %	14.8
Clay %	9.40
Textural Class	Sandy Loam

Analysis of the soil for microbial load (Table 2) also indicated that the microorganisms present in the soil includeProteus vulgaricus, Pseudomonas fragii, Ps. gelluciudum, Aspergillus niger, Saccharomyces cerevisae etc. This shows that the interactions of these microbes in the soil might have been responsible for the presence of organic matter as similarly reported by Norman (1992).

Table 2: Microbial load analysis of soil before application of CMP and AMF (mean of two years)

Sample code	Total viable Count (cfug-1)	Total coliform (cfug-1)	Total Fungi (cfug-1)	Total yeast count (cfug-1)	Isolated micro organism
A	18.6 x 10^6	0.8 x 10^6	1.2 x 10^6	1.8 x 10^6	*Pr. Vulgaricus, S. aureus, B. cereus, Ps. fragi, Ps. gelluodum, A. niger, F. oxysporum, A. tamari.*
B	18.3 x 10^6	1.0 x 10^6	1.4 x 10^6	2.0 x 10^6	*S. faecum, S. aureus, B. cereus,Ps. fragi, Ps. gelluodum, A. niger, F. oxysporum, A. tamari, S. cerevisae.*

A and B – Experimental soil samples
CMP- Compost
AMF- Arbuscular mycorrhizal fungi

Table 3: Effect of different levels of AMF and CMP on the number of leaves of tomato (mean of two years)

Treatment (g)	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT
2.5 AMF	10.33	20.00	25.67	30.33	37.67	42.00
5.0 AMF	14.33	23.50	24.66	48.33	54.67	58.33
7.5 AMF	10.67	20.33	25.67	32.50	38.77	43.00
10.0 AMF	11.67	21.67	27.67	35.33	39.33	44.00
2.5 CMP	12.00	28.00	39.67	53.67	58.67	67.67
5.0 CMP	13.67	25.67	31.33	37.00	47.67	51.67
7.5 CMP	14.67	21.00	33.00	36.67	49.33	53.00
10.0 CMP	13.67	29.33	38.00	42.33	50.67	57.33
Control	1.67	6.67	10.00	12.67	16.00	21.00
CV (%)	31.68	36.97	29.92	22.40	27.42	27.50
LSD (0.05)	Ns	Ns	*	*	*	*

AMF- Arbuscular mycorrhizal fungi
CMP- Compost
WAT- Weeks after transplanting
CV - Coefficient of variation
* - significant
ns- Non-significant

Of tomato treated with different rates of AMF and CMP at 2 weeks after transplanting (WAT) and 4WAT but differed from the control (Table 3).

The highest mean number of leaves per plant was recorded for 10 tons/ha of compost fertilizer at 4WAT (29.33) but was also observed that plants treated with 2.5 tons/ha CMP produced the highest mean number of leaves at 6WAT (39.67), 8WAT (53.67), 10WAT (58.67) and 12WAT (67.67) compared to other treatments. Among the plants treated with AMF, 5 g AMF recorded the lowest number of leaves at 6WAT, it increased from 24.66 to 48.33 at 8WAT while the least number of leaves were recorded for the control treatments in all the weeks.

The number of leaves were significantly ($P<0.05$) affected by AMF and CMP from 6 to 12 WAT. Comparison of the treatments showed that 2.5 tons/ha CMP produced the highest number of tomato leaves per plant at 12WAT. This result conform with the observation made by Morales et al. (1992) and Vince et al. (2002) which reported that nitrogen (N) and phosphorus (P) were essential nutrients for leaf production in plants. Amans and Kadam (1990) also reported increased leaf production in response to N and P. Similar results are also obtained by Achakzai et al. (2012) and Liasu and Achakzi (2007).

Table 4 also indicated that there were significant differences among AMF and CMP treatments from 6 to 8 WAT. Five tons/ha AMF produced the highest mean number of branches from 8WAT (18.67) to 12WAT (34.667), while the control treatments had the least.

Table 4: Effect of different levels of AMF and CMP on the number of branches per Plant (mean of two years)

Treatment (g)	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT
2.5 AMF	3.33	5.67	9.33	13.67	18.00	20.67
5.0 AMF	4.33	6.67	8.67	18.67	28.33	34.67
7.5 AMF	4.67	8.33	9.67	14.83	20.33	22.33
10.0 AMF	6.00	8.33	10.67	16.00	25.33	28.33
2.5 CMP	5.00	8.67	9.00	13.33	17.00	20.00
5.0 CMP	7.33	7.67	9.33	14.67	19.00	23.67
7.5 CMP	7.67	7.67	9.33	15.00	21.33	23.33
10.0 CMP	8.33	7.33	10.00	18.00	26.00	27.00
Control	4.67	6.67	7.67	9.00	12.67	15.10
CV (%)	25.12	17.91	17.21	22.84	28.76	35.60
LSD (0.05)	Ns	Ns	*	*	*	*

AMF- Arbuscular mycorrhizal fungi
CMP- Compost
WAT- Weeks after transplanting
CV - Coefficient of variation
* - significant
ns- Non-significant

The highest number of flowers were produced in AMF treated plants compared to CMP treated plants and control. Plants treated with 10 tons/ha AMF produced flowers earlier than other plants and recorded the highest number of flowers (4.00) at 6WAT.The highest number of flowers was recorded for plants treated with 7.5 tons/ha compost (2.667) at 12WAT (Table 5).

Table 5: Effects of different levels of AMF and CMP on the number of flowers per plant (mean of two years).

Treatment (g)	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT
2.5 AMF	10.33	20.00	25.67	30.33	37.67	42.00
5.0 AMF	14.33	23.50	24.66	48.33	54.67	58.33
7.5 AMF	10.67	20.33	25.67	32.50	38.77	43.00
10.0 AMF	11.67	21.67	27.67	35.33	39.33	44.00
2.5 CMP	12.00	28.00	39.67	53.67	58.67	67.67
5.0 CMP	13.67	25.67	31.33	37.00	47.67	51.67
7.5 CMP	14.67	21.00	33.00	36.67	49.33	53.00
10.0 CMP	13.67	29.33	38.00	42.33	50.67	57.33
Control	1.67	6.67	10.00	12.67	16.00	21.00
CV (%)	31.68	36.97	29.92	22.40	27.42	27.50
LSD (0.05)	Ns	Ns	*	*	*	*

AMF- Arbuscular mycorrhizal fungi
CMP- Compost
WAT- Weeks after transplanting
CV - Coefficient of variation
* - significant
ns- Non-significant

This suggest that the earlier maturing traits can be selected and considered for breeding to enhance better growth performance, agronomic characters and higher yield.

Results of the effect of different levels of AMF and CMP on tomato height (cm) are presented in (Table 6).

Table 6: Effect of different levels of AMF and CMP on tomato height (cm) (Mean of two years).

Treatment (g/)	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT
2.5 AMF	15.07	28.57	30.90	37.33	44.35	62.30
5.0 AMF	20.30	31.60	38.13	53.10	75.77	87.93
7.5 AMF	23.70	24.57	39.70	52.33	64.33	69.43
10.0 AMF	24.63	29.67	43.50	57.40	71.70	78.49
2.5 CMP	16.97	21.33	33.40	42.67	53.73	64.00
5.0 CMP	16.27	27.03	35.10	48.10	60.73	68.90
7.5 CMP	18.33	29.67	39.33	54.00	57.33	71.03
10.0 CMP	19.50	30.63	41.43	56.17	65.47	74.93
Control	10.60	11.33	14.33	21.80	28.47	32.13
CV (%)	41.22	23.26	26.15	25.80	23.54	17.07
LSD(0.05)	Ns	*	*	*	*	*

AMF- Arbuscular mycorrhizal fungi
CMP- Compost
WAT- Weeks after transplanting
CV - Coefficient of variation
* - significant
ns- non-significant

At 2WAT, there was no significant difference recorded in the height of tomato plants treated with different levels of AMF and CMP at 2 WAT. Five grammes AMF recorded the highest plant heights of 31.60cm, 75.77cm and 87.93 cm at 4, 10 and 12WAT respectively, while the highest plant heights were also recorded for 10 tons/ha AMF at 6WAT (43.50 cm) and 8WAT (57.40 cm). The highest mean cumulative number of fruits per plant (6.00) and weight of harvested fruits per plant (586.85 g) were recorded for plant treated with 5.0 tons/ha AMF which was significantly different from other treatments. Similar observation was also reported by Olawuyi et al. (2011a) who found that application of 500 kg/ha AMF significantly produced higher number and cumulative weight of cucumber fruits than other treatments.

Table 7: Effects of AMF and CMP on cumulative fruit yield of Tomato (mean of two years).

Treatment (g)	Number of fruit per plant	Weight of fruit per plant (g)
2.5 AMF	2.50	234.82
5.0 AMF	6.00	586.85
7.5 AMF	4.20	338.30
10.0 AMF	4.25	364.86
2.5 CMP	2.43	210.30
5.0 CMP	3.22	245.62
7.5 CMP	3.86	261.50
10.0 CMP	4.00	302.40
Control	0.50	25.20
LSD (0.05)	*	*

AMF- Arbuscular mycorrhizal fungi
CMP- Compost
WAT- Weeks after transplanting
* - significant
ns- non-significant

Conclusion

The results showed that 5.0 tons/ha AMF produced the highest mean cumulative number of fruits per plant (6.00) and weight of harvested fruits per plant (586.85 g). Also, among the treatments with compost fertilizer, 10.0 tons/ha CMP gave the highest mean cumulative number of fruits per plant (4.00) and 302.40 g/plant of weight of harvested. Therefore the application of 5 tons/ha of *Glomus clarum* per pot could be recommended as the optimum level for the cultivation of tomato. Mycorrhizal fungi which serve as a means of improving sustainable production technology could be adopted to increase the efficiency of fertilization in order to improve growth and yield of tomato.

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