RESEARCH | Egyptian Journal of Agricultural Research | BIOFERTILIZERS

Effect of *Nostoc clacicola* as bio-fertilizer with plastic mulch on the growth and economic value of sweet pepper

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ABSTRACT

This research was carried out during 2019/2020 and 2020/2021 seasons, at the Experimental Station of the Central Laboratory for Agricultural climate CLAC, A.R.C, Dokki, Giza. This experiment was done under a plastic greenhouse to investigate the growth, fruit quality parameters and yield of sweet pepper plants grown under two different plastic mulch color and three different treatments of *Nostoc clacicola* fertilizations. The plastic mulch treatments were transparent polyethylene and white polyethylene with 100 microns thickness. Bare soil (uncovered soil) was used as a control. Transparent and white polyethylene was laid after the establishment of the double rows (0.80 m width). Beds were manually installed to correspond to treatments and *Nostoc clacicola* fertilization treatments: *Nostoc clacicola* foliar fertilization, *Nostoc clacicola* soil fertilization and *Nostoc clacicola* foliar with soil fertilization (spray+ Soil). Vegetative growth (plant height, stem diameter, number of leaves/ plants, number of branches/ plants, leaves fresh weight and leaf area), as well as fruit yield and quality (total yield, fruit length and fruit diameter), chemical contents (Nitrogen, Phosphorus, Potassium, Leaves dry matter% and Vitamin C) of sweet pepper (Capsicum species) Gedeon F1 Hybrid. Obtained results revealed that using transparent plastic mulch with a combination of *Nostoc clacicola* foliar and soil fertilization enhanced all vegetative growth measurements and increased all assayed chemical constituents of plant leaves, as well as increasing total fruit yield and components.

Keywords: Pepper, plastic, mulch, Cyanobacteria, *Nostoc clacicola,* biofertilization

INTRODUCTION

Nowadays (it's already happened), climate changes are predicted to threaten human health, agricultural production and food security. In the future, this effect could be more extreme, and many crops could be produced under unfavorable climatic and economic conditions than that of an earlier century (Glover and Reganold 2010; Pretty and Bharucha 2014; Gowda *et al.*, 2018; Walsh *et al.,* 2020). Additionally, agriculture must be accessible within a country's supply chain to all social classes if it becomes affordable, safe & healthy, and nutritious food. Egypt can adapt to face the challenges associated with food systems (Carmelia *et al.*, 2020). Pepper crop is the world's third most important vegetable, after potatoes and tomatoes, in terms of quantity of production (Dessie and Birhanu 2017). There are significant arguments and attempts to provide many Egyptian agricultural solutions by using biofertilizers. Sweet pepper crop (*Capsicum* species) has an important rank in Egyptian agriculture due to its high revenue and nutritional value for humans. Sweet pepper (*Capsicum* species) crop has an important rank in Egyptian agriculture, due to its high revenue and nutritional value for humans. Sweet pepper catches many agricultural investors, especially in the newly reclaimed lands, for export (Ghoname *et al.*, 2010; Shahein *et al.*, 2015). Pepper crop is the world's third most important vegetable, after potatoes and tomatoes, in terms of quantity of production (Dessie and Birhanu 2017). Temperature is virtually stable below 10cm soil depth, however, acute temperature or frequent changes in soil temperature affect the soil microorganisms and plant growth (Satyen *et al.,* 2016) and (Pietikäinen *et al.*, 2004). Soil and air temperatures influence physiological processes such as photosynthesis, and respiration which affect crop yield.

Fertilization is most sensitive to the elevated temperature at mid-flowering resulting in considerable yield reduction. Currently, many crops may be affected by high temperature, which may affect crop production, due to climate change (Pretty and Bharucha 2014; Amitav 2019), nonetheless, high temperature influences the most significant groups of soil microbes, like the bacteria and the fungi, in situ. Root-zone temperature plays an important role in improving plant growth and developing vegetables by influencing the uptake of water and mineral nutrients by roots. Root-zone temperature attains greater prominence as roots are less adapted to fluctuations in temperature than shoots. The application of seaweed extracts, from marine cyanobacteria to crops, has many beneficial effects in terms of enhancement of yield and crop quality (Saadatnia and Riahi 2009). Liquid extracts from seaweeds have recently gained importance as foliar sprays for many crops including various portions of cereal, pulses and different vegetable species (Sang and Choong 2021). Seaweed extracts contain major and minor nutrients and amino acids which are reported to stimulate the growth and yield of plants, as well as develop tolerance to environmental stress (Zhang *et al.,* 2003; Deepali 2020). The ancient and diverse group of photosynthetic prokaryotes known as cyanobacteria resembles Gram-negative bacteria morphologically yet performs oxygenic photosynthesis like higher plants. They have been employed as biofertilizers in agriculture, where they are known to deliver 20 to 25 kg of nitrogen per hectare each season and improve soil fertility. Many of them also demonstrate biological nitrogen fixation. (El-Zaway 2019). Different strains of cyanobacteria live in soil where heterocystous species can fix atmospheric nitrogen. However, under microaerophilic circumstances, a number of non-heterocystous cyanobacteria can fix atmospheric nitrogen. It is known that some cyanobacteria release growth stimulants (auxin, gibberellins and cytokinin). The purified, identified and evaluated cyanobacterial isolates were then tested for their ability to fix nitrogen, their synthesis of growth-regulating compounds, and their potential as a biofertilizer (Tantawy and Atef 2010 Subramanian and Uma 1996). The cyanobacteria are a good source of several nutrients, such as fiber, minerals, proteins, vitamins and fatty acids, in comparison with other plants. Some important cyanobacteria varieties, that promote plant growth, are auxins, cytokinins and betaines (Khan *et al*. 2009; Rodriguez *et al.,* 2006; Asemgul *et al.,* 2022). Cyanobacteria are found all over the world in earthbound, freshwater and marine living spaces, however, blossoms normally happen in freshwater. Cyanobacteria increase the availability of phosphorous to crops by excretion of organic acid. (Priyanka *et al.,* 2020). Mulching is a popular agronomic practice in agriculture. It is one of the simplest and most beneficial practices used in the field (Whiting, *et al.,* 2008; Hossam *et al.*, 2022). In addition, mulch can improve both root growth and nutrient availability. El-Shaikh and Fouda, (2008) reported that the highest soil temperature was obtained with transparent polyethylene mulch. Three primary non-degradable mulch types were used in the commercial production of vegetable crops: black, clear, and white (or white-on-black) (William 1991; Díaz-Pérez 2009). This work aims to investigate the growth, fruit quality parameters and yield of sweet pepper plants grown under three different treatments of *Nostoc clacicola* and two different plastic mulches under a plastic greenhouse.

MATERIALS AND METHODS

Seeds of sweet pepper (*Capsicum annuum*) Gedeon F1 Hybrid were used. Seedlings were sown on September 1st, during the two winter seasons of 2019/2020 and 2020/2021. Multi-pot transplant trays were filled with a mixture of peat-moss and vermiculite media (1:1 v/v). After sowing, trays were covered by black plastic mulching for four days, then moved to high tables, and were followed by irrigation, fertilization and pest management practices, in the nursery. The experiment contained twelve treatments, with three replicates for each treatment.

After forty five days from sowing date transplants were set up in the plastic house on October 15th, for the two seasons on the two sides of ridges (1m width and 40 m length). The distance between transplants was 30 cm within the row. Soil in the experimental site was classified as a clay soil in texture with pH of 7.5 and EC of 1.2ds/m. The chemical and physical properties of the clay experimental soil were determined before cultivation (Chapman and Pratt, 1961) as shown in **Table (1).**

Table 1. Chemical analysis and Physical properties of soil.

	pH	EC (ds/m)	Anions (me q/L)				Cations (meq /L)			
			Cl^-	HCO_3^-	CO_3^{--}	SO_4^{--}	Na^+	K^+	Ca^{++}	Mg^{++}
Soil	7.5	1.2	2.2	2.1	-	35.8	9.1	1.0	20	10
Physical properties										
0-30cm	Sand%	Clay%	Silt %	Texture	SP%	FC%	WP%			BD g /cm3
	10.4	82.4	7.2	Clay	23.4	33.1	15.5			1.21

Aqueous extracts: 5 g of *Nostoc clacicola* were added to 100 ml of distilled water. The resulting mixture was left to macerate for 24 h, and then centrifuged at 3000 tour/minute for 15 min. The recovered supernatant was filtered through Whatman number 1 paper. In addition, the obtained extracts were stored at 4^{C}. The resulting powder was used 10cm/l water. The mixture was added every 15 days.

The determination of the quantity of the three treatments of *Nostoc clacicola* in mineral elements was performed according to the method of Page et al. *(1982*)

Table 2. Chemical composition and mineral concentration of *Nostoc clacicola* extracts

Chemical composition %	Mineral concentration	
Moisture 6.12 ± 0.02	Nitrogen (%) 8.00	Iron (ppm) 12.4 ± 0.16
crude protein 50.67 ± 1.79	Phosphorus (ppm) 123.1 ± 1.46	Zinc (ppm) 0.72 ± 0.04
Ash 10.55 ± 0.32	Potassium (ppm) 170.0 ± 2.86	Manganese (ppm) 2.60 ± 0.21
Total lipids 7.13 ± 0.18	Calcium (ppm) 63.70 ± 0.73	Cupper (ppm) 5.10 ± 0.66
crude fiber 4.11 ± 0.18	Sodium (ppm) 216.7 ± 4.41	Lycine (mg/g) 19.10 ± 1.01
carbohydrates 20.42 ± 0.27	Magnesium (ppm) 6.20 ± 0.06	Methionine (mg/g) 5.31 ± 0.8

The experimental treatments:

Plastic mulch treatments: Transparent polyethylene, white polyethylene (with 100 microns thickens) and bare soil (uncovered soil) as control. Transparent polyethylene and white polyethylene were laid after the establishment of the double rows (0.80 m width); the bed was manually installed to correspond to treatments and experimental field design

Cyanobacteria fertilization treatments

1- *Nostoc clacicola* foliar fertilization.
2- *Nostoc clacicola* soil fertilization.
3- *Nostoc clacicola* foliar with soil fertilization (spray+ Soil).

Climatic conditions:

Microclimate is a major factor in this study. Average air and soil temperatures and relative humidity were obtained, from Dokki agriculture meteorological station. Soil temperature, at 15 cm depth, was measured daily using a soil thermometer. The following data are shown in Table (3).

Table 3. Monthly averages of maximum and minimum air temperature and relative humidity % during two growing seasons

	2019/202020						**2020/2021**					
	Air temperature [°C]			**Relative humidity [%]**			**Air temperature [°C]**			**Relative humidity [%]**		
	aver	min	max	aver	min	max	aver	min	max	aver	min	max
Sept.	28.0	33.8	23.4	57.6	79.2	34.1	29.8	35.5	25.2	61.1	86.8	32.1
Oct.	25.8	31.2	20.6	58.7	81.9	35.9	26.6	31.5	22.6	61.9	83.7	36.5
Nov.	21.6	27.4	15.9	57.9	83.1	33.1	19.8	25.1	15.2	68.4	90.7	43.1
Dec.	16.3	21.3	11.6	60.5	80.8	39.9	16.9	22.8	11.8	69.1	92.0	41.9
Jan.	13.5	18.7	8.9	62.6	81.3	41.5	13.2	18.5	8.1	70.2	93.1	43.5

Experimental design:

Treatments were arranged using the split plot design. Plastic mulch treatments were arranged in the main plots and *Nostoc clacicola* fertilization treatments were arranged in the sub plots. All treatments were applied with three replicates. Randomize has been considered in the application of the studied treatments.

Vegetative growth:

Ten plants were selected and labeled on each experimental plot and the following data were recorded. Plant height, stem diameter, number of leaves/plant, number of branches/plant, Leave fresh weight and leaf area were recorded after 120 days from transplanting date. A representative sample of three plants from each experimental unit were taken during the growth period, 180 days from transplanting, to measure fresh and dry weight

Chemical analysis:

Dry samples of plant foliage were grounded, and then 0.2 g from each sample was digested in sulphuric and perchloric acids, at ratio 2:1 by volume, and used for determining the chemical constituents. Nitrogen was determined in leaves by the distillation in a Macro-Kjeldahle apparatus ADAS/MAFF (1987). Phosphorus was colourimetrically determined in leaves, in the acid digest, using ascorbic acid and ammonium moly date, as described by Watanabe and Olsen (1965).

Potassium was determined by the flame-photometrically as described by ADAS/MAFF (1987). Ascorbic acid contents (vitamin C) were determined in the fresh fruit juice, using the 2.6 Dichlorophenolindophenol method, as described in A. O. A. C (1991).

Yield components:

Data collected were total yield, fruit length and fruit diameter

Cyanobacteria isolation:

The following methods were applied on air-dried soil samples collected from Niser city using Modified Watanabe medium (El-Nawawy *et al.,* 1958) for isolation and culturing of cyanobacteria. The semi-solid medium as described by El- Ayouty and Ayyad (1972)

Identification of the isolated cyanobacteria:

Thallus colour, thallus morphology and dimension, size of heterocyst, and vegetative and reproductive cells were all used in the identification of cyanobacteria. According to Venkataraman, cyanobacteria that produce heterocysts were also grown in Watanabe medium (El-Nawawy *et al.,* 1958)

Determination of phytohormones:

Separation and determination of phytohormones (auxin, geberillin and cytokinin) were carried out by gas-liquid chromatography in Al-Azhar University (the regional center for mycology and biotechnology). HPLC analysis was performed on GBC- germey by winChrome Chromatography Ver. 1.3 which equipped a GBC U.V/vis Detector and Hypercarb (C18, Sum 100x4.6 cm) the detective wavelength was 254nm flow rate of mobilephse was 7 ml/min which 85% Acent: 15% water method according to Van Staden *et al.,* (1973)

Total nitrogen:

According to Jackson (1973), total nitrogen in the cyanobacteria was measured using the micro-kjeldahl method.

Statistical analysis:

Data were tested by analysis of variance according to Little and Hills (1975). Duncan's multiple-range test was used to compare treatments (Duncan, 1955).

Economic study:

The economic evaluation was estimated by calculating the cost of cultivation for different agriculture inputs; *i.e.*, labors, irrigation, fertilizers, harvesting cost, and other necessary experimental requirement costs. Plastic mulch costs were divided into two main categories: (i) fixed costs and (ii) variable costs. The returns of each tested treatment were calculated according to Cimmyt (1988).

RESULTS

Soil Temperature:

Data in Figure (1) shows the average soil temperature among treatments during the two study seasons. Small differences were seen in soil temperature among the mulch treatments. Diurnal soil temperatures were slightly warmer in the transparent mulch compared with white plastic mulch and without mulch

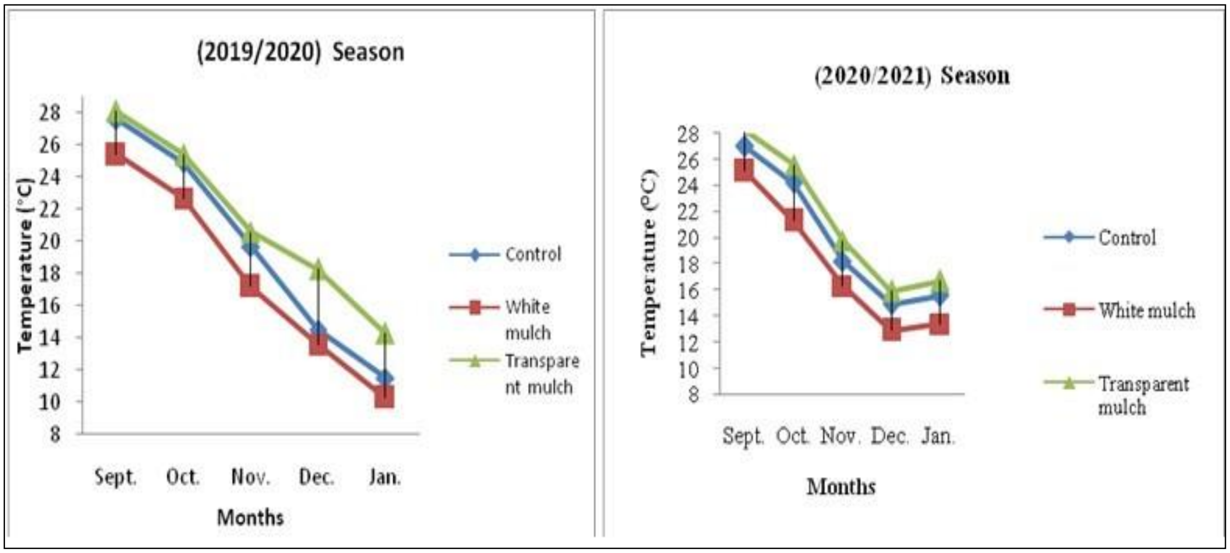

Fig. 1. Effect of using plastic mulches on average soil temperature during (2019/2020) and (2020/2021) seasons.

Isolation purification and Identification of the isolated cyanobacteria:

One strain was successfully obtained as bacterial-free cyanobacteria after being isolated and purified from soil samples taken from Nise city in the Cairo Governorate. Identified according to Geitler (1932) as *Nostoc clacicola*

Regarding the second isolate, a 20-day-old culture of this isolate on solid medium demonstrated a colonial expansion. Colonies had a low convex at their side with a rough edge and ranged in diameter from 1.1 to 1.3 mm. The colonies were opaque and dark green. A 16-day-old culture in a liquid medium exhibited an aggregative sedimentary kind of growth and an cohesive patchy growth near the flask's bottom. The culture was medium green in colour, and the spotty growth was medium yellowish green. Trichomes had no ramifications, as determined by microscopic inspection. They lacked both polarity and tapering, and were uniseriate, singular, and aggregated. There was no formation of a sheath. Trichomes are made cells: barrel cells (5.8 x 5.5 x 6.8 mm); granular, ellipsoidal cells (4.9 x 5.7 mm); and round cells.

Data in a table (4) indicated that both cyanobacterial isolates gradually increased dry weight and fixed nitrogen. After the study period, the greatest value of fixed-nitrogen (Intracellular, Extracellular, and Total) mg 100 ml-culture) was seen with both isolates (after 34 days). (El-zawawy *et al.,* 2021)

Table (4) the efficiency of *Nostoc clacicola* in dry weight and nitrogen fixed (Intracellular and Extracellular) 24 days growth period

Isolates / Culture age days	nitrogen fixed (mg N/100 ml-culture)			Dry weight (mg N/100 ml-culture)
	Intracellular	Extracellular	Total	
8	3.22	0.51	3.73	35
16	5.13	0.72	5.85	62
24	8.21	1.80	10.01	87

Table (5) Data in **Table (2)** showed that *Nostoc clacicola* could produce Indole 3 acetic acid (IAA), gibberellic acid (GA_3), as well as cytokinin (Zeatin) after 34 days, where it scored (6.12, 7.20 and 3.24 µg/100 ml). (Elzawawy 2019)

Table (5) Composition and analysis of phytohormones of *Nostoc clacicola* in filtrates (µg/100 ml) after 34 days.

Indole 3 acetic acid (IAA)	**6.12**
Gibberellic acid (GA_3)	**7.20**
cytokinin (Zeatin)	**3.24**

Vegetative growth characteristics:

Data in **Tables (6 and 7)** illustrates the response of vegetative parameters to using transparent and white plastic mulches with different treatments of *Nostoc clacicola* fertilization, which include Plant height, stem diameter, number of leaves/plant, number of branches/plant, Leaves fresh weight and leaf area of sweet pepper plants. A positive response was found when using plastic mulches. The highest significant increases in vegetative characteristics (Plant height, stem diameter, number of leaves/plant) were obtained using transparent plastic mulch. While, the highest number of branches/plants, leaf area and leaves fresh weight was found with white plastic mulch. Plant height, stem diameter, number of leaves/plant, number of branches/plant, leaves fresh weight and leaf area of sweet pepper were significantly affected using *Nostoc clacicola* fertilization treatments. The highest value was found in *Nostoc clacicola* foliar with soil fertilization treatment. The best interaction was found when transparent plastic mulch was used with a combination of *Nostoc clacicola* foliar and soil fertilization in the first and second seasons.

Table 6. Effect of using plastic mulch and *Nostoc clacicola* on plant height, stem diameter and number of leaves of sweet pepper during 2019/2020-2020/2021 seasons.

***Nostoc clacicola* treatments**	**plant height (cm)**				**stem diameter(cm)**				**Leaves fresh weight(g/plant)**			
	T M	W M	Control	Mean	T M	W M	Control	Mean	T M	W M	Control	Mean
2019/2020												
control	120.4 f	118.7 f	112.9 f	117.3 A	1.4 fg	1.4 fg	1.3 fg	1.4B	488.9h	757.8d	348.2l	531.6D
Spray	132.5 e	128.8 e	125.9 jf	129.1 B	1.6 f	1.7e	1.4 fg	1.6A	502.6g	800.4c	400.6k	567.9C
Soil	153.5 b	141.5 e	134.4 e	143.1 C	1.9 bc	1.8d	1.5 fg	1.7A	523.9f	820.2b	458.3j	600.8B
Spray+ soil	171.4 a	153.5 b	144.8 c	156.6D	2.3a	1.9bc	1.5 fg	1.9A	600.6e	945.2a	478.1i	674.6A
Mean	144.5 A	135.6 B	129.5 C		1.8A	1.7B	1.4C		529.0B	830.9A	421.3C	
2020/2021												
control	120.7 j	119.1 j	114.4 l	118.1 D	1.4 e	1.4 e	1.3 e	1.4 D	589.2h	781.5e	370.7l	580.5D
Spray	133.0 g	128.6 hi	126.3 i	129.3C	1.7 d	1.7 d	1.5 e	1.6 C	617.0g	818.9bcd	415.8k	617.2C
Soil	154.4 bc	142.0 e	135.6 fg	144.0 B	2.0b	1.9 c	1.5 e	1.8 B	754.1f	819.1bcd	494.1j	689.1B
Spray+ soil	171.7 a	154.6 bc	146.9 d	157.7 A	2.4 a	2.1 b	1.5 e	2.0 A	810.8bcd	996.0a	508.4ij	771.8A
Mean	144.9 A	136.1 B	130.8 C		1.9 A	1.8 B	1.5 e		692.8B	853.9A	447.2C	

Transparent plastic mulch (TM), White mulch (WM), *Nostoc clacicola* foliar fertilization(spray) ,*Nostoc clacicola* soil fertilization (soil), *Nostoc clacicola* foliar and soil fertilization (spray+ Soil)

Data in **Table (8),** showed the total yield and fruit physical qualities of sweet pepper plants (fruit length and diameter), using transparent and white plastic mulches with *Nostoc clacicola* fertilization treatments, during 2019/2020 and 2020/2021 seasons. The highest total yield and fruit length were observed when transparent mulch was used. However, the highest fruit diameter was found when white plastic mulch was used in both seasons. The highest total yield, fruit length and fruit diameter were found when *Nostoc clacicola* foliar plus soil fertilization was used. The effective interaction was observed when transparent plastic mulch was used with a combination of *Nostoc clacicola* foliar and soil fertilization in the first and second seasons.

Data in **Tables (9 and 10**) indicated that using transparent and white plastic mulches with different treatments of *Nostoc clacicola* fertilization had a significant effect on nitrogen, phosphorus potassium, and leaf dry matter percentage in leaves of sweet pepper and vitamin C in fruits. The highest values of nitrogen, phosphorus, and potassium percentage as well as leaf dry matter percentage in leaves of sweet pepper and vitamin C in fruits were found when white plastic mulch was used. *Nostoc clacicola* foliar and soil fertilization treatment achieved the highest values of nitrogen, phosphorus and potassium percentage in leaves of sweet pepper during both seasons. The highest interaction was obtained when white plastic mulch was used with a combination of *Nostoc clacicola* foliar and soil fertilization in both seasons.

Table 7. Effect of using plastic mulch and *Nostoc clacicola* on a number of branch and leaf areas of sweet pepper during 2019/2020-2020/2021 seasons.

	No. branches/ plant				No. leaves/ plant				Leaf area(cm2)			
	T M	W M	Control	Mean	T M	W M	Control	Mean	T M	W M	Control	Mean
2019/2020												
control	10.3i	12.6gh	6.4l	9.8D	482.3 g	410.4 h	259.7 l	384.1D	171.1h	177.4g	133.2kl	160.5D
Spray	13.4f	15.4de	8.5k	12.4C	521.3 e	491.6 f	325.8k	446.3C	180.7f	191.7d	136.0kl	169.5C
Soil	15.5d	18.6c	9.4j	14.5B	611.4 b	562.4 d	352.3j	508.7B	187.1e	197.7bc	138.2jk	174.4B
Spray+ soil	19.3b	20.3a	12.4gh	17.3A	724.6 a	602.8 c	396.8i	574.7 A	195.7c	206.0a	140.9i	180.9A
Mean	14.6B	16.7A	9.2C		584.9 A	516.8 B	333.7C		183.6B	193.2A	137.1C	
2020/2021												
control	10.4ijk	12.5fgh	6.3l	9.7D	482.0g	411.1h	261.1 l	384.7D	171.6h	177.9g	134.0kl	161.2D
Spray	13.3fgh	16.2de	9.0ijk	12.8C	522.0e	491.6 f	326.6k	446.7C	181.3f	192.6d	137.3jk	170.4C
Soil	16.0de	18.8c	10.1ijk	15.0B	612.0b	563.6 d	352.6j	509.4B	187.6e	197.7bc	138.4jk	174.6B
Spray+ soil	19.8b	21.0a	12.5fgh	17.8A	725.1a	603.7 c	396.1i	575.0 A	196.4bc	205.5a	141.8i	181.2A
Mean	14.9B	17.1A	9.5C		585.3A	517.5 B	334.1C		184.2B	193.4A	137.9C	

Transparent plastic mulch (TM), White mulch (WM), ***Nostoc clacicola*** foliar),***Nostoc clacicola*** soil, ***Nostoc clacicola*** foliar and soil fertilization (spray+ Soil).

Table 8. Effect of using plastic mulch and *Nostoc clacicola* on total yield and fruit quality of sweet pepper during 2019/2020-2020/2021 seasons.

	Total yield (Kg)/ plant				Fruit length(cm)				fruit diameter (cm)			
	T M	W M	Control	Mean	T M	W M	Control	Mean	T M	W M	Control	Mean
2019/2020												
control	6.20defg	6.17defg	4.93j	5.8D	7.2he	13.23 b	5.57 f	8.67 D	5.30 i	6.20 g	3.73 l	5.08C
spray	6.75d	6.38de	5.41f	6.2C	10.23d	13.43 b	5.73 f	9.80 C	6.33f	7.37de	4.37k	6.02B
Soil	8.29bc	8.49b	5.15f	7.4A	11.33d	14.30 a	6.47 f	10.70 B	7.43de	8.30bc	5.30i	7.01 A
Spray+ Soil	8.72a	6.45de	5.63f	6.9B	12.5c	15.50 a	7.60 e	11.87 A	8.30bc	9.37a	5.73h	7.80 A
Mean	7.4A	6.9B	5.3C		10.32B	14.12 A	6.34 C		6.84B	7.81A	4.78C	
2020/2021												
control	6.33h	6.49f	5.13l	6.0D	8.13h	13.23de	5.73 k	9.03 D	6.50 g	7.53 e	4.63 j	6.22D
spray	6.76d	6.48fg	5.51j	6.3C	10.47g	13.47cd	5.83 j	9.92 C	7.30 f	8.67c	5.40i	7.12C
Soil	8.36bc	8.56ab	5.24k	7.5A	11.4fg	14.37b	7.17 i	10.98 B	8.47 d	9.57 b	5.77 h	7.93B
spray+ Soil	8.82a	6.65de	5.71hi	7.0B	12.63de	15.6 a	8.03h	12. 09 A	9.57 b	9.90a	6.47g	8.64 A
Mean	7.5A	7.1B	5.4C		10.67B	14.17A	6.69 C		7.96 B	8.92 A	5.57C	

Transparent mulch (TM), White mulch (WM+Cyanobacteria(***Nostoc clacicola***) foliar fertilization(spray) ,Cyanobacteria (***Nostoc clacicola***) soil fertilization (soil), Cyanobacteria (***Nostoc clacicola***) foliar and soil fertilization (spray+ Soil)

Table 9. Effect of using plastic mulch and *Nostoc clacicola* on leaf mineral contents (N, P and K %) of sweet pepper during 2019/2020-2020/2021 seasons.

	2019/2020											
	N%				**P%**				**K%**			
	T M	W M	Control	Mean	T M	W M	Control	Mean	T M	W M	Control	Mean
control	2.8 hi	3.6 f	2.2 jk	2.9D	0.53 h	0.61 f	0.33 i	0.49 D	1.10 jk	2.87 cd	0.98 k	1.65 C
Spray	3.4f	4.07 c	2.2jk	3.2C	0.60 g	0.72 c	0.51h	0.61C	2.10 f	3.17 ab	1.27 i	2.18 B
Soil	3.7 d	4.4 b	2.60i	3.6B	0.64 e	0.81 b	0.51h	0.66B	2.23 ef	2.93bc	1.57h	2.24 B
Spray+ soil	4.10 a	4.6 b	2.94g	3.9A	0.71d	0.84 a	0.56hh	0.70A	2.63def	3.80 a	1.67 g	2.70 A
Mean	3.5B	4.2 A	2.5C		0.62 B	0.75 A	0.48C		2.02 B	3.19 A	1.37 C	
	2020/2021											
control	2.9 f	3.8 d	2.6 g	3.1 C	0.53i	0.62 f	0.35j	0.50 D	1.20 ij	2.93 c	0.97k	1.70D
Spray	3.7 e	4.2 c	2.7 g	3.5B	0.61gh	0.75 cd	0.54 i	0.63 C	2.33 g	3.30b	1.40ij	2.34C
Soil	3.9 d	4.7 ab	2.7 g	3.8 A	0.67 e	0.83 b	0.53i	0.68B	2.43 efg	2.60efg	1.60h	2.21B
Spray+ soil	4.2 c	4.8 a	3.0 f	4.0 A	0.73d	0.88 a	0.58g	0.73 A	2.73de	3.93a	1.77h	2.81A
Mean	3.7 B	4.4 A	2.8C		0.64 B	0.77A	0.50C		2.18B	3.19A	1.43C	

Transparent mulch (TM), White mulch (WM), ***Nostoc clacicola*** foliar fertilization(spray) ,***Nostoc clacicola*** soil fertilization (soil), ***Nostoc clacicola*** foliar and soil fertilization (spray+ Soil)

Table 10. Effect of using plastic mulch and *Nostoc clacicola* on leaves dry matter % and vitamin c of sweet pepper during 2019/2020-2021 seasons.

	2019/2020							
	Leaves dry matter %				Vitamin C			
	T M	**W M**	**Control**	**Mean**	**T M**	**W M**	**Control**	**Mean**
control	17.5h	22.7d	13.5l	17.9D	1.62hi	1.65hi	1.32kl	1.53D
Spray	18.9g	25.6c	14.3k	19.6C	1.72fg	1.83de	1.43kl	1.66C
Soil	19.5 f	27.0b	15.4j	20.6B	1.83de	1.92bc	1.53kj	1.76B
Spray+ soil	20.5 e	28.6a	16.0i	21.7A	1.93bc	2.10a	1.73fg	1.92A
Mean	19.1 B	26.0A	14.8C		1.77B	1.88A	1.50C	
	2020/2021							
control	17.93hi	23.03d	14.67l	18.54B	1.64ij	1.64hij	1.33l	1.5D
Spray	19.27g	26.07c	15.50kl	20.28C	1.74gh	1.85ef	1.42kl	1.7C
Soil	20.40fg	27.40bc	16.23jk	21.34B	1.83ef	1.93bc	1.53jkl	1.8B
Spray+ soil	20.97ef	29.57a	17.07ij	22.53A	1.93bc	2.43a	1.75fg	2.0A
Mean	19.64B	26.52A	15.87C		1.8B	2.0A	1.5C	

Transparent mulch (TM), White mulch (WM), ***Nostoc clacicola*** foliar fertilization(spray) ,***Nostoc clacicola*** soil fertilization (soil), ***Nostoc clacicola*** foliar and soil fertilization (spray+ Soil)

Economic analysis: -

The variable costs of producing one greenhouse of sweet pepper using two different plastic mulches with *Nostoc clacicola* fertilization treatments were calculated, including seasonal costs; such as labor, irrigation, fertilization, and so on (Table 11). The weight of the total yield was used to estimate sweet pepper production, during the two seasons; the price of the local market was collected based on the wholesale market during both seasons. The higher net return treatment was obtained when transparent plastic mulch was used with a combination of *Nostoc clacicola* foliar and soil fertilization during the first and second seasons.

Table 11. Effect of using plastic mulch and *Nostoc clacicola* on economic analysis of sweet pepper during 2019/2020-2020/2021 seasons.

	Total fixed and variable costs / LE			Quantity of production /m2			revenue / LE			Net return / LE		
	WM	TM	C	WM	TM	C	WM	TM	C	WM	TM	C
2019/2020 season												
control	199.63	201.30	181.30	23.57	23.45	18.74	235.68	234.54	187.41	36.05	33.24	6.11
spry	199.63	201.30	181.30	25.67	24.26	20.56	256.68	242.62	205.60	57.05	41.32	24.30
soil	199.63	201.30	181.30	31.51	24.52	19.58	315.11	245.20	195.80	115.48	43.90	14.50
spry+soil	199.63	201.30	181.30	31.47	33.12	21.39	314.73	331.17	213.89	115.09	129.87	32.59
2020/2021 season												
control	199.63	201.30	181.30	24.04	24.67	19.50	240.43	246.72	195.03	40.79	45.42	13.73
spry	199.63	201.30	181.30	25.71	24.64	20.94	257.06	246.42	209.36	57.43	45.12	28.06
soil	199.63	201.30	181.30	31.77	25.28	19.90	317.74	252.80	198.98	118.11	51.50	17.68
spry+soil	199.63	201.30	181.30	31.73	33.50	21.71	317.35	334.97	217.07	117.71	133.67	35.77

Transparent mulch (TM), White mulch (WM), *Nostoc clacicola* foliar fertilization(spray) ,*Nostoc clacicola* soil fertilization (soil), *Nostoc clacicola* foliar and soil fertilization (spray+ Soil)

DISCUSSION

Temperature influences the most significant groups of soil microbes, like bacteria and fungi, in situ. Root-zone temperature plays an important role in improving plant growth and developing vegetables by influencing the uptake of water and mineral nutrients by roots. In this regard, plastic mulch increases the soil temperature around the plants, which affects the microclimate around the plants by modifying the radiation budget of the surface. **(**El-Shaikh and Fouda 2008; Moreno *et al*., 2009) reported that the highest soil temperature was obtained with transparent polyethylene mulch as shown in fig (1). Also, (Farrag *et al.*, 2016; Pietikäinen *et al.*, 2004; Sintayehu *et al.*,2015) indicated that using polyethylene mulch enhanced plant growth parameters under the same water supply. Abdrabbo *et al*, (2009), concluded that using mulch during the winter season enhances plant growth and productivity under the same irrigation rate. On the other hand, data in Table (4) indicated that both *Nostoc clacicola* isolate gradually increased dry weight and fixed nitrogen. So, using *Nostoc clacicola* extracts were applied to improve the growth of vegetable parameters. The *Nostoc clacicola* extract contains vitamins, cytokinins, amino acids and auxins leading to increasing growth and the yield of the cultures (Crouch and Van Staden, 1993; Stirk *et al.,* 2004). Chemical and nutrient characteristics increased may be due to the application of *Nostoc clacicola* extract improving the chemical composition of sweet pepper plants. The chemical analysis of *Nostoc clacicola* extracts revealed the richness of macro-elements (Ca, K, P, Na, N), which was similar to previous works (Hong *et al.*, 2007; Kalaivanan and Venkatesalu, 2012; Hernandez-Herrera *et al.*, 2013; Said *et al.,* 2021). The enhancement of vegetative growth and chemical composition of sweet pepper plants led to yield enhancement. Results also, agreed with that of Hong *et al.*, (2007); Kalaivanan and Venkatesalu, (2012); Hernandez-Herrera *et al.,* (2013) and Said *et al.,* (2021).

CONCLUSION

Using transparent plastic mulch with a combination of *Nostoc clacicola* foliar and soil fertilization increased sweet pepper total yield nearly by 54%. While using white plastic mulch with a combination of *Nostoc clacicola* foliar and soil fertilization increased yield nearly by 15%.

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