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Partial Replacement of Chemical N Fertilizer by Plant Compost Inoculated with Some Strains of Rhizobiain Barhee Date Palms Growing in Sandy Soil

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Abstract

In sustainable agriculture, soil health and productivity depend on integrating bacterial inoculants with fertilizer management systems. Azotobacter-based biofertilizers are proposed as a substitute or supplement for artificial nitrogen fertilizers in crop production to enhance soil nutrient levels. In a laboratory experiment, around three rhizobial strains (two of *Rhizobium leguminosarum127k80c* and SU157" and one of *Brady rhizobium japonicum* USDA110spc4) were previously classified as plant growth-promoting rhizobacteria (PGPR). Barhee date palms were supplied with these microbial strains at 25 to 75 ml per palm and organic N (plant compost) fertilizers at 25 to 75% of the recommended amount as a partial replacement of chemical N fertilizer (ammonium nitrate) during 2022 and 2023 seasons. Providing Barhee date palms cultivated in sandy soil with nitrogen comprising 50 to 75% chemical nitrogen (ammonium nitrate) and 25 to 50% organic nitrogen (plant compost), along with any one of three nitrogen-fixing bacterial strains at 25 to 50 ml per palm, significantly enhanced growth characteristics, leaf pigments of nitrogen, phosphorus, and potassium, as well as flowering, fruit set, and yield per palm compared to the application of chemical nitrogen alone. The optimal bacterial strain was strain 1, succeeded by St-2, while St-3 ranked last. Enhancing Barhee date palm output. Fertilize trees with 50% commercial N fertilizer, 50% plant compost, and 50 ml/palm strain 1. 25% ammonium nitrate, 75% plant compost, and 75 ml St-3 gave the vines the best results.
Keywords: plant compost, bacterial strains, growth-yield-quality- Barhee date palms

Introduction

Fruits of date palms have a higher nutritional value since about 75% of the dry matter in dates is sugar (sucrose, glucose, and fructose). Dates are a good source of iron and potassium and a good source of calcium, magnesium, sulphur and copper. They contain about sixteen kinds of free amino acids, and the seeds contain proteins, fiber, fats, ash, and about 60% carbohydrates on a dry weight basis, with higher concentrations of potassium, phosphorus, calcium, magnesium, manganese, copper, and zinc. The major fatty acids in the seed oil are oleic and linoleic (NAS, 1980;' Ibrahiem et al., 1990; Hussein et al., 1993; and Wrigley, 1995). Date palm Barhee is marketable and eaten fresh in the fully ripe yellow (Khelal) stage, resembling a crisp apple due to its low soluble tannin concentration compared to many other cultivars (Al-Qurashi and Awad, 2011; Abd El-Haleem et al., 2020). Clean farming is proposed as a viable method to restore natural conditions and has emerged in recent decades as a positive alternative to chemical fertilizers; hence, the use of natural fertilizers is recommended to mitigate pollution and decrease the expenses associated with chemical fertilizers. Conversely, agricultural soils have deteriorated in productivity due to the indiscriminate application of some chemical fertilizers and the influence of natural circumstances (Karaman, 2006). The buildup of heavy metals due to the persistent use of mineral fertilizers leads to several severe ailments in people. Nitrogen, as a plant nutrient, is required by plants at considerably bigger levels than other elements. N is a component of numerous plant components, such as chlorophylls, nucleotides, proteins, hormones, enzymes, and vitamins (Marschner, 1995). The nitrogen deficit typically leads to stunted development and chlorotic leaves, as insufficient nitrogen restricts the production of chlorophylls and proteins. This results in inadequate absorption, causing early blooming and a reduction in the growth cycle duration. Excess nitrogen fosters the growth of aerial organs while resulting in suboptimal root development, yield, and fruiting (Mengel, 1984; Nijjar, 1985; Mengel and Kirkby, 1987; Miller et al., 1990; Yagodin, 1990). Organic fertilizers include elevated levels of critical nutrients and growth regulators, effectively addressing soil and water salinity while enhancing soil fertility both physically and chemically. (Dalbo, 1992; Porro and Lacono, 1999 and Kannaiyan, 2002).

Topsoil compaction and considerable loss of organic matter are some of the adverse effects of chemical fertilization (Massah and Azadegan, 2016). Biofertilizer is a natural substance containing live microorganisms sourced from roots or cultivated soil. Consequently, they have no adverse influence on soil health or the ecosystem. In addition to their function in atmospheric nitrogen fixation and phosphorus solubilization, they also stimulate plant growth hormones, enhance nutrient absorption, and improve tolerance to drought and moisture stress. A small quantity of biofertilizer is adequate to yield favorable outcomes, as each gram of the biofertilizer carrier has no fewer than 10 million viable cells of a particular strain (Anandaraj and Delapierre, 2010). Multiple researchers have demonstrated that inoculation with Azotobacter and Azospirillum enhances the growth production and quality of horticulture crop fruits (Kannaiyan, 2002).

The deficiency of nitrogen in soil is often addressed by chemical fertilization. Prolonged use of large doses of nitrogen fertilizers can lead to ammonia volatilization and nitrate buildup in the soil. An optimal substitute for chemical fertilizer is essential due to its detrimental impact on soil health. Numerous solutions exist to improve soil fertility; one such option is Azotobacter. It is a free-living nitrogen-fixing diazotroph that positively influences crop development and yield. (Jnawali et al. 2015).

Azotobacter is becoming recognized as a significant fertilizing agent that enhances nitrogen availability, serves as an alternative for chemical fertilizers (Mohamed and Almaroai, 2016), and synthesizes secondary metabolites, particularly phytohormones and exopolysaccharides, which are absent in chemical fertilizers. Azotobacter lowered the dosages of chemical fertilizer and decreased early blight illnesses in long beans (Hindersah et al., 2018).

Materials and Methods

This experiment was carried out during the 2022 and 2023 seasons on thirty -18-year-old Barhee date palms grown in a private orchard situated in the west Samalout district, Minia Governorate, Egypt. The palms were produced via tissue culture and planted at 6.0 x 6.0 meters apart. After two days of female cracking, hand pollination was accomplished by introducing five male threads into each female spathe. The number of bunches was fixed to be ten for each palm. The soil texture is sandy, as given in Table 1. The drip irrigation system was followed, and pruning was carried out to maintain a leaf bunch ratio of 8:1 (Sayed, 2002).

Production of different N microbial strains

The material used in this work is the rhizobia strain bacterium of the host plant: *Phoenix dactylifera* L. (Date palm). A typical soil sample was collected from Jerid palm groves. Rhizobia strains bacteria were isolated using the wet-sieving (125 and 45 µm) and decanting technique described by Gerdemann and Nicolson (1963). Clusters of rhizobia strains were transferred to Petri dishes and enumerated in three replicates under a binocular microscope at 40X magnification, categorized based on morphological parameters such as form, size, and color.

Three rhizobia strains were utilized in this investigation received from Soil Microbiology Dep., Soil, Water and Environment Res. Inst., Agric., Res. Center, Giza, Egypt. Rhizobia strains serve as sources of phytohormones; one of these strains (strain-1) is *Bradyrhizobium japonicum* USDA110spc4, while the others (St-2 and St-3) are *Rhizobium leguminosarum* 127k80c and Su157. The organisms were cultivated in a YM broth medium (Vincent 1974) for 4 to 6 days to achieve optimal viable cell concentrations of around 3–9 x 109/ml. The rhizobia strains were previously identified as plant growth-promoting rhizobacteria (PGPR) and were confirmed to produce IAA, HCN, and siderophores in qualitative assessments (Ragab and Rashad, 2003).

Every chosen date palm was given the standard horticultural techniques currently used in the orchard, except for the trees using chemical N, organic N, and biofertilization of N. Additional horticultural procedures, including pruning and irrigation, along with pest control management, were performed as normal.

Each palm tree received an annual allocation of 1000.0 g of actual nitrogen per palm, sourced from either chemical or organic means, individually or in combination. This investigation encompassed the following 10 treatments utilizing chemical nitrogen (ammonium nitrate 33.5% N), plant compost (2.0% N), and Rhizobium strains, arranged as follows:

T1- 1000 g. of nitrogen as 100% chemical N (2985.0 g. of ammonium nitrate) per palm/year.

T2- 750 g. of nitrogen as 75% chemical N (2239.0 g. ammonium nitrate) + 250.0 g. N as 25% organic N (12.5 kg. plant compost) 25 ml strain 1 per palm/year.

T3- 500 g. of nitrogen as 50% chemical N (1493.0 g. ammonium nitrate) + 500 g. N as 50 % organic N (25.0 kg. plant compost) + 50 mL strain 1 per palm/year.

T4- 250 g. of nitrogen as 25% chemical N (747.0 g. ammonium nitrate) + 750 g. N as 75 % organic N (37.5 kg. plant compost) + 75 mL strain 1 per palm / year.

T5- 750 g. of nitrogen as 75% chemical N (2239.0 g. ammonium nitrate) + 250.0 g. N as 25 % organic N (12.5 kg. plant compost) + 25 mL St- 2 per palm / year.

T6- 500 g. of nitrogen as 50% chemical N (1493.0 g. ammonium nitrate) + 500 g. N as 50 % organic N (25.0 kg. plant compost) + 50 mL St- 2 per palm / year.
T7- 250 g. of nitrogen as 25% chemical N (747.0 g. ammonium nitrate) + 750 g. N as 75 % organic N (37.5 kg. plant compost) + 75 mL St- 2 per palm / year.
T8- 750 g of nitrogen as 75% chemical N (2239.0 g ammonium nitrate) + 250.0 g. N as 25 % organic N (12.5 kg. plant compost) + 25 mL St-3 per palm / year.
T9- 500 g. of nitrogen as 50% chemical N (1493.0 g. ammonium nitrate) + 500.0 g. N as 50 % organic N (25.0 kg. plant compost) + 50 mL St- 3 per palm / year.
T10- 250 g. of nitrogen as 25% chemical N (747.0 g. ammonium nitrate) + 750.0 g. N as 75 % organic N (37.5 kg. plant compost) + 75 mL St- 3 per palm / year.

Every treatment was duplicated three times with one palm per each. During the two following seasons, ammonium nitrate (33.5% N) was administered in three equal dosages during the latter weeks of February, April, and June. One addition of plant compost (2.0% N) occurred during the first week of January. Plant compost was supplemented with three species of bacteria (SU157, USDA110spc4, and 127k80c) throughout the first week of January for both the 2022 and 2023 seasons.

Ammonium nitrate was applied around the canopy of each palm, and then bacterial strains and plant compost were placed in holes spaced 50 cm apart and 10 cm deep. Thirty of the chosen palms were given N at a set rate of one thousand grams per palm annually. (Saied, 2015).

Table 1: Mechanical, physical, and chemical properties of the tested orchard soil

Constituents	Values	Constituents	Values
Sand %	84.2	Total N %	0.035
Silt %	11.5	K (mq/ 100 g soil)	0.65
Clay %	4.3	P (ppm)	8.7
Texture	Sandy	Fe (ppm)	6.15
pH (1:2.5 extract)	7.99	Zn (ppm)	0.84
EC (1: 2.5 extract) (dSm^{-1})	1.98	Mn (ppm)	0.96
O.M. %	0.44		
$CaCO_3$ %	7.58		
Organic carbon	0.28		

Table 2: Analysis of plant compost

Parameters	Values	Parameters	Values
Cubic meter weight (kg.)	598.0	Total N %	2.1
Moisture %	28.8	Total P %	1.04
Organic matter %	31.2	Total K %	1.20
Organic carbon %	28.33	Total Mg %	1.28
pH (1:2.5 extract)	6.28	Total Fe (ppm)	19.2
EC (1:2.5 extract) (dSm^{-1})	1.11	Total Zn (ppm)	39.92
C/N ratio	13.71	Total Mn (ppm)	33.13

The design of the current study was a randomized complete block design (RCBD). There were three duplicates and one palm tree per replicate.

Data Measurements:

1. Pinnae and leaf area (Ahmed and Morsy, 1923). Number of pinnae, spines, leaf length, and spine length.
2. Leaf chlorophyll a, chlorophyll b, and total carotenoids content (mg/1.0 g F.W.) (Von-Wettstein, 1957), leaf N, P, and K (as%) on a dry weight basis (Summer, 1985 and Wilde et al., 1985).
3. Number of strands per spathe, number of flowers per strand, initial fruit setting percentage, and fruit retention percentage.
4. Yield (kg/palm) and bunch weight (kg.)
5. Average fruit weight (g), length and diameter (cm), percentages of seed and flesh weights, fruit TSS%, total and reducing sugars% (Land and Eynone, 1965), titratable acidity (A.O.A.C., 2000) fruit total crude fiber, and flesh nitrite content (ppm) (Ridnouir-Lisa et al., 2000).

Statistical analysis

Following that, the data collected throughout the seasons of 2022 and 2023 was tallied, and the variance approach described by (Mead et al., 1993) was used to conduct appropriate statistical analysis. With New L.S.D. at 5%, variances between therapies were distinguished.

Results

1. Vegetative growth characteristics

Table 3 shows that giving the palm chemical N at 50 to 75% plus organic N (plant compost) at 25 to 50% plus any one of the three rhizobia strains at 25 to 75 ml/palm greatly improved: pinnae length, number of pinnae/leaves, pinnae area, leaf area, number of spines/leaf, and spine length. Compared to using 100% chemical nitrogen or adding 25% chemical nitrogen, which includes using biological nitrogen (plant waste) and any of the three strains.

The simulation of these traits showed a strong connection to lowering the chemical N (ammonium nitrate) percentage from 75% to 50%. At the same time, the ratio of plant compost increased from 25% to 50% and the levels of bacterial strains from 25% to 75ml/palm, which then led to improvements in the six growth parameters listed above. These are the best bacterial types from best to worst: St-1, St-2, and St-3. The pinnae length (59.7, 60.5 cm), number of pinnae/leaf (242.5, 243.2 pinnae), pinnae area (64.10, 64.95 cm2), leaf area (1.71, 1.74 m2), number of spines/leaf (38.2, 38.9 spines), and spine length (17.0, 17.6 cm) were all highest on the palm that got 5 ml of St-1 N strains mixed with 50% chemical N and 50% plant compost.

The palm that got 25% chemical N and 75% organic (plant waste) N and the N strain St-3 at 75 ml per palm had the lowest values for these growth traits. This was always the case during both seasons.

Table 3: Effect of chemical N fertilizer and plant compost inoculated with some strains of Rhizobium bacteria on some vegetative growth characteristics of Barhee date palms during 2022 and 2023 seasons.

Treatments	Pinnae length (cm)		Number of pinnae/leaf		Pinnae area $(cm)^2$		Leaf area $(m)^2$		Number of spines/ leaf		Spine length (cm)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T_1- 100% chemical N	50.8	51.8	218.2	219.5	57.19	57.90	1.29	1.31	27.8	28.5	13.9	14.2
T_2- 75% chemical N +25% organic N + St-1 at 25 ml/palm	54.6	55.5	231.8	233.0	61.11	61.88	1.39	1.42	33.6	34.0	15.3	15.8
T_3- 50% chemical N + 50% organic N + St-1 at 50 ml /palm	59.7	60.5	242.5	243.2	64.10	64.95	1.71	1.74	38.2	38.9	17.0	17.6
T_4- 25% chemical N + 75% organic N + St-1 at 75 ml/palm	48.3	49.4	215.2	216.0	56.65	57.11	1.24	1.26	26.5	27.1	13.1	13.8
T_5- 75% chemical N + 25% organic N + St-2 at 25 ml/palm	53.8	54.9	228.5	229.2	59.90	60.25	1.36	1.38	31.3	32.0	14.9	15.3
T_6- 50% chemical N + 50% organic N + St-2 at 50 ml/palm	58.1	59.2	239.5	240.6	63.00	63.99	1.61	1.36	36.6	37.0	16.9	17.8
T_7- 25% chemical N + 75% organic N + St-2 at 75 ml/palm	46.8	47.8	209.8	210.5	54.25	55.10	1.19	1.21	24.5	25.2	12.6	13.3
T_8- 75% chemical N + 25% organic N + St-3 at 25 ml/palm	52.3	53.5	222.0	223.0	58.25	59.11	1.33	1.35	29.2	30.2	14.2	14.9
T_9- 50% chemical N + 50% organic N + St-3 at 50 ml/palm	57.5	58.6	232.0	233.0	62.22	63.15	1.44	1.47	35.0	36.1	16.2	17.0
T_{10}- 25% chemical N + 75% organic N + St-3 at 75 ml/palm	45.2	46.3	202.0	205.8	25.11	52.82	1.13	1.16	22.8	23.7	12.2	12.5
New L.S.D. at 5%	1.1	1.2	2.8	2.9	1.22	1.29	0.05	0.06	1.8	2.0	0.8	0.9

Chemical N = (ammonium nitrate) Organic N = (plant compost) Strain 1= St-1 Strain 2= St-2 Strain 3 = St-3

2: Leaf Pigments and minerals (N, P, K) content Barhee date palms were fertilized with nitrogen as 50 to 75% chemical N + organic (plant compost) at 25 to 50% + any N bacterial strain each at 25 to 50 ml/palm. This significantly increased the levels of six chemicals in the leaves: chlorophyll a, chlorophyll b, total carotenoids (mg/1.0 g F.W.), N.P., and K (as%). This was compared to adding nitrogen as 100% chemical or 25% chemical N, even with plant compost and any one of the three N bacterial strains (Table 4) These leaf chemical compositions got better when the percentage of chemical N (ammonium nitrate) went from 75% to 50% and the percentage of organic N (plant compost) went from 25% to 50%. At the same time, the levels of N bacterial strains went from 25 mL per palm to 50 mL per palm. These are the best N bacterial types for this job, from best to worst: St-1, St-2, and St-3.

Results in Table (4) showed that the Barhee date palms that got 50% chemical N and 50% organic N (plant compost) and St-1 bacteria at 50 ml/palm during both seasons had the highest amounts of chlorophyll a (4.44 mg/1.0 g F.W.), chlorophyll b (1.66 mg/1.0 g F.W.), total carotenoids (1.51 mg/1.0 g F.W.), leaf N% (1.92, 1.92%), leaf P% (0.246, 0.250%), and leaf K% (1.65, 1.69%).

The worst results came from palms that were fertilized with 25% artificial N (ammonium nitrate) + 75% organic N (plant compost) + a bacterial strain called St-3 at a rate of 75 ml/palm. All these scores were correct during both seasons.

Table 4: Effect of chemical N fertilizer and plant compost inoculated with some strains of Rhizobium bacteria on some leaf pigments as well as the percentages of N, P, and K in the leaves of Barhee date palms during 2022 and 2023 seasons

Treatments	Chlorophyll a (mg/ 1.0 g F.W.)		Chlorophyll b (mg/ 1.0 g F.W.)		Total chlorophylls (mg/ 1.0 g F.W.)		Leaf N %		Leaf P %		Leaf K %	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T_1- 100% chemical N	3.81	3.90	1.33	1.42	1.19	1.30	1.61	1.64	0.146	0.150	1.28	1.32
T_2- 75% chemical N +25% organic N + St-1 at 25 ml/palm	4.11	4.20	1.49	1.58	1.35	1.43	1.77	1.80	0.203	0.213	1.50	1.54
T_3- 50% chemical N + 50% organic N + St-1 at 50 ml /palm	4.44	4.53	1.66	1.75	1.51	1.60	1.92	1.95	0.246	0.250	1.65	1.69
T_4- 25% chemical N + 75% organic N + St-1 at 75 ml/palm	3.77	3.86	1.26	1.35	1.11	1.21	1.56	1.59	0.141	0.146	1.22	1.26
T_5- 75% chemical N + 25% organic N + St-2 at 25 ml/palm	3.96	4.06	1.42	1.49	1.27	1.36	1.71	1.74	0.192	0.199	1.41	1.45
T_6- 50% chemical N + 50% organic N + St-2 at 50 ml/palm	4.38	4.46	1.61	1.70	1.46	1.55	1.89	1.92	0.233	0.241	1.63	1.66
T_7- 25% chemical N + 75% organic N + St-2 at 75 ml/palm	3.62	3.73	1.22	1.30	1.07	1.15	1.51	1.55	0.133	0.140	1.16	1.20
T_8- 75% chemical N + 25% organic N + St-3 at 25 ml/palm	3.90	4.00	1.36	1.45	1.21	1.30	1.66	1.70	0.161	0.168	1.33	1.38
T_9- 50% chemical N + 50% organic N + St-3 at 50 ml/palm	4.22	4.33	1.55	1.64	1.40	1.50	1.81	1.84	0.216	0.222	1.61	1.65
T_{10}- 25% chemical N + 75% organic N + St-3 at 75 ml/palm	3.15	3.26	1.16	1.25	1.01	1.10	1.44	1.50	0.123	0.129	1.13	1.16
New L.S.D. at 5%	0.07	0.08	0.04	0.05	0.03	0.04	0.06	0.07	0.009	0.010	0.04	0.05

Chemical N = (ammonium nitrate) Organic N = (plant compost) Strain 1= St-1 Strain 2= St-2 Strain 3 = St-3

3: Flowering and fruit setting aspects

Table 5 shows that giving Barhee date palms 50 to 75% chemical N (ammonium nitrate) plus 25 to 50% organic N (plant compost) and bacteria strains (St-1, St-2, and St-3) each at 25 to 50ml/palm greatly increased the number of strains and spathe, as well as the number of flowers, and the percentages of initial fruit setting and fruit retention compared to giving N as 100% chemical N or when chemical N was combined with 25% organic N (plant compost at 75% and bacterial strains at 75 ml/palm).

Putting the three bacterial strains in order of climbing, descending, or sideways has at least three different outcomes, depending on whether they have a good effect on flowering or fruit setting. As a result of the preference, the chemical N percentage dropped from 100% to 50%, and the organic N (plant waste) percentage rose from 25% to 75%. The bacterial N percentage also rose from 25% to 50 ml/palm. Barhee date palms got the most nitrogen from 50% chemical nitrogen (ammonium nitrate) + 50% organic nitrogen (plant waste) + 50% N bacterial strain St-1, at a rate of 50 ml per palm. The lowest values were found on the palms that were given 25% chemical nitrogen, 75% plant soil, and a St-3 bacterial strain at 75 ml daily. The results were about the same for both seasons.

4: Bunch weight and the yield (kg / palm)

Results The research results disclosed in Table 5 demonstrate that date palms treated with 50–75% chemical N (ammonium nitrate) + 25–50% organic N (plant compost) + three different types of bacteria (St-1, St-2, and St-3) at 25–50 ml/palm, compared to using 100 chemical N or 25% chemical N with 75% plant compost and the bacteria strains, the bunch weight and yield per palm were improved. The promotion directly caused the amounts of chemical N (ammonium nitrate) to drop from 100% to 50%. At the same time, the amounts of organic N (plant compost) rose from 0% to 50%, and the number of bacterial strains rose from 25 to 50 ml/palm. These values went down a lot when the chemical N share was lowered from 50% to 25%. This happened even when bacterial strains were added to plant compost. The palms that got 50% chemical N (ammonium nitrate) plus 50% organic N (plant compost) plus bacteria strain (St-1) at 50 ml per palm had the biggest bunches (18.0, 18.6 kg) during both seasons. Giving date trees 50 ml/palm of strain 1, 50% plant compost, and 50% chemical N led to the best yields. After getting the treatment as planned, the yield per palm was 180.0 and the output per tree was 186.0 in 2022 and 2023 seasons, respectively.

75% of the sugarcane was chemical N (ammonium nitrate) and 25% was organic N (plant compost). Strain 3 at 75 ml/palm produced 112.5 kg of fruit in the first season and 118 kg in the second season.

Table 5: Effect of chemical N fertilizer and plant compost inoculated with some strains of Rhizobium bacteria on number of strands / spathes, number of flowers/ strands, percentages of initial fruit setting and fruit retention, bunch weight, and yield/ palm of Barhee date palms during 2022 and 2023 seasons

Treatments	Number of strands/ spathe		Number of flowers / strand		Initial fruit setting %		Fruit retention %		Bunch weight (kg)		Yield (kg. /palm)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T_1- 100% chemical N	79.2	80.0	93.5	94.1	61.8	62.0	50.8	51.0	13.95	14.40	139.0	144.0
T_2- 75% chemical N +25% organic N + St-1 at 25 ml/palm	85.9	86.7	105.0	106.0	63.9	64.1	52.8	53.3	15.95	16.40	159.0	164.0
T_3- 50% chemical N + 50% organic N + St-1 at 50 ml /palm	93.9	94.6	114.4	115.0	66.1	66.3	55.0	55.5	18.00	18.60	180.0	186.0
T_4- 25% chemical N + 75% organic N + St-1 at 75 ml/palm	78.5	79.1	89.3	90.0	59.6	60.0	49.0	50.3	13.60	14.20	136.0	142.0
T_5- 75% chemical N + 25% organic N + St-2 at 25 ml/palm	83.6	84.1	101.7	102.5	63.1	63.5	52.2	52.8	15.20	15.80	152.0	158.0
T_6- 50% chemical N + 50% organic N + St-2 at 50 ml/palm	91.3	92.0	111.2	112.0	65.2	65.5	54.3	54.6	17.50	18.10	175.0	181.0
T_7- 25% chemical N + 75% organic N + St-2 at 75 ml/palm	76.6	77.2	86.2	87.0	57.8	58.0	47.0	47.8	12.05	12.65	120.5	126.5
T_8- 75% chemical N + 25% organic N + St-3 at 25 ml/palm	81.0	81.8	96.2	97.1	62.6	62.8	51.5	52.0	14.40	14.90	144.0	149.0
T_9- 50% chemical N + 50% organic N + St-3 at 50 ml/palm	88.2	89.0	109.0	109.8	64.3	64.5	53.2	53.9	16.20	17.00	162.0	170.0
T_{10}- 25% chemical N + 75% organic N + St-3 at 75 ml/palm	73.8	74.3	81.5	82.3	56.2	56.5	45.8	46.2	11.25	11.80	112.5	118.0
New L.S.D. at 5%	1.7	1.9	3.6	3.9	2.1	2.0	1.5	1.6	0.8	0.9	5.8	6.1

Chemical N = (ammonium nitrate) Organic N = (plant compost) Strain 1= St-1 Strain 2= St-2 Strain 3 = St-3

5: Fruit physical and chemical traits

Data in Tables 6–7 cleared that different nitrogen management significantly affected the physical and chemical fruit properties. Amending palms with 25–75% chemical N, 25%–75% plant compost, and 25–75 ml/palm St-1, St-2, and St-3 bacterial strains were more effective than 100% of the chemical N in increasing fruit weight and dimensions, flesh%, TSS%, total and reducing sugars, seed weight%, titratable acidity%, total crude fiber, and pulp nitrite content. Fruit quality was shown to be significantly correlated with lower chemical N proportions (from 100 to 25%), higher plant compost proportions (from 0.0 to 75%), and lower bacterial strain rates (from 25 to 75 ml/palm).

The greatest results concerning fruit quality were received by supplying the palms along with 25% chemical N (ammonium nitrate), 75% organic N (plant compost), and a St-3 bacterial strain at 75 ml per palm.

Table 6: Effect of chemical N fertilizer and plant compost inoculated with some strains of Rhizobium bacteria on some physical characteristics of Barhee date palms during the 2022 and 2023 seasons

Treatments	Fruit weight (g.)		Fruit length (cm)		Fruit diameter (cm)		Seed weight %		Flesh %	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T_1- 100% chemical N	15.8	16.0	3.25	3.30	2.70	2.76	8.85	8.70	91.15	91.30
T_1- 100% chemical N	16.9	17.1	3.50	3.55	2.85	2.90	8.50	8.35	91.50	91.65
T_2- 75% chemical N +25% organic N + St-1 at 25 ml/palm	17.8	18.0	3.78	3.85	3.11	3.18	7.90	7.75	92.10	92.25
T_3- 50% chemical N + 50% organic N + St-1 at 50 ml /palm	15.5	15.8	3.21	3.26	2.62	2.70	8.90	8.70	91.10	91.30
T_4- 25% chemical N + 75% organic N + St-1 at 75 ml/palm	16.4	16.7	3.41	3.47	2.79	2.86	8.65	8.50	91.35	91.50
T_5- 75% chemical N + 25% organic N + St-2 at 25 ml/palm	17.4	17.8	3.71	3.77	3.01	3.09	8.10	7.90	91.90	92.10
T_6- 50% chemical N + 50% organic N + St-2 at 50 ml/palm	14.8	15.1	3.19	3.25	2.55	2.62	9.10	8.90	90.90	91.10
T_7- 25% chemical N + 75% organic N + St-2 at 75 ml/palm	16.0	16.3	3.36	3.42	2.74	2.80	8.77	8.60	91.23	91.40
T_8- 75% chemical N + 25% organic N + St-3 at 25 ml/palm	17.2	17.5	3.62	3.68	2.93	3.00	8.35	8.18	91.65	91.82
T_9- 50% chemical N + 50% organic N + St-3 at 50 ml/palm	14.4	14.8	3.12	3.20	2.52	2.59	9.15	9.00	90.85	91.00
New L.S.D. at 5%	0.6	0.7	0.12	0.11	0.08	0.09	0.04	0.05	0.12	0.13

Chemical N = (ammonium nitrate) Organic N = (plant compost) Strain 1= St-1 Strain 2= St-2 Strain 3 = St-3

Table 7: Effect of chemical N fertilizer and plant compost inoculated with some strains of Rhizobium bacteria on some chemical characteristics of Barhee date palms during 2022 and 2023 seasons

Treatments	TSS%		Total sugars %		Reducing sugars %		Titratable acidity %		Total fibre crude %		Nitrite in the flesh (ppm)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T_1- 100% chemical N	30.0	30.3	25.0	25.4	18.0	18.3	0.245	0.240	1.95	1.88	2.15	2.12
T_2- 75% chemical N +25% organic N + St-1 at 25 ml/palm	33.2	33.5	28.3	28.8	21.2	21.6	0.210	0.205	1.60	1.48	1.90	1.82
T_3- 50% chemical N + 50% organic N + St-1 at 50 ml /palm	36.0	36.2	31.2	31.6	24.3	24.9	0.165	0.160	1.30	1.15	1.25	1.12
T_4- 25% chemical N + 75% organic N + St-1 at 75 ml/palm	39.8	40.0	34.5	34.9	26.6	26.9	0.135	0.130	0.90	0.81	0.75	0.70
T_5- 75% chemical N + 25% organic N + St-2 at 25 ml/palm	32.0	32.4	27.2	27.6	20.4	20.8	0.220	0.210	1.68	1.55	1.95	1.80
T_6- 50% chemical N + 50% organic N + St-2 at 50 ml/palm	34.5	34.8	29.8	30.2	23.0	23.4	0.180	0.175	1.41	1.30	1.40	1.30
T_7- 25% chemical N + 75% organic N + St-2 at 75 ml/palm	39.0	39.5	33.8	34.2	26.9	27.3	0.145	0.140	0.95	0.86	0.80	0.73
T_8- 75% chemical N + 25% organic N + St-3 at 25 ml/palm	31.2	31.8	25.4	25.9	18.6	19.0	0.230	0.225	1.80	1.60	2.00	1.88
T_9- 50% chemical N + 50% organic N + St-3 at 50 ml/palm	33.8	34.0	28.6	28.9	21.5	21.9	0.190	0.182	1.52	1.40	1.58	1.40
T_{10}- 25% chemical N + 75% organic N + St-3 at 75 ml/palm	37.2	37.5	32.5	32.8	25.7	26.2	0.150	0.142	1.05	0.96	0.95	0.88
New L.S.D. at 5%	1.6	1.8	0.8	0.9	0.6	0.7	0.011	0.013	0.06	0.07	0.04	0.05

Chemical N = (ammonium nitrate) Organic N = (plant compost) Strain 1= St-1 Strain 2= St-2 Strain 3 = St-3

Discussion

Azospirillum produces phytohormones such as ethylene, gibberellins, and cytokinins, in addition to IAA. (Mater 1987; Bashan and Holguin 1997). Bacterial plant growth hormones can speed up plant development and increase host plant yields (Glick, 1995). The production of IAA improves the plant-Azospirillum interaction. Plant growth-boosting rhizobacteria are thought to produce phytohormones, which is an essential method for encouraging plant growth.

Many other scientists have hypothesized that PGPR may have a favorable influence on host development since it produces plant growth chemicals that directly affect host growth. The findings of this investigation clearly demonstrate that there are several components in rhizobia supernatant. It was also congruent with the findings of (Zaid and Tisserat, 1983), who showed that shoot regeneration happened most consistently on medium containing NAA. The positive effects of using plant compost on the growth and fruiting of Barhee date palms can be attributed to their important roles in improving the physical and chemical properties of the soil, such as organic matter, nitrogen fixation, the biosynthesis of natural hormones such as IAA, GA3, and cytokines, root development, nutrient availability, water retention, soil aggregation, and sandy soil exchange capacity. It was shown to have a negative impact on soil pH, salinity, and numerous soil diseases. (Marschner, 1995; Wang et al., 2000; Bonanzinga et al., 2001; Venzon et al., 2001).

Organic and biofertilization, when used as a partial replacement for inorganic N fertilizers, improved N fixation, organic matter, water retention, nutrient accessibility, root system growth, hormone and antibiotic biosynthesis, and soil pH reduction (El-Sisy, 2000; Kannaiyan, 2002; Cabrera et al., 2003).

Several scientists have already established the considerable benefits of PGPR on the growth and production of treated plants, backed up by data (Al-Wasfy and El-Khawaga ,2008; Ahmed et al., ,2011; Abdel-Wahab ,2017). These researchers hypothesized that the causes for these advantages may be 1) bacteria's good impact on food availability, 2) necessary enzymes, 3) hormonally stimulating effects on plant development, or 4) an increase in photosynthetic efficiency. The findings, which support the beneficial effects of biofertilizers and organic manure on overall growth, palm nutritional status, yield, and fruit quality, are consistent with those of (Al-Khatani and Soliman, 2012; Saied ,2015; Abou-Baker ,2015; El-Sayed et al., 2017).

Conclusions

The yield of Barhee date palms was enhanced by 50% inorganic N (ammonium nitrate) + 50% plant compost + bacterial St-1 at 50 ml per palm tree. The optimal findings in terms of Barhee date fruit quality were given by treating the palm with 25% ammonium nitrate, 75% plant compost, and 75 ml of bacterial St-3 per palm tree.

Conflicts of Interest/ Competing interest

The authors declare that they have no conflicts of interest.

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الاستبدال الجزئي للتسميد النيتروجيني الكيميائي بكمبوست النبات الملقّح ببعض سلالات بكتريا الريزوبيم فى نخيل البلح البرحى النامي فى التربة الرملية

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الملخص العربى

فى تجربة معملية تم الحصول على بعض سلالات الريزوبيا وهي: (*Rhizobium leguminosarum*"127k80c and SU157" -*Bradyrhizobium japonicum* USDA110spc4) وتم الاختيار بناء على قوة نموها فى البيئة الغذائية.

وتم تلقيح نخيل البلح البرحى بهذه السلالات البكتيرية بمعدل من 25 الى 75 مل لكل نخلة مع اضافة كمبوست النبات بمعدل من 25 الى 75% من الكمية الموصى بها للتسميد النتروجيني للنخيل كبديل جزئي للسماد النتروجيني الكيميائي (نترات الامونيوم) خلال موسمي 2022 و2023.

كان هناك تحسن ملحوظ فى جميع صفات النمو الخضري والصبغات وعناصر النتروجين والفوسفور والبوتاسيوم فى الاوراق وكذلك صفات الازهار وعقد الثمار وكمية المحصول لنخيل البلح البرحى النامية فى التربة الرملية وذلك عند تسميدها بمعدل 50 الى 75% سماد نتروجيني كيميائي (نترات الأمونيوم) وسماد عضوي (كمبوست النبات) بنسبة من 25 الى 50% وأي سلالة من سلالات بكتريا الريزوبيم الثلاثة بمعدل من 25 الى 50 مل لكل نخلة وذلك بالمقارنة بالتسميد النتروجيني الكيميائي فقط. وكانت أفضل سلالة بكتيرية هي السلالة الاولى St-1 ثم يليها السلالة الثانية St-2 واحتلت السلالة الثالثة St-3 المركز الاخير فى هذا الصدد. ولأجل تحسين كمية المحصول فى نخيل البلح البرحى فانه ينصح بتسميدها بالسماد النتروجيني المعدنى بنسبة 50% مع كمبوست النبات بنسبة 50% مع اضافة السلالة ذات الاهمية الغذائية St-1 بمعدل 50 مل لكل نخلة. اما تسميد نخيل البلح البرحى النامي فى التربة الرملية بالنيتروجين على اساس 25% نترات امونيوم مع 75 % كمبوست النبات المضاف له 75 مل لكل نخلة من السلالة ذات الاهمية الغذائية St-3 فانه يعطى أفضل النتائج بخصوص جودة ثمار البلح البرحى

الكلمات الدالة: كمبوست النبات- السلالات البكتيرية- النمو- المحصول- خصائص الجودة- نخيل البلح البارحى.