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RESEARCH ARTICLE

Effect Of Mineral Nitrogen Fertilizer And Biofertilizer On Yield And Its Components Of Some Bread Wheat Cultivars

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ABSTRACT

Wheat is the world most important cereal crop for its many properties and uses of its grain. Egyptian researchers does his best to increase yield via biofertilizers with less amount of mineral fertilizer. Thus a field experiment was conducted during in 2023/2024 and 2024/2025 growing seasons at Etay elbaroud Agricultural Research Station, Egypt. Using a split-plot design in a randomized complete block design arrangement with three replicates, the main plots contain three treatments of mineral N fertilizer (35, 55 and 75 kg N/fed) and three mix treatments with the same levels of mineral N and biofertilizer and sub plots contain three studied cultivars. The objective of this study was to investigate the effect of three nitrogen levels (35, 55 and 75 KgN/fad) and the same levels of mineral nitrogen with a biofertilizer on yield and its components of Sakha 95, Misr4 and Sids 14 wheat cultivars to maximize wheat productivity and minimize environmental pollution.The all treatments of mineral N and the mix mineral and biofertilizer had significant effects for all studied traits in both seasons and overall data. The tallest cultivar was Misr 4 in two seasons under N 75 and N 55 and under the same nitrogen levels and biofertilizer. Sakha 95 was having the highest value of number of spikes/m^2 for two seasons and overall in all treatment of fertilizer. For number of kernels/spike in overall Misr 4 had the highest number three levels of nitrogen and three levels of biofertilizer + mineral nitrogen. The heaviest 1000 kernel weight Sakha 95 in two seasons and overall Misr 4 in all levels mineral nitrogen and biofertilizer. For grain yield/fad the highest weight of GY (Ard/fed) was in the tree levels of mineral and biofertilizer in the two seasons and overall the cultivar Misr 4 had the highest weight of grain yield.

Keywords: bread wheat, nitrogen fertilizer, biofertilizer, cultivars, yield.

INTRODUCTION

Wheat is the most important and the most widely grown cereal crop in the world, for its many properties and uses of its grain (Sharma *et al*., 2023 and Liang *et al*., 2024). Increasing grain yield of wheat is an important goal to face the continuous increasing food needs of Egyptian population. Recently, a great attention of several investigations has been directed to increase wheat production to minimize the gap between the Egyptian production and consumption by increasing the cultivated area and wheat productivity per unit area (Zaki *et al* 2012). Overuse of chemical fertilizers has devastating effects on soil fertility.

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Moreover, even if chemical fertilizers are used in a balanced way, they negatively affect soil health in the long term. Nowadays scientists are trying to develop an agricultural system that not only reduces the cost of agricultural production but also protects natural resources (Abbas *et al*., 2012 and Darjee *etal*., 2024). Organic farming is a production system that limits or largely eliminates the use of synthetic or inorganic fertilizers, pesticides, and hormones (Reddy, 2005 and Aulakh, 2010). Nitrogen (N) is the most important nutrient supplied to most cereal crops like wheat (Hassan *et al*., 2014, Wang *et al*., 2017 and El-sorady *et al*., 2022). The most important role of N in plant is its presence in the structure of protein and nucleic acids. N is necessary to achieve high yield potential in crops, N fertilizer is known to affect the number of tiller m^2 , number of grains /spike, spike length and weight, 1000 grain weight and grain yield of wheat (Kandil *et al*., 2011, Campuzano *et al*., 2012 and Ozkan *et al*., 2021). Increasing the role of biofertilizer can reduce the need for chemical fertilizers and decrease adverse environmental effects. They can play significant role in fixing atmospheric N and production of plant growth promoting substance. Therefore, in development and implementation of sustainable agricultural techniques, bio-fertilizer has great importance in alleviating environmental pollution. Attia and abd Elsalam 2016., reported that the inoculation with bio- fertilization had significant effect on plant height, grain weight/spike, number of spikes/m^2, number of grains /spike, 1000 grain weight, grain in wheat. biofertilizer reduce pollution and sustain soil fertility through their effect on the physical, chemical and biological properties of soil. Kaur *et al*., 2018, Farid *et al*., 2023 and Mahmud *et al*., 2022. Therefore the investigation aimed to study the effect of mineral N and biofertilizer on yield and yield components of wheat, to improve wheat yield productivity and minimize pollution.

MATERIALS AND METHODS

The field experiment was conducted at Etay elbaroud Agriculture Research Station of the ARC, Egypt, during 2023/2024 and 2024/2025 growing seasons. To study the effect of three mineral nitrogen fertilizer levels and mix between mineral nitrogen and biofertilization (biogen) on yield and yield components of three bread wheat cultivars.

Inoculum treatments:

Wheat grains were inoculated before sowing with free-living Nitrogen-fixing bacteria (Azotobacter) under the commercial name (Biogein) that contains a specific clone of *Azotobacter chroococcum* bacteria, conc.106 cells/ml. Biogein is produced by Bio-fertilizers Unit, General Organization of Agriculture Equalization Fund, Agricultural Research Centre, Giza, Egypt.

To apply biofertilizer mix a small amount of water with sugar and adding biofertilizer on this sugar solution, then lightly sprinkle the solution on grains and mix good to ensure all grains are uniformly coated, and then dry coated grains in the shade for 24 hours before sowing to protecting microorganisms from sunlight exposure. These treatment grains were sowing and adding mineral nitrogen with the same average in experiment.

Experimental design

In each season, a split plot design in a randomized complete block design arrangement with three replications was used. The main plots contain all nitrogen treatments and mix between nitrogen and biofertilizer and sub plots contain cultivars. Experimental plot area was 4.2 m^2. (Six rows, 3.5 m long and 0.2 m apart). All recommended agricultural practices were applied as recommended for wheat crop.

The treatments of experiment:

Mineral nitrogen (N) was applied on soil: 1- 35kg N/fed mineral fertilizer (N35). 2- 55kg N/fed mineral fertilizer (N55). 3- 75kg N/fed mineral fertilizer (N75).

The treatments of the mix between mineral nitrogen (N) and biofertilizer (B) was applied on soil: 1- 35kg N/fed mineral fertilizer and biofertilizer (B+N35). 2- 55kg N/fed mineral fertilizer and biofertilizer (B+N55). 3- 75kg N/fed mineral fertilizer and biofertilizer (B+N75).

Mineral nitrogen fertilizer in the form of ammonium nitrate (33.5%N), as a source of nitrogen, was added in three doses at sowing, the first and the second irrigation. The dose of P was 15 kg P_2O_5 as super phosphate (15.5% P_2O_5) was broadcasted at the time of soil preparation and 50 kg of K as potassium sulfate (50% K_2O), was added with the first irrigation. Three Egyptian wheat cultivars were characterized by its high yield and thrives in this region were used in this investigation (Table 1)

Table 1. The cultivars used in this study and their pedigree and selection history.

Cultivar	Pedigree and selection history
Sakha95	PASTOR//SITE/MO/3/CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/4/WELL1 CMA01Y00158S-040POY-040M-030ZIM-040SY26M-0Y-0B-0ET
Misr4	NS732/HER/3/PRL/ SARA// TSI/VEE 5/6/FRET 2/5/WHEAR/SOKOLL CM SA09Y007125-050Y- 050ZTM-0NJ-099NJ-0B-0EG.
Sids14	Bow"S"/Vee"S"// Bow"S"/TSI/3/Bani Sewef 1. SD293-1SD-2SD-4SD-0SD.

Recorded Data:

Date were recorded for plant height (cm) (PH), number of spikes/m^2 (S/m^2), number of kernels/spike (K/S), 1000- kernel weight (1000-KW) (gm), grain yield (GY) (ard./fed) (one ard.= 150 kg and one fed.= 4200m^2).

Statistical analysis:

Data were subjected to the proper statistical analysis as the technique of analysis of variance (ANOVA) of split plot arrangement in randomized complete block design according to Gomez and Gomez (1984). Treatments means were compared using the least significant difference (LSD) test as outlined by Waller and Duncan (1969). Computation was done using computer software SPSS (IBM crop 2021). Combined analysis of variance across the two seasons was also performed if the homogeneity test was non-significant according to Levene (1960).

RESULTS AND DISCUSSION

Mean performance

For plant height trait Table (2) showed significant differences between the three wheat cultivars in the two seasons and overall. According data in Table 2, increasing nitrogen fertilizer rates and the mix between mineral and biofertilizer from 35 kg N/ fed to 75 kg N/ fed led to significant improvements in plant height.

Under 55 and 75 kg N/fed the tallest cultivar was Misr 4 (105.9 and 110.5 cm) respectively in the first season and (107 and 111.6 cm) respectively in the second. and also under the mix between biofertilizer and mineral (B+55 and B+75 kg N/fed) Misr 4 had (106.5 and 111.1 cm) respectively in the first season and (107.6 and 112.2 cm) respectively in the second season. As general the mix between biofertilizer and mineral nitrogen fertilizer gave taller plants. The increase in plant height due to the biofertilizer used may be attributed to the increase of cell division and enlargement, which led to raising plant height according to enhancement of dry matter accumulation that was stored in the spike, therefore gave increase in length of spike several investigators such as Ali *et al.* (2011), Farag and El-khawaga (2013), Kakraliya *et al*. (2017), Abdel-Lateef (2018) as well as Mona and Hala (2023). The significant increase in plant height can be attributed to the biofertilizers, which stimulated plant growth through better nutrient absorption (Yan *et al*., 2024).

For number of spikes/m^2 data showed in Table (3) showed that by adding mineral nitrogen or mixing mineral and biofertilizer was showed a significant increased. Sakha 95 was having the highest value of number of spikes/m^2 for two seasons and overall data and recorded under 35, 55 and 75 kg N/fed (218.3, 263.7 and 274.3) respectively in the first season and in the second season recorded (204.7, 266.7 and 277.3) respectively. Also Sakha 95 was recorded under (B+35, B+55 and B+75 kg N/fed) in first season (220.3, 276.3 and 283.7) respectively and in the second season (203.3, 279.3 and 286.7) respectively. The positive effect of such fertilizers (mineral N and biofertilizer +mineral N) on spikes number might be attributed to their roles in increasing the amount of metabolites synthesized, which promoted the numbers of tillers. This data is similar by Attia and Abd El Salam (2016) and Al-Amin *et al*. (2017) and Kaur *et al*. (2018).

Data in Table (4) showed significant differences of number of kernels/spike (K/S) for three wheat cultivars in the two seasons and overall under all fertilization treatments. Data in Table (4) also showed increasing nitrogen fertilizer rates from 35 kg N/ fad to 75 kg N/ fed led to significant improvements in number of kernels/spike and also with adding biofertilizer and mineral nitrogen. In the first season Sids 14 had the highest value of number of kernels/spike under 75 kg N/fed (70.79) and Misr 4 under 35 and 55 kg N/

fed (62.23 and 66.23) respectively, and in the second season Misr 4 had the highest value of number of kernels/spike under three levels of mineral nitrogen (35, 55 and 75 kg N/fed) (60.00, 70.33 and 74.78) respectively, and in the mix between biofertilizer+N in the first season Misr 4 had the highest value (63.79 and 74.90) respectively under B+ 35 and B+75 kg N/fed. The highest value of the second season was Sids 14 was the highest value under B+ 75 kg N/fed (75.89) and Misr 4 under (B+35 and B+55 kg N/fed) was (68.78 and 70.00), The positive effects of mixing between mineral and biofertilizers on number of kernels/spike were previously reported by Mandic *et al*. (2015), Adnan *et al*. (2016), Attia and Abd El Salam (2016) and Aulakh (2010).

Table (2). Means of plant height (cm) for three bread wheat cultivars for two seasons and overall under treatments of fertilization.

Season 1	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
Cultivars	N 75	N 55	N 35	B+ N35	B+N 55	B+N 75	
Sakha 95	102.4	97.8	96.3	100.1	97.7	101.7	99.3
Misr 4	110.5	105.9	100	101	106.5	111.1	105.8
Sids 14	107.2	100.2	101.6	103.1	105	107	104
mean	106.7	101.3	99.3	101.4	103.1	106.6	103.1
LSD 0.05							
Fertilizer(F)							2.41
Cultivars (C)							2.1
F x C							NS
Season 2	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
	N 75	N 55	N 35	B+ N35	B+N 55	B+N 75	
Sakha 95	103.5	98.9	97.4	101.2	98.8	102.8	100.4
Misr 4	111.6	107	102.6	100.4	107.6	112.2	106.9
Sids 14	108.3	101.3	102.7	104.2	106.1	108.1	105.1
mean	107.8	102.4	100.9	101.9	104.2	107.7	104.2
LSD 0.05							
Fertilizer(F)							2.19
Cultivars (C)							2.08
F x C							NS
Overall	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
	N 35	N 55	N 75	B+ N35	B+N 55	B+N 75	
Sakha 95	96.8	98.3	103.5	100.6	98.3	102.8	99.9
Misr 4	101.3	106.4	111.6	100.7	107	112.2	106.4
sids 14	102.2	100.8	108.3	103.6	105.6	108.1	104.6
mean	100.1	101.8	107.8	101.7	103.6	107.7	103.6
LSD 0.05							
Season(S)							NS
Fertilizer(F)							1.52
S x F							NS
Cultivars (C)							1.44
S x C							NS
F x C							3.21
S x F x C							NS

Table (3). Means of number of spikes/m2 (S/m2) for three bread wheat cultivars for two seasons and overall under treatments of fertilization.

Season 1	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
Cultivars	N 35	N 55	N 75	B+ N35	B+N 55	B+N 75	
Sakha 95	218.30	263.70	274.30	220.30	276.30	283.70	256.10
Misr 4	179.00	212.30	241.00	175.00	220.30	261.70	214.90
Sids 14	214.30	240.30	268.30	206.30	233.00	270.30	238.80
mean	203.90	238.80	261.20	200.60	243.20	271.90	236.60
LSD 0.05							
Fertilizer(F)							14.43
Cultivars (C)							7.51
F x C							NS
Season 2	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
	N 35	N 55	N 75	B+ N35	B+N 55	B+N 75	
Sakha 95	204.70	266.70	277.30	203.30	279.30	286.70	253.00
Misr 4	185.30	215.30	244.00	178.00	223.30	264.70	218.40
Sids 14	199.00	243.30	271.30	196.00	236.00	273.30	236.50
mean	196.30	241.80	264.20	192.40	246.20	274.90	236.00
LSD 0.05							
Fertilizer(F)							12.21
Cultivars (C)							7.59
F x C							NS
Overall	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
	N 35	N 55	N 75	B+ N35	B+N 55	B+N 75	
Sakha 95	211.50	265.20	275.80	211.80	277.80	285.20	254.60
Misr 4	182.20	213.80	242.50	176.50	221.80	263.20	216.70
sids 14	206.70	241.80	269.80	201.20	234.50	271.80	237.60
mean	200.10	240.30	262.70	196.50	244.70	273.40	236.30
LSD 0.05							
Season(S)							NS
Fertilizer(F)							8.85
S x F							NS
Cultivars (C)							5.20
S x C							NS
F x C							13.37
S x F x C							NS

For 1000 kernels weight in table (5) application of biofertilizer and all levels of mineral fertilizers either separately or mixed tended to significantly increase 1000 kernel weight in both seasons, The heaviest 1000 kernel weight were recorded by Sakha 95 in the first season by (43.20, 48.33 and 51.44 gm) respectively under 35, 55. 75 kg N/fed, under biofertilizer and mineral nitrogen (B+35, B+55 and B+75 kg N/fed) was (47.84, 52.57 and 55.26gm) respectively. In the second season Misr 4 had the heaviest weight under all levels of mineral nitrogen (35, 55 and 75 kg N/fed) was (44.40, 49.53 and 52.64 gm) respectively and in biofertilizer+ mineral nitrogen fertilization (B+35, B+55 and B+75 kg N/fed) was (49.04, 51.44 and 53.80 gm). In this context, Mengel and Kirkby (2001) stated that translocation of photoassimilate from the vegetative tissues to kernels was much affected by plant nutrition status, which leads to promote cells division and buildup of storage capacity. The increase in 1000 kernel weight by application of different fertilizers were previously reported by Noureldin *et al*. (2013) and Mandic *et al*. (2015).

For grain yield/fad in table (6) the highest weight of GY (ard/fed) in the first season and under 75 kg N/fed was Sakha 95had the highest weight (26.27 ard/fed) and under 35 and 55 kg N/fed Misr 4 had the highest weight (15.22 and 25.22 ard/fed). On the other hand used the mix of mineral and bio fertilizer (B+35, B+55

Table (4). Means of number of kernels/spike (K/S) for three bread wheat cultivars for two seasons and overall under treatments of fertilization.

Season 1	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
Cultivars	N 35	N 55	N 75	B+ N35	B+N 55	B+N 75	
Sakha 95	53.68	62.90	70.01	58.90	69.23	73.68	64.73
Misr 4	62.23	66.23	69.01	63.90	68.68	74.79	67.47
Sids 14	61.68	65.01	70.79	67.68	68.90	72.01	67.68
mean	59.20	64.71	69.94	63.49	68.94	73.49	66.63
LSD 0.05							
Fertilizer(F)							2.08
Cultivars (C)							1.38
F x C							3.32
Season 2	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
	N 35	N 55	N 75	B+ N35	B+N 55	B+N 75	
Sakha 95	60.00	67.33	70.11	68.78	70.00	73.11	68.22
Misr 4	60.00	70.33	74.78	59.33	66.11	75.89	67.74
Sids 14	60.44	67.44	71.89	54.78	64.00	71.11	64.94
mean	60.15	68.37	72.26	60.96	66.70	73.37	66.97
LSD 0.05							
Fertilizer(F)							1.64
Cultivars (C)							1.30
F x C							2.96
Overall	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
	N 35	N 55	N 75	B+ N35	B+N 55	B+N 75	
Sakha 95	56.84	65.12	70.06	63.84	69.62	73.39	66.48
Misr 4	61.12	68.28	71.89	61.61	67.39	75.34	67.61
sids 14	61.06	66.23	71.34	61.23	66.45	71.56	66.31
mean	59.67	66.54	71.10	62.23	67.82	73.43	66.80
LSD 0.05							
Season(S)							1.41
Fertilizer(F)							1.24
S x F							1.91
Cultivars (C)							0.92
S x C							1.56
F x C							2.18
S x F x C							3.18

Table (5). Means of 1000 kernel weight (gm) (1000KW) for three bread wheat cultivars for two seasons and overall under treatments of fertilization.

Season 1	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
Cultivars	N 35	N 55	N 75	B+ N35	B+N 55	B+N 75	
Sakha 95	43.20	48.33	51.44	47.84	52.57	55.26	49.77
Misr 4	41.00	47.27	48.93	43.77	48.65	50.14	46.63
Sids 14	43.57	45.48	47.90	45.04	47.32	48.50	46.30
mean	42.59	47.03	49.42	45.55	49.52	51.3	47.57
LSD 0.05							
Fertilizer(F)							0.73
Cultivars (C)							0.75
F x C							1.62
Season 2	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
	N 35	N 55	N 75	B+ N35	B+N 55	B+N 75	
Sakha 95	42.20	42.12	51.44	44.97	45.18	49.34	44.54
Misr 4	44.40	49.53	48.93	49.04	51.44	53.80	50.14
Sids 14	44.77	46.68	47.90	46.24	48.52	49.70	47.50
mean	43.79	46.11	49.42	46.75	48.38	50.95	47.40
LSD 0.05							
Fertilizer(F)							0.67
Cultivars (C)							0.77
F x C							1.65
Overall	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
	N 35	N 55	N 75	B+ N35	B+N 55	B+N 75	
Sakha 95	42.70	45.23	47.45	46.40	48.88	52.30	47.16
Misr 4	42.70	48.40	50.78	46.40	50.05	51.97	48.38
sids 14	44.17	46.08	48.50	45.64	47.92	49.10	46.9
mean	43.19	46.57	48.91	46.15	48.95	51.13	47.48
LSD 0.05							
Season(S)							NS
Fertilizer(F)							0.46
S x F							0.64
Cultivars (C)							0.52
S x C							0.65
F x C							1.13
S x F x C							1.60

andB+75 kg N/fed) Misr 4 had the highest weight was (15.37, 25.91 and 31.51 ard/fed). In the second season Misr 4 had the highest weight (15.67, 25.89 and 27.58 ard/fed) respectively under the tree levels of mineral nitrogen and Misr 4 also in mineral and biofertilizer (16.93, 26.11 and 30.85 ard/fed) this trend as the similar in

The superiority of Misr 4 might be attributed to its superiority in yield components, *i.e.* number of spikes/m^2, number of kernels/spike and 1000 kernel weight. According to other researchers found significant variation among wheat varieties in grain yield in favor of Gemmeiza 10 and Sids 12

Table (6). Means of grain yield ard./faddan (Ard/fed) (Gy) for three bread wheat cultivars for two seasons and overall under treatments of fertilization.

Season 1	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
Cultivars	N 35	N 55	N 75	B+ N35	B+N 55	B+N 75	
Sakha 95	12.65	20.56	26.27	14.35	26.13	30.24	21.70
Misr 4	15.22	25.22	26.02	15.37	25.91	31.51	23.21
Sids 14	11.08	22.40	24.82	18.31	23.22	27.46	21.21
mean	12.98	22.72	25.70	16.01	25.08	29.74	22.04
LSD 0.05							
Fertilizer(F)							2.00
Cultivars (C)							1.28
F x C							3.11
Season 2	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
	N 35	N 55	N 75	B+ N35	B+N 55	B+N 75	
Sakha 95	13.36	21.27	23.87	15.91	21.25	25.8	20.24
Misr 4	15.67	25.89	27.58	16.93	26.11	30.85	23.84
Sids 14	13.09	22.11	26.38	19.87	24.78	29.02	22.54
mean	14.04	23.09	25.94	17.57	24.05	28.56	22.21
LSD 0.05							
Fertilizer(F)							2.29
Cultivars (C)							1.07
F x C							NS
Overall	Nitrogen fertilizer			Bio-fertilizer+Nitrogen			Mean
	N 35	N 55	N 75	B+ N35	B+N 55	B+N 75	
Sakha 95	13.00	20.91	25.07	15.13	23.69	28.02	20.97
Misr 4	15.44	25.55	26.80	16.15	26.01	31.18	23.52
sids 14	12.09	22.25	25.60	19.09	24.00	28.24	21.88
mean	13.51	22.91	25.82	16.79	24.56	29.15	22.12
LSD 0.05							
Season(S)							NS
Fertilizer(F)							1.42
S x F							NS
Cultivars (C)							0.81
S x C							2.09
F x C							2.11
S x F x C							NS

(Noureldin *et al.,* 2013), (Dawood *et al.,* 2014) and Gemmeiza 11 (Khaled and Hammad, 2014 and El-Seidy *et al.,* 2017). Sharma *et al.*, 2021 reported that when plants can allocate a greater proportion of their biomass towards grain production, it can lead to increased yields and improved crop performance.

Interaction effect

Increasing nitrogen fertilizer rates from 35 kg N/ fed to 75 kg N/ fed led to significant improvement of all traits for all cultivars and when adding biofertilizer to mineral the improvement was higher. All cultivars showed significant increase for all traits especially with adding biofertilizer to mineral. Increase in yield and its components for all cultivars due to application of biofertilizer was obvious and might be due to the role of biofertilizer in enhancing soil biological activity, which improved nutrient mobilization from organic and chemical sources. Also, biofertilizer plays a significant role in regulating the dynamics of organic matter decomposition and the availability of plant nutrients and in increasing nitrogen fixation. In this respect Bahrani and Hagh (2010) and Zaki *et al* (2016) reported a positive effect on yield and yield components of wheat when inoculated with biofertilizer was found. Ramadhan (2022) used five combinations of organic and inorganic nutrient and revealed that organic and inorganic amendments affected plant growth, yield components, grain yield significantly.

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