Effect of *Azospirillum Brasilense*, *Flavobacterium Spp.* biofertilizers and Al Khasieb Organic fertilizer on growth and yield of Sweetpotato (*Ipomoea batatas* L.) under field conditions

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ABSTRACT

A field experiment was conducted in the Experimental Farm of the College of Agricultural Studies, Sudan University of Science and Technology Shambat to study the effect of inoculation with Azospirillum brasilense, Flavobacterium spp, and Al Khasieb organic fertilizer application rate on growth and yield of sweetpotato (Ipomoea batatas L). Azospirillum brasilense and Flavobacterium spp inoculum were applied at the concentration of (108Cfu/ml), with three levels of Al Khaseeb organic fertilizer; (0 t/ha, 0.8 t/ha and 1.2 t/ha). The experiment was set in factorial arrangement in a randomized complete block design with three replicates. Application of (Azospirillum +1.2 t/ha of Al Khaseeb organic fertilizer) and (Azospirillum + Flavobacterium+ 0.8 t/ha of organic fertilizer) showed significant effect on sweetpotato stem length, Leaf number, branches number after six and sixteen weeks with (107.67cm), (72) and(5); (193cm), (193) and(13) respectively compared to uninoculated control, also application of Azospirillum + Flavobacterium+ 0.8 t/ha of organic fertilizer showed the highest effect on marketable storage roots yield with (13.5 t/ha) compared to (6.71 t/ha)) for the uninoculated control. However, the application of 1.2 t/ha of Al Khaseeb organic fertilizer alone showed lowest values in some parameters. The results indicated the great potential of combined application of Azospirillum brasilense, Flavobacterium biofertilizers and Al Khaseeb organic fertilizer in improving growth and yield of sweetpotato under field conditions.

Key words: Biofertilizers, organic fertilizer, sweetpotato, growth and yield.

INTRODUCTION

Sweetpotato is one of the root crops that belong to the family Convolvulaceae. It is an inexpensive source of energy, carotene, ascorbic acid, niacin, riboflavin, thiamine and minerals (Farzana and Radziah, 2005). Sweetpotato is one of the crops that have privileges in terms of nutritional value that is rich in fiber, complex carbohydrates, and low in calories, another advantage of the sweetpotato as it contains high amount of vitamin B (Melsandi and Prijono,2015).

In Sudan the main sweetpotato producing areas are New Halfa scheme, Rahad scheme, Damazein and pervious southern states; with an average yield of 8-15t/ha. The sweetpotato stands as one of the most important crops in the rapidly expanding vegetable industry of the Sudan (Ahmed, 2000),but the problem is low yield and high production cost, therefore biofertilization could be the way to increasing the yield with affordable cost.

Biofertilization is the addition of biofertilizer to replace the chemical fertilizer completely or partially. Biofertilizer is a product that contains living micro-organisms, which exert direct or indirect beneficial effects on plant growth and crop yield through different mechanisms. The term biofertilizer as used here could include products containing bacteria to control plant pathogens, but these are frequently referred to as bio-pesticides (Siddiqui and Mahmood, 1999; Burdman, *et al.*, 2000; Vessey, 2003).

Biofertilizer use for enhancing plant growth and yield has gained great attention, because of chemical fertilizer high cost and for their hazardous effect on the environment (Ghazi, 2006). The use of biofertilizer and bio-enhancer such as N_2 (nitrogen) fixing bacteria and beneficial micro-organism can reduce chemical fertilizer application and consequently reasonable production cost could be attained. *Azospirillum* is known to be a very active nitrogen fixer under laboratory as well as soil conditions providing fast growth, better health of the plant and higher yield (Kannan and Ponmurugan, 2010).

Organic fertilizer are fertilizer derived from animal and human excreta or vegetable matter. (e.g. compost, manure)(Dittmar, *et al.*, 2009). In contrast, the majority of fertilizers are extracted from minerals (e.g., phosphate rock) or produced industrially (e.g.,ammonia). Naturally occurring organic fertilizers include animal wastes from meat processing, peat, manure and slurry (Wikipedia, 2015). *Azospirillum and Flavobacterium* spp. helps in nitrogen fixation and they also produces some growth promoting substances like (IAA) and (GA). However, the information available is so scanty on the beneficial role of biofertilizers particularly *Azospirillum and Flavobacterium* spp. on growth and yield of sweetpotato (Saikia and Borah, 2007).

MATERIALS AND METHODS

A field experiment was conducted for six months at the farm of the College of Agricultural studies (CAS), Sudan University of Science and Technology Shambat, to study the effect of *Azospirillum brasilense, Flavobacterium* spp. inoculations and organic fertilizer application rate on growth and yield of sweetpotato under field conditions. Soil was prepared with one round of normal tractor (70HP) mounted disc plough, followed by disc harrow and then other round of ridger, then thirty three plots were prepared. The plots were labeled after randomization was done for each block using computer generated random numbers using Microsoft Excel 2007. And according to the treatments labels the organic fertilizer rates broadcasted then watered. Sweetpotato cuttings originally obtained from farmer's plots in Al Seliet Agricultural Scheme, Khartoum State were propagated locally in small plots before planting in the field. *Azospirillum brasilense* and *Flavobacterium* biofertilizers were supplied by Biofertilization Department, Natural Resources and Desertification Research Institute, National Research Centre, Khartoum. The inoculum was propagated in the laboratory, and a set of colony forming units (Cfu) counts tests were done. The inoculum of *Azospirillum brasilense and Flavobacterium* were biofertilizers applied at the rate of (10^8Cfu/ml) with three levels of Al Khaseeb organic fertilizer (0t/ha 0.8t/ha and 1.2t/ha). The experiment was set in factorial arrangement in a Randomized Complete Block Design, with three replicates. Sweetpotato clean apical vine cuttings; 25 cm in length were planted, in the plots and immediately watered after planting. *Azospirillum* and *Flavobacterium* biofertilizers were applied at planting. Plants growth parameters were recorded after six and sixteen week after planting (WAP). Insecticide was sprayed when whitefly infestation was observed on the plants. The plants were watered regularly with tap water as required and grown for six months. Before harvesting shoots samples were collected with plant shoot cutter and placed in yellow paper envelopes to dry in an oven at 60C for 96hrs, for dry weights determination. The plants were harvested by separating the shoot, carefully from the soil surface. Total shoots fresh weights /plot were determined by weighing all the shoots using electric balance Model AND HV-60 KGL, Japan.

Table (1.) The treatments used in the study:

T1 :	Control.
T2:	*Azospirillum* brasilense
T3:	*Flavobacterium spp.*
T4:	0.8t/ha of Al Khaseeb organic fertilizer.
T5:	*Azospirillum* +0.8 t/ha of Al Khaseeb organic fertilizer.
T6:	*Flavobacterium* +0.8 t/ha of Al Khaseeb organic fertilizer.
T7:	*Azospirillum* + *Flavobacterium*+ 0.8 t/ha of organic fertilizer.
T8:	1.2 t/ha of Al Khaseeb organic fertilizer.
T9:	*Azospirillum* +1.2t/ha of Al Khaseeb organic fertilizer.
T10	*Flavobacterium* +1.2 t/ha of Al Khaseeb organic fertilizer.
T11	*Azospirillum* + *Flavobacterium* +1.2 t/ha of organic fertilizer.

RESULTS AND DISCUSSIONS

Table (2) Chemical and physical properties of the field experiment soil:

Depth	C. Sand	F.Sand	Silt	Clay	Lab.	Ece	pH	pH	Exchangeable cations, cmol(+)kg^{-1}				CEC
Cm	%	%	%	%	Texture	Ds/m	paste	1:5	Ca+Mg	K	Na	Sum	Cmol(+)kg^{-1}
0 - 30	4	9	55	32	Silty clay loam	0.4	7.7	8.1	41.5	1.2	1.3	44.0	44
30 - 60	3	9	39	49	Clay	0.4	7.7	8.3	43.8	1.3	0.9	46.0	46

O.M	OC	Total N	C:N	CaCo3	P	ESP	SAR	Soluble cations (meq/l)				Soluble anions (meq/l)					Sp
%	%	%		%	ppm			Ca+Mg	K	Na	Sum	CO3	HCO3	Cl	So4	Sum	%
1. 6	0.9	0.14	6.4	4	4.1	3	3	1.8	0.1	2.5	4.4		3.0	0.3	1.1	4.4	64
1.2	0.7	0.09	7.8	5	3.3	2	1	2.5	0.1	1.5	4.1		3.1	0.4	0.6	4.1	76

A) Growth attributes of Sweetpotato six weeks after planting (WAP) under field conditions:

1) Stem length:

Regarding the sweetpotato stem length six weeks after planting (WAP), results showed that application of (T9) organic fertilizer 1.2 t/ha + *Azospirillum*) gave significant effect on sweetpotato stem length, followed by application of (T7) organic fertilizer 0.8 t/ha + *Azospirillum*+ *Flavobacterium* and application of (T2) *Azospirillum* biofertilizer alone, indicating the great potential of *Azospirillum* biofertilizer in improving the sweetpotato plant's stem length proliferation and growth as general. Meanwhile application of (T8)1.2 t/ha of Al Khaseeb organic fertilizer, showed the lowest value in stem length. However application of (T1) the control showed almost similar effect with application of (T3)*Flavobacterium spp* and (T6)*Flavobacterium*+0.8 t/ha of Al Khaseeb organic fertilizer figure (1).

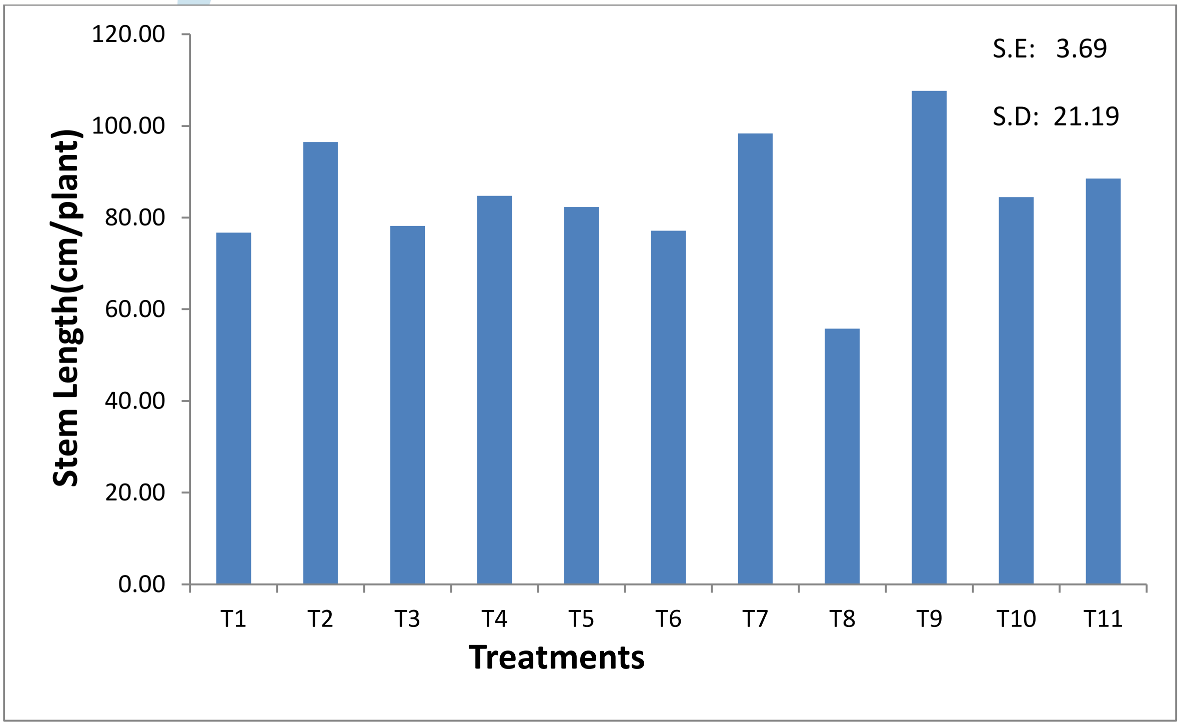
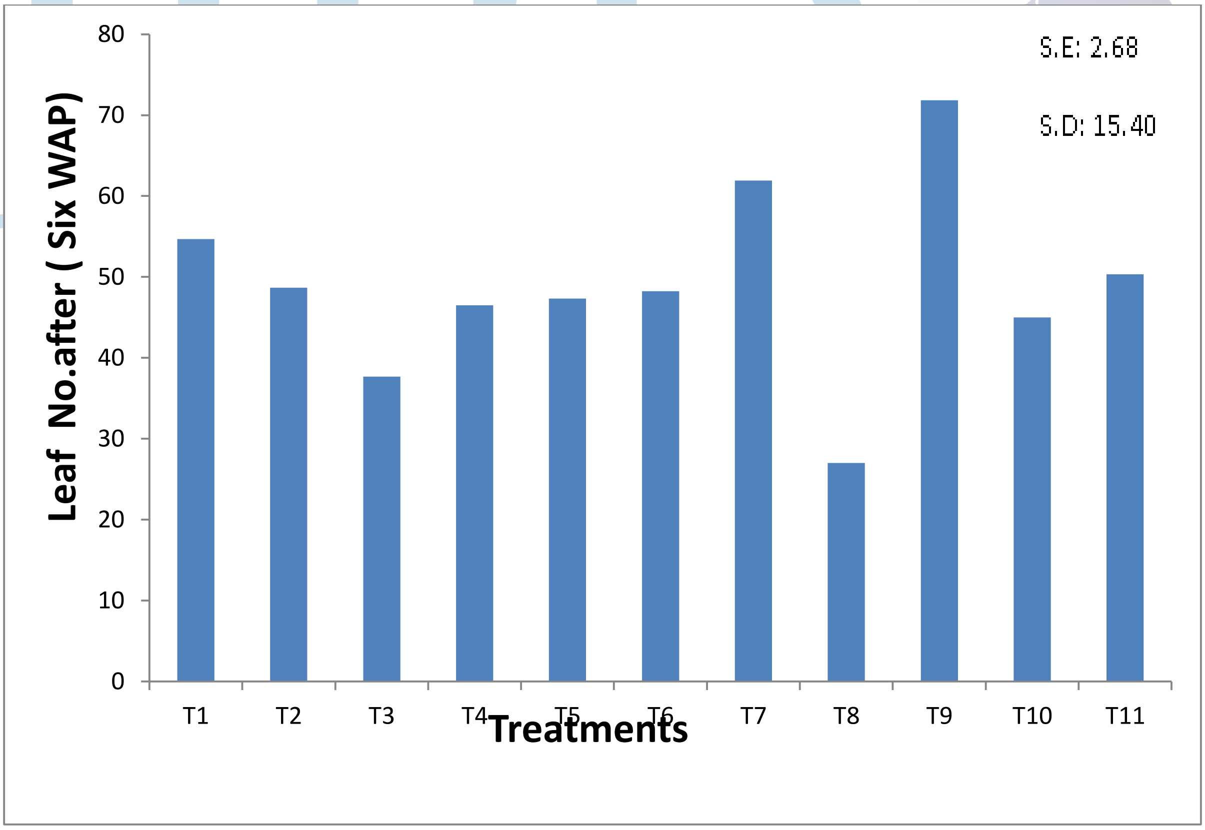


Figure (1). Effect of Biofertilization on stem length (cm/plant)six weeks after planting (WAP).

2) Leaf Number :

Sweetpotato plants' leaf number six weeks after planting (WAP), Obtained results indicated that application of (T9) organic fertilizer 1.2 t/ha + *Azospirillum*, showed the highest effect on sweetpotato leaf number, followed by application of (T7) organic fertilizer 0.8 t/ha + *Azospirillum*+ *Flavobacterium*, and it's clearly observed that application of (T8) 1.2 t/ha of Al Khaseeb organic fertilizer, also showed the lowest value in leaf number. However the application of (T1) the control showed higher value than the rest of the treatments figure (2).



Figure(2). Effect of Biofertilization on Leaf No. six weeks after Planting(WAP).

3) Branches Number:

Regarding the braches number of sweetpotato plants. it's observed from the obtained results that branches number and leaf number have the same trend with great influence for application of (T9) organic fertilizer 1.2 t/ha+ *Azospirillum* on sweetpotato plants branches gave the highest number followed by application of (T7)organic fertilizer 0.8 t/ha+ *Azospirillum+ Flavobacterium*, and it's clearly observed that application of (T8)1.2 t/ha of Al Khaseeb organic fertilizer, also showed the lowest value in branches number. However the control showed higher value than the rest of the treatments figure (3).

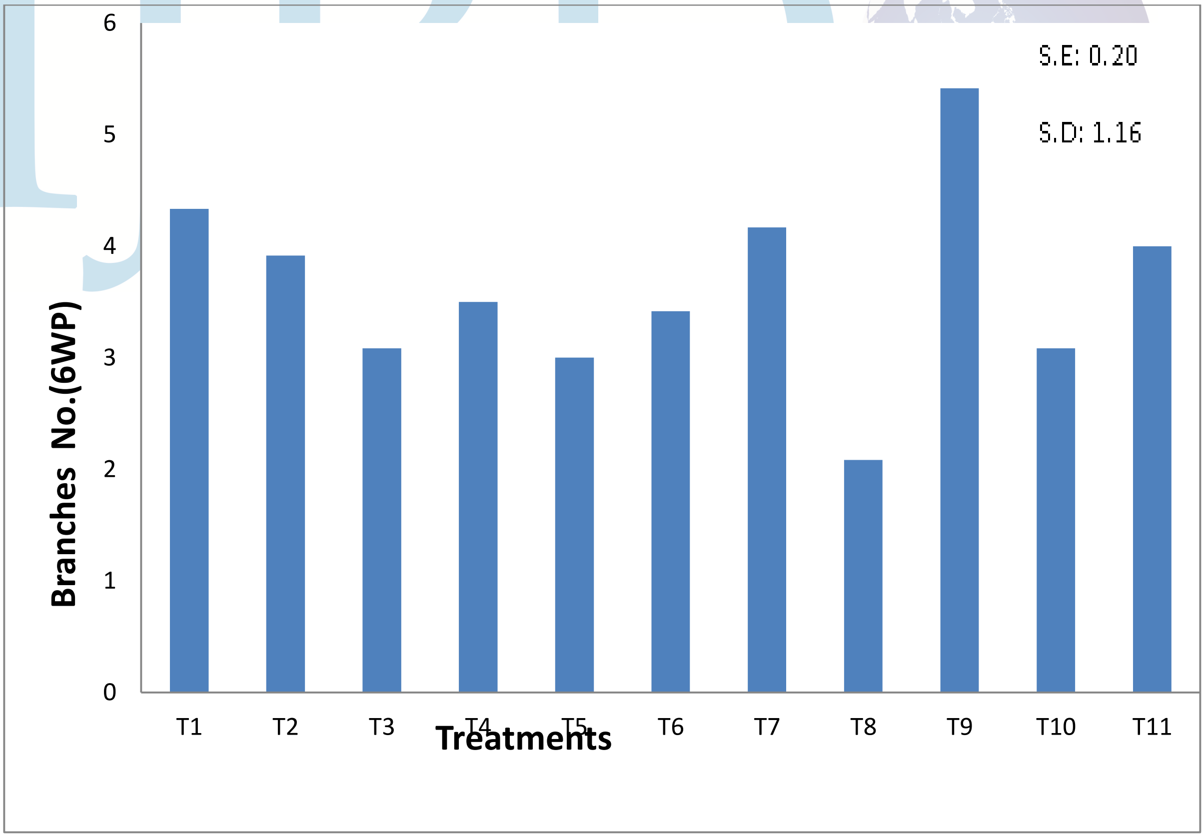


Figure (3). Effect of Biofertilization on Branches No. Six weeks after Planting(WAP).

4) Leaf Chlorophyll content:

Obtained results showed that application of (T9) organic fertilizer 1.2 t/ha+ *Azospirillum* on sweetpotato plants leaf chlorophyll content showed the highest effect, followed by application of (T4) organic fertilizer 0.8 t/ha alone and application of (T10) organic fertilizer 1.2 t/ha + *Flavobacterium*. However application of (T1) the control showed higher value in leaf chlorophyll content more than the rest of the treatments figure (4).

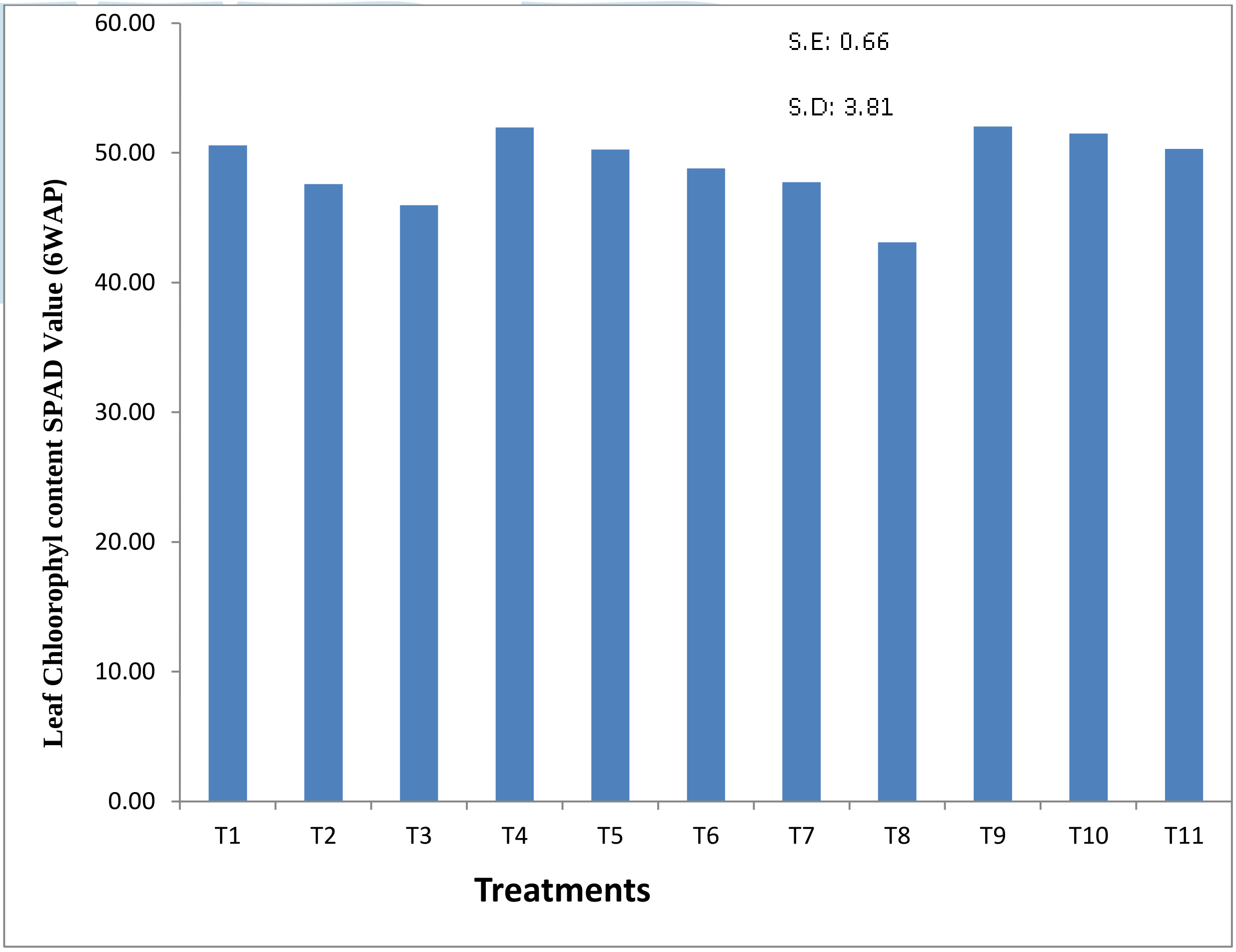
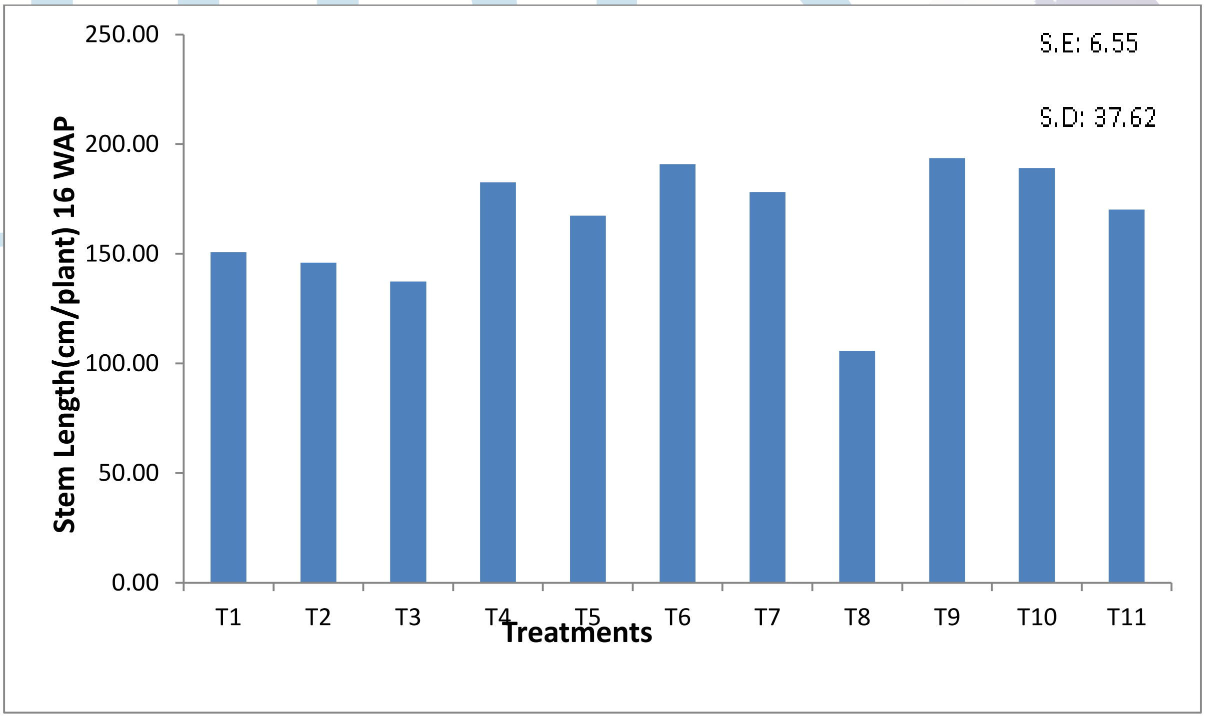


Figure (4). Effect of Biofertilization on Leaf Chlorophyll content. Six weeks after planting (WAP).

B) Growth attributes sixteen weeks after planting (WAP).

1) Stem length:

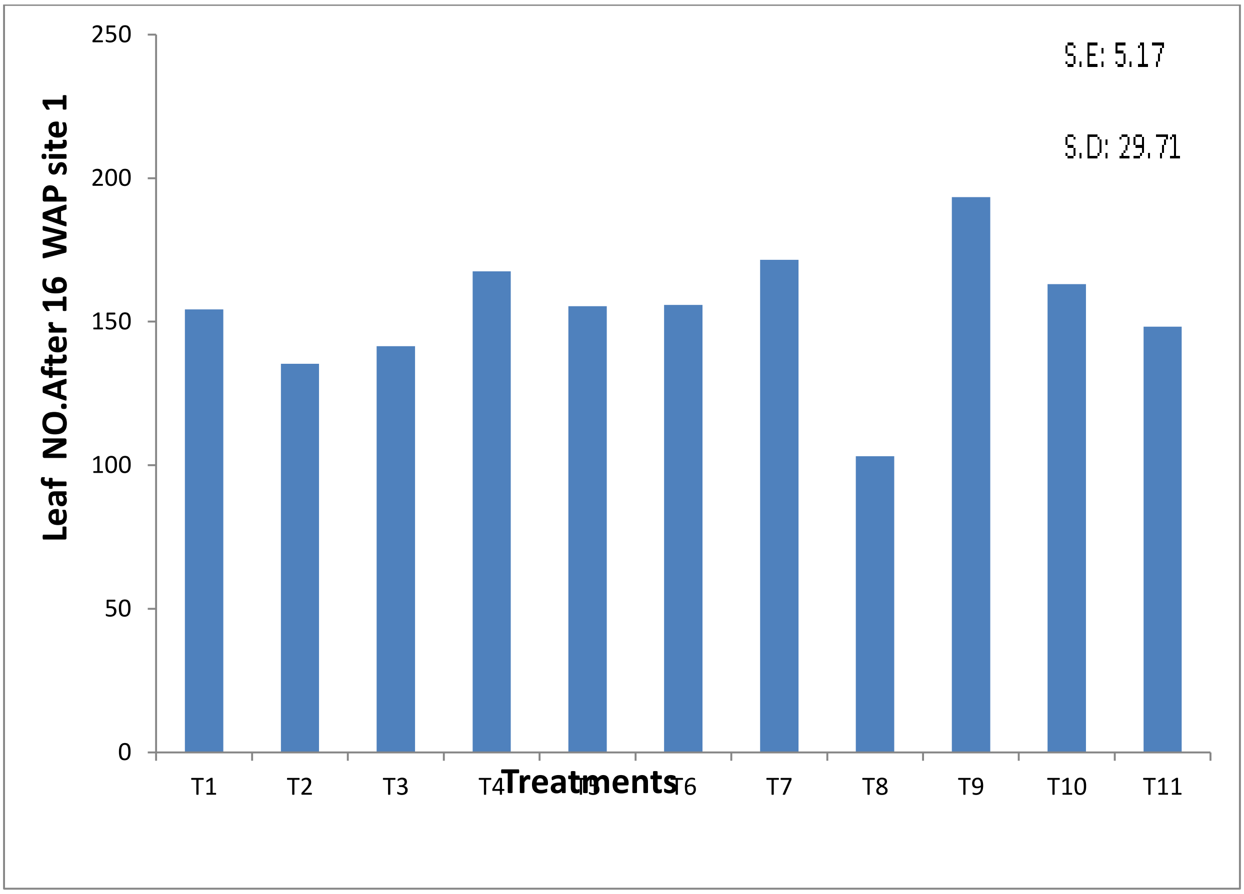
The results showed that the application of (T9) organic fertilizer 1.2 t/ha+ *Azospirillum* on sweetpotato plants stem length showed significant effect, followed by application of (T10) organic fertilizer 1.2 t/ha + *Flavobacterium* and (T6)organic fertilizer 0.8 t/ha + *Flavobacterium.* However the application of (T8) organic fertilizer 1.2 t/ha showed the lowest value for stem length sixteen weeks after planting (WAP) figures (5).



Figure(5). Effect of Biofertilization on stem length (cm/plant) sixteen weeks after planting (WAP).

2) **Leaf Number:**

Regarding the sweetpotato plants leaf number sixteen weeks after planting (WAP), the results indicated that application of (T9) organic fertilizer 1.2 t/ha+ *Azospirillum* showed great effect, followed by the application of (T7) organic fertilizer 0.8 t/ha + *Azospirillum* +*Flavobacterium* and application of (T4) organic fertilizer 0.8 t/ha. Meanwhile the application of (T8) organic fertilizer 1.2 t/ha alone showed the least value figure (6).



Figure(6). Effect of Biofertilization on leaf number sixteen weeks after planting (WAP).

3) Branches Number:

Regarding the sweetpotato plants branches number sixteen weeks after planting (WAP), the results showed great influence for application of (T9) organic fertilizer 1.2 t/ha+ Azospirillum, followed by application of (T7) organic fertilizer 0.8 t/ha + *Azospirillum*+ *Flavobacterium* and (T6) organic fertilizer 0.8 t/ha + *Flavobacterium.* However application of (T11) organic fertilizer 1.2 t/ha + *Azospirillum* + *Flavobacterium*, and (T5) *Azospirillum* + 0.8 t/ha organic fertilizer showed almost similar effect to application of (T1) the control. However the lowest values were observed with application of (T8) organic fertilizer 1.2 t/ha and application of (T2) *Azospirillum* alone figure (7).

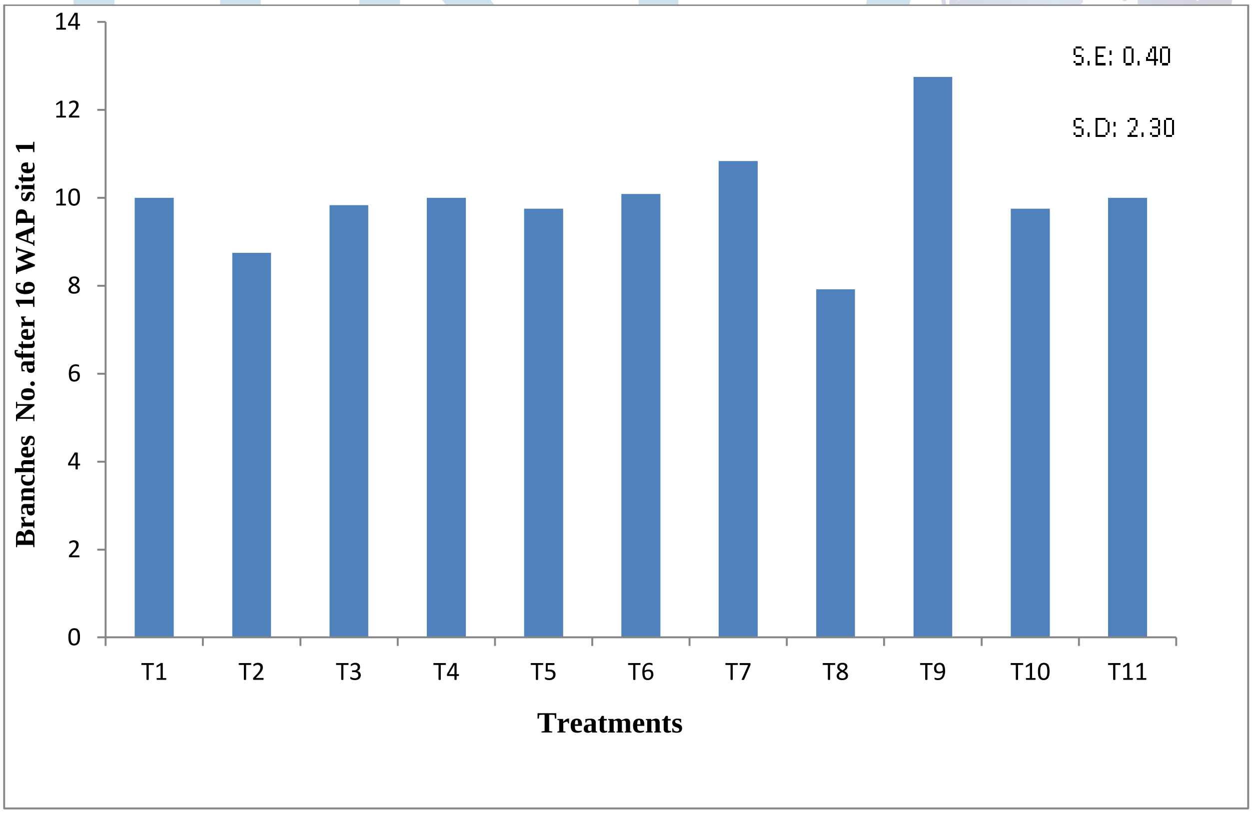


Figure (7). Effect of Biofertilization on Branches Number sixteen weeks after planting (WAP).

C) Data of Harvest (Shambat Experiment).

1) Total shoots fresh weight/plot (kg)

Obtained results showed the highest effect on total sweetpotato plant shoots for application of (T1) the control, followed by application of (T8) organic fertilizer 1.2 t/ha. However the least values for total shoots fresh weight were observed with application of (T4)0.8t/ha of Al Khaseeb organic fertilizer and (T5) *Azospirillum* +1.2 t/ha of Al Khaseeb organic fertilizer figure (8).

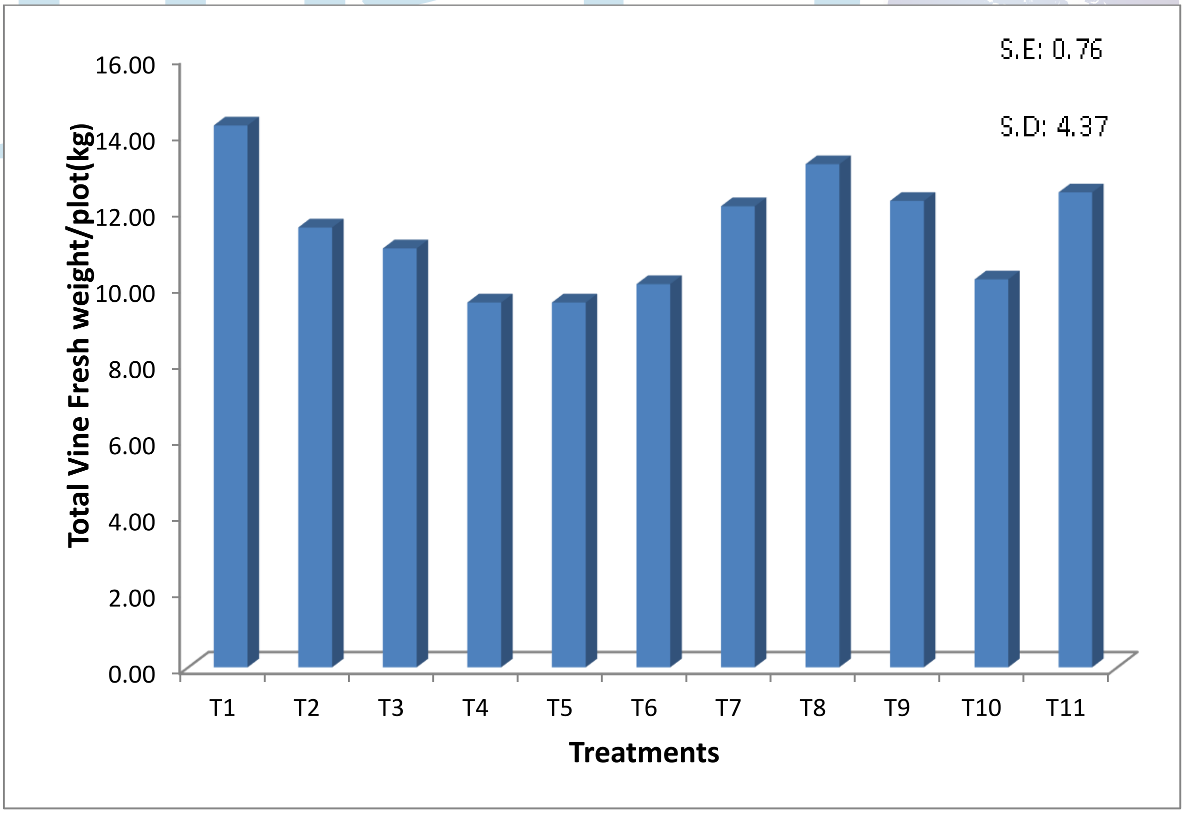


Figure (8). Effect of Biofertilization on Sweetpotato total shoots fresh weight (kg).

2) Sample storage roots fresh weight (kg)

Regarding sample sweetpotato storage roots yield fresh weight, results showed that application of (T9) organic fertilizer 1.2 t/ha+ *Azospirillum* and application of (T7) *Azospirillum*+ *Flavobacterium*+ 0.8 t/ha of organic fertilizer showed the highest storage roots yield followed by the application of (T10) *Flavobacterium* +1.2 t/ha of Al Khaseeb organic fertilizer. Meanwhile the lowest yield of storage roots was recorded with application of (T3) *Flavobacterium spp*. figure (9).

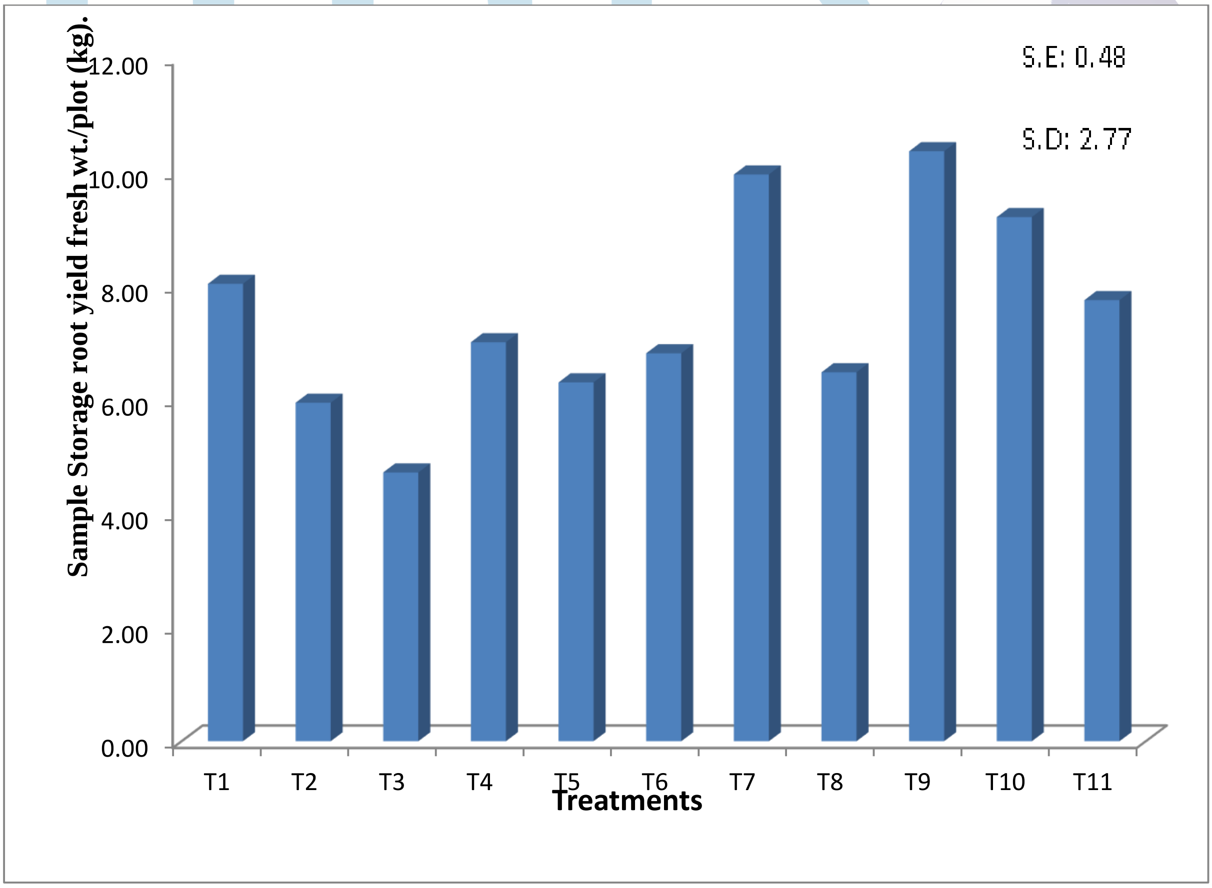


Figure (9). Effect of Biofertilization on sample sweetpotato storage root yield fresh weight (kg).

3) Total Storage roots yield fresh weight (kg)

Obtained results showed that in total sweetpotato storage roots yield fresh weight application of (T11) gave the most higher yield followed by application of (T9)organic fertilizer 1.2 t/ha+ Azospirillum, and the third one (T1) the control. The yield of control may be due the history of pervious fertilization in the experiment site. However the least value for total storage roots yield, was observed with application of (T2) *Azospirillum* brasilense figure (10).

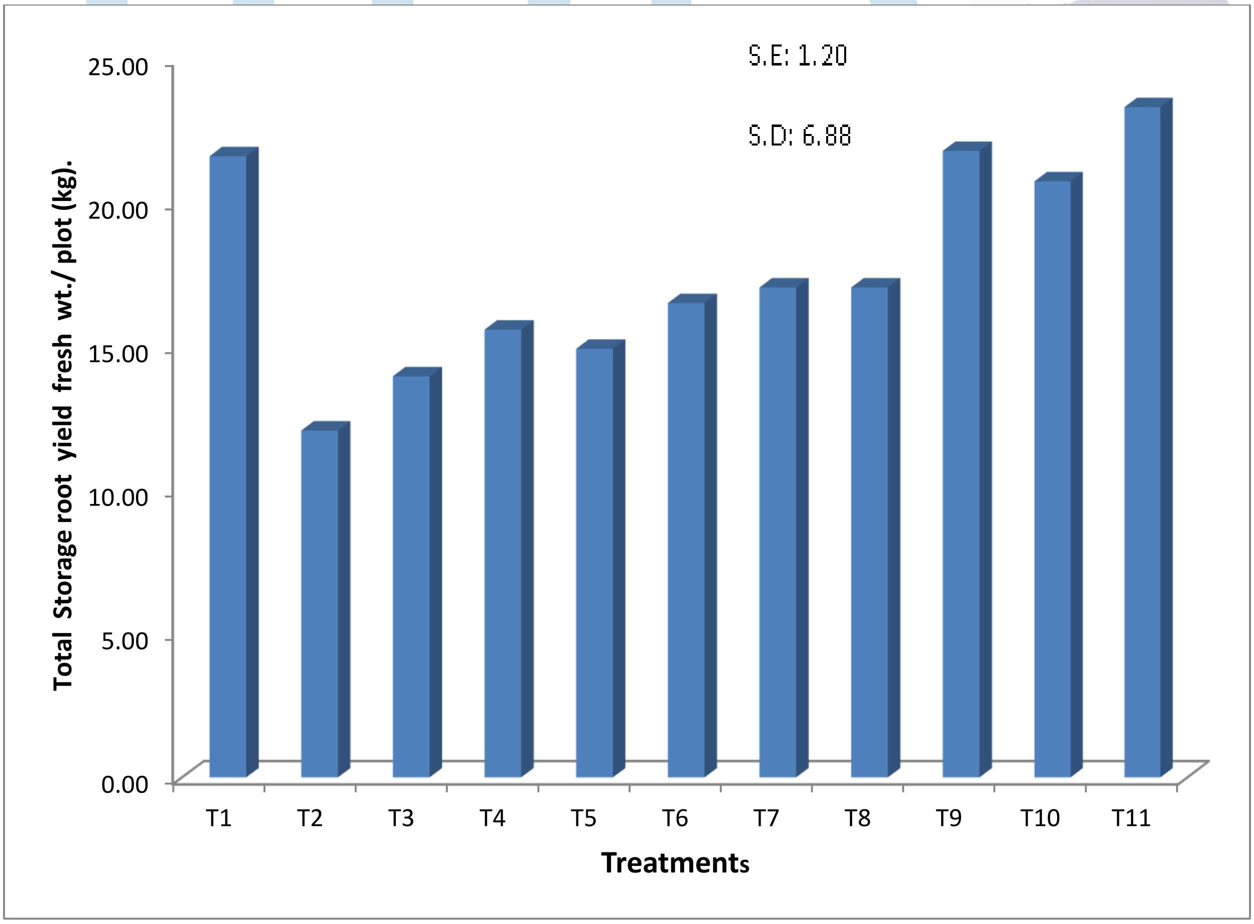


Figure (10). Effect of Biofertilization on total sweetpotato storage roots yield fresh weight (kg).

4) Marketable storage roots yield t/ha:

Regarding the quality of storage roots yield and marketable storage roots yield, the obtained results showed that application of(T7)*Azospirillum*+ *Flavobacterium* + 0.8 t/ha of organic fertilizer had great effect on Marketable storage roots yield followed by application of (T9) organic fertilizer 1.2 t/ha+ Azospirillum and (T10)*Flavobacterium*+1.2 t/ha of Al Khaseeb organic fertilizer. However the adverse effect on marketable storage roots yield was with application of (T3)*Flavobacterium spp.* showing the least value for Marketable storage roots yield figure (11).

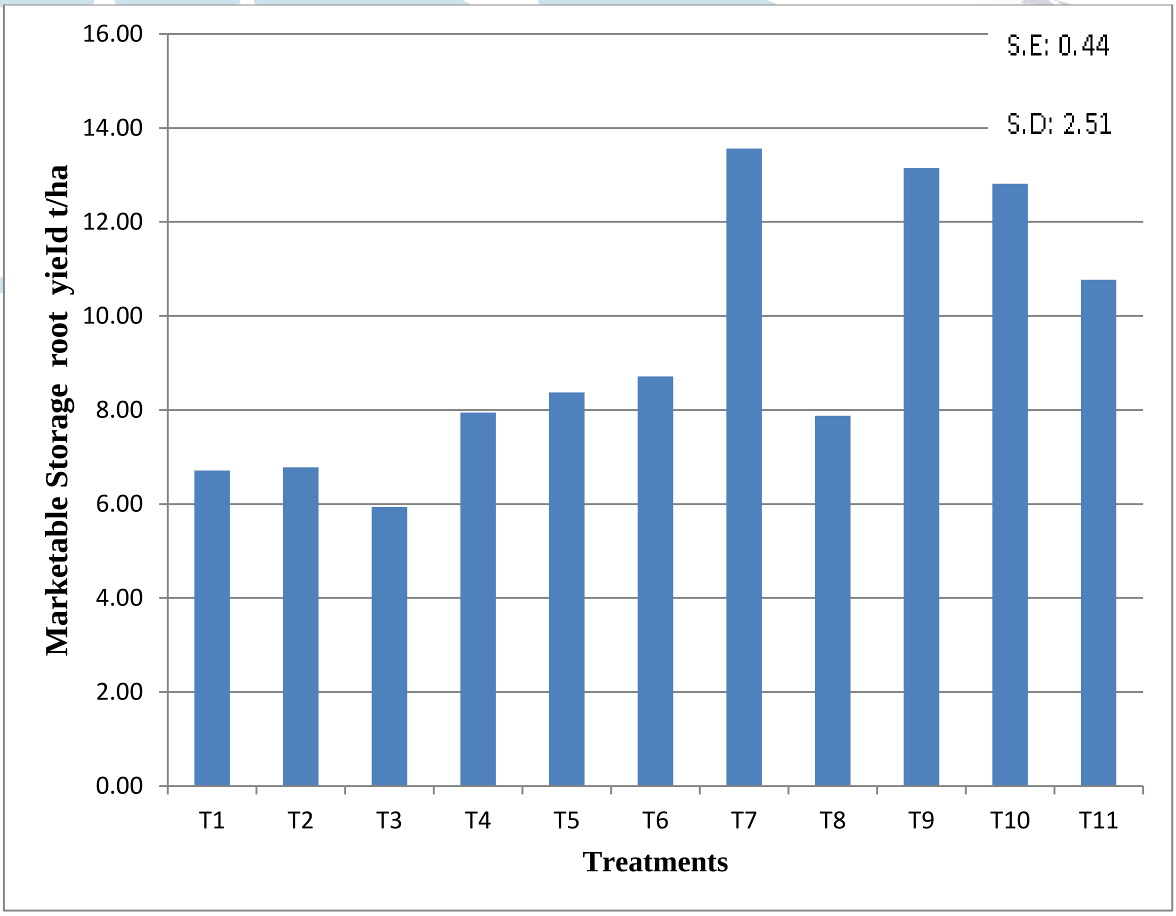


Figure (11). Effect of Biofertilization on marketable storage roots yield t/ha.

5) Nonmarketable storage root weight (kg).

The obtained results indicated that application of (T1) the control showed the highest yield of nonmarketable storage roots yield, followed by application of (T9)organic fertilizer 1.2 t/ha+ *Azospirillum*. Meanwhile least value for Non-marketable storage roots yield was observed with application of (T3) *Flavobacterium spp.* figure (12).

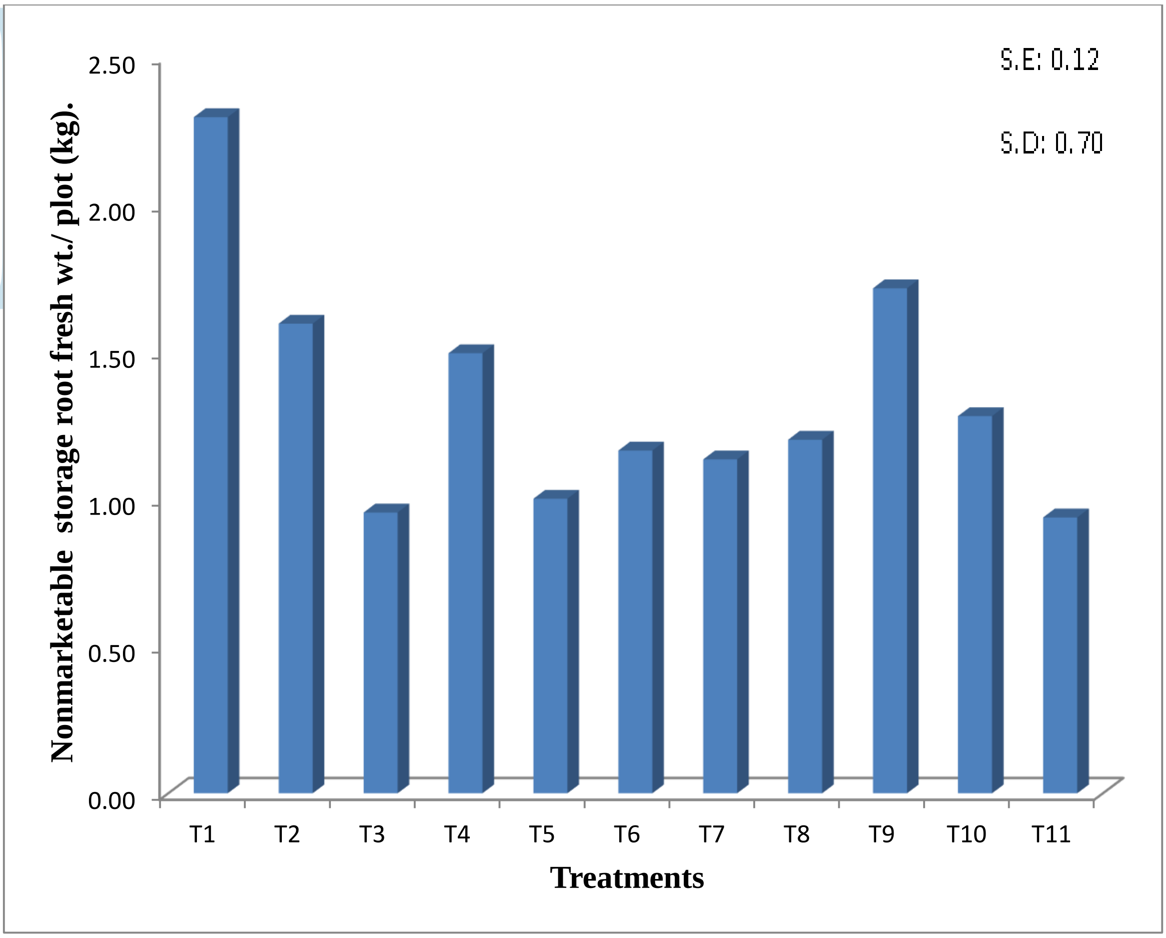


Figure (12). Effect of Biofertilization on nonmarketable storage roots yield fresh weight (kg).

6) Specific Gravity of storage roots:

Regarding the storage roots yield quality and specific gravity, the results showed that application of (T3) *Flavobacterium spp* alone has great effect with value 0f 1.04, followed by application of (T4) 0.8t/ha of Al Khaseeb organic fertilizer alone and application of (T1) the control. Meanwhile the lowest value for storage specific gravity was obtained with application of (T10) *Flavobacterium*+1.2 t/ha of Al Khaseeb organic fertilizer figure (13).

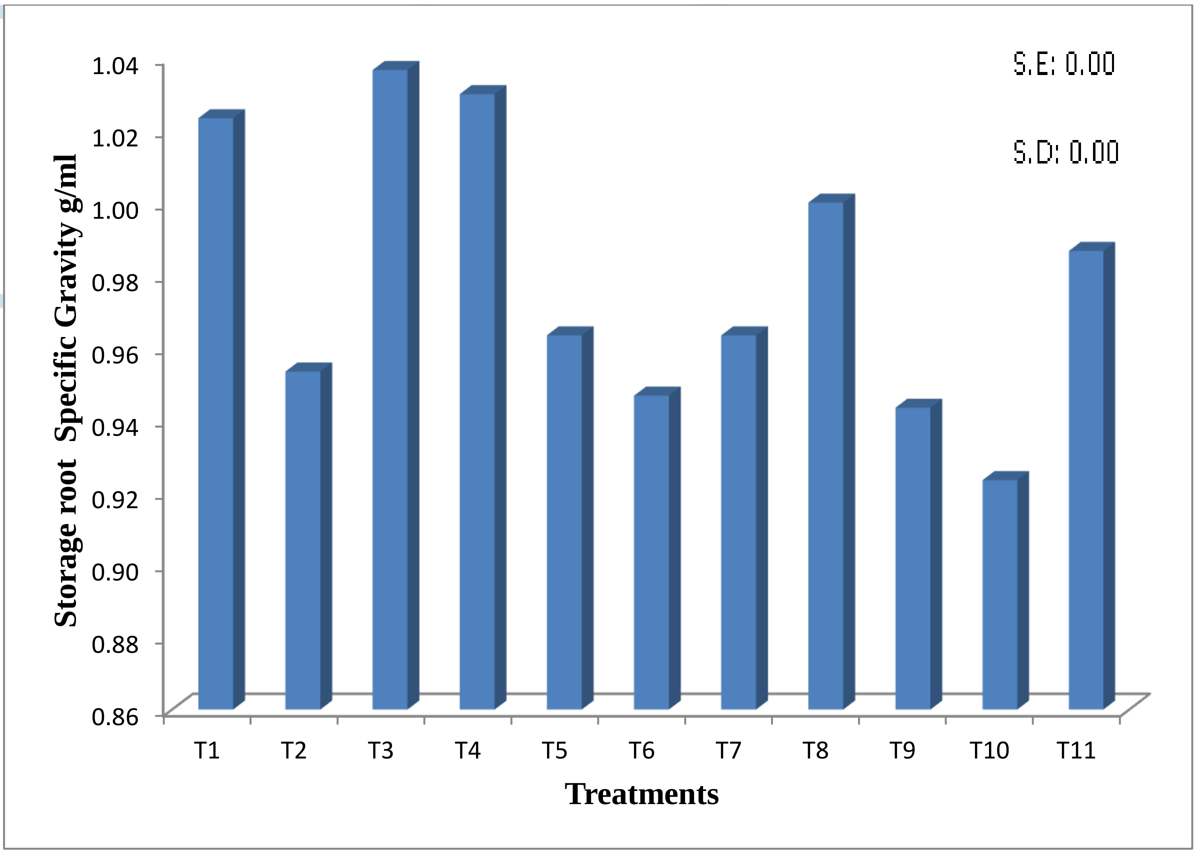


Figure (13). Effect of Biofertilization on sweetpotato storage roots specific gravity.

CONCLUSION

With the application of biofertilizers more cheap, healthy and safe sweetpotato and other crops could be produced, besides conservation of the environment and natural resources. Inoculation of both *AzospiriIIum* and *Flavobacterium* can help in reduction of organic fertilizer dose without decrease in the sweetpotato yield. *AzospiriIIum* biofertilizer + 1.2t/ha organic fertilizer was the most dominant treatment. Orange fleshed sweetpotato can improve human nutrition, combat hidden hunger (nutrients imbalances in foods) and reduce or eliminate the Vitamin A deficiency (VAD). Sweetpotato farmers are recommended to apply 1.2 t/ha of organic fertilizer with *AzospiriIIum* inoculation for improving yield of sweetpotato.

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