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RESEARCH PAPER

Improvement of wheat quality and soil fertility by integrates chemical fertilizer with rhizobial bacteria

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A B S T R A C T:

A field experiment was carried out in Erbil city at Agricultural Research Center, during winter season 2017 - 2018, to study the effect of three levels (120, 240, 360 kg.ha^{-1}) of NPK (20:20:20) fertilizer, five species of Rhizobial inoculation (Control, *Bradyrhizobium sp.* (Vigna) (B1), *Rhizobium leguminosarum bv. Viciae* (B2). *Bradyrhizobium* Mungbean (B3), *Mesorhizobium ciceri* (B4) and *Rhizobium leguminosarum bv phaseoli* (B5)) and two wheat cultivar soft (*Triticum aestivum* L.) Hawler2,and hard (*Triticum durum* L.) Seminto and their combination on leaf (Nitrogen, Phosphor, Potassium, Calcium and Iron)contents, soil nutrient (Total Nitrogen, available Phosphor, Potassium and Iron contents, leaf (Auxin IAA, Gibberellin GA and Cytokinin CK) contents, grain number.plot^{-1}, weight of 1000 grain(g), grain yield kg.hac^{-1}, biological yield kg.hac^{-1} and harvest index% by utilizing complete randomized block design (CRBD) with three replication. Rhizobial inoculation individually increased significantly all tested parameters of growth. Generally, Seminto significantly surpassed Hawler2 in most traits under study. Interaction between of chemical fertilizer with rhizobial bacteria was more evident than that of chemical fertilizer alone for all mentioned traits. The combination of chemical fertilizer, rhizobial bacteria and wheat cultivars had a synergistic effect and improved leaf (N,P,K,Ca and Fe) contents, fertility of soil, phytohormone concentration in leaves and yield components. The finding indicated that the combination between the lower levels of NPK fertilizer with *Rhizobium leguminosarum bv phaseoli* inoculation for *Triticum aestivum* increased grain yield by 114.39% over the control. We recommend using rhizobial bacteria in combination with lower levels of NPK to reduce chemical fertilizer dose and improving yield production and soil fertility because combination between mentioned factors gave the highest values of most traits under study.

KEY WORDS: Chemical fertilizer, Rhizobial bacteria, Wheat cultivars Hawler2 and Seminto.
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1.INTRODUCTION

Nutritional value of *Triticum* sp. is extremely important as it takes a significant place among the few crop species that are extensively grown as staple food sources, its grain can be ground into flour, semolina, etc., which constitute the fundamental components of bread and other bakery products, as well as pastas, and is thus the major source of nutrients for the majority of the world's population (Šramková et al., 2009).

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It is common food that contributes more calories and proteins to the world diet than any other cereal crop (Biesaga-Kościelniak et al., 2014). Improving yield is satisfied by either increasing the area under cultivation or improving the yield per unit area; the first option is very limited and has helped to increase the yield per unit area (Moradi et al., 2015).The UN predicts that the world population will grow over the next decades. For this reason, the world needs to increase crop yields through better use of water and fertilizer in order to guarantee food security and environmental protection (Foulkes et al., 2010). The total biomass is a result of the integration of metabolic reaction in the plants. Consequently, any factor influencing the metabolic activity of the plant at any period of its growth can affect the yield. Metabolic processes in wheat plants are greatly governed by both internal i.e. genetic makeup of the plant and external conditions which namely climatic and edaphically environmental factors. Thus, increasing wheat production per unit area can be achieved by breeding and cultivating the promising wheat cultivars and applying the optimum cultural practices such as suitable fertilizer(Zaki et al., 2012).

Nutrients availability is the most limiting factor for crop growth. Nutrients removal from the field, besides their uptake by crops, was also caused by wind and water erosion, leaching to deeper soil layers and for nitrogen by ammonia volatilization and denitrification. Consequently, to avoid crop yield reduction, replenishment of nutrients through chemical and natural fertilizers is necessary. The excessive uses of mineral fertilizers have generated several environmental problems: potential pollution to soil, water and air (Stajković-Srbinović et al., 2014). One potential way to decrease negative environmental impacts resulting from continued use of chemical fertilizers is inoculation with plant growth-promoting rhizobacteria (PGPR). These bacteria exert beneficial Effect on plant growth and development, and many different genera have been commercialized for use in agriculture(Adesemoye and Kloepper, 2009). Plant growth promoting rhizobacteria (PGPR) is free-living bacterial group colonizing the rhizosphere and exert a positive effect on plant health and fertility of soil (Zahir et al., 2010). Improving yield of wheat plants by interactive influence of chemical, organic fertilizer and biofertilizer is a promising purpose in wheat production for lowering high doses of inorganic fertilizer also, get more clean yield with low undesirable high doses of heavy metals and other pollutants(Jala-Abadi et al., 2012). *Rhizobium* is an important symbiotic for legumes but it plays an important role with non-legumes by producing growth hormones. The first important step for producing growth hormone is root colonization of beneficial bacteria with plants(Akhtar et al., 2013). This experiment was planned to determine the best levels of NPK to be integrated with rhizobial bacteria for obtaining more economical, environment friendly and wheat production improvement.

2.MATERIALS AND METHODS

2.1 Describing of experiment: The experiment was performed under field condition at Agricultural Research Center in Erbil, during winter season 2017 - 2018. The experimental plants used in this investigation were soft wheat (*Triticum aestivum* L.) cultivar Hawler2 and hard wheat (*Triticum durum* Desf.) cultivar Seminto obtained from the Agricultural Research Center in Erbil. Some chemical and physical properties of the soil before treatments are shown in Table (1).

Table 1 some physical and chemical properties of soil

Physical properties		Value
Particle size distribution (%)	Sand	18.1
	Silt	43.6
	Clay	38.3
Soil texture		Silty Clay loam
Chemical properties		Value
pH		7.8
Electrical Conductivity ($dS.m^{-1}$)		0.5
Total nitrogen $mg.g^{-1}$		0.51
Available Phosphorous $mg.kg^{-1}$		4.34
Available Potassium $mg.kg^{-1}$		293.70
Available Iron ppm		1.63

2.2 Treatment and experimental design: The experiment was comprised of six levels of rhizobial inoculums (Control, *Bradyrhizobium sp.* (Vigna), *Rhizobium leguminosarum bv. viciae*, *Bradyrhizobium* Mungbean, *Mesorhizobium ciceri* and *Rhizobium leguminosarum bv phaseoli*) and three levels of NPK (20:20:20) fertilizers (120, 240 and 360) $kg.ha^{-1}$. Fifty grains were planting in each plot. Thirty six treatments were tested in randomized block design with three replications. The comparisons between means were made using Tukey's's test at significant level of 5% for field experiment parameters and 1% for laboratory parameters. SPSS version 16 was used for data analysis.

2.3 Isolation of Rhizobial sp.: Five strains of rhizobia were isolated from the root nodules of (*Vigna unguiculata), (Vicia faba), (Vigna radiata L.),* (*Cicer arietinum* L) and (*Phaseoulus vulgasrous*), respectively which were growing for 2-3 months under field conditions at a different area of Erbil city. With some non-rhizospheric soil, host plants were uprooted from t he field and carried to the laboratory in polythene containers. Then estimated according to (Mehboob et al., 2011).

2.4 Preparation of inoculums: Preparation of inoculum was performed by (Mehboob, 2010).

2.5 Experimental parameters:

1- Biochemical contents: dried leaves were grinded by an electrical grinder for each replicate of the experiment; 0.3g of ground samples were digested, then total nitrogen determined by Kjeldahl method, total phosphorus and available phosphorus estimated using spectrophotometer method, total calcium, available calcium, total iron and available iron estimated by atomic absorption method, Total potassium and available potassium determined, using Flame –photometer method as described by(Ryan et al., 2001) . The total protein was calculated by multiplying the value of total nitrogen by (5.75) (Dalaly and Al-Hakim, 1987). And total soluble carbohydrate was determined by the Anthron methods(Sadasivam, 1996).

2- Determination of plant hormones: Endogenous hormones, namely auxins (IAA), gibberellic acid (GA) and cytokinins (CK) were extracted according to(Jogi et al., 2017), then plant hormones determined by HPLC. The endogenous concentration of (IAA, GA and CK) in samples was calculated from the spectra obtained using the following equation:

$$Sample\ concentration(ppm) = \frac{Concentration\ of\ standard \times Area\ of\ sample}{area\ of\ stanndard} \times \frac{Volume\ of\ sample}{Weight\ of\ sample}\ 100$$

3- Yield components: At harvest; number of $grains.plant^{-1}$, weight of 1000 grains (g), grain yield ($kg.hac.^{-1}$), biological yield ($kg.hac.^{-1}$), Harvest index(HI%) and increase grain yield (%) were estimated. Improving grain yield was estimated as described by (Ye et al., 2005)

$$Increase\ grain\ yield\% = \frac{(Grain\ yield\ of\ fertilized\ pot - Grain\ yield\ of\ control)}{Grain\ yield\ of\ control} \times 100$$

3.RESULTS

3.1 Nutrient content of leaves and soil

Table (2) showed progressive increases of leaf nutrient contents in response to different species of rhizobial bacteria. The highest value of total nitrogen ($20395.33mg.kg^{-1}$) and protein ($117.27mg.g^{-1}$) were recorded with B3 treatments, while maximum phosphorus ($3902.50mg.kg^{-1}$) content was recorded by using B5 treatment. Otherwise, the highest value of potassium ($9555.00mg.kg^{-1}$) and iron content ($376.67mg.kg^{-1}$) were obtained by B2 treatments. In contrast, the same treatments did not affect calcium and carbohydrate contents. The same table indicated that the highest value of soil total N ($1.62g.kg^{-1}$) and available K ($462.41mg.kg^{-1}$) was recorded by using B1 and B2 respectively. While B3 treatment gave highest available (P: $10.31mg.kg^{-1}$ and Fe: $4.25mg.kg^{-1}$).

Data presented in table (3) shows that carbohydrate content of leaves significantly increased by different levels of NPK fertilizer and significant difference was observed on protein, nitrogen and phosphorus contents of leaves. The greatest value of N, P, K, protein and carbohydrate content were obtained by adding 240kg.ha^{-1}, while calcium and iron content were obtained by adding NPK1. Also table (3) detected that the greatest value of total N (1.52g.kg^{-1}), available P (9.25mg.kg^{-1}), available K (434.51mg.kg^{-1}) and available Fe (3.94mg.kg^{-1}) was gained by adding 240kg.ha^{-1} NPK.

Data in table (4) indicated that Seminto significantly exceeded Hawler2 in all leaf composition contents under study except potassium and iron, which not affected by wheat cultivars. Data present in same table clearly showed that, wheat cultivars did not cause any significant effect on soil nutrient status.

Table (5) revealed that, the interaction among different wheat of rhizobial bacteria with different levels of NPK affected significantly some leaf nutrient contents for both wheat cultivars under study while affected non-significantly on potassium, calcium and carbohydrate leaf contents. The highest value of nitrogen (28253mg.kg^{-1}), phosphorus (5160mg.kg^{-1}) and protein content (162.45mg.g^{-1}) were achieved by combining (B3 with 120kg.ha^{-1} NPK of *Triticum durum*), while greatest value of iron content (505.00mg.kg^{-1}) was recorded by integrating (B2 with 120kg.ha^{-1} NPK of *Triticum durum*). Data present in same table shows that, combination between chemical fertilizers with rhizobial bacteria for both wheat cultivars significantly increased soil total nitrogen and available phosphorus. The highest value of total N (1.86g.kg^{-1}) was recorded by both (B1NPK1) and (B3NPK2) of *Triticum durum* respectively. While, the maximum value of available phosphorus concentration: 13.29mg.kg^{-1} was recorded by both (B3NPK1 of *Triticum aestivum*) and (B3NPK1 of *Triticum durum*) respectively. In contrast, avaialable (K and Fe) contents of soil did not affected by combining mentioned factors.

3.2 Plant hormone contents

Figure (1) revealed that rhizobium inoculation individually enhanced the phytohormone content of leaves significantly. The maximum value of CK: 21.42ppm, IAA: 29.00ppm and GA: 159.56ppm was obtained by B5 inoculation. On the other hand, figure (2) showed that the treated plants with NPK fertilizers had a significant effect on leaf phytohormone contents. The greatest value of CK: 20.56ppm, IAA: 23.77ppm and GA: 99.24ppm was achieved by applying 240kg.ha^{-1} of NPK. Data in figure (3) demonstrated that Seminto significantly surpassed Hawler2 in CK and IAA content of leaves, except GA content, where, Hawler2 overcame Seminto in this character.

Results given in table (6) generally clear that all phytohormones under this study were significantly affected by combination between wheat cultivars, chemical fertilizers and rhizobial bacteria. The maximum value of CK (31.45ppm) and IAA (69.49ppm) was obtained by using (B1 with 240kg.ha^{-1} NPK of *Triticum durum*) and (B5 with 120kg.ha^{-1} NPK of *Triticum durum*) respectively. However, the maximum value of GA (292.65ppm) was recorded by using (B5 with 120kg.ha^{-1} NPK of *Triticum aestivum*).

Table 2 Effect of different species of rhizobial bacteria on leaf composition contents and soil nutrient status at harvesting

Rhizobial species	Plant leaf							Soil			
	Protein mg.g^{-1}	Carbohydrate mg.g^{-1}	N mg.kg^{-1}	P mg.kg^{-1}	K mg.kg^{-1}	Ca mg.kg^{-1}	Fe mg.kg^{-1}	Total (N) mg.g^{-1}	Avai. (P)mg.kg^{-1}	Anai (K) mg.kg^{-1}	Avai (Fe) mg.kg^{-1}
Control	79.75	202.55	13869.83	2284.17	8065.83	8675.83	263.33	0.86	4.31	312.88	1.76
B1	114.00	220.75	19825.83	3397.50	9172.50	10121.67	348.33	1.62	7.70	402.20	3.65
B2	108.6	220.78	18889.	3408.	9555.	10417.	376.	1.44	7.87	462.	3.90

	1		33	33	00	50	67			41	
B3	117.27	225.57	20395.33	3632.50	8944.17	9764.17	339.17	1.40	10.31	390.90	4.25
B4	115.44	228.11	20076.00	3378.33	9085.83	10368.33	363.33	1.36	8.90	425.79	3.47
B5	111.43	247.09	19380.17	3902.50	9248.33	9980.83	368.33	1.26	8.36	440.12	3.80
Tukey's0.01	18.45	n.s.	3208.74	628.19	1194.38	n.s.	49.99	0.34	2.29	74.50	1.17

B1: *Bradyrhizobium sp.* (Vigna), B2: *Rhizobium leguminosarum bv. viciae*, B3: *Bradyrhizobium* Mungbean, B4: *Mesorhizobium ciceri* andB5: *Rhizobium leguminosarum bv phaseoli*

Table 3 Effect of different levels of chemical fertilizer on leaf composition contents and soil nutrient status at harvesting

Chemical fertilizer kg.ha^{-1}	Plant leaf							Soil			
	Protein mg.g^{-1}	Carbohydrate mg.g^{-1}	N mg.kg^{-1}	P mg.kg^{-1}	K mg.kg^{-1}	Ca mg.kg^{-1}	Fe mg.kg^{-1}	Total (N) mg.g^{-1}	Avai. (P)mg.kg^{-1}	Anai (K) mg.kg^{-1}	Avai (Fe) mg.kg^{-1}
NPK1	114.42	235.95	19898.58	3545.42	9186.25	11172.92	375.42	1.21	8.08	406.14	3.59
NPK2	116.52	238.00	20265.25	3750.83	9290.83	9627.50	332.08	1.52	9.25	434.51	3.94
NPK3	92.31	198.47	16054.42	2705.42	8558.75	8863.75	322.08	1.24	6.39	376.50	2.88
Tukey's0.01	11.12	38.99	1933.13	378.46	719.56	1726.05	30.12	0.20	1.38	44.88	0.71

NPK1= 120kg.ha^{-1}, NPK2= 240kg.ha^{-1}, NPK3= 360kg.ha^{-1}

Table 4 Effect of wheat cultivars on leaf composition contents and soil nutrient status at harvesting

Wheat cultivars	Plant leaf							Soil			
	Protein mg.g^{-1}	Carbohydrate mg.g^{-1}	N mg.kg^{-1}	P mg.kg^{-1}	K mg.kg^{-1}	Ca mg.kg^{-1}	Fe mg.kg^{-1}	Total (N) mg.g^{-1}	Avai. (P)mg.kg^{-1}	Anai (K) mg.kg^{-1}	Avai (Fe) mg.kg^{-1}
Hawle2	97.03	188.28	16874.89	3125.28	8910.83	9529.44	350.56	1.29	7.68	403.30	3.51
Seminto	118.47	260.00	20603.94	3542.50	9113.06	10246.67	335.83	1.36	8.14	408.14	3.43
Tukey's0.01	7.94	27.85	1380.555	270.28	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Table 5 Interaction effect of wheat cultivars, chemical fertilizer and rhizobial bacteria on leaf composition contents and soil nutrient status at harvesting

Wheat cultivars	Chemical fertilizer kg.ha^{-1}	Rhizobial species	Plant leaf							Soil			
			Protein mg.g^{-1}	Carbohydrate mg.g^{-1}	N mg.kg^{-1}	P mg.kg^{-1}	K mg.kg^{-1}	Ca mg.kg^{-1}	Fe mg.kg^{-1}	Total (N) mg.g^{-1}	Avai.(P)mg.kg^{-1}	Anai(K) mg.kg^{-1}	Avai(Fe) mg.kg^{-1}
		Control	72.49	151.81	12608	2485	7785	8185	230	0.71	4.04	301.07	1.57
	NPK1	B1	109.24	184.73	18998	3460	9640	13425	415	1.59	5.72	406.53	3.73
		B2	99.48	198.66	17300	3280	9910	9410	400	1.2	7.16	529.61	3.68
Hawler 2		B3	120.76	225.38	21003	3295	9020	9910	395	1.4	13.29	341.18	5.11
		B4	119.34	201.87	20755	3450	9045	12125	415	1.22	7.28	413.35	3.9
		B5	99.07	205.36	17230	4070	9050	10560	390	1.05	7.73	413.33	3.54
		Control	82.43	172.9	14335	2900	7820	9080	265	0.93	4.47	324.85	1.98
	NPK2	B1	114.09	219.11	19843	3255	9680	9090	340	1.47	10.16	415.95	4.84
		B2	107.19	178.68	18643	3835	9695	9380	375	1.49	9.75	425.74	4.78
		B3	113.58	183.92	19753	3435	9075	9770	300	1.5	8.81	491.17	4.72
		B4	115.72	212.78	20125	3375	9150	10370	340	1.75	9.67	436.78	3.29
		B5	101.42	198.64	17638	3630	9680	8450	400	1.46	12.34	502.86	4.79
		Control	74.51	169.13	12958	2490	8020	8295	315	0.92	4.16	368.74	2.01
	NPK3	B1	91.24	177.19	15868	3120	8200	8870	375	1.52	5.8	332.63	2.89
		B2	76.83	178.4	13363	2420	8455	8570	320	1.55	6.84	407.72	3.13
		B3	78.60	169.58	13670	2415	8700	8410	330	1.11	6.94	324.47	2.9
		B4	85.30	178.82	14835	2935	8745	9010	325	1.11	7.01	418.28	3.11
		B5	85.23	182.06	14823	2405	8725	8620	380	1.17	7.04	405.08	3.18
		Control	73.28	194.93	12745	1680	8105	9145	225	0.76	3.79	297.11	1.93
	NPK1	B1	120.75	261.75	21000	3455	9465	11475	360	1.86	7.56	420.04	3.5
		B2	140.	261.	24450	3660	104	1576	505	1.2	7.8	513.8	3.94

			59	15			15	5		2	9	9	
		B3	162.45	263.52	28253	5160	9270	10970	380	1.27	13.29	391.11	4.94
		B4	120.10	255.71	20888	3505	9110	10695	430	1.17	11.67	429.27	3.81
Seminto		B5	135.43	426.54	23553	5045	9420	12410	360	1.06	7.54	417.18	3.39
		Control	82.20	274.59	14295	1815	8300	9350	285	0.91	4.22	279.67	1.52
	NPK2	B1	141.18	271.32	24553	4665	9125	9435	320	1.64	11.06	469.67	4.02
		B2	136.07	293.57	23665	4365	9890	9880	335	1.65	9.13	480.11	4.78
		B3	120.26	275.25	20915	4695	9580	9995	335	1.86	12.9	436.39	4.55
		B4	137.47	293	23908	4355	9705	10935	330	1.72	10.51	441.56	3.45
		B5	146.68	282.25	25510	4685	9790	9795	360	1.84	8.01	509.31	4.61
		Control	93.60	251.91	16278	2335	8365	8000	260	0.95	5.19	305.83	1.53
	NPK3	B1	107.48	210.42	18693	2430	8925	8435	280	1.65	5.92	368.38	2.89
		B2	91.51	214.21	15915	2890	8965	9500	325	1.55	6.42	417.39	3.09
		B3	107.97	235.74	18778	2795	8020	9530	295	1.23	6.63	361.08	3.28
		B4	114.68	226.48	19945	2650	8760	9075	340	1.16	7.27	415.5	3.23
		B5	100.78	187.66	17527	3580	8825	10050	320	0.98	7.49	392.95	3.26
Tukey's0.01			59.59	n.s.	10362.61	2028.73	n.s.	n.s.	161.44	1.10	7.40	n.s.	n.s.

B1: *Bradyrhizobium sp.* (Vigna), B2: *Rhizobium leguminosarum bv. viciae,* B3: *Bradyrhizobium* Mungbean, B4: *Mesorhizobium ciceri* andB5: *Rhizobium leguminosarum bv phaseoli.*, NPK1= 120kg.hac^{-1}, NPK2= 240kg.hac^{-1}, NPK3= 360kg.hac^{-1}

Table 6 Interaction effect of wheat cultivars, chemical fertilizer and rhizobial bacteria on leaf phytohormone

Wheat cultivars	Chemical fertilizer kg.ha^{-1}	Rhizobial species	CK (ppm)	IAA (ppm)	GA (ppm)
		Control	6.22	4.37	12.49
		B1	12.73	13.17	51.87
Hawler2	NPK1	B2	8.11	11.03	45.83
		B3	11.72	12.14	159.05
		B4	8.97	11.84	66.19
		B5	20.12	17.42	292.65
		Control	6.35	4.54	12.95
		B1	7.56	14.70	56.19
		B2	10.89	12.77	102.17

	NPK2	B3	15.56	12.64	197.78
		B4	16.61	13.60	51.02
		B5	18.78	13.19	210.68
	NPK3	Control	7.15	5.13	14.08
		B1	6.82	11.44	26.56
		B2	6.79	10.88	28.85
		B3	6.99	9.06	33.30
		B4	9.40	9.00	39.15
		B5	9.11	6.99	41.17
Seminto	NPK1	Control	19.14	7.93	14.33
		B1	28.82	25.87	56.68
		B2	29.73	25.19	52.37
		B3	28.20	38.53	53.31
		B4	28.69	40.00	112.83
		B5	30.08	69.49	180.17
	NPK2	Control	21.06	8.60	17.05
		B1	31.45	58.57	44.74
		B2	30.06	33.77	181.98
		B3	29.64	29.82	53.51
		B4	30.59	28.53	70.44
		B5	28.17	54.53	192.39
	NPK3	Control	21.13	10.22	15.11
		B1	23.07	23.42	42.77
		B2	23.84	20.56	44.02
		B3	27.74	25.87	46.43
		B4	27.98	22.92	42.40
		B5	22.25	12.35	40.30
	Tukey's0.01		4.70	42.90	7.25

B1: *Bradyrhizobium sp.* (Vigna), B2: *Rhizobium leguminosarum bv. viciae*, B3: *Bradyrhizobium* Mungbean, B4: *Mesorhizobium ciceri* andB5: *Rhizobium leguminosarum bv phaseoli.*, NPK1= 120kg.hac^{-1}, NPK2= 240kg.hac^{-1}, NPK3= 360kg.hac^{-1}

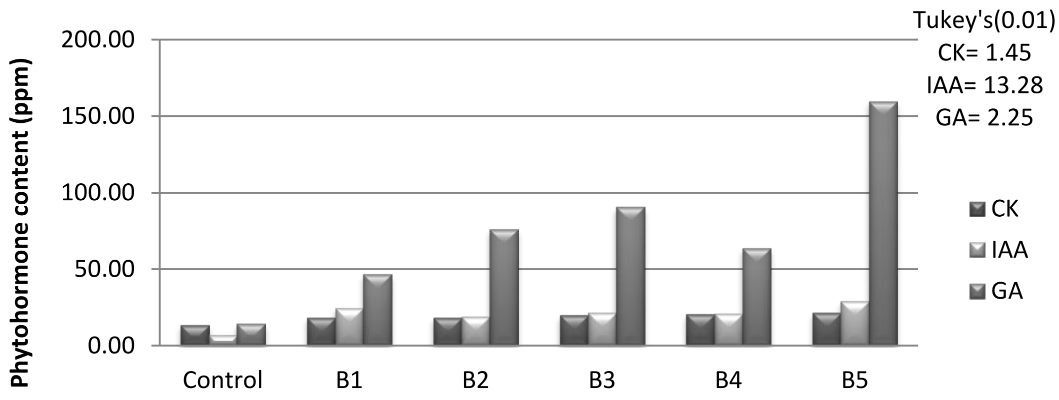

Figure (1):Effect of different species of rhizobial bacteria on leaf phytohormone contents

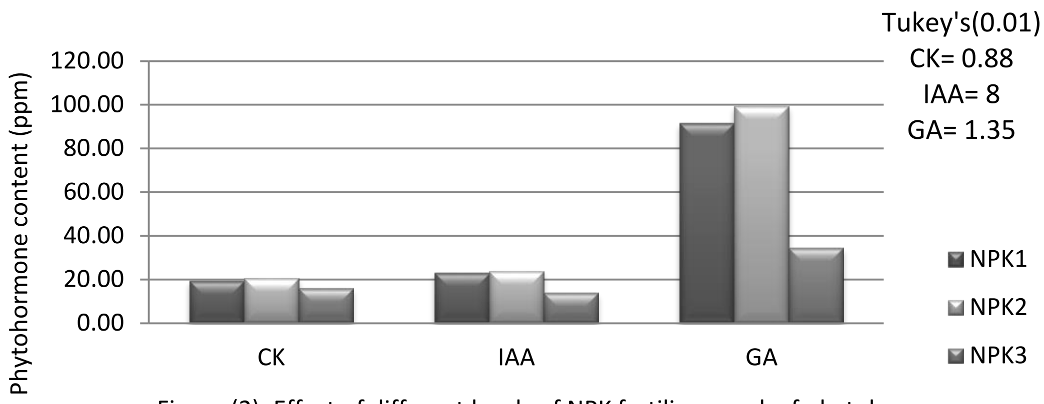

Figure (2): Effect of different levels of NPK fertilizers on leaf phytohormone contents

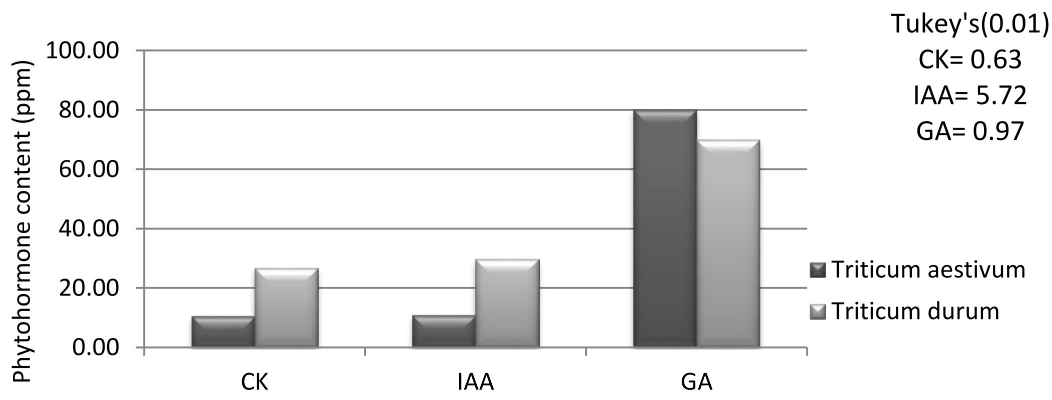

Figure (3):Effect of wheat cultivars on leaf phytohormone contents

3.3 Yield components

Table (7) showed the positive influence of rhizobial inoculation on yield components, highest grain number was 3692.22.plot^{-1}, grain yield: 854.09kg.ha^{-1} and harvest index: 29.82% were recorded by B5 inoculation. The maximum weight of 1000 grain: 50.45g and biological yield: 3009.17kg.ha^{-1} was recorded by using B1 and B2 inoculation respectively.

Data presented in table (8) indicated that, application of different levels of NPK significantly improved yield components. The maximum weight of 1000 grain (48.44g) grain yield (806.47kg.ha^{-1}) and biological yield (2984.45kg.ha^{-1}) were recorded by applying 240kg.ha^{-1} of NPK fertilizer. While, adding 120kg.ha^{-1} of NPK produced significantly higher grain number (3517.22) and harvest index (27.88%)

Table (9) showed that the effect of wheat cultivars on yield components was significant. Seminto surpassed Hawler2 for weight of 1000 grain, grain yield and biological yield, and opposite is true in case of grain number and harvest index.

Results given in table (10) showed that, interaction between wheat cultivars, chemical fertilizer and rhizobial bacteria significantly improved grain yield. As observed, application of (B5 with NPK2 in *Triticum aestivum*), (B1 with NPK2 in *Triticum durum*), (B5 with NPK1 in *Triticum aestivum*), (B4 with NPK1 in *Triticum durum*) and (B1 with NPK1 in *Triticum aestivum*) gave highest grain number 4746.67.plot^{-1}, weight of 1000 grain: 68.64g, grain yield: 991.41kg.ha^{-1}, biological yield: 3730.00kg.ha^{-1} and HI: 35.05% respectively. However figure (4) showed that NPK1 with B5 inoculation of *Triticum aestivum* enhanced grain yield by 114.39% over the control.

Table 7 Effect of different species of rhizobial bacteria on yield components

Rhizobial species	Grain number.plot^{-1}	Weight of 1000grain(g)	Grain yield kg.hac^{-1}	Biological yield kg.hac^{-1}	Harvest index%
Control	2670.17	40.99	513.74	2231.39	23.39
B1	3345.61	50.45	793.99	2836.39	28.34
B2	3394.39	48.79	789.56	3009.17	26.22
B3	3511.56	49.24	831.43	2973.39	28.03
B4	3153.28	48.86	734.64	2850.00	26.27
B5	3692.22	48.06	854.09	2889.17	29.82
Tukey's0.05	248.42	3.19	53.37	217.58	1.84

B1: *Bradyrhizobium sp.* (Vigna), B2: *Rhizobium leguminosarum bv. viciae*, B3: *Bradyrhizobium* Mungbean, B4: *Mesorhizobium ciceri* andB5: *Rhizobium leguminosarum bv phaseoli*

Table 8 Effect of different levels of NPK on yield components

Chemical fertilizer kg.ha^{-1}	Grain number.plot^{-1}	Weight of 1000grain(g)	Grain yield kg.hac^{-1}	Biological yield kg.hac^{-1}	Harvest index%
NPK1	3517.22	46.72	801.26	2904.17	27.88
NPK2	3454.39	48.44	806.47	2984.45	27.03
NPK3	2912.00	48.02	651.00	2506.14	26.12
Tukey's0.05	143.55	1.84	30.84	125.72	1.06

NPK1= 120kg.hac^{-1}, NPK2= 240kg.hac^{-1}, NPK3= 360kg.hac^{-1}

Table 9 Effect of wheat cultivars on yield components

Wheat cultivars	Grain number.plot^{-1}	Weight of 1000grain(g)	Grain yield kg.hac^{-1}	Biological yield kg.hac^{-1}	Harvest index%
Hawler2	3891.35	36.63	719.44	2523.70	28.52
Seminto	2697.72	58.83	786.37	3072.80	25.50
Tukey's0.05	97.62	1.25	20.97	85.50	0.72

Table 10 Interaction effect of wheat cultivars, chemical fertilizer and rhizobial bacteria on yield components

Wheat cultivars	Chemical fertilizer kg.ha^{-1}	Rhizobial species	Grain number.plot^{-1}	Weight of 1000grain(g)	Grain yield kg.hac^{-1}	Biological yield kg.hac^{-1}	Harvest index%
Hawler2	NPK1	Control	3316.67	27.89	462.43	1745.00	26.50
		B1	3953.33	44.32	876.13	2500.00	35.05
		B2	4053.00	38.40	778.27	3216.67	24.19
		B3	4510.00	37.23	839.55	3033.33	27.68
		B4	3810.00	37.89	721.73	2216.67	32.56
		B5	4633.33	42.79	991.41	2911.67	34.05
	NPK2	Control	3206.67	30.54	489.73	1898.33	25.80
		B1	4293.00	40.03	859.30	3045.00	28.22
		B2	4016.67	40.48	813.06	2955.00	27.51
		B3	4090.00	42.27	864.39	3093.33	27.94

		B4	3720.00	36.91	686.53	2911.67	23.58
		B5	4746.67	37.22	883.46	2623.33	33.68
	NPK3	Control	3210.00	30.09	482.98	1966.67	24.56
		B1	3673.33	36.47	669.75	2256.67	29.68
		B2	3886.67	32.08	623.36	2363.33	26.38
		B3	3640.00	37.01	673.65	2248.33	29.96
		B4	3661.67	35.33	646.76	2475.00	26.13
		B5	3623.33	32.43	587.46	1966.67	29.87
Seminto	NPK1	Control	2196.00	47.91	526.08	2496.67	21.07
		B1	4007.33	48.83	978.35	3016.67	32.43
		B2	2997.00	56.06	840.00	3150.00	26.67
		B3	3136.67	56.42	884.87	3200.00	27.65
		B4	2460.00	62.23	765.43	3730.00	20.52
		B5	3133.33	60.69	950.81	3633.33	26.17
	NPK2	Control	2175.00	55.62	604.88	2783.33	21.73
		B1	2120.00	68.64	727.56	3366.67	21.61
		B2	3293.00	59.71	983.23	3586.67	27.41
		B3	3295.00	57.45	946.49	3300.00	28.68
		B4	3033.33	59.55	903.18	3050.00	29.61
		B5	3463.33	52.89	915.82	3200.00	28.62
	NPK3	Control	1916.67	53.88	516.36	2498.33	20.67
		B1	2026.67	64.43	652.86	2833.33	23.04
		B2	2120.00	65.98	699.44	2783.33	25.13
		B3	2397.67	65.03	779.62	2965.33	26.29
		B4	2234.67	61.23	684.20	2716.67	25.19
		B5	2553.33	62.31	795.55	3000.00	26.52
Tukey's0.05			837.77	10.76	179.98	733.74	6.20

B1: *Bradyrhizobium sp.* (Vigna), B2: *Rhizobium leguminosarum bv. viciae*, B3: *Bradyrhizobium* Mungbean, B4: *Mesorhizobium ciceri* andB5: *Rhizobium leguminosarum bv phaseoli.*, NPK1= 120kg.hac^{-1}, NPK2= 240kg.hac^{-1}, NPK3= 360kg.hac^{-1}

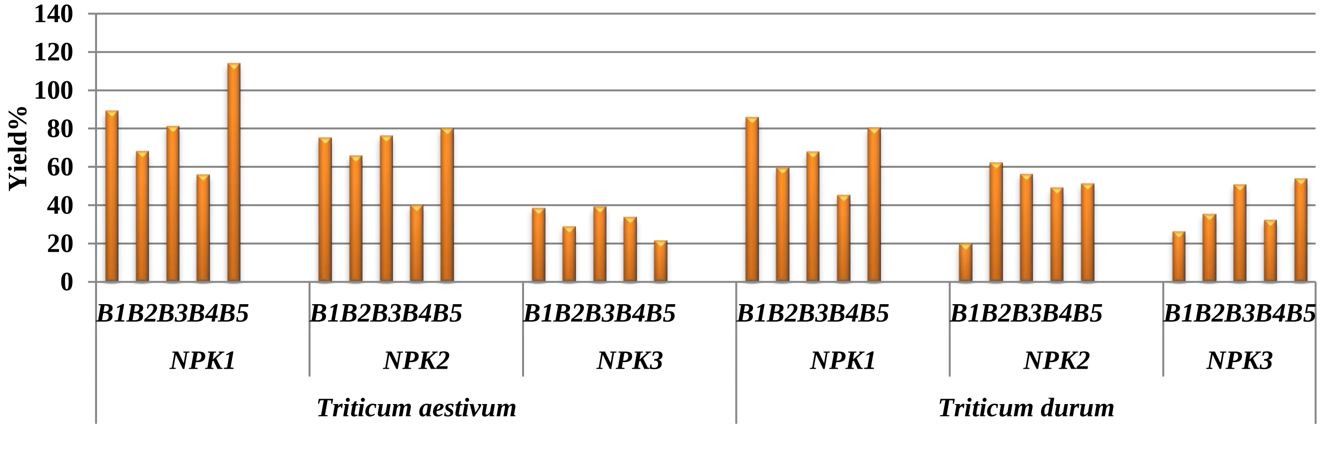

Figure (4): interaction effect of wheat cultivars, chemical fertilizers and rhizobial bacteria on percentage increase of grain yield

4.DISCUSSION

Nutrient deficiency cause significant impact on agriculture, resulting in reduced crop yield or plant quality reduction (Morgan and Connolly, 2013). (Kumar, 2015) suggested that, to overcome the problem of nutrient deficiency and to increase wheat yield, the farmers are applying chemical fertilizers. Chemical fertilizer has its benefits and disadvantages in terms of nutrient supply, quality of the soil and crop growth (Chen, 2006). Less or more plant population and insufficient cro p nutrition are the primary factors responsible for l ow yield (Khursheed and Mahammad, 2015). Chemical fertilizers improve crop yields by providing essential plant nutrients which are easily available to plants; however, their abuse can be harmful for the environment and their use implies increased production costs which reduce the economic viability of agricultural products(Kholssi et al., 2018). Application of biofertilizers became of great necessity to get a yield of high quality and to avoid the environmental pollution(Das et al., 2008). Plant growth promoting rhizobacteria are able to increase mineral and nitrogen availability in the soil as a way to augment growth(Saharan and Nehra, 2011). Increasing of leaf nutrient contents by rhizobial inoculation primarily related to the bacterial production of phytohormone, which caused changes in root morphology and physiology that resulted in increased nutrient and water uptake from the soil(Mia and Shamsuddin, 2010). However, increasing of leaf nutrient contents may be due to the role of Rhizobial bacteria in an increasing the availability of insoluble phosphorus through phosphate-solubilization (Data presented in table (5) supported this results) and siderophore production (which are compounds having low molecular weight and high affinity for iron) (Mehboob, 2010). The positive effect of rhizobial bacteria on soil fertility may be due to the fact that soil microbes are active drivers of soil nutrient cycling, being associated with the decomposition of organic matter, and the transformation and cycling of nutrients, which help to maintain crop productivity and the physical and chemical quality of the soil(Anik et al., 2017). Increasing of leaf phytohormone contents in wheat plants may be correlated to the role of rhizobial bacteria in biosynthesis of plant growth regulators, including auxins, gibberellins, cytokinins, and ABA . The microbial regulators modulate plant hormone levels in plant tissue, and they have been found to have effect that are similar to exogenous phytohormone application(Egamberdieva et al., 2017), the results achieved in the figure (1) largely confirm the positive effect of rhizobial bacteria on plant hormones. Production of phytohormones by inoculation has been suggested as one of the most plausible mechanisms of action affecting plant growth. Soil microbes are potential sources of these phytohormones(Shakhawat, 2007). Enhancing yield components by using rhizobial bacteria may be because of one or more growth promoting mechanisms which may imply that the ability of rhizobia to produce different metabolites like organic acids, vitamins, enzymes and exopolysaccharides in the rhizosphere could be responsible for improve yield production(Mehboob et al., 2011). (Etesami et al., 2009) revealed that inoculation of wheat with beneficial bacteria has the potential to increase the yield of wheat and improve the higher plant growth. (Adnan et al., 2014) suggested that rhizobial bacteria could be used as PGPR for wheat crop in prevailing soil and climatic conditions. This results partially agreed with those obtained by(Mohamed, 2000) concerning wheat plants. In general, the capacity of plant species and their genotypes to absorb and metabolize components differs genetically.

1. CONCLUSION

From the study, it might be concluded that the combination between the lower levels of NPK fertilizer with different species of rhizobial bacteria had positive effect on wheat production and soil fertility.

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