The Effect of Bio and Mineral Fertilizers on Growth and Yield of Wheat (Triticum estivum L.)

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Abstract. A field experiment was conducted at the college of Agriculture – university of Anbar during the winter season of 2018-2019 using complete randomized blocks design (RCBD) to investigate effects of bio-fertilizer (BF) and different rates of mineral fertilizers (MF) from fertilizer recommendation (FR) on the growth and yield of wheat (IBAA cultivar). The growth and yield traits consisted of plant height (PLH), number of tillers (NT), number of spike (NS), number of grains per spike (NGPS), weight of 1000 grains (WG), biological yield (BY), and grain yield (GY). Treatments consisted of: control T0 (without BF and MF); BF (T1); 100% of FR (T2); BF+25% of FR (T3); BF+50%FR (T4); BF+100% FR (T5). Results indicated that the treatment of adding biological fertilizer with 100% mineral fertilizer(T5) was superior in most of the studied characteristics except for the total number of organisms in the soil. The fertilization treatment (T4) did not differ significantly from treatment (T5) in most of the characteristics included in the study except that increasing of microorganisms in the soil. Thus, 50% of the mineral fertilizer can be substituted with the biological fertilizer to reduce the risk of contamination and reduce the cost of mineral fertilizer.

1. Introduction

Due to the high cost of mineral fertilization, which is accompanied by environmental pollution (under unwise application), bio fertilizers, which are vaccines google translation (Inoculant) containing some living microorganisms. Where the effectiveness of some microorganisms and their vital activity can be employed, and harnessed optimally by pollinating seeds with microorganisms, as they work to stabilize nitrogen and melt phosphorus and potassium as well as produce hormones stimulating growth, amino acids and vitamins that improve soil properties, leading to increased crop productivity. The role of bio fertilizers in increasing nutrient availability is evident through various mechanisms, including reducing the degree of interaction through the secretion of organic acids, as well as producing phytohormones and antibiotics to protect themselves and the plant from bacterial and fungal diseases [1]. The use of soil microorganisms that can stabilize atmospheric nitrogen, dissolve phosphates, manufacture growth-stimulating substances, decompose the plant residues of the previous crop to free up and release important and essential vital nutrients and increase the content of the soil humic content will be the beginning of environmental treatment of nutrition management and the employment of a sustainable agricultural system [2], which will be environmentally friendly because it contains different microbes that help plants to obtain nutrients and increase their tolerance to certain environmental stresses to reduce the risk of environmental contamination with chemical fertilizers to ensure human safety [3]. Abd [4] found that the use of bio fertilizer with 75% of the recommended amount of mineral fertilizer had a significant effect on the growth properties of wheat crop, including plant height (117.8 cm), length of spike (14.3 cm), weight of 1000 grains (46.7 g), grains (5.046 tons. ha-1) and biological yield (6.47 tons. ha-1). He concluded that the use of bio fertilizers saved 25 and 50% of the recommended fertilizers of mineral nitrogen. A number of researchers have found that the addition of bacterial bio fertilizer with mineral fertilizer has increased the wheat grain yield by 44% [4]. Recent studies have given importance to the use of bio fertilizers, which reduce the use of chemical fertilizers by about 40 to 50%, which contributes to sustainable agriculture, and the use of bio fertilizers increases plant growth and crop productivity to more than 30% in addition to obtaining...
a healthy and high-quality product [5]. Bio-inoculation has provided enough phosphorus for the plant, especially in the early start of the growth stage, which has increased the accumulation of nutrients in the plant, due to the various capacities of the organisms associated with a nutrient dissolvent, the production of growth auxins, stimulating the growth of the roots, and then increasing their absorption capacity[6].

Wheat is the world's first grain crop in terms of importance, cultivated areas and world production. Therefore, recent studies have tended to produce wheat towards self-sufficiency of many countries, but population density and low production yields stand in the way of the development of its productivity, so applied research should be focused on this crop in addressing the increase in the yield rate in the unit of space by taking economic, agricultural and policy measures to achieve good yields for this crop. Therefore, this study aims to determine the response of the wheat crop to bio fertilizer, and the possibility of compensating part of the mineral fertilizer with bio fertilizers and the amount of this in order to reduce the cost of agricultural production and reduce environmental pollution.

2. Materials and Methods

A field experiment had been conducted at the research station in college of Agriculture in university of Anbar in 2018-2019 season to study influence of bio fertilizer and levels of adopted fertilizer recommendation on wheat (IBAA 99 cultivar) growth and yield. The bio fertilizer contains of Bacillus subtilis and Pseudomonas putida in addition to complex enzyme systems of Protease Lipase, Chitinase, Amylase and biological stimulators (Gibberellin and Cytokinin) 0.3%. The experimental design was the complete randomized blocks (RCBD) of three replications, the land was divided in blocks of (1x2) m2 of 0.5 m width borders to prevent interactions between fertilizers additions and irrigation water. A surface soil (0-0.3 m) was sampled, air dried, crushed, and sieved through 2 mm mesh diameter sieve to analyse chemical and physical properties (Table 1).

| Parameter          | Unit     | Value  | Parameter          | Unit     | Value  |
|--------------------|----------|--------|--------------------|----------|--------|
| EC                 | ds.m⁻¹   | 3.71   | Sand               | g.kg⁻¹   | 150    |
| pH                 |          | 7.9    | Silt               | g.kg⁻¹   | 490    |
| OM                 | g.kg⁻¹   | 8.5    | Clay               |          | 360    |
| Biomass (CFU)      | g. soil⁻¹| 104*1.47 | Soil Texture      |         | Silty Clay Loam |
|                    |          |        |                    | bulk density | 1.45 |
| Available Elements | Mineral in Soil | | Olsen P           | 8.6      | mg.kg⁻¹ |
| Available-N        |          | 80     | Available-K        | 180      | mg kg⁻¹ |

EC= electrical conductivity; pH=Log (hydrogen concentration); OM=organic matter.
Six fertilization treatments were used which are:
T0 (without Bio Fertilizer and Mineral Fertilizer) [zero BF & MF]
T1 (Bio Fertilizer) [BF]
T2 (MF according to Fertilizing Recommendations [FR])
T3 (BF+25% MF)
T4 (BF+50%FR)
T5 (BF+100% FR)
The nitrogen fertilizer applied as urea form (46% N) in three batches; at cultivation, after 2 months of germination, and at bedding. The phosphate fertilizer was applied as TSP form (Triple super phosphate) (20% P). The potash fertilizer was applied as potassium sulphate form (41.5% K) in one batch at cultivation. The seeds of wheat had been dashed in microbial inoculant according to recommendation after addition of 1:10 suspension of Arabian glue: distilled water to assure adhesion of vaccine with seeds [7]. The wheat (IBAA99 cultivar) seeds have been dashed with 100 ml of Arabian glue suspension which was prepared previously, then they good mixed, left for 30 minutes except control seeds which left without dashing for sooner cultivation in the field. IBAA99 cultivar seeds were implanted in November at average of 120 kg. ha$^{-1}$, every experimental unit has 5 lines of 2 m length with 20 cm distances among them, the free irrigation method was used with water of Euphrates River using a specified discharge pump and depending on the weighted method, service operations of tillth and weeding were conducted whenever the plant needed it. At the end of experiment, the plants were harvested then the plant height PLH at the point of contact with soil surface till the top of spike was measured, the number of tillers NT, number of spikes at square meter NS, number of grains per spike NGPS of ten spikes average, the weight of 1000 grains WG using sensitive balance were also measured. Grains yield GY from every experimental unit was extracted and converted to Mg. ha$^{-1}$, biological yield BY was appointed as well and finally the total number of organisms in the soil [8]. The differences of means were compared using least significant different LSD at 0.05% probability level.

3. Results and Discussions

3.1. Plant height PLH (cm)
Table (2) illustrates a significant decrease in PLH in control treatment (T0) which reached 70.41 cm with percentages of 16.50% and 21.52% compared to T1 and T2 respectively. High values of mean PLH in T2, T5, and T4 were 85.56, 85.57, and 85.30 cm which aren’t differed significantly with other addition treatments.

| Treatment | Plant height (cm) | Tillers plant$^{-1}$ | Number of Spike m$^{-2}$ | Number of seed Spike$^{-1}$ | Weight of 1000 seeds (g) | Grain yield Mg ha$^{-1}$ | Bio yield Mg ha$^{-1}$ | *106cfu gm$^{-1}$ soil |
|-----------|------------------|----------------------|-------------------------|---------------------------|--------------------------|------------------------|------------------------|------------------------|
| T0        | 70.41            | 2.69                 | 310.0                   | 45.33                     | 30.33                    | 4.10                   | 7.668                  | 3.65                   |
| T1        | 82.03            | 3.74                 | 345.3                   | 65.33                     | 32.23                    | 4.89                   | 8.161                  | 7.83                   |
| T2        | 85.56            | 4.72                 | 480.3                   | 84.33                     | 40.72                    | 6.90                   | 15.020                 | 3.97                   |
| T3        | 82.34            | 3.61                 | 444.2                   | 72.67                     | 36.17                    | 6.03                   | 12.244                 | 8.57                   |
| T4        | 85.30            | 3.64                 | 491.3                   | 82.33                     | 39.43                    | 6.31                   | 14.490                 | 7.33                   |
| T5        | 85.57            | 4.67                 | 501.3                   | 83.00                     | 40.94                    | 6.83                   | 15.483                 | 3.53                   |
| LSD 0.05  | 4.553            | 0.634                | 57.06                   | 3.708                     | 2.427                    | 1.047                  | 2.604                  | 1.096                  |

3.2. Number of tillers per plant (NT) (tiller. plant$^{-1}$) (TPP)
Table (2) showed superiority of all fertilization treatments FTs to T0. T2 and T5 recorded the highest mean of NT reached 4.72 and 4.67 TPP with rise percentages of 75.46 and 73.61% in comparison with T0 which stated the least NT value followed by T1 which reached 3.74 TPP that significantly higher than T0.

3.3. Number of tillers in a plant (NT) (tiller. Plant$^{-1}$):
Table 2 showed the superiority of all fertilizers treatments over the control treatment (T0) which gave the lowest average of 2.69 tiller per plant$^{-1}$. The two treatments T2 and T5 recorded the highest average number of tillers with 4.72 and 4.67 tillers per plant$^{-1}$ with an increase of 75.46 and 73.61%
compared to the control treatment (T0), followed by treatment T1, which averaged 3.74 tiller per plant\(^1\). The reason may be due to the availability of plant nutrients that increase the size of the branches, and then the increase in the interception of solar rays, which was reflected in the increase in manufactured materials and thus the supply of branch primers in a way that ensures the continuity of growth and production of branches, and these results are similar to what was mentioned in [9].

3.4. Number of spikes (NS) (spikes.m\(^{-2}\)) (SPSM)

The results of statistical analysis in table 2 documented a significant effect of FTs toward T0 except T1 which wasn’t differ significantly on T0 that recorded the least mean of NS reached 310 SPSM, whereas T5 showed the highest mean of this trait mounted 501.3 SPSM, this treatment doesn’t differ significantly on T2, T3, and T4 that recorded 480.3, 444.2, and 491.3 SPSM.

3.5. Number of grains per spike (NGPS) (grain. spike\(^{-1}\)) (GPS)

The treatment of zero addition of FTs (T0) caused a significant decrease in the mean NGPS, at 45.33 GPS. The T2 surpassed the highest mean of NGPS at 84.33 GPS, and was not significantly different from the T4 treatment, which gave 82.33 GPS and T5 treatment, which gave 83.00 GPS.

3.6. The weight of 1000 grains (WG) (g)

All of fertilizer treatments were higher than T0 except T1 that didn’t differ significantly on them, maximum GW value was recorded in T5 treatment is 40.94 g that was mean 34.98% up to the T0 which had minimum average value of 30.33 g. Also, the T5 didn’t differ significantly on T2 which was 40.72 g and T4 which was 39.43 g.

The BF and MF have an active role in supplying the plant with the necessary nutrients and thus increasing the growth indicators of the plant like WG due to the regularity work of plant hormones when the availability of nutrients K, P and N, which increased the division of cells and increased the number of branch tillers carrying flowering and fertile spikes. The increased vegetative growth of the plant also improves the exploitation of active rays of photosynthesis, especially at the beginning of growth season, which increases the availability of the anabolized substances in support of the emergence plant. Also support emergence, reform branch starters, the success of their continued growth too, and the availability of soil-added nitrogen affects increased growth and increased the number of fertile branches and thus increased the number of spikes for its importance in the vital processes of the plant as well as the contribution of phosphorus to the formation of nuclear acids and the formation of some energy-rich compounds this helps to reach the branch to the stage of the formation of spikes and then increase their number [10]. The bio fertilizer has an important role in increasing growth indicators, especially if added with mineral fertilizer, as the microbes (Bacillus subtilis & Pseudomonas putida) works on the production of plant growth hormones including Auxins, Gibberellins, cytochins, and Abscisic acid [11], and also existed enzymes in bio fertilizer and their role in supplying nutrient elements.

3.7 Biological yield (BY) (Mg. ha\(^{-1}\)) (MGPH)

There are significant differences among fertilizer treatments presented in table 2, as the T5 had a highest BY value of 15.483 MGPH which was 89.72% higher than T1 that had mean BY value of 8.161 MGPH, the next was T2 treatment which had BY value of 15.020 MGPH; ie 84.05% higher than T1; but it was 77.55% higher than T1 in T4 treatment. The T4 treatment didn’t differ significantly on T5 treatment. The rise of BY values may be attributed to the contribution of available MF elements (N, P, and K) in increasing plant growth and thus increasing BY, also the BF have an active role in absorption of nutrients especially when they applied with MFs [12]; [13].

3.8 Grains yield (GY) (MGPH)

All treatments (T2, T3, T4, T5) except T0 and T1 had no significant differences among them, where the highest GY value was in T2 (6.90 MGPH) and the least was 6.03 MGPH in T3. GY values were 6.31, 6.83 MGPH in T4, T5 respectively, T3 recorded an increase in average GY of 9% and 1% compared to T4 and T5 respectively whereas T0 showed minimum GY of 4.10 MGPH. The reason for the increase in the GY is due to the role of MF in the providing the plant with macronutrients (N P K) which led to an increase in the characteristics of growth such as the number of spikes and the weight
of 1000 grains and the number of grains in the spike (Table 2) and this was reflected in the yield of grains as a result of the efficient transfer of carbon synthesis products and the storage of carbohydrate and protein materials in grains.

3.9 Microbes density in soil after harvesting (MD) (cfu. g⁻¹ soil):
Statistical analysis showed the significant effect of different treatments on the mean MD in soil after harvesting. Generally speaking, it is clear from table 2. That T1, T3, T4 recorded increase in MD values of (7.83 × 10⁶), (8.57 × 10⁶), and (7.33 × 10⁶) cfu. g⁻¹ soil, respectively compared to 3.65 × 10⁶ cfu. g⁻¹ soil in T0 and T5 that recorded minimum MD of 3.53 × 10⁶ cfu. g⁻¹ soil. The application of BF obviously rose up MD values of T3 and T4 but dropped down to minimum value in T5 along with increasing MF percentage. The increasing of bacterial MD in inoculated compared to non-inoculated treatments was attributed the roots excretion of saccharides, organic and amino acids, vitamins, and other substances which stimulate microorganisms as they are the power source to increase their populations [14].

4. Conclusion
The treatment in which biological fertilization was added with half the quantity of fertilizer recommendation did not differ significantly from the treatment in which the whole fertilizer recommendation was added in most of the characteristics included in the study except that it excelled in increasing the number of microorganisms in the soil. Thus, it is possible to replace 50% of mineral fertilizer, reduce pollution and save the price of mineral fertilizer.

References
[1] Vessey, JK 2003, Plant growth promoting rhizobacteria as biofertilizer. Plant and Soil. 255, 571-586.
[2] Wu, SC, Cao, ZG, Li, ZH and Cheung, KC 2005, Effect of biofertilizer containing N-fixer, P and K solubilizers and AM fungi on maize growth: a greenhouse trial. Sci. Direct, Geoderma., 125, 155-166.
[3] Jawad MM; Al-Shahwany, A and Khudhair, SH 2015, Effect of Bio-chemical Fertilizer on Proline Accumulation, Catalase and Peroxidase Enzymes Activity in Leaves of Two Wheat Cultivars (Ipa99 and Rabyaa) Under Water Deficit Stress. Iraqi Journal of Science, 2 (56), 1350-1358.
[4] Abd El-Lattief, EA 2014, Effect of integrated use of farm yard manure (FYM) and chemical fertilizers (NPK) on productivity of bread wheat under arid conditions. Inter. J. of Advan. Res., 3(12), 2278-6252.
[5] Oldroyd ,GED and Dixon ,R 2014, Biotechnological solutions to the nitrogen problem. Current Opinion in Biotech., 26:19-24.
[6] Sellamuthu,G , Soundarapandian ,S and Jasdeep, CP 2017,Azotobacter chroococcum: Utilization and potential use for agricultural crop production: An overview., Int. J. Adv. Res. Biol. Sci. 4(3), 35-42.
[7] Al-Joboor, W, MJ , Ahmed, M 2020, Effect of addition date of phosphorus, zinc, zinc source and bio-inoculation on the growth of maize (Zea mays L.). Int. J. Agricult. Stat. Sci., 16, (1), 1779-1785.
[8] Bashan Y, Holguin, G, Lifshitz,R 1993, Isolation and characterization of plant growth-promoting rhizobacteria. In: Glick BR, ThompsonJE (eds) Methods in plant molecular biology and biotechnology. CRC Press, Boca Raton, 331–345.
[9] Black, CA 1965, Method of Soil Analysis. Part 1 (1). Physical properties. Am. Soc. Agron. Inc. publisher, Madison, Wisconsin, USA.
[10] Abd Al-Razek, A and Sheshhtawy, AA 2013, Response of some wheat varieties to bio and mineral nitrogen fertilizers. Asian J. of Crop Sci., 5(2): 200-208.
[11] Muhammad H, Zaman, A, Shad ,SK and Shah .Z 2014, Effect of beneficial microbes (BM) on the efficiency of organic and inorganic N fertilizers on wheat crop. Sarhad J.Agric., 30(1),7-14.
[12] Ansary, MH, Rahmani, HA, Ardakani, MR, Paknejad, F, Habibi, D and Mafakheri, S 2012, Effect of Pseudomonas fluorescent on proline and phytohormonal status of maize (Zea mays L.) under water deficit stress. *Annals of Biological Research*. 3 (2), 1054-1062.

[13] Omar K and Sarhan, TZ 2010, The effect of inoculation with Azotobacter bacteria and different levels of nitrogen fertilizer on 1-vegetative growth of potato plant (Solanum tuberosum L.). *Mesopotamia J. of Agric.* 38 (1 Appendix).

[14] Mohamed A Y, Mahmuod, M E and Ihab, IS 2013, Impact of organic manure, bio-fertilizer and irrigation intervals on wheat growth and grain yield *American-Eurasian J. Agric. and Environ. Sci.*, 13 (11), 1488-1496.