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Micro-Biota and Organic Amendments Improve *Sesame indicum* Quality and Quantity in Sandy Soil

Amany M. Hammad[(1)]*, Ibrahim M. Elareny[(2)], and Heba S. Shehata[(1)]

[(1)]*Soils, Water and Environment Research Institute, Agricultural Research Center, Giza, Egypt*

[(2)] *Field Crops Research Institute, Agricultural Research Center, Giza, Egypt*

THE STUDY focuses on effect of the complementation between the plant growth promoting rhizobacteria (PGPR) such as *Streptomyces erythrogriseus 2, Bacillus cereus 54-1,* and *Spirulina platinsis* on the growth and the quantity of oil sesame under different rates of familiar manure 0, 2, 4 ton/fed. Results indicated inoculation mixture of *Bacillus cereus54-1, Streptonyces erythrogreiseus sp 2* and *Spirulina platinsis* had the greatest effect on dehydrogenase activity (254.0 µg TPF/g dry soil), while root colonization *Bacillus cereus54-1,* the uppermost values with 60 % colonization. The photosynthetic test was carried out where implementation of all microbes resulted in the highest chlorophyll a content with 2.03 mg/ g dry weight. Growth parameters was estimated, the treatment of bacteria *Bacillus cereus54-1, Streptonyces erythrogreiseus sp 2* gave the highest values of Root length, shoot height, number of branches and shoot dry weight were 22.1,22.2 cm/plant root length 153,156.2 cm/plant shoot height,4.5,4.5 number of branches and 50.3,49.4 gm./plant shoot dry weight. *Bacillus cereus54-1, Streptonyces erythrogreiseus sp 2* gave the highest values of shoot height, number of pods weight of 1000 seed and seeds Kg/fed number being, 169.7,159.0 cm/plant, pods number /plant and 5.4,5.97 weight of 1000 seed/plant, and 5.8,5.67seed Kg/Fadden respectively. However, the highest values of N, P and K were, 17.29, 7.9 and 62.20 (mg.kg^{-1} soil) obtained under the treatment of bacterial *Bacillus cereus54-1,* respectively. The highest seed oil percent was observed in treatments *Bacillus cereus 54-1 and Streptomyces erythrogreiseus sp 2* where the heights seed oil percent was 51,48 Kg/fed compared to the control one it was 39 Kg/fed. Inoculation of the *Spirulina platinsis* gave high protein content 19.62 followed by bacterial of *Bacillus cereus54-1* 19.53. All these results were obtained by adding compost 2 ton/Fadden.

Keywords: plant growth promoting rhizobacteria, Sesame, photosynthetic pigments, Microbial root colonization, Quality.

1. Introduction

It's known that, one of the oldest oil seed plants, sesame is a yearling plant that contains a high percent of oil (45%) and protein (19%–25%) and is suitable for hot and semi-hot climates. One of the main pillars of modern sustainable agriculture is the use of biological inorganic fertilizer in agronomic ecosystems to decrease the consumption of chemical inputs and ensure the production sustainability of agricultural systems, sometimes as a replacement and more often as a supplement to chemical, fertilizers (Asl, 2017, Omara and Farrag, 2022).

Sesame plant is an important crop and it is belonging to the family (Boghdady et al., 2012 and Shaban *et al*., 2012). Its oil has a stable chemical construction and rarely exposed to oxidation process under the hot climate

*Corresponding author e-mail: aanyh177@gmail.com
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conditions. It has ability to tolerate drought (Hamza & Abd El-Salam, 2015) and it has not capability to tolerate higher water levels than its needs, which may cause root infections. It has a high proportion of both edible oil (42-54%) and protein (22-25%). Its seeds contain 80% of unsaturated fatty acids in the oil (Mahrous et al., 2015), as well as some of vitamins and minerals like a high content of vitamin E (Shasmitha, 2015), calcium, phosphorus, and potassium (Mahrous *et al*., 2015 and Labib *et al* 2019).

Different bacterial genera are vital components of soils. They are involved in various biotic activities of the soil ecosystem to make it dynamic for nutrient turn over and sustainable for crop production (Ahemad *et al*. 2009). They stimulate plant growth through mobilizing nutrients in soils, producing numerous plant growth regulators, preventing or inhibiting phytopathogens, enhancing soil structure, and bioremediating polluted soils by securing harmful heavy metal species and degrading xenobiotic chemicals are all ways to protect plants against phytopathogens like pesticides (Ahemad, 2012, Ahemad and Malik, 2011, Hayat *et al.*, 2010, Rajkumar *et al*. 2010). Umar et al (2011) used organic fertilizer and inorganic and found that, the productivity level of sesame farms under inorganic fertilizer application was higher (27%) over sesame farm under organic fertilizer. Farm size, labor, education and farming experience as well as inorganic fertilizer were factors influencing productivity level of the two enterprises.

Official microorganisms that are produced for specific releasing phosphate, potassium, and iron ions, as well as nitrogen fixation. These are positioned close to the roots to help in the plant's colonisation and nutrition intake. These bacteria play multiple roles, so they can not only aid in the uptake of one element but also in the absorption of other elements, the prevention of diseases, the enhancement of soil quality, the stimulation of plant growth, the improvement of product quality and quantity, and the improvement of plant tolerance to environmental stresses. (ASl, 2017).

Moreover, intensive agriculture is based on the application of increased levels of chemical fertilizers. Both pesticides and chemical fertilizers, when used indiscriminately, can affect human and livestock health and accumulate in soils and water, polluting ecosystems. (Pimentel, 2012). The application of microorganisms, especially bacteria, with plant growth promoting features, the so-called plant probiotics, may be a possible solution to increase crop production while avoiding the above-mentioned problems related to the application of chemical fertilizers and pesticides and, moreover, allowing the abstention of better-quality products (Flores-Felix *et al* 2015).

Organic fertilizer like animal manure is cheaper and affordable by average many farmers. Application of poultry manure and other farm wastes have been found to increase the carbon content, water holding capacity, aggregation of the soil and a decrease in the bulk density. This can help in checking or reducing the effect of water and wind induced erosion (Umar et al 2011, Khalifa, 2022). Bio-fertilizer is valuable replacements to inorganic fertilizers which advances the soil quality. Elkholy *et al* (2005) reported that biologic fertilizers consist of some beneficial microorganisms, which by applying due to good quality, high yielding planting store material can be produced; these fertilizers can be enormously advantageous for farmer with small participation of cost exactingly in developing countries. Efficient utilization of nitrogen is a vital target in crop management. One of the new successes is using bio-fertilizer which delays nitrification process for enough prolonged time and augments the soil fertility (Panel, *et al*., 2020)

Bacteria known as plant growth promoting rhizobacteria (PGPR) are the most auspicious.

PGPR can be applied to improve plant health and accelerate plant growth, without environmental corruption. Inoculating squash with salt-tolerant PGPR strains has a positive effect on nutrients uptake, growth characteristics and yield and yield components as well as fruits quality (Abdel-Rahman et al. 2021).

It is suggested that root-colonizing bacteria that produce phytohormones may stimulate plant growth and help in nutrient recycling in the rhizosphere and thus PGPR can alleviate salinity effects. In addition, PGPR might also increase nutrient uptake by plants from soil and thereby reduce inorganic fertilizer requirements. As well as, PGPR suppress the pathogens by creating siderophores, antibiotics or bacterial and fungal antagonistic substances and/or by producing biologically active substances such as hydrogen cyanide (HCN) and ammonia (El-Sayed and Hagab, 2020; Yaseen et al. 2020; Taha, etal. 2020; Riaz et al, 2021 and Abdel Latef et al. 2021). The genus *Bacillus* is free-living nitrogen fixers and have other PGP traits, which make them suitable candidates for application. (Grady *et al* 2016).

The bacteria isolated from panchagavya belonged to *Bacillus safensis* or *Bacillus cereus*, which displayed characteristics that encouraged plant development (Radha and Rao, 2014). *Bacillus pumilus* and *Bacillus subtilis*, two plant growth-promoting bacteria (PGPB), were discovered in fermented panchagavya (Ram et al., 2019).

Living microorganisms called biofertilizers boost plant development and growth by increasing the availability of mineral nutrients. Solubilizing phosphorus, and production of phytohormones (Mushtaq et al., 2021).

Additionally, the genus cyanobacteria secrete a range of substances that have an impact on how plants grow and develop. These bacteria create growth-promoting regulators, vitamins, amino acids, and other compounds, according to research. and other plant-friendly substances. Polypeptides, antibacterial and antifungal substances that exert phytopathogen biocontrol and polymers, especially exopolysaccharides, that improve plant productivity and growth (Mohsen *et al* 2016). The effect of foliar spray or soil application methods of potassium humate and *Spirulina platensis* cyanobacterium (individually or combined) as bio-organic fertilizer on sesame yield and its attributes, combined foliar application recorded the highest values of plant height, number of branches/plant, seed weight/ plant and 1000 seed weight. While, combined soil applications gave the highest values of seed and straw yield. Cyanobacteria can benefit plants by producing growth promoting hormones such as gibberellin like, cytokinin like and auxin like compounds. These compounds boosted grain weight, protein content, root and shoot growth, and seed germination (Mohsen et al 2016).

Soil bacteria belonging to the *Streptomycetes* are regarded as promising biocontrol organisms due to their potential to produce a vast array of secondary substances including vitamins, alkaloids, plant growth hormones, enzymes, and enzyme inhibitors, makes them excellent biocontrol agents.They can have both favourable and unfavourable impacts on plants, promoting symbiosis, enhancing growth, enhancing resilience to abiotic stress, and enhancing resistance to bacterial and fungal infections.Studies even demonstrate that using Streptomyces helps crop plants develop more quickly (Doolotkeldieva *et al* 2015). Dolotkeldieva *et al* (2015), establishment and developed of beneficial groups, such nitrogen-fixing bacteria, are significantly aided by the presence of the biocontrol bacterium *Streptomyces fumanus* in the rhizosphere. Olanrewaju and Babalola (2019) The *Streptomyces* genus, is a good source of bioactive compounds, antibiotics, and extracellular enzymes. These genera have shown over time great potential in improving the future of agriculture, the emergence of PGPS either as biofertilizer or biocontrol has led to new discoveries into other ways these microbes can be useful. *Streptomyces* are not left out in this discovery, although many studies have focused on the biocontrol activities of these genera due to its high production of bioactive compounds which are used as defense mechanisms. Different lytic enzymes are produced by streptomycetes as a result of their metabolic activities.

Such enzymes can break down insoluble organic polymers like chitin and cellulose into substitute Sugars that can be bound to and taken up by multiple ABC transporters (Seipke *et al* 2012, .and Sai *et al* 2018).

The aim of the present study is to enhancement quality and productivity of sesame plant in sandy soils concluded that organic fertilizing (compost), with 4tons fed-1 to obtain high growth yield, and its components as well as quality of snap.

2. Materials and Methods

An experiment was carried out with one variety of sesame plant (*Sesame indicum*) during summer season 2020 and 2021 at Agriculture Research Station – Ismailia City.

2.1. Microorganisms used in the present study

- *Streptomyces erythrogresious* sub sp. 2 which was isolated from soil (Hammad, 2015), was plated in starch nitrate liquid medium (Tadashi 1976) the flasks were incubated at 28^{o}C for 7-14 days on rotary checker. This strain was examined previously for the antimicrobial characteristics against different indicator strain pathogenic, Gram negative, Gram positive bacteria and pathogenic fungi, it shows antimicrobial activity and the active constituent were assigned as Butanol.

- *Bacillus cereus* sub sp 54-1 isolated from soil (Hammad, 2015), was plated in Nutrient liquid medium. The flasks were incubated at 37oC for 24-48 hr. This strain was examined previously for the antimicrobial characteristics against different indicator strain pathogenic, Gram negative, Gram positive bacteria and the substance producing were identified as abacteriocen.

- *Spirulina platensis*, kindly provided from Agriculture research Centre, Soils Water and Environment Research Institute, Microbiology department. It was grown and propagated on Zarrouk medium (Zarrouk 1966).

Soil was low in available nitrogen (11.9 mg kg^{-1}) and very low in available phosphorus (2.33 mg Kg^{-1}) and high in potassium (70.9 mg Kg^{-1}) both years respectively, in this experiment. Available soil NPK were determined according to the method described by Dewis and Freitas (1970). Soil aggregates size distribution (%) was carried out according to Rouiller *et al* (1972) and the soil aggregate percentage was calculated as the total differences between each fraction and it's control except the last two fractions which are 0.125 – 0.063 and < 0.063 mm. Soil classified as Typic Torriorthents, sandy, mixed, thermic, very deep according to USDA (2014).

2.2. Agricultural practices

A field experiment was performed during the two successive seasons of 2019-2020 and 2020-2021 in a newly reclaimed sand textured at Ismailia, Agricultural Research Station, Ismailia Governorate, located between latitude 30o 35o 30o N, longitude 32^{o} 14^{o} 50^{o} and elevation 3 metres from the sea level. The experimental design was complete randomized with three replicates. The area of each plot m^{2} (3*3). Some properties of farmyard cattle manure were shown in Table 2, and the treatments in our investigation are shown in Table 3.

Seeds were washed several times with sterilized water, then soaked in the suspension for periods of 30 min before cultivation with bio fertilizers treatments. The seeds were dried after treatment in the shade, and then the light-dried seeds were planted in soil, making sure the same amount of the suspension was used for soaking of seeds. Each organism was tested in three replicates. Control seeds was treated with sterile water. The inocula were grown in liquid medium and added with living cells and spores suspension for soaking of seeds (Doolotkeldieva *et al* 2015). The chemical analysis of the experimental soil was done according to the method described by Jackson (1973), as shown in Table 1.

TABLE 1. Some chemical and physical properties of experimental soil .

pH	7.98	N	11.9
SP, %	21.5	P	2.33
EC (dS m^{-1})	0.93	K	70.6
Soluble cations (mmolc Kg^{-1})		Particle size distribution (%)	
Ca^{++}	4.6	Coarse sand	83.5
Mg^{++}	1.77	Fine sand	11.88
Na^{+}	3.44	Total sand	92.22
K^{+}	0.051	Silt	2.41
Soluble anions (mmolc $kg^{-1)}$		Clay	3.99
$CO_3^{=}$	0.00	Textural class	Sandy
HCO_3^{-}	1.95		
Cl^{-}	5.10		
$SO_4^{=}$	1.66		
Cl^{-}	5.06	Dry sieving aggregates (size distribution%)	
$SO_4^{=}$	1.54		
SAR	1.88	1-0.5mm	21.55
ESP	1.66	0.5–0.25 mm	36.85
O.M (g kg^{-1})	4.3	0.25 – 0.125 mm	17.65
$CaCO_3$ (g kg^{-1})	25.8	0.125–0.063mm	8.55

TABLE 2. Some properties of farmyard cattle manure.

Test	Value
Saturation Percent (%)	179
pH (1:10)	8.20
EC, dS m^{-1} (1:10)	22.19
Available Ca (%)	26.32
Available Mg (%)	20.42
Available Na (%)	85.36
Available K (%)	106.41
CO_3^{-} (%)	0.00
HCO_3-%)	30.66
Cl-%	150.85
So4--%	56.99
N (Av %)	123.0
P (Av %)	3.40
K (Av %)	95.0

Seeds of sesame were grown in ridges 50 cm apart and 3.5 cm long, distance between each hill were 20 cm. Seeds of sesame (*Sesumm indicum*) were kindly obtained from Agricultural Research Centre, Giza, Crops Research Institute.

The following treatments in our experiment as follows:

TABLE 3. Treatments used in the experimental site.

Symbol	Treatment
T1	Inoculation with *S. plateinsis*
T2	Inoculation with *S. erythrogriseus* sp2
T3	Inoculation with *B. cereus* 54-1.
T4	Mixture of T1 + T2 + T3 treatments
T5	*S. platinsis* + 2 ton /feddan farmyard manure.
T6	*S. erythrogriseus* sp2 + 2 ton /feddan farmyard manure
T7	*B. cereus* 54-1 + 2 ton /feddan farmyard manure
T8	Mixture of T1 + T2 + T3 treatments + 2 ton /feddan farmyard manure
T9	S. plateinsis + 4 ton /feddan farmyard manure
T10	*S. erythrogriseus* sp2 + 4 ton /feddan farmyard manure
T11	B. cereus 54-1 + 4 ton /feddan farmyard manure
T12	Mixture of T1 + T2 + T3 treatments + 4 ton /feddan farmyard manure

T13	Control (uninoculated)

The field was watered by sprinkling. The soil was classified as Typic Torriorthents, sandy, mixed, thermic, very deep according to USDA (2014). The experimental area was divided into equal plots of 3 x 3 m. Three separate plots The field was watered by sprinkling. The soil was classified as Typic Torriorthents, sandy, mixed, thermic, very deep according to USDA (2014). The experimental area was divided into equal plots of 3 x 3 m. Three separate plots were used in a split-plot design. replicates for each treatment. The experimental unit consisted seven ridges 3 meter in length and 60 cm apart (plot area = 3 x 3.5 = 10.5 m2). The distance between plants was 50 cm.

2.3 Plant sampling and determination

Three replicates of each treatment were uprooted after 60 days of planting to determine dehydrogenase activity according to (Skujins, 1976). According to Metzner *et al* the photosynthetic pigments (chlorophyll a, chlorophyll b, and carotenoids) were quantified (1965).Using the technique outlined by Bilal *et al* microbial root colonisation was seen (1993).Clean fresh root samples were cut off at ten centimetres, and any soil fragments were removed., then immersed with 2 ml of test tubes containing a 2.3.5-triphenyl tetrazolium chloride solution (TTC). Following that, tubes were kept at 30 ^{o}C in the dark for 24 hours. After mersing roots in TTC, samples were left to dry in room temperature.

Colonization was examined under light microscope where plant tissues and tetrazolium reduction were visible as red color due to reduction of tetrazolium by bacterial cells. The percentage of colonization was calculated as follows:

Colonization length = Root length – Non-colonized length Colonization % = Colonization length X 100 Root length Plant samples were collected at harvest stage after 160 days from each plot. Shoot length (cm), branches numbers, pods number, fresh and dry shoot yields (ton fed-1), weight of 1000 seed (ton fed^{-1}) and seed yield (ton fed^{-1}) were calculated.

Total N, K and P were determined in the digested plant solution. Total nitrogen (N) form (NO_3^- and NH_4^+) was determined according to Markus *et al* (1985) using micro kejldahl. Total phosphorus (P) was extracted by ammonium bicarbonate according to Soltanpour (1991) and determined by (ICP-Plasma JY). Total potassium (K) was

were used in a split-plot design. replicates for each treatment. The experimental unit consisted seven ridges 3 meter in length and 60 cm apart (plot area = 3 x 3.5 = 10.5 m2). The distance between plants was 50 cm.

determined by using flame photometer according to Jackson (1973).

2.4 Bio assay of three microorganisms

The three microorganisms were assayed for antagonistic activity *in vitro*, *S. platensis* was grown and propagated on Zarrouk medium (Zarrouk 1966). *S. erythrogriseus* sp2 were plated in starch nitrate agar medium (Tadashi 1975) the plates were incubated at 28oC for 7-14 days Nutrient agar medium was used to plate B. cereus sub sp. 54-1, and the plates were cultured at 37°C for 24-48 hours. The traditional diffusion method was used to carry out the antagonistic activity (Cooper, 1963). And 1972). Which is based on the observation of inhibition zone of microbial growth on a nutrient agarized medium.

2.5 Statistical analyses

Snedecor and Cochran state that statistics were pplied to the data (1981).The least significant difference (L.S.D.) test was used to compare mean values at a level of p 0.05.For data statistical analysis, SPSS (v. 24, IBM Inc., Chicago, IL, USA) and Costat (v. 6.400 CoHort software, California, USA) were used.

3. Results

3.1 Dehydrogenase activity

The existence of microorganisms was reflected in the dehydrogenase activity present in the rhizoplane. This was adverted to data in Fig. 1, which explicate that inoculation mixture of *B. cereus* 54-1, *S. erythrogreiseus* sp 2 and *S. platinsis* had the greatest effect (254.0 µg TPF/g dry soil), followed by inoculation with the bacterial *Bacillus cereus* 54-1 (232.0 µg TPF/g dry soil), while the control had the least record (105.2 µg TPF/g dry soil).

3.2 Root colonization

As recognized in Fig. 1, microbial root colonization was highly affected by the supplemented treatments. Inoculation of the bacterial mixture of *B. cereus* 54-1, *S. erythrogreiseus* sp 2 and *S. platinsis* in addition to *B. cereus* 54-1, *S. erythrogreiseus* sp 2 he uppermost values with 60 % and 40% colonization, followed by *S. platinsis* 30 %, contrary to the control which showed only 10 %.

3.3 Photosynthetic pigments

The implementation of *B. cereus* 54-1 and *S. erythrogreiseus* sp 2 as seed treatment and soil incorporation individually and in mixtures with *S. platinsis*, significantly increased chlorophyll a content but was not significant in response to chlorophyll b and carotenoids. This was clearly demonstrated in Fig. 2, where implementation of all microbes resulted in the greatest level of chlorophyll a, at 2.03 mg/g dry weight while, the control had the least value of 1.20 mg/g dry weight.

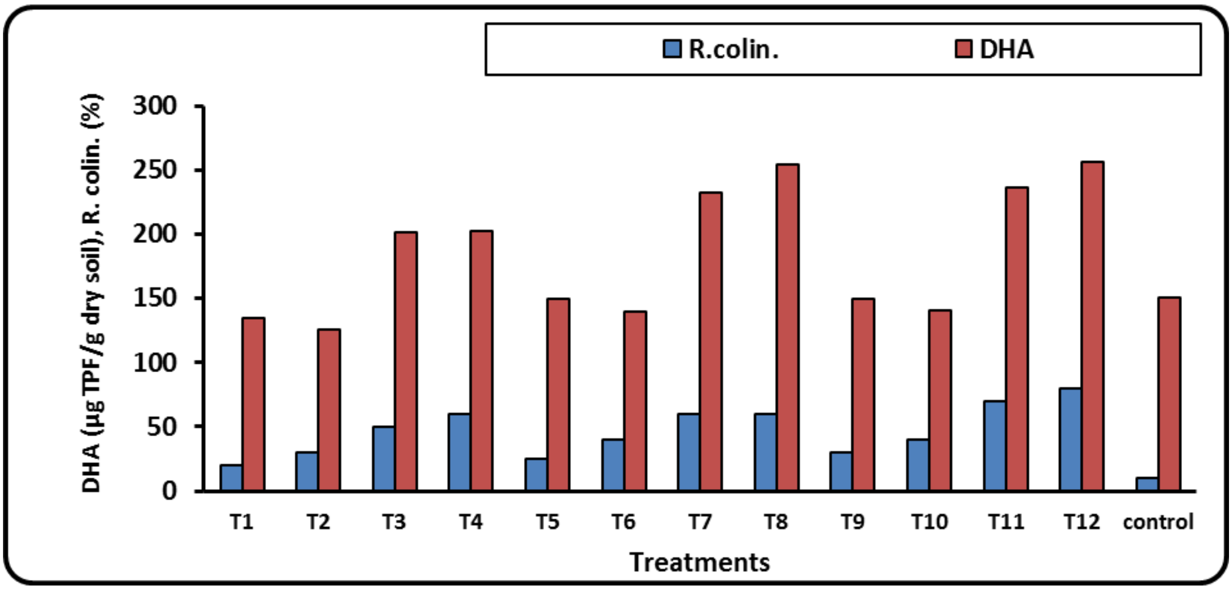

Fig. 1. Impact of some microbiota *B. cereus 54-1 and S. erythrogreiseus sp 2, S.platensis* and organic matter treatments root colonization and dehydrogenase (DHA) of sesame plants; 0: Zero compost, 2: 2 ton fed^{-1}; 4: 4 ton fed^{-1}; Spi: *Spirulina platensis;* Str: *Streptomyces erythrogresious*; Bac: *Bacillus cereus*.

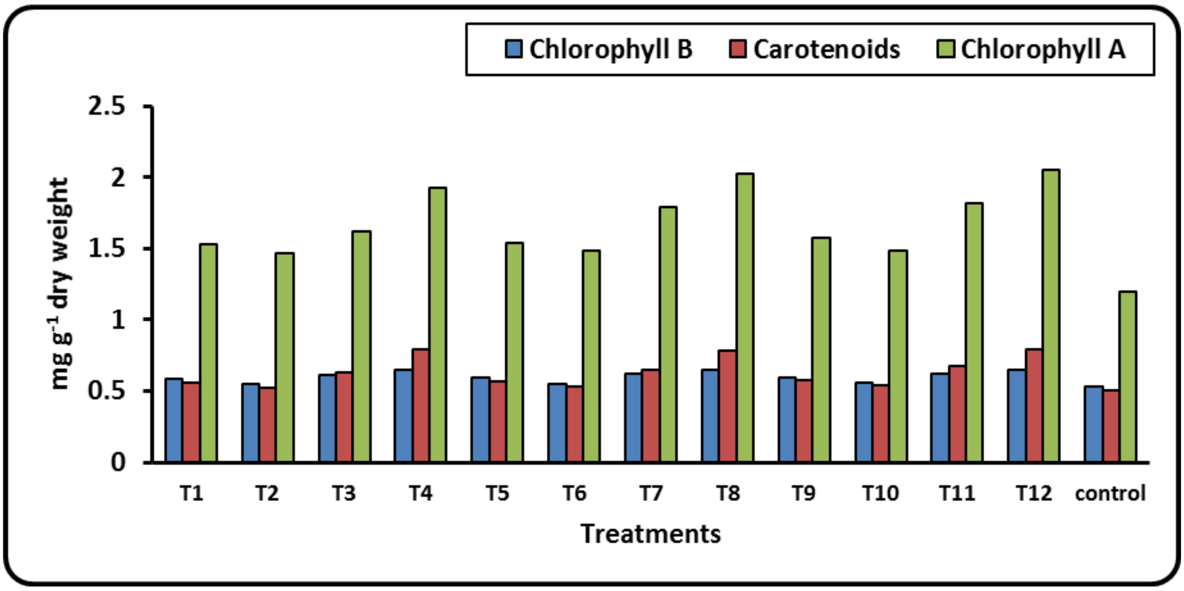

Fig. 2. Impact of some microbiota *B. cereus 54-1 and S. erythrogreiseus sp 2, S.platensis* and organic matter treatments on chlorophyll a, b and carotenoids of sesame plants; 0: Zero compost, 2: 2 ton fed^{-1}; 4: 4 ton fed^{-1}; Spi: *Spirulina platensis;* Str: *Streptomyces erythrogresious*; Bac: *Bacillus cereus*.

3.4 Growth parameters

Manipulation of beneficial microbiota showed highly significant effects on yield parameters. It was clear from Table 4 that, the superior effect in yield production was achieved by the bio agents as general trend which positively reflected in dry and fresh weights of root, shoot length and number of branches

Root length, shoot height, branches number and shoot dry weight were greatly influenced by inoculation with the different bio agents compared with un-inoculated one. The same factors also affected by the percentage of compost added. Table 4 showed that, the treatment of bacteria *B. cereus* 54-1, *S. erythrogreiseus* sp 2 gave the highest values of Root length, Shoot height, number of branches and shoot dry weight were 22.1,22.2 cm/plant root length 153,156.2 cm/plant shoot height,4.5,4.5 number of branches and 50.3,49.4 gm./plant shoot dry weight. All these results were obtained by adding compost 2 ton/Fadden. The mixed culture of *S. plateinsis*. , *B. cereus* 54-1and *S. erythrogreiseus* sp 2 and *S. plateinsiso* only gave results less than each culture separately that's means that there is a competition between the three organisms which explained by laboratory experiment.

Shoot length, pods number, weight of 1000 seed and subsequently seeds Kg/fed were greatly influenced by inoculation with the different bio agents compared with un-inoculated one. The same factors also affected by the percentage of compost added. Table 5 showed that, the treatment of bacteria *B. cereus* 54-1, *S. erythrogreiseus* sp 2 gave the graetest values of shoot height, pods number weight of 1000 seed and seeds Kg/fed number being, 169.7,159.0 cm/plant, pods number /plant and 5.4,5.97 weight of 1000 seed/plant, and 5.8,5.67seed Kg/Fadden respectively. All these results were obtained by adding compost 2 ton/Fadden. The mixed culture of *S. plateinsis*. , *B. cereus* 54-1and *S. erythrogreiseus* sp 2 gave results less than each culture separately that's means that there is a competition between the three organisms which explained by laboratory experiment.

3.5 Yield parameters

TABLE 4. Impact of some microorganisms used and organic matter treatments on growth parameters of sesame plants

Compost (ton fed^{-1})	Microorganisms used	Root length cm plant $^{-1}$	Shoot height cm plant $^{-1}$	Number of branches plant^{-1}	Shoot dry weight g plant^{-1}
		Summer season (2020)			
0.0	**T1**	21.2 c	115.0 i	3.6 d	47.0 d
	T2	20.7 d	119.2 i	3.4 d	43.8 d
	T3	22.1 b	121.3 i	3.4 d	40.8 e
	T4	15.9 f	133.0 h	3.9 d	40.1 e
2.0	**T5**	22.1 b	151.6 g	4.3 d	49.0 c
	T6	20.8 d	156.2 f	4.5 c	49.4 c
	T7	21.7 c	153.0 f	4.5 c	50.3 b
	T8	19.8 e	150.0 g	4.1 d	43.8 d
4.0	**T9**	22.4 b	160.0 d	4.6 c	52.1 b
	T10	22.2 b	165.2 c	4.6 c	53.4 a
	T11	20.8 d	162.3 d	4.6 c	50.6 b
	T12	20.8 d	152.0 f	4.3 d	49.2 c
	T13	15.5 f	100.0 j	3.0 d	35.0 e
		Summer season (2021)			
0.0	**T1**	23.2 a	117.0 i	3.9 d	45.0 d
	T2	22.7 a	118.2 i	3.6 d	44.8 d
	T3	23.1 a	123.3 i	3.3 d	41.8 d
	T4	17.9 f	135.0 h	3.6 d	40.5 d
2.0	**T5**	23.5 a	152.6 f	4.5 c	49.5 c
	T6	23.2 a	158.2 e	4.9 b	49.9 c
	T7	24.1 a	155.0 f	4.8 c	50.8 b
	T8	19.9 d	151.0 g	4.3 d	43.4 d
4.0	**T9**	23.5 a	162.0 d	4.8 c	53.3 a
	T10	24.6 a	163.2 d	4.8 c	55.6 a
	T11	23.3 a	165.3 c	4.7 c	52.6 b
	T12	19.9 e	154.0 f	4.1 d	48.2 d
	T13	15.1 f	100.0 j	3.0 d	33.0 e
L.S.D. 5 %		2.164	15.185	1.707	8.39

T1: Inoculation with *S. plateinsis;* **T2:** Inoculation with *S. erythrogriseus* sp2; **T3**: Inoculation with *B. cereus* 54-1; **T4**: Mixture of T1 + T2 + T3 treatments; **T5**: *S. platinsis* + 2 ton /feddan farmyard manure; **T6**: *S. erythrogriseus* sp2 + 2 ton

/feddan farmyard manure; **T7**: *B. cereus* 54-1 + 2 ton /feddan farmyard manure; **T8**: Mixture of T1 + T2 + T3 treatments + 2 ton /feddan farmyard manure; **T9**: *S. plateinsis* + 4 ton /feddan farmyard manure; **T10**: *S. erythrogriseus* sp2 + 4 ton /feddan farmyard manure; **T11**: *B. cereus* 54-1 + 4 ton /feddan farmyard manure; **T12**: Mixture of T1 + T2 + T3 treatments + 4 ton /feddan farmyard manure; **T13**: Control (uninoculated).

TABLE 5. Impact of some microorganisms used and organic matter treatments on yield parameters of sesame plants.

Compost (ton fed^{-1})	Microorganisms used	Shoot height cm plant^{-1}	Number of pods plant^{-1}	Weight of 1000 seed	Seed yield (kg fed^{-1})
		Summer season (2020)			
0.0	**T1**	143.0 g	75.00 j	4.30 h	530 i
	T2	134.5 h	87.00 i	4.10 h	514 i
	T3	149.6 g	90.00 i	4.00 h	540 i
	T4	142.0 g	74.00 j	3.90 h	520 i
2.0	**T5**	156.7 e	94.00 h	4.93 g	540 h
	T6	159.0 d	103.00 f	4.21 h	567 e
	T7	169.7 b	129.00 c	4.72 g	580 c
	T8	155.4 e	90.00 i	4.40 h	523 i
4.0	**T9**	159.0 d	93.00 h	5.20 e	551 g
	T10	159.6 d	112.00.e	5.97c	579 d
	T11	166.7 c	130.00 b	5.40 e	591 a
	T12	158.3 e	97.00 h	4.96 g	573 d
	T13	130.0 h	80.00 j	3.00 i	400 j
L.S.D. 0.05		0.822	14.27	1.0758	35.055
		Summer season (2021)			
0.0	**T1**	145.00 g	77.00 j	4.50 h	533 g
	T2	136.50 h	89.00 i	4.30 h	516 i
	T3	151.60 f	92.00 h	4.20 h	542 h
	T4	144.00 g	76.00 j	3.70 i	522 i
2.0	**T5**	158.70 d	95.00 h	4.53 h	543 h
	T6	155.00 e	105.00 f	4.41 h	569 d
	T7	168.70 b	131.00 a	4.92 g	583 b
	T8	156.40 e	92.00 h	4.30 h	525 i
4.0	**T9**	158.00 e	95.00 h	5.40 e	553 g
	T10	160.60 d	114.00 d	5.67 d	581 c
	T11	168.70 b	132.00 a	5.60 d	593 a
	T12	159.30 d	98.00 h	4.86 g	576 d
	T13	130.00 h	80.00 j	3.00 i	402 j
L.S.D. 0.05		0.822	14.27	1.0758	35.055

T1: Inoculation with *S. plateinsis;* **T2:** Inoculation with *S. erythrogriseus* sp2; **T3**: Inoculation with *B. cereus* 54-1; **T4**: Mixture of T1 + T2 + T3 treatments; **T5**: *S. platinsis* + 2 ton /feddan farmyard manure; **T6**: *S. erythrogriseus* sp2 + 2 ton /feddan farmyard manure; **T7**: *B. cereus* 54-1 + 2 ton /feddan farmyard manure; **T8**: Mixture of T1 + T2 + T3 treatments + 2 ton /feddan farmyard manure; **T9**: *S. plateinsis* + 4 ton /feddan farmyard manure; **T10**: *S. erythrogriseus* sp2 + 4 ton /feddan farmyard manure; **T11**: *B. cereus* 54-1 + 4 ton /feddan farmyard manure; **T12**: Mixture of T1 + T2 + T3 treatments + 4 ton /feddan farmyard manure; **T13**: Control (uninoculated).

3.6 Plant analysis
3.6.1 Macronutrient concentrations and uptake in sesame plant

Mineral content is an essential component of the nutritive values of sesame plant. Table 6 displayed the significant difference among treatments. It was conspicuous that, inoculation with *B. cereus 54*-1and *S. erythrogreiseus* sp 2 enhanced N, P and K concentrations and uptake, these values were, 148.75, 133.27 and 8.7, 8.08 and 158.75 and 146.6 kg fed^{-1}, respectively. Also, data implied that the inoculation with bacterial mixture bioagents and *S. platinsis* gave the lowest levels of phosphorus and potassium and nitrogen.

Microbiota inoculation on oil fertility statues after plant (*Sesum indicum*) cultivation. Data in Table 7 showed the availability of nitrogen, phosphorus and potassium (NPK-macronutrients, mg kg^{-1} soil). The available nitrogen and potassium significantly increased under the treatment of the individual *B. cereus 54*-1and *S. erythrogreiseus* sp 2than the mixed culture of three organisms. Available phosphorus concentrations significantly increased in the presence of *B. cereus54*-1and *S. erythrogreiseus* sp 2 than in the mixed treatment compared with control. It is worth noting that, the individual *B. cereus54*-1and *S. erythrogreiseus* sp 2 treatment gave the best value than the mixture treatment of three treatments. Mostly, the differences between microbiota treatments were not significant while they were significant as compared with control. However, the greatest values of N, P and K were, 17.29, 7.9 and 62.20 (mg kg^{-1} soil) obtained under the treatment of bacterial *Bacillus cereus54-1*, respectively. The smallest available N, P, and K values were 14.11, 6.3 and 60.2 (mg kg^{-1} soil), respectively, obtained under *S. plateinsis* and were 2.36 (mg kg^{-1} soil).

3.6.2 Seed oil percent

The addition of bio agents was effects on seed oil (Fig. 3). Treatments showed the highest seed oil percentage were *B. cereus* 54-1 and *S. erythrogreiseus* sp 2 where the heights seed oil percent was 51,48 Kg/fed compared to the control one it was 39 Kg/fed. As recognized in Fig. 3 seed protein percent was highly affected by the supplemented treatments. Inoculation of the *Spirulina platinsis* gave high protein content 19.62 followed by bacterial of *B. cereus54*-1, *S. erythrogreiseus* sp 2and *S. platinsis* in addition to the uppermost values with 19.53 and 19.42, contrary to the control which showed only 15. On sesame plant could significantly increase oil seed percentage.

3.7 Impact of applied microorganisms

Combine application of algal and bacterial were being used as microbial consortium for the yield enhancement. They showed promising way to improve efficacy of bio fertilizer strains. The results shows that there is antagonistic activity between the three organisms which explain the previous results where the mix of three organisms give results weaker than each organism separately. Fig 4 shows the antagonistic activity of three microorganisms. Which explained by the antimicrobial activity of both two organisms *B. cereus* 54-1 and *S. erythrogreseus* 2.

TABLE 6. Impact of some microorganisms used and organic matter treatments on N, P, and K of sesame plants.

Compost (ton fed^{-1})	Microorganisms used	N (kg fed^{-1})	P (kg fed^{-1})	K (kg fed^{-1})
	Summer season: 2020			
0.0	**T1**	194.68 f	16.75 e	366.44 c
	T2	264.59 e	19.73 c	353.10 e
	T3	296.51 d	19.14 c	372.62 c
	T4	267.60 e	17.07 d	357.25 e
2.0	**T5**	292.58 d	18.82 d	372.62 c
	T6	329.30 b	19.96 b	362.24 d
	T7	367.55 a	21.69 a	392.26 b
	T8	303.70 d	19.81 b	401.53 a
4.0	**T9**	298.66 d	20.78 b	342.94 f
	T10	336.15 b	21.20 a	359.27 e
	T11	370.74 a	22.78 a	362.24 d
	T12	330.12 c	21.00 a	385.96 b
	T13	172.96 f	14.87 e	324.19 f
L.S.D. 5 %		12.986	1.089	12.056

T1: Inoculation with *S. plateinsis;* **T2:** Inoculation with *S. erythrogriseus* sp2; **T3**: Inoculation with *B. cereus* 54-1; **T4**: Mixture of T1 + T2 + T3 treatments; **T5**: *S. platinsis* + 2 ton /feddan farmyard manure; **T6**: *S. erythrogriseus* sp2 + 2 ton /feddan farmyard manure; **T7**: *B. cereus* 54-1 + 2 ton /feddan farmyard manure; **T8**: Mixture of T1 + T2 + T3 treatments + 2 ton /feddan farmyard manure; **T9**: *S. plateinsis* + 4 ton /feddan farmyard manure; **T10**: *S. erythrogriseus* sp2 + 4 ton /feddan farmyard manure; **T11**: *B. cereus* 54-1 + 4 ton /feddan farmyard manure; **T12**: Mixture of T1 + T2 + T3 treatments + 4 ton /feddan farmyard manure; **T13**: Control (uninoculated) . **N.B:** 1 Fed= 0.4047 ha.

TABLE 7. Impact of some microorganisms used and organic matter treatments on N, P, K of soil of sesame plants.

Compost (ton fed^{-1})	Microorganisms used	N (mg kg^{-1} soil)	P (mg kg^{-1} soil)	K (mg kg^{-1} soil)
0.0	**T1**	14.11 f	6.92 d	62.51 a
	T2	14.32 f	6.32 e	61.20 a
	T3	14.11 f	6.35 e	61.68 a
	T4	14.35 f	6.30 e	62.68 a
2.0	**T5**	17.44 c	6.78 d	62.48 a
	T6	17.98 b	7.00 c	62.63 a
	T7	17.29 e	7.91 b	62.28 a
	T8	16.18 e	7.81 b	60.43 a
4.0	**T9**	16.01 e	7.42 c	60.20 a
	T10	16.46 e	8.08 a	60.56 a
	T11	17.36 d	7.08 c	60.48 a
	T12	17.46 c	8.18 a	60.30 a
	T13	12.23 g	6.02 e	58.50 a
L.S.D. 5 %		1.58	1.95	12.08

T1: Inoculation with *S. plateinsis;* **T2:** Inoculation with *S. erythrogriseus* sp2; **T3**: Inoculation with *B. cereus* 54-1; **T4**: Mixture of T1 + T2 + T3 treatments; **T5**: *S. platinsis* + 2 ton /feddan farmyard manure; **T6**: *S. erythrogriseus* sp2 + 2 ton /feddan farmyard manure; **T7**: *B. cereus* 54-1 + 2 ton /feddan farmyard manure; **T8**: Mixture of T1 + T2 + T3 treatments + 2 ton /feddan farmyard manure; **T9**: *S. plateinsis* + 4 ton /feddan farmyard manure; **T10**: *S. erythrogriseus* sp2 + 4 ton /feddan farmyard manure; **T11**: *B. cereus* 54-1 + 4 ton /feddan farmyard manure; **T12**: Mixture of T1 + T2 + T3 treatments + 4 ton /feddan farmyard manure; **T13**: Control (uninoculated).

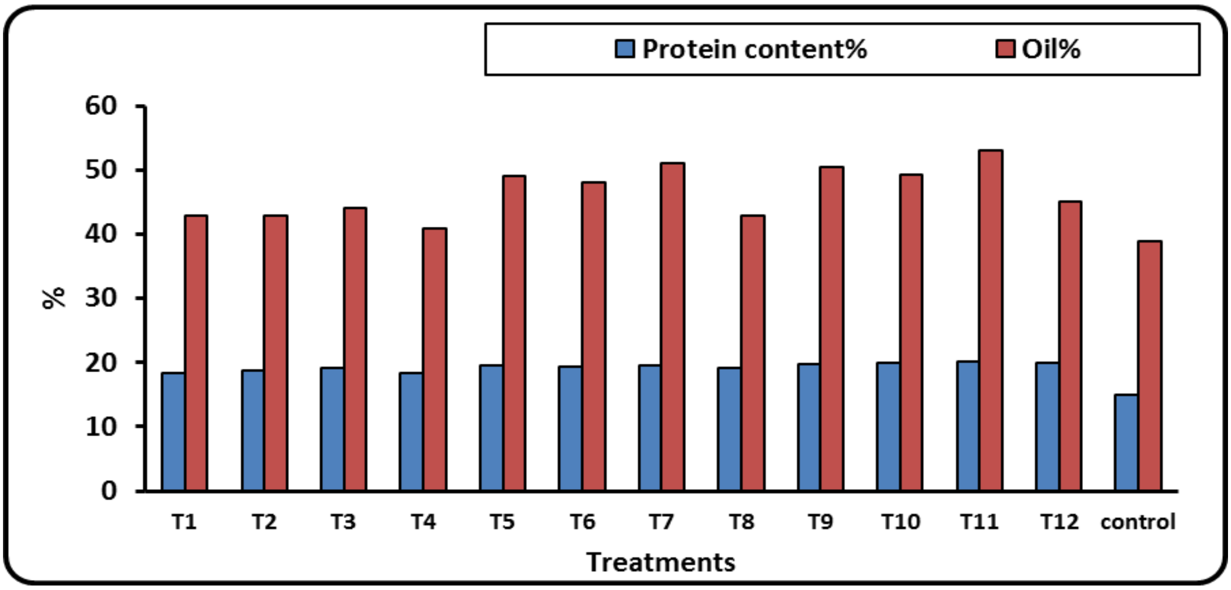

Fig. 3. Impact of some microbiota *B. cereus 54-1 and S. erythrogreiseus sp 2, S.platensis* and organic matter treatments on oil% and protein content of sesame plants; 0: Zero compost, 2: 2 ton fed^{-1}; 4: 4 ton fed^{-1}; Spi: *Spirulina platensis;* Str: *Streptomyces erythrogresious*; Bac: *Bacillus cereus*.

Fig. 4. Antagonistic activity of *Bacillus cereus 54-1, Streptomyces erythrogreseus 2* and *Spirulina plateinsis.*

4. Discussion

Bio fertilizers were more suited for high crop yields, disease protection, and pesticide resistance.Numerous microorganisms (PGPR) have been identified as producers of cytokines that aid in plant growth and germination, including *Azospirillum*, *Bacillus*, *Pseudomonas*, and *Enterobacter*.For root inoculation to be successful, the ability of the bacteria that promote plant development to survive under various soil and temperature conditions may be crucial.The auxins that rhizobacteria create can affect plant development, including root expansion that enhances nutrient intake and hence increases plant growth (El-Tapey *et al.* 2019). The most significant nitrogen-fixing organisms in many agricultural soils were thought to be cyanobacteria.

Cyanobacteria were well known for their capacity to produce chemicals that promoted growth, including plant hormones, vitamins, and amino acids. They also increased the water holding capacity through their jelly structure, increased the organic matter in soil after their decomposition, preventing weeds growth (El-Shinnawy, 2016).

Numerous microorganisms might be classified as intracellular (EPGPR) or extracellular (EPGPA), with the latter occurring inside root cells and the former existing in the rhizosphere, on the rhizoplane, or in the spaces between cells of the root cortex. Azotbacter and *Bacillus* are a couple of instances of EPPR (Munees and Mulugeta, 2014).

Plant health, production, and soil fertility are all influenced by interactions between plant microbes in the rhizosphere.Plant growth promoting bacteria (PGPB) can be classified as a plant growth promotion (PGPR) feature if they increase plant growth and protect plants from illnesses by a range of methods, including biological nitrogen fixation, phosphate solubilization, and phytohormones. If the inoculation proved successful, the usage of artificial fertilisation might be decreased or completely removed (Souza *et al.* 2015). Besids, *Azotobacter chroococcum* as a N_2 fixers, it also used as plant growth promoter (Afifi *et al*. 2014) and (El-Tapey *et al.* 2019).

Inoculation with bacteria improved the plant contents of nitrogen compared to inoculation with cyanobacteria either application of 75%. Similar trend was occurred for both phosphorus and potassium determination. Control treatment recorded lower nitrogen, phosphorus and potassium contents at the first season; 0.237, 0.020 and 0.242 g plant^{-1} respectively, while recorded 0.256, 0.021and 0. 230 g plant^{-1}, respectively at the second season. Data on plant NPK contents in this work indicated that all inocula increased the nutrients contents. Rhizobacteria that promote plant development

In nutrient-poor environments, PGPR was crucial in assisting plants with establishment and growth. It also helped to reduce the usage of agrochemicals and supported environmentally friendly, sustainable food production.

The demand for PGPR biofertilizers has increased along with the growth of organic farming; PGPR promotes plant growth by increasing mineral and water uptake in a variety of plant species; cyanobacteria have been shown to attach to root hairs and effectively colonise root surfaces; and root hair proliferation and deformation. produce surface humus after death in the soil and maintaining a reserve supply of elements such as N and P. This might attribute to the plant growth promoting effect which stimulate nutrient uptake by inoculated plants. (El-Shinnawy, 2016).

Significant effects on plant height and yield of canola plant after using Azotobacter and Bacillus were recorded by EL-Howeity and Asfour (2012).

Megawer and Mahfouz. (2010) reported that 1000 seed weight increased by multiple inoculation compared to single inoculation. The increases in 1000 seed weight and number of pods were the key contributors to the increases in dry seed weight.

These results agreed with Rifat *et al.* (2010) and Abd El-Hamid *et al.* (2013) whose mentioned that, the biofertilizer helps in fixing N2, solubilizing minerals phosphorus and other nutrients. EL-Gamal (2015) mentioned that, P is assimilated by a mixture of cyanobacteria, which is incorporated into their cells during growth and released after decomposition in the form of soluble organic P molecules including sugar-P, lipid-P, nucleic-P, and nucleotide-P, etc. Some cyanobacteria like *Anabaena oryzae* and *Nostoc muscorum* have been reported (Zian, 2018) to solubilize insoluble phosphate and make it available to the crop plants.

Nitrogen could promote vegetative growth of plant through increasing soil fertility so that the number of branches increased. The biological fertilisers with bacteria that fix nitrogen enable the plant absorb more nutrients, resulting in the growth of aerial organs and an increase in the number of side branches. Expressed that synthetic fertilizers have a significant impact on the number of branches, with the largest number of branches in sesame plants seen in an integrated application of 50% chemical fertiliser + nitrox in, and the smallest number also seen in a combination of 25% chemical fertiliser + nitroxin. (Jahan *et al.* 2013), expressed that the greatest number of branches in fennel has been obtained from 50% chemical fertilizer + biological fertilizer and this results is matched with present experiment. (Karami *et al.* 2011), observed that consumption of nitrogen biofertilizer in fenugreek plant increased growth and number of branches and leafs of this plant (Asl, 2017), our results were agreed with this results.

Since the number of branches per plant was large in both of these fertilizing treatments and there is a direct relation between number of pods and branches, the number of pods in plant has been increased. The amount of pods produced by each plant was significantly impacted by phosphorus fertiliser.The treatments with 200 kg per hectare triple superphosphate and biophosphor with 100 kg per hectare triple superphosphate had the most pods per plant, whereas the control treatment had the fewest pods per plant (lack of using fertilizer).Due to the plant's quantity of branches was large in both of these fertilizing treatments and there is a direct relation between number of pods and branches, the number pods in plant has been increased. Under the influence of the aforementioned fertiliser, plants produced more photosynthesis-related material and produced more sesame pods overall. The use of biological fertilisers greatly enhanced the height, number of branches per plant, number of pods, weight per 1,000 seeds, and seed production of sesame plants (Asl, 2017).

Streptomyces spp., influence soil fertility through the participation of numerous elements and act as nutrient boosters. They are known to create a number of enzymes, such as amylase, chitinase, cellulase, invertase, lipase, keratinase, peroxidase, pectinase, protease, phytase, and xylanase, which transform the complex nutrients into simple mineral forms. They also produce siderophores and solubilize phosphate. This nutrient cycle ability makes them good candidates for natural fertilizers (Jog *et al* 2016). The relationship between PGPS and their host plant and the biochemical processes involved deserve deeper investigation. This information would make it possible to manipulate those interactions, especially the metabolic processes that result in a harmonious coexistence of the host plant and its endophytes. Most *Streptomycetes* are free-living in the soil as saprophytes and are able to colonize the rhizosphere and rhizoplane of the host plant. For example, some PGPS, initially known as soil-dwelling microorganisms, were found to efficiently colonize the inner tissues of selected host plants as endophytics, therefore proving their ability to fully or partly conduct their life cycle inside plant tissues (Meschke, and Schrempf 2010; Sai *et al*. 2018).

In accordance of our results. Chuang (2020), examined Streptomyces sp on *Arabidopsis thaliana* and he found that IAA production by *Streptomyces* sp. was moderate, and it was also capable of solubilizing phosphate. *Streptomyces* sp. inoculation increased the number of lateral roots, fresh weight, and chlorophyll content in *Arabidopsis thaliana*. Additionally, by creating more fresh weight and chlorophyll content, the inoculation of *Streptomyces* sp. considerably improved vegetative growth on *Arabidopsis* and *Brassica* sp. By increasing fresh weight under salt and heat stress, *Streptomyces sp.* also improved resistance to abiotic stress in *Arabidopsis* and *Brassica* sp. Under salt stress, *Streptomyces* sp. inoculation in Arabidopsis enhanced catalase enzyme activity and lowered malondialdehyde (MDA) and hydrogen peroxide (H_2O_2) generation. *Streptomyces* sp. caused protein accumulations, including nitrogen absorption, at the molecular level in Arabidopsis (GS1), carbohydrate metabolism (cFBPase), and the light-harvesting chlorophyll (Lhcb1) protein. Ravinder *et al.* (2022) examined when used to promote the growth of the chilli plant (*Capsicum annuum* L.), *Streptomyces puniceus* RHPR9 significantly increased the seed vigour index (2047) and increased plant biomass (65%) compared to the uninoculated control. The NPK concentrations and uptake increased in calyx and shoot in response to bioagents. Soil organic matter content and soil aggregates increased while EC and pH decreased. Generally, the application of microbial mixtures modified physio-chemical soil properties and consequently reflected on roselle yield production these studies as carried out by Gaafar et al (2021).

Gaffar *et al.* (2021), using *Bacillus subtilis* as bio fertilizer in *Roseella* plant while their results emphasized that the tested bioagents significantly increased the yield and growth of roselle plant in comparable to the untreated plants. Also, inoculation increased soil dehydrogenase activity, root colonization and photosynthetic pigments. Significant enhancement in soil fertility properties was occurred, where the soil NPK availability improved.

Abdel-Rahman *et al*. (2021) stated that, the application of PGPR inocula can save half of the fertilizer requirements and minimize the overuse of chemical fertilisers, particularly nitrogenous fertilisers, contributed to environmental damage. Additionally, it might be suggested as a novel efficient *rhizobacteria* to encourage plant growth, boost agricultural production in salinity-prone environments, lower production costs, and lessen environmental pollution.

5. Conclusion:

According to the problem of environmental pollution and the hunger crisis caused by the world's expanding population, it appears that using organic fertilisers can not only reduce environmental pollution, eutrophication, groundwater pollution, and disease brought on by overusing conventional chemical fertilizer, but also due to its capacity to enhance physiological traits as well as yield and yield components of crops. Consequently, it's recommended to replace organic fertilizers with bio fertilizers produced by bacteria especially in sandy soils due to the potential for increased ground water pollution and the leaching of conventional chemical fertilisers. Moreover, the appropriate selection of fertilizer rate increased to maximize the agronomic productivity of sesame crop and minimize fertilizers loss. Hence B. cereus 54=1gave the best result, while mixture of three organisms gave weak results compared with every organism individual. On the other hand the excess of organic fertilizers from 0 Ton/F to 2Ton/F gave good results and vis versa the excess of organic fertilizers from 2 to 4 Ton/F gave weak results.

<u>6. Conflicts of interest</u>

The authors declare that they have no competing interest.

<u>7. Formatting of funding sources</u>

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