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CONTRIBUTION OF COMBINATIONS OF MINERAL AND BIO-FERTILIZER AND ORGANIC FERTILIZER IN THE CONCENTRATION OF N P K ON SOME PHYSIOLOGICAL CHARACTERISTICS AND YIELD OF OATS (*AVENA SATIVA* L.)

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Abstract

A field experiment was carried out during the growing seasons of 2016-2017 and 2017-2018 in Al-Zubair district, Basra Province, to study the effect of combinations of mineral ,bio-fertilizer and organic matter fertilization in the concentration of N, P and K nutrients, some physiological growth parameters and yield of oat, var. shifaa. *Azotobacter*, Phosphorus solubilizing bacteria and potassium solubilizing bacteria were used in the experiment, in seven levels: (B_0 = control, B_1 = mineral NPK, B_2 = NPK biofertilizer, B_3 = N bio. + mineral PK, B_4 = NP bio. + mineral K, B_5 = NK bio. + mineral P and B_6 = PKbio. + mineral N), the experiment was conducted according to split-plot design using randomized complete block design (RCBD) with three replicates, the fertilizers combinations were placed in the main plots, while the two levels of organic fertilizer (O_0 and O_1) were placed in the sub-plots.

The results showed that fertilization with bio-fertilizer NPK (B_2) was associated with the highest values for both seasons for nitrogen and phosphorus concentration in vegetative part, crop growth rate, relative growth rate, net assimilation rate, flag leaf area and leaf duration time. Also gave the highest grain yield reached 7.689 and 11.645 Mg ha^{-1} with an increase rate of 174 % and 194.81% than control treatment for both seasons respectively. Application of organic fertilizer (O_1) was achieved an increase in most parameters and gave highest grain yield (6.103 and 9.859 Mg ha^{-1}), with an increase rate of 22.97 and 30.17% for two seasons respectively, than control (O_0). The interaction between the two factors was significantly affected in some studied traits and combination $O_1 \times B_2$ gave highest grain yield reached 8.269 and 12.491 Mg ha^{-1} for two season respectively. It can be concluded that the mineral fertilizer can be replaced with organic and bio-fertilizers, thus reducing cost and pollution caused by mineral fertilization.

Key words: combinations of mineral, bio-fertilizer, organic fertilizer, yield

Introduction

The oat (*Avena sativa* L.) is one of the most important grass crops, belongs to Poaceae family, it is grown both for fodder and grain production Being a dual purpose crop ,the demand for oat as a food has risen because of the recognized nutritive value of the oat grain.

Technological change has been the basis for increasing agricultural productivity and promoting agricultural development that reduce pollution and production cost, Continuous application of expensive chemical fertilizers causes reduction of organic matter content in soil and also microbial activity drastically. Biofertilizers contain micro-organisms, provide nutrients N, P, K and other nutrients, antibiotics, hormones like auxins, cytokinins, vitamins which enrich root rhizosphere. (Abu Al-Saud, *et al.*, 2013). Microorganisms are complemented with chemical fertilizers to provide nutrients to plant in order to reduce the cost of agricultural production and reduce environmental pollution; Bio-fertilizers are used to reduce the addition of chemical fertilizers by at least 25% and they work in agriculture sustainability (Ahemad and Kibret, 2014). The addition of organic fertilizer with the bio-fertilizer promotes growth by converting nutritionally important elements to available form through biological process such asnitrogen fixation and solubilization of rock phosphate (Abedi *et al.*, 2010), Srbinovic *et al.*, (2014) found that organisms in rhizosphere (*Sinorhizobium* *meliloti*, *B. megaterium, Pseudomonas* Sp., *Enterobacter* Sp. and *A. chroococcum*) were significantly increased Oat leaf content of N, P and K 8.33, 3.35 and 11.45 mg plant^{-1} respectively compared to the control (8.12 mg plant^{-1}). Umadevi *et al*., (2014) found that using of Bio-fertilizer (*A. chroococcum*) with 80 Kg N ha^{-1} gave the highest oat grain yield, 1.989 and 1.985 ton ha^{-1} for two seasons respectively.

The study was carried out to determine the optimal combination of organic and mineral fertilizer with the level of organic fertilizer and its effect on the plant content of N, P, K and some parameters of physiological growth and yield of oats in the southern region of Iraq.

Materials and methods

A field experiment was carried out during the agricultural seasons 2016-2017 and 2017-2018 in Al-Zubair district, Basra Province, which lies in the south-east of Iraq between latitudes 29 and 31.30 degrees northward and longitudes 46.30 and 48.30 degrees eastward. Some chemical and physical analysis of field soil was conducted as presented in table 1. The experiment was carried out according to the Split Plot Design using the R.C.B.D. in three replicates, the experiment included two factors. The first is combinations of bio- and mineral fertilizer which was placed in the main plot and used in seven levels: (B_0=control, B_1=mineral NPK, B_2=NPK biofertilizer, B_3=N bio.+mineral PK, B_4=NP bio.+mineral K, B_5=NK bio. + mineral P and B_6=PK bio.+mineral N),. The second factor include the use of organic fertilizer used in two levels (0 and 20 ton h^{-1}) placed in the sub-plot. Some physical and chemical characteristics were determined table 2. The bio-fertilizer NPK contained three separate types of microorganisms: nitrogen-fixing bacteria (*Azotobacter chroococcum*), two species of phosphorus solubilizing bacteria (*Pseudomonas putida* and *Pantoea agglomerans*) and two species of potassium solubilizing bacteria (*Bacillus subtilus* and *Bacillus mucilaginosus*).

Table 1: Some chemical and physical characteristics of soil (before sowing).

Characters	First seasons	Second season	Unit
pH	8.0	7.8	
Electrical conductivity (E.C)	4.30	4.70	ds m^{-1}
Available N ($NH_4^+ + NO_3^-$)	84.0	80.0	
Available P	3.5	2.9	mg Kg^{-1}
Available K	127	150	
Organic matter	0.30	0.15	%
Clay	20.53	20.13	
Silt	21.44	21.54	
Sand	58.03	58.33	
Texture	Sandy loam	Sandy loam	

The soil was divided into three blocks, each one contains seven main plots and each main plot divided into two sub-plot. Each experimental units occupied 6 m^2 with dimensions of 2 × 3m, included 11 rows with a length of 3 m and a 20cm distance between the rows. The oat seeds shifaa variety were sowing in 12/11/2016 and 15/11/2017 for two agricultural seasons respectively, at a rate of 120 kg h^{-1}, the bio-fertilizer was prepared according to the company recommendations by mixing 50g of bio-fertilizer with one liter of water and immediately sprayed on the seeds before planting after spraying the seeds with a sugar solution (sugar + water) to ensure adhesion and encourage the bio-fertilizer bacteria to growth.

As for the control treatment, the sugar solution was added only then, organic fertilizer was added and mixed with the soil when preparing the plots for planting. The urea fertilizer (46% N) was added at a rate of 120kg h^{-1} on two equal batches, the first, after one month of planting and the second at the elongation stage (Al-Hasnaoui, 2016). Phosphate fertilizer was added at rate of 100kg h^{-1} as a DAP fertilizer (46% P_2O_5), and the potassium fertilizer was added at rate of 120 kg h^{-1}as potassium sulphate (52% K_2O) on two equal batches, the first, after one month of planting and the second at the elongation stage (Al-Abidi, 2011). Irrigation was carried out immediately after planting, and harvest was achieved when 50-75% of the plants reached full maturity. Statistical analysis of all parameters was carried out using SPSS and the mean was compared using the LSD test at a probability level of 0.05% (Al-Rawi, 2000).

Chemical analysis of plant samples

0.2g of dried plant sample was taken for both vegetative part and dry grains after passing through a 1 mm diameter sieve. Then, sample was digested by Sulfuric acid and then by mixture of 4% perchloric acid ($HClO_4$) + 96% Sulfuric acid (H_2SO_4) with heating until formation clear solution (Parsons and Cresser, 1979). The digestion product transferred to 50ml volumetric flask to estimate the proportions of N, P and k elements as follows:

Table 2: Some chemical and physical characteristics of organic fertilizer for both seasons.

Trait	pH	E.C ds.m^{-1}	Organic matter %	Organic carbon %	Total nitrogen%	Phosphorus%	Potassium%
First seasons	6.6	6.3	55.3	32.1	3.1	0.6	0.29
second seasons	6.3	5.0	53.7	20.2	2.6	0.9	0.36

Nitrogen concentration (%): Total nitrogen was determined by distillation after adding NaOH10N by a micro-Kieldahl apparatus according to method reported by (Haynes, 1980).

Phosphorus concentration of (%): phosphorus was measured in digested samples using the Spectrophotometer at a wavelength of 882 nm according to method by Myrphy and Riely (1962) and as described by (Page *et al*., 1982).

Potassium concentration (%): Measured by flame photometric (Page *et al*., 1982).

Physiological growth Characteristics:

Some parameters of physiological growth of plant were studied from area (30 × 30)cm^2 taken randomly from each experimental unit in the period between elongation and flowering stages where the period of rapid growth:

Crop growth rate (gmm^{-2} day^{-1}) (C.G.R)

C.G.R. = $(1 / A) \times (W_2-W_1) / (T_2-T_1)$ (Hunt, 1982), Whereas A=area occupied by the plant sample (m^2).W_1= dry weight of sample at the elongation stage (T_1).W_2= dry weight of sample at the flowering stage (T_2).

Relative growth rate (mg day^{-1}) It has been calculated according to following equation:

$$RGR = \frac{LogeW2 \quad LogeW1}{T2 \quad T1} \text{ (Hunt, 1982)}$$

Net Assimilation rate (gm m^{-2} day^{-1}) (NAR)

It has been calculated from the following law: N.A.R= $[(W_2-W_1)/(T_2-T_1)]\times[(\text{Log } LA_2-\text{Log } LA_1)/(LA_2-LA_1)$, Where LA_1 and LA_2 are total leaf are at time T_1 and T_2 respectively. W_1 and W_2 are total dry weight at time T_1 and T_2 respectively.

Flag leaf area (cm^2)

It was calculated from the average of ten randomly selected plants in the flowering stage according to the following equation:

flag leaf area = leaf length × max width × 0.75 (Thomas 1975)

Leaf Area Duration (day) L.A.D.

It has been calculated from the following: L.A.D. = $(LAI_1 + LAI_2) \times (T_2-T_1) / 2$

$L.A.I_1$ = leaf area index at the flowering stage. $L.A.I_2$ = leaf area index in the physiological maturity stage. T_2 = Second date of harvest (Physiological Maturation)

T_1=First date of harvest (flowering).

Results

Nitrogen concentration in the vegetative part

The results of table 3 indicated the superiority of bio-fertilizer treatment (B_2) which recorded the highest nitrogen concentration (1.46% and 1.19%) for the two seasons respectively, and not differ significantly than treatment B3 for both seasons which recorded 1.40% and 1.17% while the control recorded the lowest nitrogen concentration (0.90 and 0.95%) for the two seasons respectively. As indicated in the same table 3, the addition of organic fertilizer led to increase the nitrogen concentration for the two seasons; it was recorded 1.47 and 1.18% for the two seasons respectively with an increasing by 47.47 and 13.16% compared with control treatment which recorded 0.99 and 1.04% for the two seasons respectively. These results confirm the results of Narula (2000), Salman and Al-Shammary (2011), whom found an increase in the concentration of nitrogen in the vegetative part of some crops when adding organic fertilizer. The combination of bio-fertilizer and organic fertilizer showed significant effect, the combination of $O_1 \times B_1$ recorded the highest percentage of nitrogen at 1.29% in the second season only, while the combination $B_5 \times O_0$ showed the lowest concentration of nitrogen in the vegetative part which was 0.92% (Table 5).

Phosphorus concentration in the vegetative part

Table 3 indicates the superiority of B_2 treatment which gave the highest concentration of phosphorus (0.73% and 0.38% for the two seasons respectively), while, B_3 and B_0 treatments recorded the lowest concentration of 0.51% and 0.21% for the first and second season respectively. The treatment of organic matter was significantly affect and recorded the highest values observed in two seasons, giving 0.73 and 0.36%, while the control gave the lowest concentration of 0.47 and 0.24% for two seasons respectively (Table 3). Interaction between organic and bio-fertilizer showed a significant effect where the combination $O_1 \times B_2$ recorded the highest phosphorus concentration of 0.98 and 0.48% for both seasons (Table 4), and interaction between the two control treatments recorded the lowest phosphorus concentration of 0.36 and 0.19% respectively.

Potassium concentration in the vegetative part

As shown in table 3, results indicated the superiority of B_2 treatment which recorded the highest value for potassium concentration (0.72%), while B_5 treatment recorded the lowest (0.35).The mineral and bio-fertilizer had no significant effect in the second season. The addition of organic fertilizers increased the concentration of potassium in the vegetative part in the first season only and recorded 0.57%, while the control treatment gave 0.43%. This is in agreement with Othman *et al*., (2012), whom pointed to the increase of potassium concentration in the vegetative part of the wheat crop when adding organic fertilizers. The interaction between the two factors was significantly in the first season only a shown in Table 4 the factorial treatment ($O_1 \times B_2$) gave the highest concentration of potassium in the vegetative part (0.89%), while $O_0 \times B_0$ recorded the lowest (0.27%).

Concentration of elements in the grains

Nitrogen concentration in the grains

Analysis of variance for nitrogen concentration showed that there was a significant effect of mineral and biofertilizers on this parameter in the second season only, where B_2 treatment recorded the highest concentration reached to 2.21% compared with 2.10 and 1.97% by using B0 and B1 respectively. The addition of organic fertilizer for both seasons led to increase nitrogen concentration in the grain from 3.09 and 1.96% to 3.53 and 2.23% for both seasons respectively. A significant effect for interaction between the two factors was found in the second season only table 4, where the B_0 and B_2 treatments were significantly higher when organic fertilizer was added and recorded the highest nitrogen concentration (2.30%), while the interaction between the two control treatments recorded the lowest concentration which was 1.72%.

Phosphorus concentration in the grains

The results of table 3 showed that B_5 treatment was superior in the first season and recorded 0.75%P in grains, While the control treatment recorded the lowest (0.46 %). No significant effect for bio-fertilizer addition in the second season. Addition of organic fertilizer increased the concentration of phosphorus in the grains and gave 0.76 and 0.44% for the two seasons respectively, while the control treatment recorded lowest concentration of 0.52 and 0.33% for two seasons respectively. The interaction was significantly effected phosphorus concentration for two seasons table 4 where the B_5 and B_6 treatments had significant superior when adding organic fertilizer (O_1) and gave the highest percentage of 0.84 and 0.50%, while the interaction between the two control treatments was the lowest percentage of 0.31 and 0.24 %, this is in agreement with Kumar *et al*., (2014) and Nosratabad *et al*., (2017), they obtained an increase in the concentration of phosphorus in wheat grains when

Table 3: NPK concentration in vegetative part and grain of oat as influenced by bio - organic fertilizer for two seasons.

First season						Treatments	
Grains			vegetative part				
%k	%P	%N	%k	%P	%N		
0.30	0.46	2.85	0.38	0.57	0.90	B_0	Biofertilizer
0.35	0.65	3.21	0.51	0.54	1.20	B_1	
0.35	0.70	3.27	0.72	0.73	1.46	B_2	
0.25	0.59	3.52	0.41	0.51	1.40	B_3	
0.30	0.69	3.35	0.68	0.59	1.16	B_4	
0.35	0.75	3.56	0.35	0.59	1.26	B_5	
0.32	0.65	3.24	0.43	0.67	1.19	B_6	
N.S	0.03	N.S	0.03	0.02	0.11	L.S.D	
0.30	0.52	3.09	0.43	0.47	0.99	O_1	Organicfertilizer
0.33	0.76	3.53	0.57	0.73	1.47	O_2	
N.S	0.02	0.11	0.02	0.01	0.08	L.S.D	
Second season							
0.21	0.36	2. 10	0.75	0.21	0.95	B_0	Biofertilizer
0.20	0.38	1.97	1.12	0.37	1.12	B_1	
0.24	0.37	2.21	0.89	0.38	1.19	B_2	
0.38	0.38	2.12	0.83	0.27	1.17	B_3	
0.32	0.38	2.19	0.90	0.30	1.16	B_4	
0.31	0.39	2.14	0.90	0.30	1.10	B_5	
0.40	0.43	2.05	0.96	0.28	1.11	B_6	
0.01	N.S	0.03	N.S	0.02	0.03	L.S.D	
0.28	0.33	1.96	0.90	0.24	1.04	O_1	Organicfertilizer
0.30	0.44	2.23	0.92	0.36	1.18	O_2	
N.S	0.03	0.02	NS	0.03	0.054	L.S.D	

Table 4: NPK concentration in vegetative part and grain of oat as influenced by interaction between bio - and organic fertilizer for the first season.

First season							
Grains			vegetative part			Organic fertilizer	Biofertilizer
% k	% P	% N	% k	% P	% N		
0.28	0.31	2.63	0.27	0.36	0.76	O_0	B_0
0.32	0.60	3.08	0.48	0.79	1.23	O_1	
0.25	0.55	3.22	0.54	0.41	0.89	O_0	B_1
0.45	0.75	3.20	0.48	0.66	1.41	O_1	
0.34	0.59	3.29	0.54	0.48	1.09	O_0	B_2
0.35	0.80	3.26	0.89	0.98	1.84	O_1	
0.26	0.43	3.05	0.47	0.49	0.97	O_0	B_3
0.24	0.75	4.00	0.35	0.53	1.84	O_1	
0.33	0.65	3.20	0.61	0.54	0.93	O_0	B_4
0.27	0.73	3.51	0.74	0.64	1.39	O_1	
0.35	0.66	3.29	0.24	0.45	1.21	O_0	B_5
0.34	0.84	3.82	0.46	0.74	1.33	O_1	
0.31	0.47	2.97	0.43	0.56	1.10	O_0	B_6
0.32	0.82	3.51	0.42	0.78	1.28	O_1	
0.05	0.02	NS	0.04	0.03	NS	L.S.D	
Second season							
0.18	0.24	1.72	0.64	0.19	0.94	O_0	B_0
0.23	0.47	2.30	0.85	0.22	0.96	O_1	
0.13	0.35	2.03	1.24	0.31	1.05	O_0	B_1
0.27	0.41	2.07	1.01	0.43	1.19	O_1	
0.25	0.32	1.94	0.87	0.28	1.09	O_0	B_2
0.23	0.42	2.30	0.91	0.48	1.29	O_1	
0.40	0.36	2.14	0.87	0.21	1.14	O_0	B_3
0.34	0.38	2.27	0.93	0.33	1.20	O_1	
0.33	0.32	2.17	0.88	0.29	1.10	O_0	B_4
0.30	0.45	2.20	0.92	0.31	1.22	O_1	
0.32	0.33	1.99	0.86	0.23	0.92	O_0	B_5
0.30	0.44	2.29	0.95	0.37	1.27	O_1	
0.38	0.36	1.77	1.01	0.21	1.07	O_0	B_6
0.42	0.50	2.16	0.91	0.36	1.15	O_1	
0.03	0.04	0.05	N.S	0.03	0.04	L.S.D	

using bio- fertilizer with presence of organic fertilizer.

Potassium concentration in the grains

The results shown in table 3 indicated that B_6 Treatment was superior in the second season and gave the highest concentration of potassium in the grains (0.40%), while B_1 treatment gave the lowest (0.20%) and didn't differ significantly than control treatment. The application of organic fertilizer didn't affect the concentration of potassium in the grains for both seasons. Intraction between organic and bio-fertilizer were significantly affect the concentration of potassium in grains, where $O_1 \times B_1$ was superior in the first season (Table 4) and recorded 0.45% , while $O_1 \times B_6$ in the second season recorded the highest concentration reached 0.42% (Table 4). The results confirm with Salman *et al.,* (2008) in stimulating the growth of the plant root and vegetative part and then increasing potassium concentration in plant.

Physiological Characteristics:

Crop growth rate (CGR)

The results of table 5 indicated significant superiority of B_2 treatment for two seasons which gave 12.79 and 6.23 gm m^{-2} day^{-1},with an increase percentage of 138.61 and 131, 60% for two seasons respectively than control treatment which recorded the lowest mean for CGR 5.36 and 2.69gm^{-2} day^{-1} for two seasons respectively. Addition of organic fertilizer was significantly affected in CGR which recorded 11.74 and 5.02gm^{-2} day^{-1} for two seasons, while the lowest CGR was 8.49 and 4.13 $gmday^{-2}$ for two seasons recorded by control. The results of Table (6) showed the superiority of the combination ($O_1 \times B_4$) which recorded 14.90gm^{-2} day^{-1}, while ($O_0 \times B_4$) was superior in the second season which recorded 6.37gm^{-2} day $^{-1}$. The lowest value of CGR was recorded by using ($B_0 \times O_0$) in the first and second season (4.59 and 2.64 gm^{-2} day^{-1} respectively). The Availability of the necessary nutrients for plant growth from its various biological and organic sources as well as improve the physical properties of soil due to the effect of organic fertilizer, and the effectiveness of the bacterial organisms provided by the bio-fertilizer has improved the growth characteristics, which reflected on the crop growth rate.

Relative growth rate (RGR)

The results of table 5 showed superiority of B_2 treatment for both seasons that recorded the highest relative growth rate (17.57 and 12.38mg gm^{-1} day^{-1}) for two seasons with an increase percentage of 70.91 and 69.59% than control treatment which gave 10.28 and 7, 30mg gm^{-1} day^{-1} for two seasons respectively. Applying of organic fertilizer (O_1) affected significantly and recorded 16.82 and 12.67 mg gm^{-1}day^{-1} for the two seasons respectively, with an increase of 31.71 and 34.21% than the control treatment which recorded lowest mean of relative growth rate was 12.77 and 9.44mg gm^{-1} day^{-1} for two seasons. Interaction shown in table 6 pointed to the superiority of the factorial treatments $O_1 \times B_2$ in the first season and gave 18.49 mg gm^{-1} day^{-1}. In the second season, the Interaction $O_1 \times B_5$ was and $O_1 \times B_3$ recorded the highest value of RGR and gave 16.29 and 14.57 mg gm^{-1} day^{-1} respectively (Table 6).

Flag leaf area

Data in table 3 indicated that the fertilization with treatment B_2 led to an increase in the flag leaf area and recorded 24.43 and 25.92 cm^2 for two seasons respectively with an increase by 58.33 and 16.23% compared with control (B_0) which recorded 15.43 and 22.35 cm^2 for the two seasons respectively. Addition of organic fertilizer (O_1) gave the highest value for flag leaf area 23.17 and 26.06 cm^2 for two seasons while the control treatment showed the least 19.28 and 21.49 cm^2 respectively. The results of table 6 indicated superiority of ($O_1 \times B_2$) which recorded 26.55 cm^2, while the interaction between the two control treatments recorded the least(12.24 cm^2).

Leaf Area Duration

The treatment B_2 was superior for two seasons (Table 5) recorded the highest leaf area duration by 143.07 and

Table 5: Physiological traits and grain yield of oat as influenced by bio - organic fertilizer for two seasons.

Grain yield Mg h^{-1}	Total number of tillers per m^2	NAR gm-2 day-1	LAD day	FLA m^2	RGR mg gm-1 day^{-1}	CGR gm-2 day-1	Treatments	
First Season								
2.578	422.83	1.38	118.07	15.43	10.28	5.36	B_0	
7.066	424.05	1.70	124.20	19.16	14.44	10.09	B_1	
7.689	499.00	2.16	143.07	24.43	17.57	12.79	B_2	Biofer-
6.166	479.40	2.08	136.80	21.84	15.86	10.70	B_3	tilizer
5.600	467.16	2.00	140.34	22.44	16.33	10.60	B_4	
5.364	462.02	1.90	135.31	22.71	14.22	10.80	B_5	
4.263	439.64	1.90	130.55	21.91	14.89	9.40	B_6	
0.151	11.36	0.21	3.79	2.56	0.58	0.21	L.S.D	
4.962	400.95	1.63	128.60	19.28	12.77	8.49	O_1	Organic
6.102	516.65	2.12	137.87	23.17	16.82	11.74	O_2	fertilizer
0.11	7.50	0.53	2.77	0.58	0.85	1.00	L.S.D	
3.950	600.00		109.69	22.30	7.30	2.69	B_0	
7.623	677.90		116.60	22.74	11.47	4.16	B_1	
11.645	894.41		124.90	25.92	12.38	6.23	B_2	Biofer-
8.825	838.90		121.80	24.82	10.88	4.77	B_3	tilizer
11.007	851.85		114.79	23.80	11.71	4.03	B_4	
8.950	779.63		123.03	23.77	13.53	3.90	B_5	
8.832	757.4		112.82	22.53	10.06	3.95	B_6	
0.680	31.87		7.30	1.97	0.53	0.29	L.S.D	
7.574	735.98		112.46	21.49	9.44	4.13	O_1	Organic
9.859	849.77		122.48	26.06	12.67	5.02	O_2	fertilizer
0.310	14.74		2.80	0.84	0.65	0.16	L.S.D	

Table 6: Physiological characteristics and grain yield of oat as influenced by interaction between bio - and organic fertilizer for two seasons.

Grain yield Mg h-1	Number of tillers per m2	NAR gm-2 day-1	LAD day	FLA cm^2	RGR mg gm-1 day-1	CGR gm-2 day-1	Organic fertilizer	Biofer-tilizer
2.200	294.59	1.25	112.49	12.24	8.90	4.59	O_0	B_0
2.965	551.07	1.$^{5-11}$	123.65	18.61	11.66	7.13	O_1	
6.679	483.26	1.69	127.52	17.71	11.55	8.51	O_0	B_1
7.453	364.85	1.70	120.88	20.60	17.36	11.67	O_1	
7.109	410.88	1.94	138.21	22.31	16.65	10.84	O_0	B_2
8.269	584.96	2.44	151.94	26.55	18.49	12.73	O_1	
5.111	436.48	1.94	133.22	18.72	13.89	8.52	O_0	B_3
7.220	522.33	2.21	140.38	24.95	17.74	12.87	O_1	
5.298	364.84	1.50	138.89	20.94	15.43	12.27	O_0	B_4
5.899	555.90	2.50	141.80	23.93	17.23	14.90	O_1	
4.552	366.28	1.61	133.20	20.81	11.33	8.39	O_0	B_5
6.175	557.77	2.50	137.42	21.61	17.11	13.35	O_1	
3.787	426.33	1.80	123.65	22.21	11.66	7.31	O_0	B_6
4.739	452.96	2.00	142.05	25.92	18.12	11.52	O_1	
0.630	18.34	0.284	4.26	1.76	2.19	1.22	L.S.D	
440.70	1.40		104.91	20.81	5.75	2.64	O_0	B_0
5.109	759.26	1.50	114.47	23.79	8.84	2.73	O_1	
6.088	607.41	2.10	105.35	18.68	12.14	4.64	O_0	B_1
9.157	748.38	1.75	127.85	26.80	10.79	3.68	O_1	
10.798	703.70	3.74	118.51	20.30	9.37	3.17	O_0	B_2
12.491	911.11	2.00	129.09	25.55	12.38	5.42	O_1	
7.285	829.63	2.04	118.65	23.68	10.40	4.41	O_0	B_3
10.360	848.18	2.05	124.48	30.96	14.57	5.12	O_1	
10.138	737.04	1.37	114.72	24.41	9.66	6.37	O_0	B_4
11.875	966.66	2.06	114.86	27.24	13.75	6.08	O_1	
8.509	737.04	2.40	112.67	24.36	10.76	3.58	O_0	B_5
9.390	822.22	1.56	133.40	23.17	16.29	6.26	O_1	
7.041	896.29	1.67	112.39	21.16	8.03	4.08	O_0	B_6
10.634	892.59	2.97	113.24	23.89	12.10	5.83	O_1	
1.42	38.99	0.035	7.392	N.S	2.01	0.45	L.S.D	

124.90 days respectively, with an increase percentage of 23.13% and 13.87% than the control treatment which recorded the lowest duration 118.07 and 109.69 days for both seasons respectively. The addition of organic fertilizer to oats resulted in a significant increase in the number of days for leaf area duration in both seasons (137.87 and 122.48 days), while the control treatment recorded the lowest 118.07 and 109.69 days for both season respectively. The interaction ($B_2 \times O_1$) was superior for both season and recorded 151.94 and 129.09 days, while ($O_0 \times B_0$) gave 112.49 and 104.91 days (Table 6).

Net Assimilation Rate NAR

Results of table 5 indicated that B_2 treatment gave 2.16 and 2.87 gm m^{-2}day for two seasons respectively with an increase percentage of 56.52 and 99.30 % than control treatment B_0 which recorded the lowest 1.38 and 1.44 gm m^{-2} day for two seasons respectively. Application of organic fertilizer significantly influenced the net assimilation ratio in the first season only, and gave 2.12 gm m^{-2} day^{-1}, while control (O_0) recorded 1.63 gm m^{-2} day^{-1}. TheInteraction between B_4 and B6 with O_1 was superior in the first season gave 2.50gm m^{-2} day^{-1} (Table 6), while Interaction ($B_2 \times O_0$) in the second season gave the highest 3.74gm m^{-2} day^{-1}, whereas the interaction ($B_0 \times O_0$) in the first season and ($B_4 \times O_0$) in the second season recorded the lowest 1.25 and 1.37 gm m^{-2} day^{-1} for both season respectively (Table 6).

Number of tillers

The highest number of tillers was found in B_2treatment (Table 5) gave 499.00 and 894.41 tiller m^{-2} for the two seasons respectively, with an increase percentage of18.10

and 49.07% than control treatment which recorded the lowest number of tillers 422.83 and 600 tiller m^{-2} for two seasons. Respectively AL-Shamma and Al-Shahwany (2014) reports in accordance with the results ,where the number of wheat tillers increased when using combinations of *Azotobacter* and *Pseudomonas sp*. and *Bacillus sp*. Addition of organic fertilizer was significantly affected in this trait for both seasons. O_1 treatment gave the highest number of tillers 516.65 and 849.77 tiller m^{-2} for two seasons, while control treatment gave the least 400.95 and 735.98 tiller m^{-2} for two season respectively. Interaction was significantly affected in the number of tiller for both season (Table 6), The first season showed superiority of the treatment ($O_1 \times B_2$) gave 584.96 tiller m^{-2}. In the second season the interaction ($O_1 \times B_4$) was superior and recorded 966.66 tiller m^{-2}, while the combination ($O_0 \times B_0$) recorded the lowest for both seasons 294.59 and 440.70 tiller m^{-2} respectively (Table 6). This is in agreement with Kumar *et al*., (2014) who indicated an increase in the number of wheat tillers when adding organic fertilizer with *Azotobacter* and *Bacillus*.

Grain yield

The results in table 5 shows that the B_2 treatment had a significant effect in increasing the grain yield for both seasons, and gave the highest 7.689 and 11.645 Mg h^{-1} respectively with an increase percentage of 174% and 194.81% compared to control treatment. The addition of organic fertilizer d had a significant effect in increasing grain yield for both seasons which reached 6.102 and 9.859 Mg h^{-1} respectively as compared to control (4.962 and 7.574Mg h^{-1}). The interaction of $O_1 \times B_2$ had significant effect and gave the highest grain yield for both seasons which reached 8.269 and 12.491 Mg h^{-1}while combination of $O_0 \times B_0$gave the lowest yield 2.200 and 2.791 Mgh^{-1} for both season respectively (Table 6).

Discussion

The increase in the concentration of elements (N and P) in vegetative part and grains at B_2 treatment (NPK biofertilizers) is attributed to the fact that this treatment contains different species of microorganisms for nitrogen-fixing and solubilizing for phosphate and potassium that have important roles in plant nutrition (Mazid and Khan, 2014). *Azotobacter* bacteria have a good ability to fix atmospheric nitrogen in their cells and then in the soil, which promotes deep root growth and enhances its ability to absorb nutrients (Dashti, 2010). This result agrees with Salman and Al-Shammary (2011) whom pointed that the addition of *Azotobacter* increased the concentration of nitrogen in the vegetative part of wheat.The increase in phosphorus concentration may be due to the ability of the *Azocobacter chrococcum* to dissolve the mineral phosphorus and transformed it into organic phosphorus (Dobbelaere *et al*., 2003) as well as to the essential role of the phosphate-solubilizing bacteria (*Pseudomonas putida* and *Pantoea agglomerans*) which have a positive effect on Phosphorus readiness in the soil by reducing the degree of soil reaction in the rhizosphere area, which changes of phosphorus balance process in the soil, thus affecting the process of ion transport and accelerating the degradation of organic and inorganic phosphorus (Abd *et al*., 2016).

All the characteristics of the physiological growth including, flag leaf area, leaf area duration, the number of tillers, and the grain yield were superior at B_2 treatment. This is due to the effectiveness of *Azotobacter*, *Pseudomonas* and *Bacillus* bacteria in providing sufficient amounts of nitrogen, phosphorus and potassium, as well as to the production of growth-regulating substances that lead to increase the growth of total root which increases the absorption of water and nutrients from the soil (Akbari *et al*., 2007), in addition to the biological nitrogen fixation by *Azotobacter* and then increasing the available nitrogen which play an important role in increasing cell division, improve plant growth, increase the leaf area and crop growth rate, as well as to availability of bio-nutrients at early time of the plant growth stage leading to an increase in the vegetative growth, which resulted in the efficient exploitation of light and thus increase the length and efficiency of assimilation, led to an increase in the accumulation of dry matter, which reflected positively on the net accumulation product (Yao *et al*., 1990). The increase of the leaf area and crop growth rate was also reflected in the increase the bio-processes of plant by activating the process of photosynthesis and increasing the nutrient availability, absorption and assimilation by the plant, thus delaying the aging of leaves and thus increasing the leaf area duration (Issa, 1990).

The most characteristics of the study were superior at the addition of organic fertilizer, and this is due to the role of organic fertilizer in improving physical, chemical and biological properties of soil, and increasing their ability to water retention and increasing their content of the main nutrients, especially nitrogen, phosphorus and some other nutrients, making it easier to absorbing by the plant roots, therefore increase the concentration in the total vegetative, as well as to its role in reducing the soil pH in the rhizosphere by releasing hydrogen ions, various organic acids and carbon dioxide as it decomposes and formation of carbonic acid, which dissolves phosphorus non-soluble compounds, which leads to an increase of available phosphorus values in the soil and then increase the concentration of phosphorus in the grains (Al-Zubaidi, 2012 and Al-Dawri and Hamada, 2018). The organic fertilizer, which contains nutrients and hormones, which work to achieve nutritional balance of the plant in the early stages of growth and thus improve photosynthesis, which leads to increase the various metabolic activities that responsible for division and elongation, thus increase the growth rates (Kashif *et al*., 2014). The organic fertilizer is also used as energy sources and suitable environment for the activity of microorganisms by bio-fertilizer.

The interaction between NPK biofertilizers (B_2) and the addition of organic fertilizer was significantly affected in most of the characteristics of the study. The organic fertilization provides nutrients, energy sources and suitable environment for the activity of the microorganisms that found in the bio-fertilizer resulted in an increase in their growth, number, activities and effectiveness, reflect on their ability to fix atmospheric nitrogen or solubilize phosphor, potassium and perhaps some other nutrients from clay minerals and all these reflect on plant growth and yield.

In general, the results indicated the possibility of partial or total compensation of mineral fertilizers by adopting organic and bio-fertilizers from a known source of nutrient content, and specifications in order to obtain high productivity.

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