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Fertilization Affects Growth Aspects, Chemical Composition and Productivity of Wheat Crop

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THE CURRENT Study was carried out to evaluate the effect of different mineral nitrogen levels alone or combined with bio-fertilizers (*Rhizobium radiobacter* sp strain inoculation and Yeast) on the physical and chemical properties of soil and wheat productivity. Field experiments were carried out in sandy soil of farm at 6 October Agriculture Company, El-Qasasin, Ismailia Governorate, Egypt. Wheat grains at a rate of 60kg fed^{-1} were divided into to three divisions. In first division, mineral nitrogen fertilizer rates (25, 50, 75 and 100kg N fed^{-1}) were added. In second division, grains were inoculated with *Rhizobium radiobacte* sp strain (PGPR) mixed with 400mL of adhesive liquid (Arabic gum). In third division, 33% N ammonium nitrate at rates (25, 50, 75 and 100kg N fed^{-1}) were applied three times 21, 40 and 60 days after implanting and potassium sulphate (48% K_2O) at a rate of 75kg fed^{-1} was applied on two doses after 21 and 45 days from planting. The results showed that soil pH was around 7.90 to 8.01. Soil salinity was 1.61 and 1.24 for soil treated with mineral nitrogen and a mixture of (yeast + bacteria) with a relative increasing of mean values nitrogen were 2.70, 3.63 and 5.22%. The available soil Fe, Mn, and Zn were 2.65 to 3.12mg/kg for Fe; 1.35 to 1.63mg/kg for Mn, and 0.60 to 0.85mg/kg for Zn. In conclusion, this study confirms the use of bio-fertilizers to get high-quality yields of wheat and avoid environmental pollutions.

Keywords: Bio fertilizer, Mineral fertilizer, *Rhizobium radiobacter*, Sandy soil, Wheat, Yeast.

Introduction

Today, the major challenge that facing humanity is food insecurity. Globally, cereals are considered the main staples food, including wheat. It is one of the most important crops that have a sizeable gap between production and consumption in the Middle East and North Africa making them the import-dependent region among world countries (Sadler & Magnan, 2011; Woertz, 2017). In Egypt, the unpredictable changes in climate will make this region warmer and drier with less rainfall in the future (Bucchignani et al., 2018), with expecting an increase in import in this region (OECD, FAO, 2018). Therefore, Egypt became the largest wheat importing in the world, in 2019/2020 imported about 12.80 million tons of wheat (about 53% of total supply), and expected to rise to 12.85 million tons in 2021 (USDA, 2020), while the wheat production was about 1.4 million ha of land with average yield 6.42tons/ha, and still considered the highest in Africa. However, there is still a large gap between consumption and production, which, averaged between 41% and 68% in the last 20 years and this gap effects the country`s foreign exchange reserve (MALR, 2021).

Egypt has espoused the strategy of reducing the production and consumption gaps by following three different paths: development the newly reclaimed lands to expand the cultivated wheat area,

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increasing grain productivity (vertical expansion), and reducing the wheat losses along the wheat value chain from field to fork. In addition to, Egypt completed good progress in developing new wheat cultivars with high productivity and performs good agricultural follows to maximize grain productivity per unit of cultivated area, while, the expanding wheat areas are limited as a result of a shortage of water resources (Yigezu et al., 2021).

Wheat production in Egypt has improved through the development of breeding and cultivation techniques. The use of high yielding seed varieties, expanding the amount of certified seeds distributed to farmers, ideal sowing time, laser leveling techniques and increasing areas of wheat raised bed cultivation to more than 420,000 HA have made the largest contributions to significant vertical expansion (i.e., increasing yields by unit area) during the last six years (USDA, 2021).

Bio-fertilizers are considered as an alternative to chemical fertilizers with more advantages. It plays a vital role in enhancing the growth as well as the yield of plant crops, increasing the soil fertility, where they contain microscopic microorganisms which are used as fertilizers for plant growth such as *Azospirillum sp*. and *Azotobacter* sp (Itelima et al., 2018). Therefore, it has many advantages in organic agriculture, controlling environmental pollution and in the improvement of soil health as well as in reducing input use (Gutiérrez-Rojas et al., 2011; Jalilian et al., 2012). The useful effects of *rizobacteria* on plant growth are attributed to nitrogen fixation and production of phytohormones as gibberlines, cytokinins and auxins that stimulate root growth and proliferation resulting in effective uptake of nutrients and water (Cercioglu et al., 2014; Kumar & Urmila, 2018). In this aspect, the present study was designed to assess the effect of fertilization on growth aspects, chemical composition and productivity of wheat crop.

Materials and Methods

The experimental work was carried out in sandy soil farm at 6th October Agriculture Company, El-Qasasin, Ismailia Governorate, Egypt.

Materials

Soil

The soil samples were selected from different experimental pilot units at surface depth (0–30) cm. Some physical and chemical properties were determined (Jackson, 1967) as indicated in Table 1.

Wheat grains variety (Masr 1) were obtained from the Crop Institute, Agriculture Research Center, Giza, Egypt. Wheat grains at a rate of 80kg fed^{-1} were divided into four divisions. The first division for rate 20kg received mineral nitrogen fertilizer rates (25, 50, 75 and 100kg N fed^{-1}). Grains at a rate of 20kg in the second division were inoculated with *Rhizobium radiobacter* strain (PGPR) mixed with 400ml of adhesive liquid (Arabic gum). Grains were mixed with the inoculations, then immediately strewed and covered with soil to reduce the exposure of *Rhizobium radiobacter* to the sun. More amounts of *Rhizobium radiobacter* were added three times on days 30, 45 and 65 by mixing with liquid and sprays on soil and plant with a rate of 10L/ fed (ca.10^6 cfu. mL^{-1}) after 15 and 30 days of sowing mixed with 200L water/fed. Grains at a rate of 20kg in the third division were treated with yeast inoculation following the same processes described method in the second division. The fourth division was treated with a combination of yeast with bacteria at a rate of 10kg of each.

TABLE 1. Physical and chemical properties of the tested soil

Coarse sand (%)	**Fine sand (%)**	**Silt (%)**	**Clay (%)**	**Soil texture**		**OM (%)**	**SAR**	**$CaCO_3$ (%)**
7.90	76.56	6.88	8.66	Sandy		0.60	7.56	3.19
pH (1:2:5)	EC (dS/m)	Soluble cations (meq/L)				Soluble anions (meq/L)		
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}
8.22	2.84	6.38	3.99	17.18	0.85	3.75	10.89	13.76
Macronutrients (mg/kg)			Micronutrients (mg/kg)					
N	P	K	Fe			Mn		Zn
36.50	3.92	185	2.47			1.22		0.59

Mineral fertilizer

Ammonium nitrate (33% N) application at rates of 25, 50, 75 and 100kg N fed^{-1} were applied three times, 21, 40 and 60 days after implant Two doses of potassium sulphate (48% K_2O) at 75kg fed^{-1} rate were applied, after 21 and 45 days from planting.

Bio-fertilizers

The bio-fertilizers *Rhizobium radiobacter* strain with accession number HQ395610 and *Candida incommunis* strain were obtained from the Department of Microbiology, Soils and Water Research Institute, Agricultural Research Center, Giza, Egypt.

Methods

Experimental design

Each experiment was carried out in a split plot design with four replicates. The using two bio-fertilizers (yeast and bacteria) were randomly arranged as the main plot, where the levels of mineral nitrogen fertilizer were randomly distributed as subplots. The area of all experimental units was one feddan which was divided into four divisions: the first was treated with mineral nitrogen fertilizer levels as a control, the second was treated with *Candida incommunis*, the third was treated with *Rhizobium radiobacter*, while the fourth was treated with a combination of *Candida incommunis* and *Rhizobium radiobacter*. Each of the experimental plot units was 5m length x10m width. All farming processes were finished before start planting. Superphosphate (15.5% P_2O_5) was used at a rate of 200 kg fed^{-1} during soil tillage before planting as indicated in Table 2.

Soil analyses

Determination of particles size distribution: It was determined by dry sieving according to Nelson & Sommers (1982).

Determination of electrical conductivity in dS/m (EC): ECe was measured in the soil paste extract (Shirokova et al., 2000).

Estimation of soil pH: The soil pH was measured in saturated soil paste using Beckman s' pH meter (Jackson, 1967).

Determination of exchange of sodium percentage (ESP): ESP values were carried out from the equation developed by Richards (1954), using SAR values of the saturated soil paste.

Determination of calcium carbonate content: It was estimated using Collin's Calciumeter according to Jackson (1967).

Determination of soluble cations, anions and organic matter content: Both of cations (Mg^{+2}, Ca^{+2}, K^{+}, and Na^{+}) and anions (Cl^{-}, CO_3^{-2}, HCO_3^{-} and SO^{-2}_4) were determined in soil paste extract according to Page et al. (1982).

TABLE 2. Distribution of mineral and bio-fertilizers in a split-plot design

Treatments	Bio-fertilizers											
	Yeast				Bacteria				Yeast + bacteria			
Replicate 1									25x25	25x50	25x75	25x100
(Mineral	25	50	75	100	25	50	75	100	50x25	50x50	50x75	50x100
Fertilization)									75x25	75x50	75x75	75x100
									100x25	100x50	100x75	100x100
Replicate 2									50x50	50x75	50x100	50x25
(Yeast)	50	75	100	25	50	75	100	25	75x50	75x75	75x100	75x25
									100x50	100x75	100x100	100x25
									25x50	25x75	25x100	25x25
Replicate 3									75x75	75x100	75x25	75x50
(Bacteria)	75	100	25	50	75	100	25	50	100x75	100x100	100x25	100x50
									25x75	25x100	25x25	25x50
									50x75	50x100	50x25	50x50
Replicate 4	100	25	50	75	100	25	50	75	100x100	100x25	100x50	100x75
(Yeast +									25x100	25x25	25x50	25x75
bacteria)									50x100	50x25	50x50	50x75
									75x100	75x25	75x50	75x75

Determination of available nitrogen: It was extracted from soil using 2N KCl solution and measured according to the modified Kjeldahl method (Page et al., 1982).

Determination of available P: Phosphorus was extracted by 0.5 N sodium bicarbonate ($NaHCO_3$) and calorimetrically determined (Jackson, 1967).

Determination of available K: Potassium was extracted using ammonium bicarbonate DTPA-extract and determined using the Flame photometer (Soltanpour & Schwab, 1977).

Determination of available micronutrients: The micronutrients were extracted using ammonium bicarbonate DTPA (Soltanpour & Schwab, 1977) and determined using Inductively Coupled (ICP) Spectrometry model 400.

Plant analyses

Determination of macronutrients: Samples of grains and straw were ground. 0.5 g powder of each was digested by a mixture of H_2SO_4/ $HClO_4$ (Sommers & Nelson, 1972). Nitrogen was determined by micro- Kjeldahl (Cottenie et al., 1982). Phosphorus was Spectrophotometrcally determined using the ammonium molybdate/ stannous chloride method (Chapman & Pratt, 1978). Potassium was determined by a flame photometer (Page et al., 1982).

Determination of micronutrients: Mn, Zn, and Fe were determined by using Atomic Absorption (model GBC 932) according to Page et al. (1982).

Determination of growth parameters of wheat plants: Plant samples of 30, 45 and 65 days from sowing as well as those collected at either after flowering or harvesting stages were subjected to determine the following characters:

a) Flag leaf area (cm^2): Five main branches for 5 plants from each treatment were subjected to leaf area calculation by choosing the maximum width of each leaf multiplied by its leaf length and 0.75.

*b) Plant height (cm)***:** At the harvest stage, plant height was measured in cm for each representative sample from the soil surface to the apical spike of the main stem. The results were expressed in cm/plant as a mean of 5 plants.

Determination of wheat yield components: Wheat yield components, i.e., spike characteristics, the number of spikes/m^2, 1000 kernel weight, grain yield, straw yield and harvest index were determined.

*a) Spike characteristics***:** Five spikes were randomly chosen from each plot to measure the following: Spike length (cm) as an average of ten spikes; Number of spikelets/spike; Number of grains/spike as an average of grains number per ten main spikes, and weight of grains/spike (g) as average weight grains per ten main spikes.

*b) Number of spikes /m^2***:** One m^2 was randomly chosen from each plot to measure the number of spikes/ m^2.

*c) 1000- kernels weight (g)***:** A triplicate sample of 1000 kernels was randomly chosen from each plot and weighed according to the method outlined by A. A. C. C. (1983).

d) Grain yields (ardab/fed): To evaluate the grain yield as ardab/fed, 4 rows (2 from each side) were exempted from the plot area of 16.4m and the rest rows were included to obtain the considered grain yield.

e) Straw yield (ton/fed): Straw of harvested samples was determined in Kg/m^2 then converted to ton/fed.

f) Biological yield (ton/fed): It was estimated from the addition of grain yield in kg/ fed + straw yield in kg/fed and then converted to ton/fed.

g) Harvest index %: (grain yield/total yield × 100)

Chemical analysis

Chemical composition: Crude protein, ash, crude fiber and fat contents were determined according to the methods outlined by A.O.A.C. (2000). Carbohydrates were calculated by difference.

Determination of mineral elements content: The mineral elements were determined according to the methods described in the Perkin–Elmer (1982) as follows: The experimental sample (2g) was ashed in a muffle furnace at 500°C. The ash was dissolved in HCl (5mL, 20% v/v), the solution was filtered through an acid- washed filter paper into a 50mL volumetric flask. The solution was diluted to a known volume with deionized water and well mixed. Using the condition listed in the standard condition section, a standard solution should be prepared in suitable dilution. On the other hand, samples ought to be diluted if necessary, to bring the optimum concentration of the element. To overcome potential ionic interferences when calcium and magnesium were determined, the final sample dilution and all standard and blank should contain 1% (w/v) lanthanum. The concentration of each element was calculated.

Statistical analysis

The data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split plot design. The treatment means were compared using the least significant difference (LSD) at a 5% level of significance test which was developed by Waller & Duncan (1969**)** using IBM SPSS statistics version 19 software (IBM Corp., Armonk, NY, USA).

Result and Discussion

Rhizobium rediobacter supplied additional nitrogen in an ecofriendly manner which plays important role in the production and quality of wheat. Chemical fertilizers, an important source of plant nutrient requirement, but with long-term using may lead to many problems as environmental pollutions and destruct the physical and chemical properties of the soil. Application of bio-fertilizers has become of great urgently to increase the yield and the quality of wheat, as well as the environmental pollution decreasing.

Effect of bio- fertilizer and different mineral nitrogen rates on pH, EC and macro- micronutrients availability in the investigated soil.

The soil of all experimental pilot units was characterized by conditions ranging from low to medium alkaline, where the pH values ranged from 7.90 to 8.01. Data presented in Table 3 revealed that the addition of different levels of mineral N (25, 50, 75 and 100Kg N/fed) and bio-fertilization (yeast and bacteria) had no significant effect on soil pH in all treatments. The highest values of soil pH were 8.01 in 25 and 50 kg N/fed without bio-fertilizer treatment and the lowest values were 7.90 in 75 and 100 kg N/fed with (yeast+ bacteria) mixture treatment. El-Maaz et al. (2014) reported that the increase in the applied mineral nitrogen levels combined with bio-fertilizer had led to a decrease in the soil pH. As a result of the active microorganism, biological activity in particular and organic acid produced, these finding was expected (Shaban & Omar, 2006). Also, the use of bio-fertilizers on Egyptian soils has decreased the pH, which results in increasing the trace elements availability, enhancing plant growth (Mohamed et al., 2021).

The use of the different rate of mineral nitrogen combined with the bio-fertilizers led to enhancing dehydrogenase activity and H_2 production in the rhizosphere of soil-root environment, thus increasing the hydrogen moles which reacts in the root zone to form hydrocarbon acids that decrease soil pH (Alori et al., 2019).

The values of soil salinity EC (ds/m) insignificantly decreased by increasing the mineral nitrogen fertilizer levels from 25 to 100kg N. The highest mean value (EC) in soil treated with mineral nitrogen was 1.61, while the lowest mean value (EC) was 1.24 for soil treated with a combination of yeast and bacteria. The corresponding relative decreases were 17.26, 26.40 and 28.93% for soils treated with mineral fertilizer at rates (50, 75 and 100 kg N/fed), respectively, compared to soil treated with 25 kg N/fed without bio- fertilization. The corresponding relative decreases in values of EC in soil treated with yeast combined with nitrogen mineral fertilizer at different rates (50, 75 and 100kg N/fed) were 18.92, 29.73 and 34.05%, respectively, compared to soil treated with 25kg N/fed. Also, the relative decreases in values of EC as affected by bacteria combined with a mineral nitrogen fertilizer at different rates (50, 75 and 100kg N/fed) were 12.73, 21.21 and 26.06%, respectively, compared to soil treated with the combination of mineral nitrogen 25kg N/ fed with bacteria. On the other hand, the relative decreases EC values were 15.86, 18.62 and 24.14% for soil treated with (yeast + bacteria) combined with mineral nitrogen rates (50, 75 and 100kg N/ fed), respectively, compared to soil treated with 25kg N/fed. Generally, the corresponding relative decreases in EC mean values were 8.69, 13.04 and 22.98% for soil treated with yeast, bacteria and (yeast + bacteria) combined with different rates of mineral nitrogen fertilizer, respectively, compared to mineral nitrogen fertilizer alone. Consequently, it could be concluded that the application of bio-fertilizer (*Rhizobium radiobacter* and *Candida*) resulted in an insignificant decrease in soil pH and EC values.

TABLE 3. Effects of bio-fertilizers and different mineral nitrogen rates on pH, EC and macro-micro nutrients availabilities in soil

Treatments	Mineral N fertilizer rate (kg/fed)	pH	EC	Macronutrients (mg/kg)			Micronutrients (mg/kg)		
				N	P	K	Fe	Mn	Zn
Mineral	25	8.01	1.97	39.10	4.10	190	2.65	1.35	0.62
	50	8.01	1.63	40.90	4.30	198	2.75	1.38	0.60
	75	8.00	1.45	41.25	4.77	200	2.80	1.42	0.67
	100	7.98	1.40	42.00	4.80	202	2.83	1.45	0.69
	Mean	8.00	1.61	40.81	4.50	197.5	2.76	1.40	0.65
Yeast	25	8.01	1.85	39.22	4.55	196	2.70	1.37	0.65
	50	8.00	1.50	41.77	5.00	200	2.85	1.44	0.69
	75	7.98	1.30	42.55	5.25	210	2.93	1.47	0.75
	100	7.97	1.22	44.10	5.75	212	2.98	1.52	0.78
	Mean	8.00	1.47	41.91	5.14	204.5	2.87	1.45	0.72
Bacteria	25	8.00	1.65	40.12	5.22	205	2.74	1.39	0.67
	50	7.96	1.44	41.33	5.73	217	2.93	1.45	0.73
	75	7.94	1.30	44.90	5.98	227	3.00	1.49	0.77
	100	7.93	1.22	42.80	5.85	225	3.02	1.54	0.82
	Mean	7.96	1.40	42.29	5.71	218.5	2.92	1.47	0.75
Yeast +bacteria	25	7.95	1.45	40.88	5.35	204	2.80	1.40	0.69
	50	7.93	1.22	42.00	5.75	216	2.98	1.55	0.75
	75	7.90	1.18	45.00	6.25	226	3.09	1.60	0.81
	100	7.90	1.10	43.89	6.00	224	3.12	1.63	0.85
	Mean	7.92	1.24	42.94	5.84	217.5	3.01	1.55	0.78
L.S.D., at 0.05 (Rate)		N.S	N.S	0.34	0.33	0.04	0.216	0.38	0.03
L.S.D., at 0.05 (Treatments)		N.S	N.S	0.34	0.33	0.06	0.216	0.38	0.03
Interaction		N.S	N.S	0.68	0.66	0.08	0.43	0.76	0.05

The addition of different levels of mineral N (25, 50, 75 and 100kg N/fed) combined with or without bio-fertilization (yeast and bacteria) possessed a significant effect on some available macronutrients, i.e. N, P and K (mg/kg soil) in the studied soil after wheat harvest. The maximum mean values of N, P and K were obtained in soil treated with the mixture of (yeast + bacteria) combined with 75kg N/fed compared to other treatments (Fig. 1).

Bio-fertilizer plays a very significant role in improving soil fertility through fixing atmospheric nitrogen. Also, the soil available N increased with increasing mineral nitrogen combined with bio-fertilizers. As well as, the available nitrogen was significantly increased in soils treated with bio-fertilizer in combination with mineral fertilizers as compared with those treated with mineral fertilizers alone (Nosheen et al., 2021).

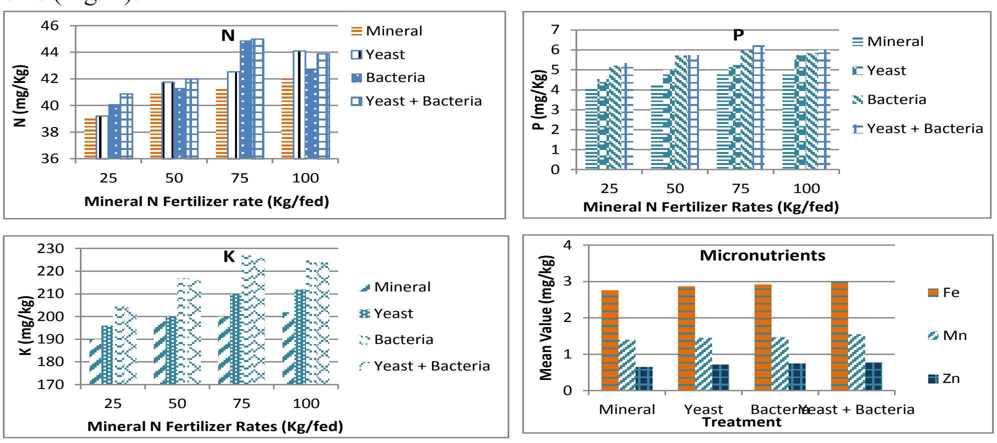

Fig. 1. Effect of bio-fertilizers and different mineral nitrogen rates on macro and micro-nutrient availability in the investigated soil

Also, pronounced increases in soil available micronutrient elements content (Fe, Mn and Zn mg/kg soil) were achieved as a result of treating the soil with mineral N at different rates and bio-fertilizers. The high increases of (Fe, Mn and Zn mg/kg) that obtained from additions of bio-fertilizer combined with mineral N may be ascribed to the enhancement of active microorganisms and the produced soil organic acid in the root zone which decreased soil pH (Thomas & Singh, 2019).

‘*Effect of different mineral nitrogen rates and bio-fertilizers on some morphological characteristics of wheat.*

The effect of bio-fertilizers, i.e., yeast, bacteria and their mixture combined with different mineral nitrogen fertilizer rates (25,50,75 and 100kg/fed) on the wheat plant height (cm), spike length (cm), number of grains/spike, straw weight/plant (g), grains weight/spike (g), 1000-grain weight (g), grain yield (ton/fed), straw yield (ton/fed) and harvest index (%) compared to different mineral nitrogen fertilizer rate as control were determined. The highest mean value of plant height (87.90cm); number of grains (53.74g); straw weight/plant (3.33g); grains weight/spike (2.64 g); 1000-grain weight (35.52g); grain yield (2.19ton/fed) and harvest index (46.70 %) as affected by bacteria (Fig. 2). Also, spike length (12.90cm) and straw yield (2.60ton/fed) as affected by yeast mixed with bacteria combined with 75kg mineral N fertilizer (Table 4).

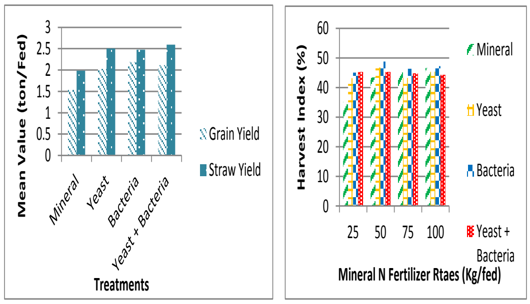

Fig. 2. Effect of bio-fertilizers and different mineral nitrogen rates on yield components and harvest index of wheat

TABLE 4. Effects of bio-fertilizers and different mineral nitrogen rates on yield and yield components of wheat

Treatments	Mineral N fertilizer rate (kg/fed)	Plant height (cm)	Spike length (cm)	No. of grains/ spike	Straw weight / plant (g)	Grains weight/ spike (g)	1000-Grain weight (g)	Grain yield (ton/fed)	Straw yield (ton/fed)	Harvest index (%)
Mineral	25	65.38	9.85	36.90	1.98	1.55	26.55	0.87	1.60	35.20
	50	78.52	11.50	45.63	2.51	1.89	29.35	1.50	1.95	43.50
	75	79.46	11.95	49.27	2.34	1.93	32.41	1.83	2.18	45.60
	100	80.96	12.18	49.73	2.85	2.13	32.95	1.97	2.26	46.60
	Mean	76.08	11.37	45.38	2.42	1.88	30.32	1.54	1.99	43.60
Yeast	25	80.96	11.88	47.63	2.40	1.95	30.85	1.62	2.13	43.20
	50	81.95	12.35	50.69	2.93	2.24	33.64	1.95	2.22	46.80
	75	82.63	12.97	53.47	2.99	2.40	34.52	2.10	2.75	43.30
	100	92.85	12.98	57.42	3.66	2.49	38.41	2.44	2.94	45.40
	Mean	84.61	12.51	52.30	3.00	2.28	34.35	2.03	2.51	44.70
Bacteria	25	82.63	11.98	48.96	2.46	2.38	31.84	1.78	2.17	45.10
	50	86.35	13.14	54.20	3.55	2.52	35.10	2.29	2.40	48.80
	75	97.63	13.68	59.46	3.79	2.93	40.52	2.58	2.98	46.40
	100	84.96	12.55	52.34	3.52	2.75	34.62	2.14	2.38	47.30
	Mean	87.90	12.81	53.74	3.33	2.64	35.52	2.19	2.48	46.70
Yeast + bacteria	25	83.00	12.33	49.00	2.75	2.33	32.65	1.85	2.23	45.30
	50	85.63	12.80	54.61	3.55	2.43	35.94	2.36	2.85	45.30
	75	87.12	13.55	58.63	3.62	2.95	36.47	2.40	2.96	44.86
	100	86.32	12.90	50.63	2.86	2.84	34.52	1.88	2.35	44.40
	Mean	85.52	12.90	53.22	3.20	2.64	34.89	2.12	2.60	44.90
L.S.D., at 0.05 (Rate)		0.29	0.28	0.24	0.22	0.03	0.21	0.30	0.21	0.65
L.S.D., at 0.05 (Treatments)		0.34	0.44	0.28	0.23	0.07	0.25	0.34	0.25	0.33
Interaction		0.59	0.57	0.48	0.45	0.05	0.42	0.59	0.42	1.30

Bio-fertilizations with (yeast or bacteria) combined with mineral N fertilizer at different rates had positive effects on the plant height (cm), the numbers and weight of spike/m^2 as well as straw grain, and yields (g/m^2 or ton/fed). This results from the desirable effects of bio-fertilization which plays an important role in the acclimatization processes of wheat which was reflected in enhancing these characters (Mahdi et al., 2010**)**. Simultaneously, the positive effects of bio-fertilizers treatment on yield criteria may be attributed to their acceleration of N^{-2} fixing activity and the production of plant growth promoting substances such as indole acetic acids, cytokines-like substances and gibberellins (Tawfik & Gomaa, 2005).

Direct effects of the application of bacteria *Rhizobium radiobacter* and yeast on wheat grown and yield quality were shown in Table 4. The data obtained revealed that the values of yield components increased with soil treated with bio-fertilizers combined with different mineral nitrogen fertilizer rates (25,50 and 75kg N/fed) on the wheat plant height (cm), spike length (cm), a number of grains/spike, straw weight/plant (g), grains weight/spike(g), 1000-grain weight (g), grain yield (ton/fed), straw yield (ton/fed) and harvest index (%) compared to the different mineral nitrogen fertilizer rate alone (Amin & Kurosh, 2015).

Effect of different types of bio-fertilizers and mineral nitrogen fertilizer rate on the chemical composition of wheat

Data presented in Table 5 revealed that the addition of different levels of N and bio-fertilizers had significant effects on the protein and carbohydrate contents of wheat grains. The mean value of wheat protein was high at treatment with bacteria (13.31%) compared to control (12.11%). While, the highest protein value was observed in soil treated with a mixture of bacteria and mineral nitrogen at a rate of 75kg N/fed compared to the other remaining treatments. All chemical contents of wheat grains were significantly affected by (yeast+ bacteria) treatment compared to control. Also, the control treatments (nitrogen mineral fertilizer) were characterized by protein content of 12.11%, carbohydrates 81.31%, fat 1.81%, fiber 2.83%, and ash 1.97%. This may be due to the stimulation of protein synthesis as a result of the applied treatments (Dhiman & Dubey, 2017).

TABLE 5. Effects of bio-fertilizers and different mineral nitrogen rates on the chemical composition of wheat grains

Treatments	Mineral N fertilizer rate (kg/fed)	Protein (%)	Carbohydrate (%)	Fat (%)	Fiber (%)	Ash (%)
Mineral	25	11.69	81.78	1.78	2.81	1.94
	50	12.0	81.44	1.80	2.81	1.95
	75	12.31	81.06	1.82	2.84	1.97
	100	12.38	80.94	1.82	2.85	2.01
	Mean	12.11	81.31	1.81	2.83	1.97
Yeast	25	12.44	80.97	1.80	2.82	1.97
	50	13.31	80.08	1.80	2.83	1.98
	75	13.5	79.81	1.85	2.85	1.99
	100	13.38	79.84	1.88	2.86	2.04
	Mean	13.16	80.18	1.83	2.84	1.99
Bacteria	25	12.5	80.92	1.80	2.83	1.95
	50	13.56	79.82	1.80	2.86	1.96
	75	13.63	79.72	1.81	2.88	1.96
	100	13.56	79.71	1.85	2.89	1.99
	Mean	13.31	80.04	1.82	2.87	1.97
Yeast + bacteria	25	12.44	81.04	1.82	2.81	1.94
	50	13.38	80.06	1.84	2.81	1.96
	75	13.56	79.81	1.86	2.83	1.97
	100	13.63	79.7	1.84	2.84	1.99
	Mean	13.25	80.15	1.81	2.82	1.97
L.S.D., at 0.05 (Rate)		0.42	0.57	N.S.	N.S.	N.S.
L.S.D., at 0.05 (Treatments)		0.46	0.68	N.S.	N.S.	N.S.
Interaction		N.S.	N.S.	N.S.	N.S.	N.S.

Wheat grains inoculated with nitrogen-fixing bacteria and two strains of yeast had a positive effect on the nitrogen content of wheat plants. These results may be due to the effect of bio-fertilization which plays an important role in the assimilation of plants that was reflected in enhancing these characteristics. Also, this could be attributed to the role of plant phytohormones like GA, IAA and CKs which promote plant growth, cell division, breaking the special dominances, hence encouraging photosynthesis and assimilating accumulation (Zaki et al., 2017). Total carbohydrates and crude protein in leaves, as well as grains, were significantly increased by all bio treatments as Azotobacter, *Azospirillium, Rhizobium* and *Pseudomonas*, farmyard manure (FM) (0, 15ton/fed) and mineral fertilizer (NPK) at rates of (0, 25, 50 and 100%), particularly the combined treatment of Bio+FM+50% NPK (Agamy et al., 2012).

Conclusion

Bio-fertilizers application in agriculture has a greater impact on organic agriculture and also on the control of environmental pollution, soil health improvement and reduction in input use. The study aimed to evaluate the effect of mineral nitrogen levels alone or combined with bio-fertilizers (*Rhizobium radiobacter* inoculation and *Candida incommunis*) on some physicochemical properties of soil, wheat yield and quality.

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References

A. A. C. C. (1983) "*Approved Methods of the AACC*", 8th ed. S Paul, MN: American Association of Cereal Chemistry (Method 38-10, approved April 1961).

A. O. A. C. (2000) Association of Official Agricultural Chemists, "*Official and Tentative Methods of Analysis*", 11th ed. Washington, D.C., USA.

Agamy, R.A., Mohamed, G.F., Rady, M.M. (2012) Influence of the application of fertilizer type on growth, yield, anatomical structure and some chemical components of wheat (*Triticum aestivum,* L.) grown in newly reclaimed soil. *Australian Journal of Basic and Applied Sciences*. **6**(3), 561-570.

Alori, E.T., Aboyeji, C.M., Dunsin, O., Adegbite, K.A., Aremu, C.O., Bamiro, O., et al. (2019) MgO fertilizer sole and combined with organic and inorganic fertilizers: Effect on soil chemical properties, turmeric performance, and quality in a tropical alfisol. *The Scientific World Journal*, Article ID 8140276 |

Amin, F., Kurosh, H. (2015) Comparison between effect of chemical and biological fertilizers on yield and yield components wheat (*Triticum aestivum L*) Pishtaz cultivar. *Indian Journal of Natural Sciences*, **5**(30), 7792-7796.

Bucchignani, E., Mercogliano, P., Panitz, H.J., Montesarchio, M. (2018) Climate change projections for the Middle East–North Africa domain with COSMO-CLM at different spatial resolutions. *Advances in Climate Change Research*, **9**, 66–80.

Cercioglu, M., Okur, B., Deli, S., Ongun, A.R. (2014) Changes in physical conditions of a course textured soil by addition of organic wastes. *Eurasian Journal of Soil Science*, **3**, 7-12.

Chapman, H.D., Pratt, P.E. (1978) "*Methods of Analysis for Soil, Plant and Waters*". Univ. of Calif. Div. Agric. Sci. Precede publication, 4043p.

Cottenie, A., Verloo, M., Velghe G., Cameriynck, R. (1982) "Chemical Analysis of Plant and Soil." Laboratory of Analytical and Agrochemistry, State Univ., Ghent, Belgium.

Dhiman, S., Dubey, Y.P. (2017) Effect of bio-fertilizers and inorganic fertilizers on yield attributes, yield, quality of *Triticum aestivum* and *Zea mays* in an Acd Alfisol. *International Journal of Current Microbiology and Applied Sciences*, **6**(7), 694.

El-Maaz, E. I.M., Ahmed, H.M.R.M., Shaban, Kh.A. (2014) Soil chemical properties and wheat productivity as affected by organic, bio fertilization and cultivation methods in saline soil. *Minufiya Journal of Agricultural Research*. **39**(6), 1955-1968.

Gutiérrez-Rojas, I., Torres-geraldo, A.B., Moreno-Sarmiento, N. (2011) Optimizing carbon and nitrogen sources for *Azotobacter chroococcum* growth. *African Journal of Biotechnology*. **10**, 2951-2958.

Itelima, J., Bang, W., Onyimba, I., Oj, E. (2018) A review: Biofertilizer; a key player in enhancing soil fertility and crop productivity. *Journal of Applied Biotechnology Reports*, **2**, 22-28.

Jackson, M.L. (1967) "*Soil Chemical Analysis*". Constable and Co. L.T.P., London, England.

Jalilian, J., Modarres- Sanavy, S.A.M., Saberali, S.F., Sadat Asilan, K. (2012) Effects of the combination of beneficial microbes and nitrogen on sunflower seed yields and seed quality traits under different irrigation regimes. *Field Crops Research*, **127**, 26-34.

Kumar, A., Urmila (2018) Impact of biofertilizers in enhancing growth and productivity of wheat: A review. *International Journal of Chemical Studies*, **6**(4), 360-362.

Mahdi, S.S., Hassan, G.I., Samoon, S.A., Rather, H.A., Showkat, A.D., Zehra, B. (2010) Bio-fertilizers in organic agriculture. *Journal of Phytology*, **2**(10), 42-54.

Ministry of Agriculture & Land Reclamation (MALR) (2021) Bulletins of Food Ballance Sheet (2000–2019); Cairo, Egypt.

Mohamed, M.H.M., Petropoulos, S.A., Ali, M.M.E. (2021) The application of nitrogen fertilization and foliar spraying with calcium and boron affects growth aspects, chemical composition, productivity and fruit quality of strawberry plants. *Horticulturae*, **7**, 257.

Nelson, D.W., Sommers, L.E. (1982) Total carbon, organic carbon, and organic matter. p. 539–579. In: "*Methods of Soil Analysis. Part 2*", A.L. Page (Ed.) . 2nd ed. Agron. Monogr. 9. ASA and SSSA, Madison, WI.

Nosheen, S., Ajmal, I., Song, Y. (2021) Microbes as biofertilizers, a potential approach for sustainable crop production. *Sustainability*, **13**, 1868.

OECD, FAO (2018) The Middle East and North Africa: Prospects and challenges. In: OECD-FAO Agricultural Outlook 2018–2027; OECD Publishing: Paris, France; Food and Agriculture Organization of the United Nations: Rome, Italy, 2018.

Page, A.L., Miller, R.H., Keeney, D.R. (1982) "*Methods of Chemical Analysis. Part 2: Chemical and Microbiological Properties*", 2nd ed.. American Society of Agronomy, Inc. and Sci. Soc. of America, Inc. Public. Madison, Wisconsin, U.S.A.

Perkin–Elmer. (1982) "*Analytical Methods for the Atomic Absorption Spectrophotomertry*", perkin-Elmer, Norwalk, C. T.

Richards, A.L. (1954) Diagnosis and improvement of saline and alkali soils. U.S. Dept. Agric. Hand Book, 60. U.S.A. 208p.

Sadler, M., Magnan, N. (2011) Grain import dependency in the MENA region: Risk management options. *Food Security*, **3**, S77–S89.

Shaban, Kh.A., Omar, M.N.A. (2006) Improvement of maize yield and some soil properties by using nitrogen mineral and PGPR group fertilization in newly cultivated saline soils. *Egyptian Journal of Soil Science*, **46**(3), 329-342.

Shirokova, Y., Forkutsa, I., Sharafutdinova, N. (2000) Use of electrical conductivity instead of soluble salts for soil salinity monitoring in Central Asia. *Irrigation and Drainage Systems*, **14**, 199–205.

Soltanpour, P.N., Schwab, A.B. (1977) Anew soil test for simultaneous extraction of macronutrient in alkaline soil. *Communications in Soil Science and Plant Analysis*, **8**, 195.

Sommers, L.E., Nelson, D.W. (1972) Determination of total phosphorus in soil. A rapid perchloric acid digestion procedure. *Soil Science Society of*

America Proceedings, **36**, 902-904.

Tawfik, M.M., Gomaa, A.M. (2005) Effect of organic and bio-fertilizers on the growth and yield of wheat plants. *Egyptian Journal of Agricultural Research*, **2**(2), 711-725.

Thomas, L., Singh, I. (2019) Microbial biofertilizers: Types and applications. In: "*Biofertilizers for Sustainable Agriculture and Environment*"; Springer: Berlin/Heidelberg, Germany, pp. 1–19.

United States Department of Agriculture, USDA. (2020) Grain and Feed Annual Egyptian Wheat Imports Hold Steady Despite Increased Local Production; Foreign Agricultural Services; Report Number: EG2020-0005; Washington, DC, USA.

United States Department of Agriculture (USDA), (2021) Grain and Feed Annual Report.

Waller, R.A., Duncan, D.B. (1969) A bayes rule for the symmetric multiple comparison problems. *Journal of the American Statistical Association*, **64**, 1484-1504.

Woertz, E. (2017) Agriculture and development in the wake of the Arab spring. In: Combining Economic and Political Development: The Experience of MENA; International Development Policy Series 7; Luciani, G., Ed.; Graduate Institute Publications: Geneva, Switzerland, pp. 144–169.

Yigezu, Y.A., Moustafa, M.A., Mohiy, M.M., Ibrahim, S.E., Ghanem, W.M., Niane, A., Abbas, E., et al. (2021) Food losses and wastage along the wheat value chain in Egypt and their implications on food and energy security, natural resources, and the environment. *Sustainability*, **13**, 10011.

Zaki, N.M., Hassanein, A.M.S., Mohamed, M.H. (2017) Effect of organic and bio-fertilizer on yield and some chemical composition of two peanut cultivars under newly reclaimed sandy soil condition. *Middle East Journal of Applied Sciences*, **7**(4), 937-943.

تاثير التسميد على جوانب النمو والتركيب الكيميائي وإنتاجية محصول القمح

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أجريت الدراسة الحالية لتقييم تأثير مستويات النيتروجين المعدني المختلفة بمفردها أو مجتمعة مع الأسمدة الحيوية (تلقيح سلالة *Rhizobium Radiobacter* sp والخمائر) على الخواص الفيزيائية والكيميائية للتربة وإنتاجية القمح. أجريت التجارب الحقلية بالتربة الرملية بالمزرعة التابعة لشركة 6 أكتوبر الزراعية بالقصاصين بمحافظة الإسماعيلية، مصر. تم تقسيم حبوب القمح بمعدل 60 كجم / فدان الى ثلاث اقسام. في القسم الأول تم إضافة معدلات السماد النيتروجيني المعدني بنسب (25 ، 50 ، 75 ، 100 كجم نتروجين /فدان). في القسم الثاني، تم تلقيح حبوب القمح بسلالة البكتيريا *Rhizobium radiobacte* sp (PGPR) ممزوجة بـ 400 مل من السائل اللاصق (الصمغ العربي). في القسم الثالث، تم وضع 33٪ نترات أمونيوم بمعدلات (25 ، 50 ، 75 و 100 كجم نتروجين / فدان) ثلاث مرات بعد 21 ، 40 و 60 يومًا بعد الزراعة وكبريتات البوتاسيوم (48٪) بمعدل 75 كجم / فدان على جرعتين بعد 21 و 45 يوم من الزراعة. أظهرت النتائج أن درجة حموضة التربة تراوحت بين 7.90 و8.01. وتراوحت ملوحة التربة بين 1.61 و 1.24 للتربة المعالجة بالنيتروجين المعدني وخليط (خميرة + بكتريا) مع زيادة نسبية لمتوسط قيم النيتروجين كانت 2.70 و 3.63 و 5.22٪. اما العناصر المعدنية مثل الحديد والمنجنيز والذنك في التربة كانت 2.65 إلى 3.12mg / kg للحديد؛ 1.35 إلى 1.63 مجم/ كجم للمنغنيز و 0.60 إلى 0.85 مجم / كجم للزنك. تؤكد هذه الدراسة ان استخدام الأسمدة الحيوية تساعد في انتاج قمح عالي الجودة كما انها تقلل من التلوث البيئي.