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The nematicidal efficacy of fulvic acid, yeast fungus (*Saccharomyces cerevisiae)* and L-tryptophan on plant parasitic nematodes, growth, and yield of banana plants

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ABSTRACT

Two field experiments were conducted during seasons of 2019 & 2020 to evaluate the efficacy of fulvic acid, yeast fungus (*Saccharomyces cerevisiae*) and the amino acid L-tryptophan singly or in combination (fulvic acid + yeast + tryptophan) against the root knot nematodes (*Meloidogyne* spp.) on banana plants in compared with oxamyl. The obtained results indicated that fulvic acid, yeast and tryptophan alone or in combination were the most effective treatments against the soil populations with reductions ranged from 42.1 to 58.4% during both seasons (2019&2020). In the same context, application of fulvic acid, yeast and tryptophan alone or in combination were recorded the highest reductions in females (ranged from 45.0 to 80.0%), egg masses (ranged from 39.1 to 86.1%) and root galls (ranged from 20.0 to 80.0%) during both seasons (2019&2020). On the other hand, vegetative and fruiting indices such as pseudostem and bunch weight, as well as fingers number and weight were improved with the application of fulvic acid, yeast and tryptophan alone or in combination. Furthermore, total carbohydrates and the levels of N, P and K were increased during both seasons significantly.

Key words: Plant parasitic nematodes, Fulvic acid, Tryptophan, Yeast, Safety control, Banana.

INTRODUCTION

Banana plantations (*Musa* spp.) is the leading tropical fruit in the world markets with a highly organized and developed industry and considered one of the highly profitable fruit crops and called the green gold (Gamliel and Van Bruggen, 2016). Banana fruits had a digestive process, due to its magnesium and potassium content. It has also help lower blood pressure and contain vitamin B6 (De la Torre *et al.*, 2008).

Banana plantations infected by many pests, where plant parasitic nematodes are the most deadly ones, as it causes great economic losses to bananas (Hamouda, *et al.*, 2019; Bakr *et al*.,2020). There are many nematicides that have effective role in attacking parasitic nematodes, but are not safe for human health as well as, it very expensive (Rani *et al.*, 2017).

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Therefore, it is necessary to use alternative methods that are safe for human health and effective against plant parasitic nematodes(Sweelam *et al*.,2021).

Fulvic acid is a natural compound classified among organic acids , which contains humic substance with high oxygen and low carbon content, and has a great ability to chelate other elements despite its small molecular weight (Huaanpu and Zhimin, 2004). Fulvic acid also facilitates the absorption of water, salts, nutrients leads to increase plant immunity against plant parasitic nematode, thus improves the vegetative and fruiting characteristics of the plant (Hamzah and Saad, 2020).

Yeast fungus, *Saccharomyces cerevisiae* increases plant resistance against harmful pests, especially parasitic nematodes, by increasing the concentration of total phenolic compounds in the roots (Karajeh, 2013). *Saccharomyces cerevisiae* produces the hormone cytokine, which leads to activate the process of division and nutrition of plant cells, consequently increases growth, and branching, total vegetative, quality of flowering and fruits process (Ignatova *et al.,* 2015). Amino acid (AA) L-tryptophan has a direct effect on parasitic nematodes, where it acts directly as a nematicide on nematodes or indirectly by chemotherapeutic effects on plants (Maareg *et al.*, 2014, Selim *et al*.,2019). In addition , amino acids stimulate the plant tolerances by increasing its resistance against parasitic nematodes and also improves the vegetative and fruiting qualities of plants (El-Nuby, 2021).

This study aims to evaluate some alternative nematicide agents that are safe and effective against nematodes infecting banana plantations, in addition to improve the vegetative and fruiting qualities of banana plants under field conditions.

MATERIALS AND METHODS

A field study has been carried out during two successive seasons (2019/2020) on banana. *Musa* sp. variety Williams grown in the Experimental Orchard Station of the Faculty of Agriculture at EL-Raheb, Menoufia Governorate. The experiment was carried out on first and second ratoon plants, to study the effect of three treatments, fulvic acid, yeast fungus, *Saccharomyces cerevisiae* and amino acid (AA) L-tryptophan single or in combination, to control plant parasitic nematodes that infected banana plants compared with the nematicide ,Oxamyl 24% L, as well as their effect on the vegetative, fruiting growth and leaf chemical composition of Williams banana.

Preparation and application of fulvic acid:

Extraction of fulvic acid was run according to method described by Sanchez *et al.,* (2002). The compost samples were treated with either 0.5 N NaOH or 1.0 N KOH (Bidegain *et al.,* 2000). The obtained extract contains impurities, which purified as described by Chen *et al.,* (1978). While the full purification of fulvic acid was completed according to method described by Kononva (1966). Fulvic acid was applied at 3000 ppm at a rate of 50 cm^3 per plant every two months (Hamzah and Saad, 2020).

Preparation and application of yeast (*Saccharomyces cerevisiae*):

For yeast application, dry active bread yeast (*Saccharomyces cerevisiae*) was dissolved in warm tap water (≈ 35 °C) at 5 g/liter to form a suspension and then a weight of sucrose (5 g) was added to activate the yeast. The mixture was stirred until fully homogenized, then kept for 3 hours at room temperature and placed in fridge until used on the same day (El-Nuby, 2021). It was applied every two months throughout the experimental period in the rhizosphere area of each plant at a rate of 50 ml /plant.

Preparation and application of tryptophan:

The amino acid L-tryptophan was obtained kindly from Pharmaceutical Department National Research Center, Giza, Egypt. It was applied every two months throughout the experiment period at a concentration of 1000 ppm at a rate of 150 ml in the rhizosphere / plant (El-Nuby,2021).

Application of Oxamyl:

Vydate 24% L: Oxamyl (2-dimethylthio) glyoxal-0-methylcarbamoyl monoxime) was applied only one time at the beginning of each experiment around the roots of plants at a rate of 30 ml/plant according to Metwally *et al.,* (2019).

Experimental design:

Field experiment was carried out as randomized complete block design during two successive seasons (2019/2020) on Williams banana (*Musa* sp.). First ratoon was planted in March 2019 and the fruit collection began from December 2019. The second ratoon was planted in March 2020 and the fruit collection began in December 2020. Planting spaces were 4.0 × 4.0 meters apart and three suckers were selected in each hole yearly. For all plants of the experiment, each plot (hole) was surrounded by a belt from each side to control treatments and irrigation practices. All treatments were applied directly with agriculture and each treatment was replicated three times with three plants/ hole. Irrigation was sufficiently carried out at considerable intervals, avoiding susceptibility either to drought or to water logging.

The chemical and physical properties of the experimental soil indicated that, the texture of the soil was clay loam, the EC ranged between (0.27-0.33) mmhos/cm, pH ranged between (7.81-7.96) and CaCo3 ranged between (2.1-3.4%). So it could be concluded that the soil in this location was clay loam, none saline and none calcareous (Cottenie *et al.*,1982).

Composite soil samples (1000 cm^3) were taken for examining the parasitic nematodes before and after planting for two, four, six, eight, ten and twelve months after planting during the two seasons (2019 and 2020). At the end of the experiment, some vegetative and fruiting characteristics were taken and some chemical analysis were performed on the plant.

Nematode Extraction and Enumeration:

Each composite soil sample was carefully mixed, and an aliquot of 100 cm^3 was processed for nematode extraction according to method described by Southey (1970) each treatment was replicated three times. An aliquant of 1 ml each of nematode suspensions were pipetted off, placed in a Hawksley counting slide and examined by using a stereomicroscope. Nematode identification to generic level was based on morphology of the adult and juvenile forms, according to the description of Mai and Lyon (1975). The most common genera *Meloidogyne*, *Pratylenchus* and *Xiphinema* but the most numerous genus was *Meloidogyne*, and the rest of genera were in very few numbers.

At the end of the experiment roots were carefully washed, the nematode galls were counted and rated as mentioned Southey (1970) in Table (1) as well as one gram per root was stained by acid fuchsine lactophenol to count root knot nematode stages inside the roots with the aid of a dissecting microscope. Egg masses were assessed by staining the roots with Phloxin-B solution (0.15 g/l tap water) for 20 minutes according to Daykin and Hussey (1985).

Table (1): Rating scale levels of galls numbers.

Number of galls/ root system	Gall index
0	0
1-2	1
3-10	2
11-30	3
31-100	4
>100	5

Chemical analysis:

Total carbohydrate percentages in the dried leaves were determined by using the colorimetric method of Dubois, *et al.*, (1956). Nitrogen, Phosphorus and Potassium percentages were determined in the dried leaves by Kjeldah methods, using Spectro-photometericly and by Flame photometer, respectively (Cottenie, *et al.*, 1982). Reduction percentages were counted according to the formula of Henderson and Tilton (1955)as:

$$\text{Reduction\%} = \left[1 - \left(\frac{\text{Treatment after}}{\text{Treatment before}} \times \frac{\text{Control before}}{\text{Control after}}\right)\right] \times 100$$

Increase or Decrease % = treatment– control / control x 100

Statistical analysis:

The obtained data were subjected to analysis of variance (ANOVA) using CoStat Software, Version 6.4 (2008). The mean differences were compared by Least Significant Difference (L.S.D. 5%)

RESULTS AND DISCUSSION

In the first season (2019):

Results in Table (2) showed that, Tryptophan was the best individual treatment effect on plant parasitic nematode in soil with a decrease of (49.5%) followed by yeast (44.9%) and fulvic acid (42.1%) compared with control.

As for the combined treatment (fulvic acid + yeast + Tryptophan), its effectiveness was higher than that occurred in application of each treatment separately, as it led to an increase in the decrease rate of parasitic nematode stages to (56.6%), while chemical nematicide Oxamyl had a slightly higher effectiveness than that found by the combined treatment, which recorded a percentage mortality of (61.3%). compared with control.

Our results are in agreements with those that found by Hamzah and Saad (2020) who admitted that, fulvic acid is a natural chelating substance that helps to chelate; facilitate elements fixation in the soil; convert these elements from complex forms to simple components which are easily absorbed by banana roots consequently thus leads to increased immunity and plant resistance against parasitic nematodes. Dias *et al.*, (1999) recorded that, fulvic acid and humic acid resulting from the decomposition of organic fertilizers lead to the death rate 90% of plant-parasitic nematodes. Fulvic acid changes the soil pH and salinity and thus create unsuitable environment for the growth and development of parasitic nematodes, and reducing its risks (Habash and AL-Banna, 2011).

Table (2): Effect of fulvic acid, yeast and Tryptophan singly or in combination on population number of plant parasitic nematodes infected banana plants and reduction % under field conditions along 2019 year

Treatments	Aver. no. of plant parasitic nematodes / 100 cm^3 soil							Overall mean
	Pre-treatment	Months post-treatments						
		2	4	6	8	10	12	
Fulvic acid	1749.0	1678.0b	1493.0b	1328.0b	1184.0b	967.0b	705.0b	1225.8b
Yeast	1724.0	1612.0c	1434.0c	1294.0c	1093.0c	837.0c	596.0c	1144.3c
Tryptophan	1753.0	1584.0d	1360.0d	1187.0d	1004.0d	739.0d	468.0d	1057.0d
Fulvic acid + Yeast + Tryptophan	1709.0	1476.0e	1194.0e	971.0e	752.0e	483.0e	391.0e	876.3e
Oxamyl 24% L	1761.0	1413.0f	1097.0f	908.0f	601.0f	498.0f	310.0f	804.5f
Control	1776.0	1879.0a	1939.0a	2109.0a	2373.0a	2604.0a	2731.0a	2272.5a
LSD 5%	-	7.1	7.1	7.1	7.1	7.1	7.1	8.8
Reduction %								
Fulvic acid	-	9.3	21.8	36.1	49.3	62.3	73.8	42.1
Yeast	-	11.6	23.8	36.8	52.6	66.9	77.5	44.9
Tryptophan	-	14.5	28.9	42.9	57.1	71.2	82.6	49.5
Fulvic acid + Yeast + Tryptophan	-	18.4	36.0	52.1	67.1	80.7	85.1	56.6
Oxamyl 24% L	-	24.2	42.9	56.6	74.5	80.7	88.6	61.3

Means in each column followed by the same letter (s) are not significant differences at 5% level

In the second season (2020):

Data in Table (3) confirm that the results of the second season (2020) are in agreements with those the results which recorded in the first season (2019) approximately, the combined treatment (fulvic acid + yeast + tryptophan) caused a reduction rate of (58.4%) in banana parasitic nematodes followed by singly treatments. Tryptophan (51.9%), yeast (48.9%), then fulvic acid (44.1%) compared with control. As for the nematicide Oxamyl, it decreased parasitic nematode stages with a slightly higher percentage than that found by the safe combined treatment under field conditions.

These results are consistent with Hamouda *et al.*, (2019) who determined that, *S. cerevisiae* reduced root-knot nematodes that infect banana plants. Karajeh (2013) found that the yeast *S. cerevisiae* caused increments the plant's immunity and thus created resistance to root knot nematodes that infect cucumbers, consequently it reduces root knots by a good percentage. Osman *et al.,* (2020) reported that yeast *S. cerevisiae* led to a significant decrease in the numbers of root-knot nematodes that infect beans under field conditions, its benefit from carbohydrates, produce ethanol and carbon dioxide, which have toxic effects on nematodes. Besides yeast caused increments of plant resistance, it competes with nematodes in 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).

Since *Meloidogyne* was the most numerous genus among the banana-parasitic nematodes genera, the results of Table (4) revealed that, Tryptophan led to a decrease in mature females, egg masses and root gall index during the two growing seasons 2019 & 2020 of 69.6 & 71.1 & 60.0% and 69.1 & 65.4 & 60.0%, respectively, followed by yeast, then fulvic acid. As for the combined treatment fulvic acid + yeast + Tryptophan led to decrease in mature females, egg masses and root gall index during the 2019 and 2020 growing seasons by 80.6 &78.9 & 80.0% and 79.4 & 79.1 & 80.0%, respectively, As for the nematicide Oxamyl gave slightly higher results than that occurred in the combined treatment during the two years under study.

These results are in harmony with El-Nuby (2014) who recorded that, the amino acid Tryptophan reduces the attractiveness of the roots to the root-knot juvenile; causes acquire roots some hardness and the synthesis of some compounds that reduce the attack of the root-knot juvenile on tomato plants. El-Nuby (2021) showed that tryptophan has a repellent effect on root-knot nematodes, and it has an indirect effect on increasing plant resistance to root-knot nematodes. Amdadul Hoque *et al.,* (2014) found that tryptophan reduced mature females, egg masses and root galls of tomato root knot nematodes. Karajeh (2013) recognized that, yeast led to the reduction of root knots and mature females in the root knot nematode that infects cucumber plants. Hamzah and Saad (2020) reported that fulvic acid reduced mature females, egg masses and root galls of root knot nematodes infected tomato plants. Abo-Korah (2021) cleared that the use of safety combined treatments for controlling plant parasitic nematodes can give an effect equal to or more than nematicides, but it is cheaper and safer on humans and plants.

Data in Table (5) revealed that, all treatments have significant differences. Tryptophan gave the best results in single treatments, it led to an increase length and circumference of pseudostem and total leaves during the two growing seasons 2019 & 2020 by 10.4 & 14.2 & 20.3% and 14.2 & 13.2 & 19.7% , respectively compared with control. As for the combined treatment fulvic acid + yeast + Tryptophan gave the best results among all the treatments, including the nematicide Oxamyl, as it led to an increase length and circumference of pseudostem and total leaves during the two growing seasons 2019 & 2020 with percentages by 15.0 & 17.3 & 34.5% and 18.6 & 17.6 &27.2% respectively, compared with control.

The obtained results are in agreement with El-Kenawy (2017) who recorded that, fulvic acid improves the properties of fruits, encourages vegetative growth and increases yield for grapevines. It also activates enzymes and energy compounds inside the plant, which consequently activates the internal cytokines, increases the division of plant cells, thus increased rate of growth and development in the plant. Chen *et al.,* (2004) reported that, fulvic acid transports trace minerals directly to metabolic locations inside plant cells thus, improving the vegetative qualities of the plant.

Results in Table (6) showed the superiority of the combined treatment fulvic acid + yeast + tryptophan over the rest, as it led to an increase in the proportion of nitrogen, phosphorous, potassium and total carbohydrates during the two growing seasons 2019 and 2020 at rates

14.9,8.1,19.9,17.8% and 16.0,8.1,20.2and 18.1%, respectively compared with control.

These results are coincident with Merwad (2011) and Hamouda *et al.*, (2019) who reported that yeast, *S. cerevisiae* increased growth, vegetative mass, quality of fruits, quantity produced, and improved the chemical properties of the plant. Moller *et al.*, (2016) 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 plant productivity, and increasing the proportions of major elements in the leaves.

Table (3): Effect of fulvic acid, yeast and tryptophan on number of parasitic nematodes infected banana and reduction % under field conditions along 2020 year

Treatments	Aver. no. of plant parasitic nematodes / 100 cm³ soil							Overall mean
	Pre-treatment	Months post-treatments						
		2	4	6	8	10	12	
Fulvic acid	1779.0	1641.0b	1429.0b	1297.0b	1201.0b	984.0b	730.0b	1213.7b
Yeast	1793.0	1638.0b	1417.0c	1228.0c	1012.0c	797.0c	602.0c	1123.2c
Tryptophan	1817.0	1613.0c	1314.0d	1140.0d	971.0d	797.0c	483.0d	1053.0d
Fulvic acid + Yeast + Tryptophan	1801.0	1499.0d	1145.0e	1006.0e	790.0e	513.0d	419.0e	895.3e
Oxamyl 24% L	1831.0	1471.0e	1110.0f	932.0f	648.0f	480.0e	351.0f	832.0f
Control	1824.0	1972.0a	2128.0a	2114.0a	2357.0a	2593.0a	2761.0a	2154.2a
LSD 5%	-	8.9	8.9	8.9	8.9	8.9	8.9	8.8
	Reduction %							
Fulvic acid	-	14.6	31.1	37.1	47.7	61.0	72.8	44.1
Yeast	-	15.5	32.3	40.9	56.3	68.7	77.8	48.9
Tryptophan	-	17.9	38.0	45.9	58.6	69.1	82.4	51.9
Fulvic acid + Yeast + Tryptophan	-	23.0	45.5	51.8	66.1	79.9	84.6	58.4
Oxamyl 24% L	-	25.7	48.0	56.1	72.6	81.6	87.3	61.6

Means in each column followed by the same letter (s) are not significant differences at 5% level

Table (4):Effect of certain treatments on decrease % of mature females, egg-masses production and root gall index of *Meloidogyne* spp through two seasons .

Treatments	Mature females /5g root	Egg-masses /5g root	Root gall index	Decrease %		
				Mature females	Egg-masses	Root gall
1st season (2019)						
Fulvic acid	14.1b	20.0b	4.0b	48.4	47.4	20.0
Yeast	11.0c	14.3c	3.0c	59.7	62.4	40.0
Tryptophan	8.3d	11.0cd	2.0d	69.6	71.1	60.0
Fulvic acid + Yeast + Tryptophan	5.3e	8.0de	1.0e	80.6	78.9	80.0
Oxamyl 24% L	4.1e	5.3e	1.0e	84.9	86.1	80.0
Control	27.3a	38.0a	5.0a	-	-	-
LSD 5%	1.8	3.6	0.4	-	-	-
2nd season (2020)						
Fulvic acid	16.0b	21.3b	4.0b	45.0	39.1	20.0
Yeast	11.3c	15.0c	3.0c	61.2	57.1	40.0
Tryptophan	9.0d	12.1c	2.0d	69.1	65.4	60.0
Fulvic acid + Yeast + Tryptophan	6.0e	7.3d	1.0e	79.4	79.1	80.0
Oxamyl 24% L	3.9f	5.9d	1.0e	86.6	83.1	80.0
Control	29.1a	35.0a	5.0a	-	-	-
LSD 5%	1.7	3.5	0.4	-	-	-

Means in each column followed by the same letter (s) are not significant differences 5% level.

Table (5): Effect of certain treatments on length, pseudostem circumference and leaf number of banana Williams planted in soil naturally infested with nematodes during two successive seasons (2019 & 2020).

Treatments	Pseudostem length (cm)	Pseudostem circumference(cm)	Total no. of leaves	Increase %		
				Pseudostem length	Pseudostem circumference	Total no. of leaves
1st season (2019)						
Fulvic acid	261.7d	77.3d	34.3cd	5.1	5.5	10.6
Yeast	269.0c	80.0c	35.0c	8.0	9.1	12.9
Tryptophan	274.9b	83.7b	37.3b	10.4	14.2	20.3
Fulvic acid +Yeast + Tryptophan	286.3a	86.0a	41.7a	15.0	17.3	34.5
Oxamyl 24% L	268.7c	76.3d	33.7d	7.9	4.1	8.7
Control	249.0e	73.3e	31.0e	-	-	-
LSD 5%	3.5	1.8	0.9	-	-	-
2nd season (2020)						
Fulvic acid	267.0d	79.0d	35.7d	9.5	4.4	11.6
Yeast	272.0c	82.7c	37.0c	11.6	9.2	15.2
Tryptophan	278.3b	85.7b	38.3b	14.2	13.2	19.7
Fulvic acid +Yeast + Tryptophan	289.0a	89.0a	40.7a	18.6	17.6	27.2
Oxamyl 24% L	264.0d	78.0d	34.3e	8.3	3.0	7.2
Control	243.7e	75.7e	32.0f	-	-	-
LSD 5%	3.6	1.9	0.7	-	-	-

Means in each column followed by the same letter (s) are not significant differences at 5% level.

Table (6): Effect of safety treatments on nitrogen(N) phosphorus(P) potassium (K) and total carbohydrates % in banana Williams leaves of banana plants in soil naturally infested with nematodes during the 2019 and 2020 seasons.

Treatments	N (%)	P (%)	K (%)	Total carbohydrates(%)	Increase %			
					N	P	K	Total carbohydrates
1st season (2019)								
Fulvic acid	2.89d	0.218c	3.41d	31.07d	4.7	4.3	6.2	2.8
Yeast	2.94c	0.217c	3.52c	32.41c	6.5	3.8	9.7	14.4
Tryptophan	3.01b	0.222b	3.63b	32.87b	9.1	6.2	13.1	15.9
Fulvic acid +Yeast + Tryptophan	3.17a	0.226a	3.85a	33.39a	14.9	8.1	19.9	17.8
Oxamyl 24% L	2.82e	0.214d	3.29e	29.71e	2.2	2.4	2.5	4.8
Control	2.76f	0.209e	3.21f	28.34f	-	-	-	-
LSD 5%	0.02	0.001	0.04	0.09	-	-	--	-
2nd season (2020)								
Fulvic acid	2.90d	0.219c	3.45d	30.74d	5.4	4.3	7.1	8.5
Yeast	2.96c	0.216cd	3.57c	32.49c	7.6	2.9	16.5	14.7
Tryptophan	3.06b	0.223b	3.68b	32.91b	11.3	6.2	14.3	16.2
Fulvic acid +Yeast + Tryptophan	3.19a	0.227a	3.87a	33.45a	16.0	8.1	20.2	18.1
Oxamyl 24% L	2.83e	0.213de	3.31e	29.74e	2.9	1.4	2.8	4.9
Control	2.75f	0.210e	3.22f	28.33f	-	-	-	-
LSD 5%	0.04	0.004	0.05	0.19	-	-	-	-

Means in each column followed by the same letter (s) are not significant differences at 5% level

Results in Table (7) show that there are significant differences between all treatments during the 2019 and 2020 planting seasons. In confirmation of the previous results, the combined treatment Fulvic acid + Yeast + Tryptophan gave the best results over the rest as it led to an increase in the bunch weight, number of fingers per bunch and finger weight during the 2019 and 2020 planting seasons by 73.5 & 71.6 & 24.8% and 80.6 &76.8&28.3%, respectively compared with control.

These results are in coincidence with those obtained by Surendar, *et al*., (2013) who found that, amino acid Tryptophan is the main component of protein which act as powerful chelating agents for microelements because the molecular weight of amino acids is very small, and the microelements associated with them are easy to permeate into the plant. Hence, its effectiveness increase the plants' tolerance to adverse difficult conditions such as heat, thirst, salinity and frost. Ranjit and Jyoti (2013), recorded that, Tryptophan helps in the formation of oxen's which active the plant growth; increase the physiological activity of the plant, stimulate plant hormones and growth materials. Also it has a role in early cropping and thus leads to increments in the productivity of banana plants.

Table (7): Effect of adopted treatments on bunch weight, number of fingers / bunch and finger weight of banana plants in soil naturally infested with nematodes during 2019 and 2020 seasons.

Treatments	Bunch weight (kg)	Finger number / bunch	Finger weight (g)	Increase %		
				Bunch weight	Finger numbers	Finger weight
1st season (2019)						
Fulvic acid	17.9cd	173.0d	110.91d	15.5	24.2	16.7
Yeast	19.0c	191.3c	113.54c	22.6	37.3	19.5
Tryptophan	23.3b	204.3b	115.38b	50.3	46.7	21.4
Fulvic acid + Yeast + Tryptophan	26.9a	239.0a	118.64a	73.5	71.6	24.8
Oxamyl 24% L	17.3d	163.0e	105.04e	11.6	17.0	10.5
Control	15.5e	139.3f	95.03f	-	-	-
LSD 5%	1.7	5.3	0.9	-	-	-
2nd season (2020)						
Fulvic acid	19.0d	186.0d	111.94 d	18.8	30.9	19.2
Yeast	20.9c	197.7c	114.67c	30.6	39.2	22.1
Tryptophan	24.9b	229.0b	116.47b	55.6	61.3	24.0
Fulvic acid + Yeast + Tryptophan	28.9a	251.0a	120.47a	80.6	76.8	28.3
Oxamyl 24% L	18.0d	179.7d	107.07e	12.5	26.6	14.0
Control	16.0e	142.0e	93.92f	-	-	-
LSD 5%	1.4	7.1	1.3	-	-	-

Means in each column followed by the same letter (s) are not significant differences at 5% level.

Finally, it could be concluded that the best and optimum in its aptly, forceful and competency occurred by application of combined treatment (fulvic acid + yeast + tryptophan) where it improved vegetative, fruiting and chemical characteristics of banana plants, superior to the nematicide Oxamyl. Combined treatment also succeeded in reducing plant parasitic nematode populations and root galls by slightly less than the applicable of nematicide Oxamyl through both seasons (2019&2020), it consider cheaper and safer for humans and plants, consequently the present study recommends the use of combined treatment of fulvic acid + yeast + tryptophan in integrated control programs for parasitic nematodes that infect banana plants.

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