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Potential of *Spirulina platensis* and *Saccharomyces cerevisiae* in Integration with Organic Amendments Towards Root–Knot Nematode, *Meloidogyne incognita* on Soybean

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ABSTRACT

A greenhouse experiment was carried out to assess the potential of the cyanobacterium, *Spirulina platensis*, yeast, *Saccharomyces cerevisiae* and two organic amendments namely, molasses and yeast extract singly or integrated for the management of root-knot nematode, *Meloidogyne incognita* on soybean**.** Results revealed that soil drenched with *S. cerevisiae* outperformed *S. platensis* in promoting plant criteria i.e. plant length, shoot and root weights and total plant fresh weight and reducing nematode parameters in terms of total nematode population and root galling. A synergistic impact on plant and nematode characters resulted in the combination of *S. cerevisiae* and *S. platensis*. However, the beneficial effect of both *S. platensis* and *S. cerevisiae* increased with the introduction of molasses to soil recording 96.6, 91.3 and 92.3% reduction in nematode population, number of females and galls, respectively as well as 14.8 and 261.1% improvement in plant length and total plant fresh weight, respectively**.** Meanwhile, integration of cyanobacterium with organic amendments (yeast extract and molasses) recorded the highest significant ($P \leq 0.05$) values of chlorophyll A and B, nitrogen, phosphorus and potassium. The present findings suggest that soil application with both *S. platensis* and *S. cerevisiae* as well as organic amendments could be environmental safe, cost-effective and promising alternative of nematicides against *M.incognita*.

Keywords*:* Biocontrol agent, cyanobacterium, yeast, molasses, yeast extract, *Meloidogyne incognita*, soybean

INTRODUCTION

Soybean (*Glycine max* L.) is a vital globally leguminous crop and a major source of oil and protein which comprise approximately 20 and 40% of the soybean, respectively (Clemente and Cahoon, 2009). Plant parasitic nematodes are among the most important pests of soybean causing an estimated annual crop loss of $78 billion worldwide (Lima et al., 2017) and an average crop yield loss of 10–15%. Root-knot nematodes, *Meloidogyne* spp., particularly *M. incognita* are amongst the most important widespread pathogens and consistent threat to soybean production that have been emerged in recent years (Roth et al., 2020). A total of 75% yield loss has been reported on early-maturing soybean in a field infested with *M. incognita* (Emerson et al., 2018). Biological control using bacteria and fungi is considered to be an efficient alternative method that can be combined with others within an integrated management system as aim to decrease the negative environmental impacts of the excessive nematicides. During the last decade, great interest has been paid to the use of cyanobacterium and yeast as bio fertilizers in agriculture because of their bioactivity and safety for human and the environment. Cyanobacterium, *Spirulina platensis* belonging to Cyanophyta is a blue-green alga with medicinal and nutritional interest due to its richness in proteins, minerals, carbohydrates, phytopigments and antioxidants (Bitam and Aissaoui, 2020).

Extracts and exudates of cyanobacterium have been reported to inhibit egg hatching and cause immobility and mortality of 2ndjuveniles of plant parasitic nematodes *in vitro* (Holajjer et al., 2013). Various studies have shown the nematicidal potential of *S. platensis* against root-knot nematode (Shawky et al., 2009; Sharaf et al., 2016; Hamouda et al., 2019; El-Eslamboly et al., 2019). Yeast, *Saccharomyces cerevisiae* is a promising plant growth promoter for different crops as well as a biocontrol agent of root-knot nematodes (Karajeh 2013; Mokbel and Alharbi 2014; Youssef and El-Nagdi, 2018). Yeast increases plant resistance against harmful pests, especially parasitic nematodes, by increasing the concentration of total phenolic compounds in the roots (Karajeh, 2013). Hamouda et al. (2019) revealed that the usage of *S. cerevisiae* and *S. platensis* in combined treatment revealed the greater antagonistic action on *M. incognita* in potted banana. The addition of organic amendments may improve soil structure and fertility, so that plant vigor improves and plants are better able to tolerate the effects of nematodes (Stirling, 1991; El-Nagdi et al., 2019), but direct effects on nematodes may occur through the release of toxic compounds during decomposition, stimulation of natural enemies or through changes in the level of plant resistance. Sugarcane molasses as organic amendment was found effective to manage root-knot nematodes (Khan et al., 2016). The present study was carried out to investigate the effectiveness of *S. platensis* and *S. cerevisiae* and two organic amendments, molasses and yeast extract on *M. incognita* and plant growth of soybean under greenhouse conditions.

MATERIALS AND METHODS

A greenhouse experiment was conducted at the Nematological Research Unit (NERU), Faculty of Agriculture, Mansoura University, Egypt, in order to evaluate the nematicidal properties of cyanobacterium (blue green alga), *Spirulina platensis*, yeast, *Saccharomyces cerevisiae* as well as yeast extract and molasses as organic amendments against *M. incognita* infecting soybean.

Microbial and organic agents

All tested agents except yeast were obtained from Microbiology Dept., Fac. Agriculture, Mansoura Univ., Mansoura, Egypt.

Cyanobacterium, Spirulina platensis

Aqueous extract of the blue green alga, *Spirulina platensis* was prepared and concentrations of 50 and 100 ppm were done.

Yeast, Saccharomyces cerevisiae

Dried powder of yeast, *Saccharomyces cerevisiae* was purchased from a local shop and a total of 0.5g of yeast was dissolved in 100 ml of distilled water and concentrations of 50 and 100 ppm were prepared.

Organic amendments

Yeast extract powder and molasses both were obtained from Microbiology Dept., Fac. Agriculture, Mansoura Univ., Mansoura, Egypt.

Yeast extract

A total of 0.5g of yeast extract powder was dissolved in 100 ml of distilled water and concentrations of 50 and 100 ppm were prepared.

Molasses

A total of 0.5 g of molasses mixed with 100 ml distilled water and concentrations of 50 and 100 ppm were prepared.

Nematicide

Oxamyl (Vydate) 24% L. Methyl-N'N'- dimethyl-N [(methyl) carbamyloxy]-1-thioxamidate, was used at the rate of 0.3 ml / pot.

Experimental design

Soybean seeds cv. Giza111 were sown, three seeds per hole, in plastic pots (15 cm-d) containing sterilized sandy loam soil (1:1). Two weeks later, seedlings were thinned to one plant per pot and inoculated with 600 second stage juveniles (J2s) of *M. incognita* spread around the base of plant and as close to the roots as possible. Simultaneously, cyanobacterium (*S. platensis*), yeast (*S. cerevisiae*) as well as molasses and yeast extract as organic amendments were applied as soil drench singly and in combination at a rate of 4ml/ pot. Plants free of nematodes and treatments were served as healthy plants (Check). While those receiving nematode inoculum were served as inoculated untreated plants (Control). Two days after nematode inoculation the conventional nematicide, oxamyl was applied to soil at the rate of 0.3ml/pot.

Treatments were as follows: 1) Cyanobacterium; 2) Yeast; 3) Molasses; 4) Yeast extract; 5) Cyanobacterium + yeast; 6) Cyanobacterium + molasses; 7) Cyanobacterium + yeast extract; 8) Yeast + molasses; 9) Yeast extract + molasses; 10) Cyanobacterium + yeast + molasses; 11) Cyanobacterium + yeast extract + molasses; 12) Oxamyl 24% L; 13) Plant free of nematode, and 14) Nematode only.

Pots were set up in a completely randomized design with four replicates for each treatment. Pots were irrigated with tap water as needed. Plants were harvested 45 days after nematode inoculation. Data dealing with shoot and root fresh weights, dry shoot weight, shoot and root lengths, were recorded. Second stage juveniles (J_2s) were extracted from 250g soil using sieving and modified Baermann technique (Goodey, 1957). The nematode suspensions were examined in a Hawksely counting slide with an anatomy microscope to quantify the numbers of juveniles. Roots were stained with acid fuchsin in lactic acid (Bybd et al., 1983) and numbers of galls, developmental stages and females were determined.

Biochemical tests

At the end of experiment, dried leaves of soybean were subjected to biochemical tests. Chlorophyll A and B, were estimated according to the method of Bradford (1976) while Nitrogen (N), phosphorus (P) and potassium (K), were estimated using the method described by Malik and Singh (1980).

Data analysis

Data of the current investigation were subjected to statistical analysis of variance (ANOVA) (Gomez and Gomez, 1984) using CoStat computer software (CoStat, 2005), and means were compared according to Duncan’s multiple range test at $P \leq 0.05$ (Duncan, 1955).

RESULTS

Data in Table (1) represent the impact of cyanobacterium, yeast, molasses and yeast extract applied singly or in integration on *M. incognita* infecting soybean Giza 111 under greenhouse conditions. Results indicated that *M. incognita* infection caused a

Table 1: Impact of various bio-agents on plant growth parameters of soybean infected with-root-knot nematode, *Meloidogyne incognita* under greenhouse conditions.

	Length (cm)				Weight (g)							
Treatments	Shoot	Root	Total plant length	Inc. or Dec.%	Shoot weight	Inc.%	Root Weight	Total plant fresh weight	Inc. %	Shoot dry weight	Inc. or Dec.%
Cyanobacterium (*Spirulina platensis*)	58.1a	21.3 b	79.4 ab	3.1	7.7 cd	67.4	1.6 bc	9.3 d	72.2	3.6 a-c	20.0
Yeast (*Saccharomyces cerevisiae*)	46.0 a	25.0 b	71.0 ab	-7.8	7.8 cd	69.6	2.0 a-c	9.8 cd	81.5	2.2 c	-26.7
Molasses	55.8 a	29.0 b	84.8 ab	10.1	8.5 b-d	84.8	3.4 a	11.8 b-d	118.5	3.6 a-c	20.0
Yeast extract	55.3 a	28.8 b	84.0 ab	9.1	10.7 bc	132.6	2.6 ab	13.3 bc	146.3	3.6 a-c	20.0
Cyanobacterium + yeast	38.3 a	30.0 b	68.3 ab	-11.3	8.4 b-d	82.6	2.6 ab	10.7 cd	98.2	3.1 bc	3.33
Cyanobacterium + molasses	48.8 a	31.8 b	82.0 ab	6.5	11.5 b	150.0	3.1 ab	14.6 bc	170.4	3.6 a-c	20.0
Cyanobacterium + yeast extract	38.7 a	32.0 b	70.7 ab	-8.2	10.9 bc	137.0	2.9 ab	13.2 c	144.4	2.1 c	-30.0
Yeast + molasses	44.7 a	31.8 b	76.5 ab	-0.6	8.4 b-d	82.6	2.4 ab	13.3 bc	146.3	3.5 a-c	16.7
Yeast extract + molasses	32.0 a	21.3 b	53.3 b	-30.8	8.5 b-d	84.8	1.6 bc	10.1 cd	87.0	4.6 ab	53.3
Cyanobacterium + yeast + molasses	55.0 a	33.3 b	88.3 ab	14.8	16.5a	258.7	3.1 ab	19.5 a	261.1	3.7 a-c	23.3
Cyanobacterium+ yeast extract+ molasses	39.3 a	32.8 b	72.1 ab	-6.4	6.8 d	47.8	3.5 a	10.3 cd	146.3	3.2 a-c	6.7
Oxamyl 24%	69.7 a	32.5 b	102.1ab	32.6	7.3 cd	58.7	2.6 ab	9.8 cd	81.5	2.8 bc	-6.7
Plant free of nematode	65.3 a	45.0 a	110.3a	43.2	9.9 b-d	115.2	3.5 a	13.5 bc	150.0	5.1 a	70.0
Nematode only (N)	52.7 a	24.3 b	77.0 ab		4.6 c		0.8 c	5.4 e		3.0 bc	-

Each value is the mean of four replicates. N= 600 J2s. Means in each column followed by the same letter(s) are not significantly different ($P \leq 0.05$) by Duncan's multiple range test. Increase or decrease % (Inc. or Dec.%) = [Treated - nematode only (control) / nematode only (control)] ×100 significant decrement in plant growth parameters with reduction percent in plant length and shoot weight reached 30.19 and 53.54%, respectively. Yeast, *S. cerevisiae* stimulated soybean plant criteria in terms of shoot fresh weight (69.57%) and total plant fresh weight (81.48%) better than aqueous extract of cyanobacterium, *S. platensis*. Hence, in dual treatment, integration of both yeast and cyanobacterium showed a synergistic impact on such parameters recording 82.61and 98.15%, respectively.

Notably, single treatment of organic amendment namely, yeast extract showed the best augmentation in shoot weight and plant fresh weight with percentages of increase amounted to 132.61 and 146.30, respectively. However, integration of molasses with cyanobacterium significantly increased the effectiveness of *S. platensis* on soybean plant fresh weight (170.37%) better than yeast extract addition (144.44%). Similar trend was noticed with shoot dry weight. Apparently, triple applications gave better results than did single or dual ones. Hence, combined treatment of molasses with both *S. platensis* and *S. cerevisiae* gave the best augmentation in total plant length (14.8%), shoot weight (258.7%) and total plant weight (261.1%). Conversely, soil treated with the aqueous extract of the single microbial agent, *S. platensis* and two organic amendments gave a non-significant increase in such parameters. Oxamyl recorded the best result (32.6%) in improving plant length only followed by molasses (10.1%). Among the observed data, shoot dry weight of soybean was not significantly ($P \leq 0.05$) increased compared to positive and negative control.

The levels of N, P, K and chlorophyll in leaves of soybean infected with *M. incognita* varied significantly among the studied treatments (Table 2). Control treatment recorded the lowest values of chlorophyll A, B and NPK. However, irrespective to oxamyl, integration of cyanobacterium with yeast extract and molasses recorded the highest significant values of chlorophyll A (0.69); chlorophyll B (0.40), N (4.11), P (0.365) and K (2.75) with percentages of increase amounted to 24.17, 18.89 and 24.43% (Fig.1, a-e).

Table 2: Impact of various bio-agents on chemical constituents of dried leaves of soybean infected with *Meloidogyne incognita* under greenhouse conditions.

Treatments	Chlo. A mg/ g	Chlo.B mg/ g	N %	P %	K%
Cyanobacterium (*Spirulina platensis*)	0.59 m	0.28 m	3.40 m	0.314 m	2.28 m
Yeast (*Saccharomyces cerevisiae*)	0.61 k	0.30 k	3.55 k	0.323 k	2.38 k
Molasses	0.60 l	0.29 l	3.47 l	0.318 l	2.33 l
Yeast extract	0.62 j	0.33 J	3.61 j	0.327 j	2.42 J
Cyanobacterium + yeast	0.66f	0.37 f	3.88 f	0.347 f	2.63 f
Cyanobacterium + molasses	0.63 i	0.33 i	3.68 i	0.331 i	2.48 i
Cyanobacterium + yeast extract	0.67 e	0.38 e	3.96 e	0.354 e	2.67 e
Yeast + molasses	0.64 h	0.34 h	3.76 h	0.347 h	2.53 h
Yeast extract + molasses	0.65 g	0.35 g	3.81 g	0.341 g	2.57 g
Cyanobacterium +yeast+ molasses	0.68 d	0.39 d	4.03 d	0.360 d	2.70 d
Cyanobacterium+ yeast extract +molasses	0.69 c	0.40 c	4.11 c	0.365 c	2.75 c
Oxamyl	0.70 b	0.42 b	4.17 b	0.369 b	2.80 b
Plant Free of nematode	0.72 a	0.43 a	4.26 a	0.375 a	2.86 a
Nematode only (N)	0.58 n	0.27 n	3.31 n	0.307 n	2.21 n

Each value is the mean of four replicates. N= 600 J2s. Means in each column followed by the same letter(s) are not significantly different ($P \leq 0.05$) by Duncan's multiple range test.
Chlo=Chlorophyll; N=Nitrogen; P=Phosphorus; K=Potassium.

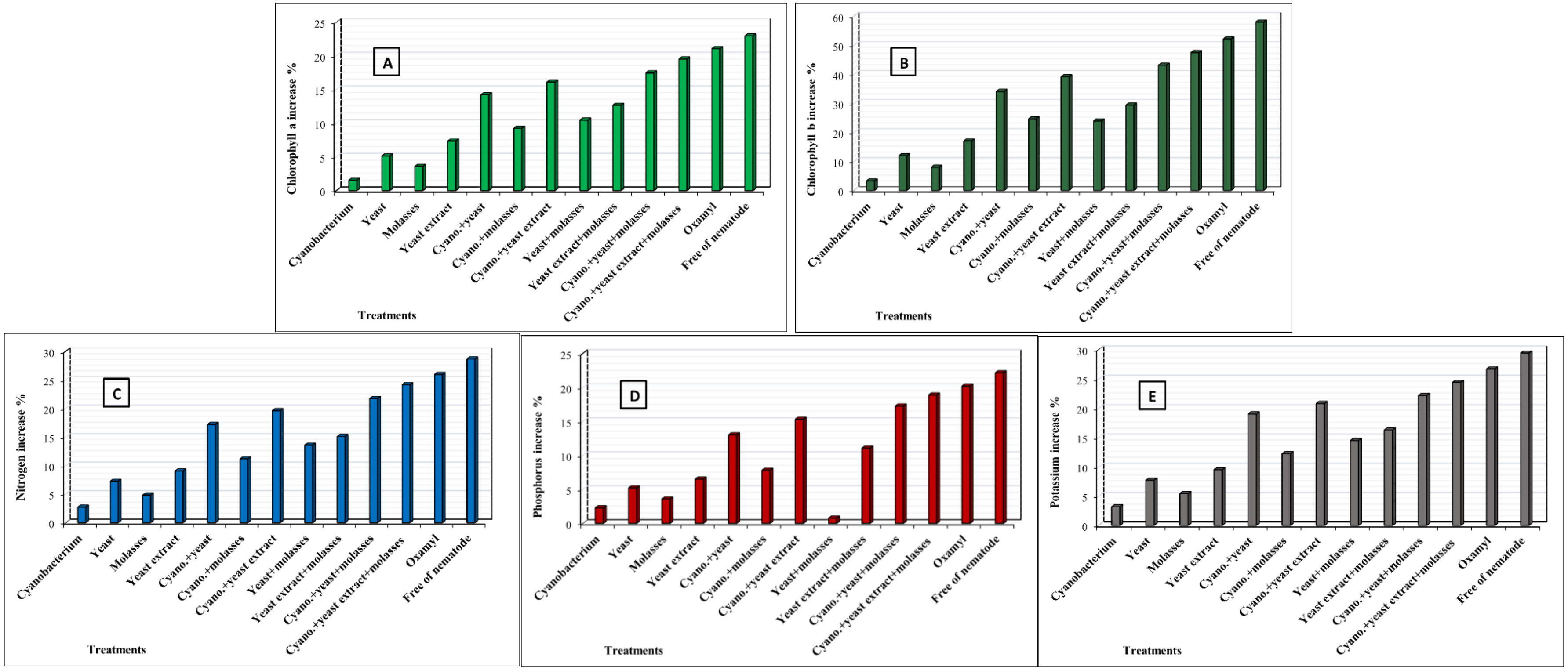

Figure.1: Effect of tested bio-agents on increase percentages of chemical constituents in dried leaves of soybean infected with *Meloidogyne incognita* under greenhouse conditions.

The role of tested bio- agents in reducing development and reproduction of *M. incognita* infecting soybeans was accentuated in Table (3) and Fig. (2). Untreated plants infected with *M. incognita* harbored higher number of nematode population, where RF=1.49. All treatments resulted in a remarkable suppression in nematode population densities compared to control. The highest percentage of reduction in nematode parameters was obtained with oxamyl (100%). Yeast, *S. cerevisiae* significantly suppressed numbers of total nematode population (55.0%), females (66.7%) and galls (69.2%) better than *S. platensis* recording reproduction factor (RF) equal to 0.70.

Table 3: Reduction percentage in soil and root population of *Meloidogyne incognita* infecting soybean as influenced by various bio-agents applied singly or in integration under greenhouse conditions.

Treatments	Reduction % in numbers of			Red. % in total population	Red. % in No. of galls
	J2s in soil/pot	Develop. Stages	Females		
Cyanobacterium (*Spirulina platensis*)	48.7	78.9	58.3	48.9	61.5
Yeast (*Saccharomyces cerevisiae*)	54.8	75.8	66.7	55.0	69.2
Molasses	40.2	93.9	83.3	42.8	92.3
Yeast extract	96.9	90.9	91.7	96.9	91.3
Cyanobacterium+ Yeast	73.6	87.9	75.0	73.7	76.9
Cyanobacterium + molasses	75.9	81.8	75.0	73.9	76.9
Cyanobacterium + yeast extract	80.3	87.9	83.3	80.3	69.2
Yeast + molasses	51.9	75.8	58.3	52.2	61.5
Yeast extract + molasses	75.6	78.3	75.0	75.6	76.9
Cyanobacterium + yeast+ molasses	96.9	96.9	91.7	96.6	92.3
Cyanobacterium +yeast extract+ molasses	89.3	87.9	83.3	89.3	76.9
Oxamyl	100	100	100	100.0	100

Red. % (Reduction%) = [Nematode only (control) – Treatment / Nematode only (control)] ×100
Reproduction Factor (RF) = Final population (P_f) / Initial population (P_i)

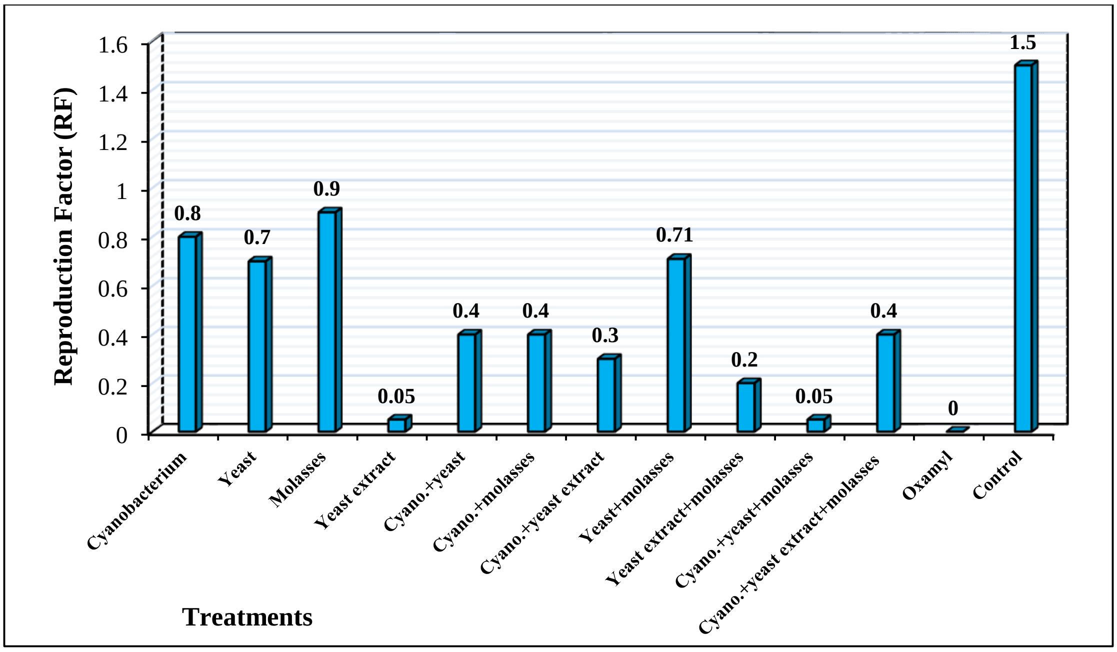

Figure 2: Impact of tested bio-agents on reproduction factor of *Meloidogyne incognita* infecting soybean.

However, an antagonistic properties were recovered with the integration of both microbial bio-agents; yeast + cyanobacterium against such nematode parameters scoring 73.7, 75.0 and 76.9%, respectively recording RF= 0.40 compared to individual applications.

The individual applications of organic amendment, yeast extract outperformed molasses, and significantly minimized numbers of total nematode population (96.9%), females (91.7%) and galls (91.3%) recording RF= 0.05. However, the introduction of molasses significantly ($P \leq 0.05$) enhanced the effectiveness of *S. platensis* against nematode parameters and significantly minimized total nematode population (73.9%), number of females (75.0%) and galls (76.9%) recording RF= 0.40.

Apparently, irrespective to yeast extract, triple application consisting of yeast + cyanobacterium + molasses surpassed other treatments and significantly ($P \leq 0.05$) reduced nematode population in soil and root (96.6%) showing a synergistic impact giving RF =0.05 and galls reduction =92.3%.

DISCUSSION

Several approaches including biological control and organic amendments have been launched with different degrees of success in the management of root-knot nematodes associated with soybean (Oyekanmi and Fawole, 2010). Yeast and cyanobacterium both are considered as new promising alternatives of chemical fertilizers and nematicides. Yeast, *S. cerevisiae* led to a significant decrease in the numbers of root-knot nematodes infecting beans (Osman et al., 2020) and cucumber (Karajeh, 2013). Its contents of carbohydrates produce ethanol and carbon dioxide, which have toxic effects on nematodes. Besides, yeast causes increments of plant resistance, as it competes with nematodes for nutrients and plays a role for making the physical and chemical properties of the soil unsuitable for the activity of plant parasitic nematodes (El-Nuby, 2021). The previous results confirmed the present findings in which the individual treatment of *S. cerevisiae* stimulated soybean plant criteria in terms of shoot fresh weight and total plant fresh weight, and significantly induced the highest reduction percentages in nematode criteria in terms of number of total nematode population, females and number of galls. Treatment of *S. cerevisiae* increased nitrogen, phosphorus potassium and the photosynthetic pigments (chlorophyll A, B) in soybean plant. These results confirmed the findings of Moller et al. (2016) who reported that yeast produces many active natural ingredients such as enzymes, plant hormones and oxen's groups (indole-3-acetic acid, IAA), which have an effective impact on increasing the productivity of the plant and the proportions of major elements in the leaves. The effectiveness of cyanobacterium, *S. platensis* was also expressed by suppressing root galling and final nematode population as well as improving vegetative and root growth of soybean. The nematicidal potential of such microbial agent is likely due to the huge production of secondary metabolites having nematicidal properties such as phenols, antioxidants, polyphenols, and flavonoids (Shawky et al., 2009; Chtourou et al., 2015). The presence of hormone components i.e., indoles, cytokinins, gibberellins, brassinosteroids, and other plant growth regulators including amino acids, peptides, and polyamines has beneficial influence on plant productivity and proportions of major elements (Lee et al., 2008; El-Eslamboly et al., 2019).

Soil drench with both *S. platensis* and *S. cerevisiae* gave better performance in plant vigor and nematode control providing soybean with various compounds (phytohormones and proteins) which led to an increment in major elements (nitrogen, phosphorous, potassium) and the photosynthetic pigments. This finding was conformed with that of Hamouda et al., (2019) who reported that the usage of *S. cerevisiae* and *S. platensis* in combination treatment revealed the greater antagonistic action on *M. incognita* in potted banana. The presence of flavonoids, polyphenols, phenylalanine, and antioxidants in yeast and cyanobacterium algal extract may affect nematode penetration and reduce gall formation (Chtourou et al., 2015). The present study revealed that molasses and yeast extract both had a significant effect on the management of root-knot nematode, *M. incognita* and consequently soybean plant growth. The addition of molasses with *S. platensis* and *S. cerevisiae* as soil drench achieved the highest significant reduction in nematode population and root galling of *M. incognita* infecting soybean and improved plant growth and chemical constituents as well. As reported by Schenck (2001), molasses soil amendments may supply carbohydrates and alter the C/N ratio. This affects the soil microbial ecology, usually resulting in lowered populations of plant parasitic nematodes as well as having other favorable effects on plant growth. The same author added that molasses do not pose a threat to the environment that chemical pesticides do, since it is readily decomposed in soil to CO_2 and harmless organic products. Also, its suppressant effect was probably due to antagonism by microorganisms, to changes in oxygen concentration due to microbial metabolism of molasses, or to the release of toxic compounds from decomposing molasses. The leaf nutrient concentrations i.e. NPK and chlorohyll A and B were significantly influenced by various biotic treatments and help in optimizing fertilizer scheduling (Pestana et al., 2005; Rodriguez-Navarro et al., 2011; Ortiz-Liebana et al., 2022) and reached their maximum values by the addition of *S. platensis* and yeast extract and molasses.

CONCLUSION

It can be concluded that *S. platensis* and *S. cerevisiae* as well as organic amendments (yeast extract or molasses) can be recommended as environmentally and friendly agents for the bio-management of root-knot nematode, *M. incognita* on soybean in organic farming.

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الملخص العربى

كفــاءة اســـتخـدام الطحلــب *Spirulina platensis* وفطر الخميرة *Saccharomyces cerevisiae* بالتكامل مع المحســنات العضــوية فى خفض الاصـــابة بنيماتودا تعقد الجذور *Meloidogyne incognita* على نبات فول الصويا

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اجريت الدراسة الحالية تحت ظروف الصوبة وتناولت تأثير استخدام المستخلص المائى للطحلب *Spirulina platensis* وهو من الطحالب الخضراء المزرقة وفطر الخميرة *Saccharomyces cerevisiae* واثنان من المحسنات العضوية (الخميرة والمولاس) فى صورة فردية او مشتركة فى التقليل من الاصابة بنيماتودا تعقد الجذور*M. incognita* على نبات فول الصويا ، واشارت النتائج الى ان سقى التربة باستخدام الخميرة *S.cerevisiae* تفوق على المعاملة باستخدام الطحلب *S. platensis* من حيث القياسات النباتية (طول النبات- وزن المجموع الخضرى والجذرى) والقياسات النيماتودية (التعداد الكلى للنيماتودا فى التربة والجذر -عدد العقد النيماتودية).وكان لاستخدام الطحلب والخميرة معا اثر نشط على القياسات النباتية والنيماتودية. وتبين الاثر المعنوى عند استخدام المولاس مع كل من الطحلب والخميرة مسجلا خفض للتعداد الكلى للنيماتودا (%٩٦.٦) وعدد الاناث (% ٩١,٣) وعدد العقد الجذرية (%٩٢,٣) وزيادة فى طول النبات (%١٤,٨.) والوزن الكلى للنبات (٢٦١,١ %). كما تشير النتائج الى زياده معنوية فى محتوى الكلوروفيل ا وب وعنصر النيتروجين والفوسفور والبوتاسيوم عند المعاملة بالطحلب المختبر وكلا المحسنات العضوية (مسخلص الخميرة والمولاس) . وبناء على النتائج الحالية يعد كل من الطحلب *S. platensis* و فطر الخميرة *S. cerevisiae* والمولاس وسائل مكافحة آمنة بيئيا ،غير مكلفة وبدائل للمبيدات النيماتودية ضد نيماتودا تعقد الجذور.