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Original Research Article

Effects of Enhanced Bio-fertilizer (N-fixer bacteria) with Nitrogen Fertilizer on wheat yield in New Halfa Irrigated Scheme at East of Sudan

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Abstract

Multi locations experiment was conducted or two consecutive winter seasons (2017/ 2018 and 2018/ 2019), at three regions (Southern, middle and Northern) of New Halfa scheme to study the effect of bio-fertilizers (namely N–fixing Bacteria) with N fertilizer on grain yield of wheat. The experimental locations (sites) were Hajer (L1), Faculty of Agriculture (L2) and Shebaik (L3) which represented three types of soils and environments of New Halfa scheme Eastern Sudan. The experiment was arranged according to randomized complete block design (RCBD) with three replicates in each site. The bio fertilizers treatments were inoculation with N-fixing Bacteria (FB *Azotobacter chroococcum*) solely or with 43 kg, 86 kg N hectare in addition to control treatment. The yield attributes parameters include grains number and weight per plant, spike length, number of spikelets per spike, 100–grain weight and grain yield/ha. The results revealed that, inoculation seeds with Bacteria increased yield parameters particularly in first season at all sites. Addition of N to bio fertilizer (FB+86kg N\ha) relative to control treatment significantly increased all aforementioned yield traits particularly grain yield/ha by more than 54% at northern site (Shebaik) of New Halfa Scheme, which was associated with significant increased in related character 1000–grain weight. Inoculation, application of bio fertilizer with N, can greatly increased yield of wheat at all regions of New Halfa scheme.

Keywords: bio-fertilizers, N–fixing Bacteria, N, wheat, grain yield

INTRODUCTION

Wheat (Triticum aestivum L.), is one of the major food crops in the world, it is a cool-season annual monocot C3 plant which is representative of graminaceous species common to temperate and savannas zones (Wall et al., 2006). According to Hari and Perumal (2010) bio-fertilizer is most commonly referred to as selected strains of beneficial soil microorganisms cultured in the laboratory and packed in suitable carriers. Moreover, Micro-organisms used as bio-fertilizer include: Nitrogen fixers (N-fixers) e.g., Rhizobium Spp., Cyanobacteria, and Azotobacter chroococcum (Choudhury and Kennedy., 2004; Khosro, 2012). The increased in spike length, number of spikelets per spike due to addition of bio fertilizer was reported by (Chauban et al., 2011; Amin and Kurosh., 2015). The interaction between bio fertilizer and nitrogen levels had significant effect on yield and yield components of wheat (Soleimanzadeh and Gooshchi, 2013). Kandil et al., (2011) found that application of bio fertilizer had favorable effects on 1000-grain weight particularly with combination with chemical fertilizers. Many studies have been performed on different crops using bio fertilizer to increase grain yield. Esmailpour et al. (2013) noticed that using bio-fertilizer Azotobacter had led to an increase in grain yield of wheat (3,360 kg ha-1) in comparison to the control (2,839 kg ha-1). Also, among the biological

fertilizer's application of Nitroplus has the highest (540g.m-2) and control treatment had the lowest (490g.m-2) grain yield and differences between them were significant (Amin and Kurosh, 2015). The continuous use of higher levels of chemical fertilizers by the farmers has led to the problem of soil degradation, which is proving detrimental to crop production in our country. In this context, it is necessary to provide conditions for effective use of natural processes, such as bio fertilization, the process of fixing nutrients through microorganisms (Astarai and Koocheki.,1996). However, current trends in agriculture are focused on search for alternative to chemical fertilizer due to huge cost of procurement, contamination of environment, and couple with improper application leading to the degradation of soil quality. Integrated application of N fixing bacteria with chemical fertilizer may increase the availability of nitrogen in the soil, which led to higher crop production. Poor soil nutrients concentration especially, low N coupled with unscientific method of cultivation are major constraints to wheat production in Sudan.This may play a vital role in enhancing crop productivity and sustaining soil fertility, which lead to prove great promise for increasing farmer`s income. These factors interrelate providing an important insight to the study of the effects of amended chemical fertilizers (nitrogen and phosphorous) and cultivars on wheat in New Halfa scheme. Accordingly, the objective of this study was: - investigate the interactive effects of bio fertilizer amended with N on yield of wheat at three different sites (Hajer, Faculty of Agriculture and Shebaik) represent Southern, Central and Northern regions of New Halfa scheme.

MATREIALS AND METHODS

Multi locations field experiment was conducted for two consecutive seasons (2017/018 and 2018/019) in New Halfa Agricultural scheme on Kassala State in Eastern Sudan between latitudes 13° 21'-14° 1' North, longitude 36° 11'- 36° 46' East, over the three proposed soil series of, Khashm el Girba, Asupri and Sabaat which were represented production areas of South, Central and North of New Halfa scheme.

Experimental treatments and layout:

A wheat cultivar; Bohain was used in this study and the seeds for the two seasons were obtained from Agricultural Research Station in New Halfa. The experimental locations (sites) were Hajer (L1), Faculty of Agriculture (L2) and Shebaik (L3) which represented three types of soils and environments of New Halfa scheme Eastern Sudan. The experiment was arranged according to randomized complete block design (RCBD) with three replicates in each site. The bio fertilizers treatments were inoculation with N-fixing Bacteria (FB *Azotobacter chroococcum*) solely or with 43 kg, 86 kg N hectare (in the form of urea 46%N because it was a common fertilizer material and can be applied uniformly in research plot) in addition to control treatment (without fertilization). The treatments were control without any fertilizer FB= only N fixation Bacteria; FB$_+$ 43kg N\ha= N fixation Bacteria with 43kgN/ha; FB$_+$86kg N/ha = N fixation Bacteria with 86kg N/ha. The land was prepared by disc ploughing, harrowing, leveling, and ridging at 80 cm apart as. The plot size was 6× 3.75 meters consisting of four ridges 5-meter in length. Seeds were sown manually at a rate of 120 kg/ha, in three lines 15 cm apart, on the second week of November in both seasons. Weeding was done manually and with herbicides many times per season.

At harvest, the two inner rows in each plot were used for the determination of the following yield components: -

Spike length (cm): Ten spikes from each subplot were randomly selected and the average length of spike was measured.

Number of spikelets spike^{-1}: From the ten selected spikes the average number of spikelets per spike was determined.

Number of grains spike^{-1}: The previous spikelets were threshed manually after drying and the average number of grains per spike was determined.

Grains weight (g plant^{-1})

Grains obtained from the 10 randomly selected plants were weighed using sensitive balance to determine the average grain weight per plant.

100-grain weight (g): From each plot, 1000 grains were randomly selected and weighed using sensitive balance to determine the average1000- grain weight.

Grains yield (kg ha^{-1})

In each plot, all plants grown in an area of 1.7 m^2 in the two central ridges were harvested, air-dried, weighed to determine the average yield per unit area.

Statistical analysis

Data was statistically analyzed using Statistix 10 software package, version 10 for RCBD according to Gomez and Gomez (1972). Means comparison was worked out by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

RESULTS AND DISCUSSION

Inoculated seeds with N –fixing bacteria when combined with chemical fertilizer (N) at high level significantly increased the mean length of spikes and number of spikelets\spike at all locations (Tables1, 2). The longest spikes were observed at

Hagir location (L1)due to application of FB+86kg N\ha. While the highest number of spikelets\spike was recorded at Faculty location (L2) in the second season (Table 2). Increasing N level with FB significantly increased the mean grain number and weight per plant (Tables3, 4). In this regard, application of FB+86kg N\ha as compared to other treatments, the highest number of grains \plant (222.1 and 236.5) was recorded at (L3 and L2) in the first season (Table 3) while the heaviest grains weight per plant (6.2 g) were recorded at (L1 and L2) in the first season (Table 4). Generally, application of chemical fertilizer with inoculation with Bacteria gave the highest values of 1000- grain weight at all sites (Table5). Superiority of FB+86kg N\ha treatment was observed in increasing the mean 1000- grain weight particularly in the first season as compared with other fertilization treatments (Table 5). The heaviest 1000-grain weight (42.80 and 48.10 g) were recorded at (L1 and L3) in the first season (Table 5).

Inoculation wheat grains with nitrogen fixation bacteria only significantly increased the grain yield by more than (3.19%,7.94%band 31.30%) relative to control treatment as average of the two seasons at L1, L2and L3, respectively (Table 6). While application of 43kg N/ha with FB relative to control was increased the grain yield by more than (0.7, 9.13 and 43.72%) at L1, L2and L3, respectively(Table 6). Moreover, application of 86kg N/ha with FB relative to control was increased the grain yield by more than (22.32, and 54.40%) at L1 and L3, respectively (Table 6). Moreover, application of 43kg N/ha with FB relative to FB treatment was increased the grain yield by more than(1.1 and 9.47%) at L2 and L3(Table 6).

Superiority of FB+86kg N\ha treatment was observed in increasing the mean grain yield/ha relative to FB solely by 18.53, 12.97 and 17.60% at the three locations (Table 6). In wheat N is required to ensure photosynthetic activity, growth and grain yield and to produce grain storage proteins that have a key role in technological quality. Thus, combination between chemical fertilizer (N) and bio fertilizer increased availability of soil nutrients, N for wheat plant growth. This might explain the results obtained in most of yield parameters measured in this study. The positive effects of bio fertilizer on grain yield and yield components measured in this study could be attributed to the positive effects of these fertilizer on improving growth characters and consequently enhanced crop to produce more number of spikes, spikelets grains per spike and increasing individual grain weight which, in turn, positively increased grain yield. The increased in spike number, spike length, number of tillers, grain weight per plant, spikelets per plant due to application of solely Bacteria (fixing or soluliblizing) observed in this study were agreed of these results reported by (Chauhan *et al*,2011). Also, Esmailpour *et al.* (2013) noticed that using bio-fertilizer Azotobacter solely or combined with high level of N had led to an increase in grain yield of wheat in comparison to the control.

It has been reported that wheat yield increased up to 30% with Azotobacter inoculation and up to 43% with Bacillus inoculation Bacteria (Kloepper et al,1991). The organic manure fertilizer provides nutrients, energy sources and suitable environment for activity of the microorganisms that found in bio fertilizer resulted in an increase in their growth, number, activities and effectiveness, reflect on their ability to fix atmospheric N or solubilizing P and perhaps some on plant growth, physiological and yield attributes as reported by (Alfreeh et al, 2019).

The significant increases in yield attributes at Shebaik and Hajer sites compare to Faculty site might be due to the differences in soil types because the later site (Faculty) located in area which covered with Khashm el Girba soil series it is a clay soil which richer with CaCO3 might interact, with phosphate and become in unavailable form for wheat plant while the other two sites did not affect P availability to plant and as a result increased plant growth and yield of grains.

Table (1): Effects of Nitrogen Fixation Bacteria (FB)on mean of wheat Spike length (cm)during 2017/2018 and 2018/2019 seasons

Sites	Treatment	control	FB	FB+43kgN/ha	FB+86kgN/ha	mean
L1	2017/2018	5.20	5.80	7.50	7.40	6.48
	2018/2019	5.10	7.23	7.13	7.80	6.82
	Mean	5.142	6.51	7.32	7.60	
	$LSD_{0.05}$ = 0.24					
L2	2017/2018	6.30	7.03	6.04	6.92	6.57
	2018/2019	6.30	6.12	6.10	6.20	6.18
	Mean	6.30	6.30	6.10	6.56	
	$LSD_{0.05}$ = 0.26					
L3	2017/2018	6.14	6.02	6.10	6.70	6.24
	2018/2019	5.60	6.20	6.20	6.72	6.18
	Mean	5.84	6.10	6.12	6.71	
	$LSD_{0.05}$ = 0.30					

Table (2): Effects of Nitrogen Fixation Bacteria (FB)on mean of wheat Number of Spikelets/ spike during 2017/2018 and 2018/2019 seasons

Sites	Treatment	control	FB	FB+43kgN/ha	FB+86kgN/ha	mean
L1	2017/2018	10.32	11.52	12.04	13.16	11.76
	2018/2019	11.76	15.41	15.00	14.70	14.22
	Mean	11.04	13.47	13.52	13.93	
	$LSD_{0.05}$ =0.98					
L2	2017/2018	9.51	12.71	14.59	16.70	13.38
	2018/2019	10.62	11.58	12.62	8.22	10.76
	Mean	10.57	12.15	13.61	12.46	
	$LSD_{0.05}$ = 0.20					
L3	2017/2018	9.53	11.3	11.42	10.62	10.72
	2018/2019	10.90	10.31	9.28	10.24	10.18
	Mean	10.22	10.80	10.35	10.43	
	$LSD_{0.05}$ = 0.30					

Table (3): Effects of Nitrogen Fixation Bacteria (FB)on mean of wheat Number of grains/plant during 2017/2018 and 2018/2019 seasons

Sites	Treatment	control	FB	FB+43kgN/ha	FB+86kgN/ha	mean
L1	2017/2018	116	129.1	147.1	146.9	134.78
	2018/2019	77.1	142.8	156.7	169.1	136.43
	Mean	96.6	135.95	151.9	.0158	
	$LSD_{0.05}$ =0.22					
L2	2017/2018	133.9	169.0	224.5	236.5	190.98
	2018/2019	164.4	137.0	194.8	194.1	172.58
	Mean	149.2	153.0	209.7	215.3	
	$LSD_{0.05}$ = 0.13					
L3	2017/2018	133.5	122.9	85.531	222.1	166.01
	2018/2019	118.0	128.6	173.0	190.5	152,53
	Mean	125.8	125.8	179.3	206.3	
	$LSD_{0.05}$ = 4.92					

Table (4): Effects of Nitrogen Fixation Bacteria (FB)on mean of wheat grain weight per plant (g) during 2017/2018 and 2018/2019 seasons

Sites	Treatment	control	FB	FB+43kgN/ha	FB+86kgN/ha	mean
L1	2017/2018	41.20	38.14	34.31	42.80	39.11
	2018/2019	39.70	35.90	38.70	41.44	38.84
	Mean	40.43	37.01	36.51	42.10	
	$LSD_{0.05}$ = 0.30					
L2	2017/2018	32.93	28.44	29.64	37.5	32.13
	2018/2019	28.10	28.10	28.7	34.10	29.75
	Mean	30.52	28.71	29.14	35.8	
	$LSD_{0.05}$ = 0.93					
L3	2017/2018	42.06	38.5	37.41	48.10	41.52
	2018/2019	35.10	41.50	36.53	40.6	38.43
	Mean	39.02	39.10	36.10	44.8	
	$LSD_{0.05}$ = 0.14					

Table (5): Effects of Nitrogen Fixation Bacteria (FB)on mean of wheat 1000-grain weight (g) during 2017/2018 and 2018/2019 seasons

Sites	Treatment	control	FB	FB+43kgN/ha	FB+86kgN/ha	mean
L1	2017/2018	42.80	41.20	34.31	38.14	39.11
	2018/2019	41.44	39.70	38.70	35.90	38.94
	Mean	42.10	4.43	36.51	37.o1	
	$LSD_{0.05}$ = 0.24					
L2	2017/2018	32.93	37.5	29.64	28.44	32.13
	2018/2019	34,10	28.10	28.7	28.10	29.75
	Mean	33.94	33.22	29.14	28.71	
	$LSD_{0.05}$ = 0.22					
L3	2017/2018	48.10	38.5	37.41	42.06	41.52
	2018/2019	40.6	41.50	36.53	35.10	38.38
	Mean	44.8	39.10	36.10	39.02	
	$LSD_{0.05}$ = 0.21					

Table (6): Effects of Nitrogen Fixation Bacteria (FB)on mean of wheat grain yield (kg/ha) during 2017/2018 and 2018/2019 seasons

Sites	Treatment	control	FB	FB+43kgN/ha	FB+86kgN/ha	mean
L1	2017/2018	1663	1839	1699	2020	1805
	2018/2019	1652	1581	1601	2034	1717
	Mean	1657	1710	1650	2027	
	$LSD_{0.05}$ = 0.70					
L2	2017/2018	985	1199	1115	1545	911.3
	2018/2019	1558	1546	1660	1556	1580
	Mean	1271	1372	1387	1550	
	$LSD_{0.05}$ = 0.90					
L3	2017/2018	1229	1555	1643	1780	1551.8
	2018/2019	1134	1549	1754	1870	1576.8
	Mean	1182	1552	1699	1825	
	$LSD_{0.05}$ = 0.27					

SUMMARY

- The results indicated that inoculation grains of wheat using N- fixing Bactreia enhanced yield at all location in both seasons
- The positive effects of N fertilizer with bio fertilizers significantly increased grain yield of wheat (particularly at northern site (Hajer) of New Halfa scheme) which was associated with significant increases in most yield related characters (number of yielded tillers, grains per plant and 100- grain weight).
- The results indicated that N-fixation bacteria can significantly increase N in the soil which increased yield of wheat.

From the present study it could concluded that the application of bio fertilizer with N, greatly increased yield of wheat due to increase syntheses of dry mater and absorption of essential nutrients in reducing PH value by secreting organic acids which brought about the dissolution of nutrients to organic materials and render them to available for growing of plant.

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