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# Evaluation of Combined Effect of Nitrogen Fertilizer and Vermicompost on Quantitative and Qualitative Characteristics of Wheat Verities in Amareh Region (Southern Iraq)

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**RESEARCH ARTICLE**



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## ABSTRACT

**BACKGROUND:** Balanced and efficient use of applied N is of paramount importance in the overall nutrient management system than any other plant nutrient in order to reduce its negative impact on the environment. For economic production keep equilibrium between fertilizer and biofertilizer is necessary in sustainable agriculture.

**OBJECTIVES:** This research was done to assess effect of fertilizer and biofertilizer on crop production and protein content of wheat varieties under warm and dry climate condition.

**METHODS:** Current study was consisted according split-plot experiment based on Randomized Complete Block Design with three replications. The main plot included the combination of chemical and biological fertilizers ($F_1$: 150 $kg.ha^{-1}$ urea fertilizer, $F_2$: 150 $kg.ha^{-1}$ urea fertilizer with 5 $t.ha^{-1}$ vermicompost, $F_3$: 5 $t.ha^{-1}$ vermicompost) at three level. The sub plot consisted three varieties of wheat ($V_1$: Rashid, $V_2$: Bahous 99, $V_3$: Aba 99).

**RESULT:** The results showed that the effect of combination treatment of chemical and biological fertilizers and verities on plant height, seed yield, yield components, biological yield, and harvest index and seed protein percentage was significant. Also, the interaction of the combination of chemical and biological fertilizers and verities on the number of spikes per unit area, the number of seeds per spike, the 1000 seed weight, seed yield and biological yield was significant. The highest seed yield belonged to the combined treatment of nitrogen chemical fertilizer and vermicompost and Bahous 99 Varity with an average of 468.11 $gr.m^{-2}$, and lowest seed yield belonged to application of vermicompost fertilizer and the Rashid Varity with an average of 394.2 $g.m^{-2}$.

**CONCLUSION:** In general, it can be said that in order to achieve the maximum quantitative and qualitative yield of wheat, it is suggested to cultivate the Varity of Bahous 99 with the combined application of nitrogen fertilizer and vermicompost in Amara region in southern Iraq.

**KEYWORDS:** *Biofertilizer, Plant height, Protein content, Seed yield, Urea.*

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## 1. BACKGROUND

Wheat as one of the most important cereal plants, has a major contribution to human nutrition and also provides forage for animals (Radwan *et al*., 2015). Global wheat production should increase by at least 2.5% annually until 2022 in order to compensate for the increase in demand for this product (Fao, 2019). Wheat is one of the oldest and most important crops due to its easy cultivation and high adaptability to different environmental conditions (Zhou *et al*., 2019). One of the important factors in wheat production is achieving high seed yield and high quality of seeds, which itself depends on several factors, including seed genetics, high-yielding varitys, environmental conditions, and seedling establishment (Tadesse *et al*., 2019). In common agriculture, nitrogen is one of the most important and effective nutrients in the growth and development of crops, which plays an important role in plant nutrition, and its deficiency is common in arid and semi-arid regions. Therefore, in many areas, especially in soils poor in organic matter, it is a limiting factor for crop growth and production (Belete *et al*., 2018). In the last few decades, the spread of nutritional diseases in societies and the destruction of the environment as a result of the use of conventional agricultural management, which has caused water pollution, decline in the quality of agricultural products, and a decrease in soil fertility with the use of chemical inputs, have prompted experts to look for a solution. to preserve the health of human society and the environment, and in the end, they found the best solution to grow crops using minimal inputs (types of chemical fertilizers and pesticides), which became known as sustainable agriculture (Ebrahim Nia and Daghestsni, 2014). Vermicompost is one of the most important organic fertilizers. Vermicompost is a biological organic fertilizer that is produced through the conversion of organic waste in a non-thermophilic process by the joint action of earthworms and soil microorganisms (Joshi *et al*., 2015). When these materials pass through the worm's body, they are impregnated with the mucus of the digestive system, vitamins and enzymes, which are enriched as an organic fertilizer and are very useful for the construction and improvement of soil nutrients, production and consumption. Therefore, vermicompost is worm excrement along with a percentage of organic and food materials and worm carcasses (Zaller, 2007). Vermicompost fertilizer improves the physicochemical and biological characteristics of the soil, and in addition to its low specific weight, it does not contain any odors, anaerobic bacteria, fungi, and weeds. In addition to the ability to absorb water with a high volume, vermicompost provides suitable conditions for granulation and the ability to store nutrients needed by plants (Gorooei *et al*., 2016). In addition to these cases, earthworms can reduce the concentration of these substances in the plant's root environment by absorbing metals and heavy elements from the soil and accumulating them in their body tissues, and in this way, prevent plant pollution and the increase in the concentration of these toxic substances in the plant. This issue improves the quality of root and plant growth and reduces the risk of toxicity of the products obtained from these plants (Bei *et al*., 2006). Aslam *et al*. (2019) investigated the effect of vermicompost on wheat plant growth and stated that vermicompost fertilizer, in addition to increasing the number of tillers, spike length, number of spikes per square meter, number of seeds per spike, 1000 seed weight, biological yield and harvest index caused the physical and chemical characteristics of the soil were improved. Seimarizadeh *et al*. (2022) by studying the effect of vermicompost on the yield and yield components of wheat stated that by increasing the consumption of vermicompost, the supply of water and nutrients for the plant increased and the studied traits such as the number of spikes per square meter, the number of seeds per spike , 1000 seed weight, biological yield and harvest index increased. Biri *et al*. (2016) investigated the use of vermicompost and nitrogen on the growth and yield of Sorghum and reported that the use of vermicompost and nitrogen fertilizers had a positive and significant effect on most of the assessed traits. So that in some of the mentioned traits (number of panicles per plant, seed yield and protein yield), the application of organic fertilizers had an effect equal to the effect of half of the nitrogen fertilizer used. Therefore, it can be stated that in order to reduce the consumption of chemical fertilizers and achieve the goals of sustainable agriculture, a large part of the nitrogen requirement of Sorghum plant can be provided by using organic fertilizers.

## OBJECTIVES

Generally considering the importance of organic fertilizers in sustainable agriculture and increasing the yield of crops, this research was designed and implemented with the aim of investigating the combined effect of nitrogen chemical fertilizer and vermicompost on the quantitative and qualitative yield of wheat varitys and also to identify the best varity for cultivation in the Amareh region of Iraq.

## 3. MATERIALS AND METHODS

### 3.1. *Geographical information and climatic characteristics*

This experiment was carried out in the cropping season of 1400-01 in a field in Amareh city in southern Iraq with a longitude of 47 degrees and 2 minutes east and a latitude of 31 degrees and 54 minutes north and a height of 31.5 meters above sea level. The climate of Iraq (except its northern part) is mainly desert with cool and sometimes cold winters and dry and hot summers.

### 3.2. *Chemical and physical properties of studied soil*

To determine the physical and chemical characteristics of the soil, before any land preparation operations, samples were randomly collected from five points at a depth of 0-30 cm, and after drying in the air and passing through a 2 mm sieve, some physical and chemical properties were determined. The results of soil analysis were shown in table 1.

**Table 1.** Physical and chemical properties of studied field

| Soil texture | K (ppm) | P (ppm) | OC (%) | N (%) | pH | EC ($ds.m^{-1}$) | Soil depth (cm) |
|---|---|---|---|---|---|---|---|
| Clayloam | 271 | 11.2 | 0.84 | 0.05 | 7.6 | 4.5 | 0-30 |

3.3. *Treatments information*

Current study was consisted according split-plot experiment based on Randomized Complete Block Design with three replications. The main plot included the combination of chemical and biological fertilizers ($F_1$: 150 $kg.ha^{-1}$ urea fertilizer, $F_2$: 150 $kg.ha^{-1}$ urea fertilizer with 5 $t.ha^{-1}$ vermicompost, $F_3$: 5 $t.ha^{-1}$ vermicompost) at three level. The sub plot consisted three varieties of wheat ($V_1$: Rashid, $V_2$: Bahous 99, $V_3$: Aba 99). The experiment consisted of 27 plots. Each plot has seven planting lines, each four meters long, and the distance between the planting lines was 20 cm. The distance between two repetitions was 1.5 meters, and the distance between the two sub-plots was half a meter, and the distance between the two main plots was one meter.

3.4. *Farm Management*

The land preparation operation included a 20 cm deep plow, then two perpendicular discs were used, and a trowel was used to remove the depressions and elevations resulting from the plow. Then the desired dimensions were estimated on the ground and the whole map was laid out on the ground and demarcation and drainage were done. To provide the required nutrients, all the required phosphorus was used from the triple superphosphate source based on 80 kg of pure phosphorus and 150 kg of potassium sulfate per hectare according to the soil test in all treatments before cultivation. The amount of nitrogen fertilizer from the source of urea in the amount of 150 $kg.ha^{-1}$ was given to the plant in the form of surface spreading, 50% before planting (base) and 50% at the end of the tillering stage (beginning of stem growth). All the vermicompost fertilizers in the examined treatments were applied to the soil at a depth of 15-20 cm before planting. The seed planting operation (with a density of 400 plants per square meter) was done manually according to the climatic conditions of the region on November 10, 1400. After planting, the field was immediately irrigated.

3.5. *Measured Traits*

The final harvest was done on May 15, 1401 when the seeds were almost hard and their moisture content reached about 14%. At the end, in the seed physiological growth stage, the area of 1.5 square meters from the four middle lines of each plot was measured after removing the margins for the final harvest and the following traits. In order to determine yield and yield components, two side rows and half a meter from the beginning and end of the plot were removed as marginal effects, and finally, the final harvest was done from an area equal to 1.5 square meters from the four middle lines of each plot. To determine the number of spikes per unit area, the total number of spikes harvested in the area of 1.5 square meters (from the four middle lines) was counted and considered as the number of spikes per unit area (Amraei *et al*., 2016). In order to calculate the number of seeds per spike, 20 spikes were completely randomly separated from the total harvested spikes of each plot (from the four middle lines) and after separating the seeds from the spike, the number of seeds was counted. The number of seeds per spike was calculated by dividing the number of seeds by the number of spikes (Yaghoubian *et al*., 2017). For this purpose, 2 samples of 500 seeds from the produced seeds of each plot were randomly separated and weighed. If the difference in the weight of two samples was less than 5%, their total weight was considered as the weight of a thousand seeds (Sabzevari and Khazaie, 2009). In order to determine the seed yield, in the ripening stage and after removing 0.5 meters from the beginning and end of the four middle lines, a surface equivalent to 1.5 square meters was harvested. After threshing, the seeds were separated from the straw and after weighing the seeds, the seed yield was calculated in grams per square meter (Amraei *et al*., 2016). To calculate the plant height, the height of about 20 plants was randomly calculated from soil surface to the end of stems at the time of harvesting and their average was considered as the plant height. (Yaghoubian *et al*., 2017). At the time of harvesting, all plants in an area of 1.5 square meters were harvested from each plot (from the four middle lines by removing half a meter from the beginning and end of each line). In order to determine the biological yield, about 500 grams of the harvested plants were separated and after transferring the samples to the laboratory, they were placed in a ventilated oven at a temperature of 75 degrees Celsius for 48 hours, and after drying, their weight was weighed. Calculation to be calculated through the proportion of dry weight per unit area (Gardner *et al*., 1985). The harvest index was calculated by dividing the seed yield by the biological yield, as a percentage (Gardner *et al*., 1985). To determine the seed protein percentage, first, the seed nitrogen percentage was measured by Kjeldahl apparatus, which includes digestion, distillation and titration stages. The amount of seed protein was also obtained by multiplying the seed nitrogen percentage by a factor of 5.7 (Keeney and Nelson, 1982).

*3.6. Statistical Analysis*

Analysis of data variance was done with SAS software (Ver.9.1), and the averages were compared with Duncan's test at 5% probability level, and graphs were drawn with Excel software.

## 4. RESULT AND DISCUSSION

4.1. *Plant height*

Plant height under influence of different levels of nitrogen fertilizer and vermicompost and varities was significant at 1% probability level, but their interaction was not significant (Table 2). The highest plant height (92.88 cm) was assigned to provide half of the plant's fertilizer in chemical form and the rest in the form of vermicompost, and the lowest one (78.42 cm) was for application vermicompost (Table 3).

**Table 2.** Summary of the results of analysis of variance of measured traits

| S.O.V | df | Plant height | Number of Spike per m$^{-2}$ | Number of Seed per spike | 1000 seed weight |
|---|---|---|---|---|---|
| **Replication** | 2 | 3.18 | 200.1 | 1.66 | 4.08 |
| **Fertilizer** | 2 | 1862.03** | 8172.5* | 192.73** | 436.25** |
| **Error I** | 4 | 140.1 | 900.11 | 16.25 | 13.02 |
| **Varieties** | 2 | 2275.25** | 9553.4** | 281.4** | 621.80** |
| **Fertilizer × Varieties** | 4 | 89.43$^{ns}$ | 11724.52** | 367.1** | 815.43** |
| **Error II** | 12 | 106.7 | 813.22 | 13.66 | 10.01 |
| **CV (%)** | | 12.13 | 8.05 | 11 | 8.52 |

$^{ns}$, * and **: no significant, significant at 5% and 1% of probability level, respectively.

**Continue table 2.**

| S.O.V | df | Seed yield | Biological yield | Harvest index | Seed protein content |
|---|---|---|---|---|---|
| **Replication** | 2 | 98.41 | 169.5 | 2.43 | 0.08 |
| **Fertilizer** | 2 | 361230** | 183267** | 329.01** | 70.24** |
| **Error I** | 4 | 2500.8 | 12544.3 | 13.51 | 4.85 |
| **Varieties** | 2 | 470332** | 176891** | 182.37** | 61.09** |
| **Fertilizer × Varieties** | 4 | 81257** | 105663* | 3.01$^{ns}$ | 0.17$^{ns}$ |
| **Error II** | 12 | 1681.19 | 1127.4 | 11.32 | 2.04 |
| **CV (%)** | | 9.67 | 7.64 | 11.02 | 12.31 |

$^{ns}$, * and **: no significant, significant at 5% and 1% of probability level, respectively.

Among agricultural varities, Bahous 99 varity had the highest plant height (90.2 cm), and it was 10% higher than the varity Rashid (Table 3). Better adaptation to environmental conditions, more use of resources and a longer growing period were the reasons for the higher height of the high-yielding varity Bahous 99 and its superiority over other varitys. On the other hand, the height of the plant, like any other vegetative or reproductive organ, is strongly influenced by nutrients and water. The plant's access to sufficient water and nutrients is very effective in increasing the height of the plant through the effect on the division and enlargement of the cells. In general, the growth of the aerial parts of the plant is more affected than the root, and the plants that suffer from nitrogen deficiency, flower earlier and have less vegetative growth. Nitrogen often limits crop yield by affecting the function of all plant cells and their structure (Gardner *et al*., 1985).

**Table 3.** Mean comparison effect of different level of fertilizer and varieties on studied traits

| Treatments | Plant height (cm) | Number of Spike per $m^{-2}$ | Number of seed per spike | 1000 seed weight (gr) |
|---|---|---|---|---|
| **Fertilizer combination** | | | | |
| **F1** | 84.06b | 351.11b | 33.67ab | 36.41b |
| **F2** | 92.88a | 395.02a | 36.03a | 40.16a |
| **F3** | 78.42c | 316.35c | 31.58b | 34.77c |
| **Varieties** | | | | |
| **$V_1$** | 81.15bc | 310.23c | 31.04b | 35.02c |
| **$V_2$** | 90.2a | 400.14a | 37.15a | 39.21a |
| **$V_3$** | 84.01b | 352.11b | 33.1b | 37.11b |

*Mean which have at least once common letter are not significant different at the 5% level using (DMRT).
$F_1$: 150 kg.ha$^{-1}$ urea fertilizer, $F_2$: 150 kg.ha$^{-1}$ urea fertilizer with 5 t.ha$^{-1}$ vermicompost, $F_3$: 5 t.ha$^{-1}$ vermicompost.
$V_1$: Rashid, $V_2$: Bahous 99, $V_3$: Aba 99.

**Continue table 3.**

| Treatments | Seed yield (gr.m$^{-2}$) | Biological yield (gr.m$^{-2}$) | Harvest index (%) | Seed protein content (%) |
|---|---|---|---|---|
| **Fertilizer combination** | | | | |
| **F1** | 420.19b | 1395.1a | 30.11b | 11.41b |
| **F2** | 450.21a | 1405.32a | 32.03a | 12.8a |
| **F3** | 401.37c | 1365.4b | 29.39b | 10.6b |
| **Varieties** | | | | |
| **$V_1$** | 391.57c | 1371.88c | 28.54c | 9.66c |
| **$V_2$** | 462.05a | 1410.36a | 32.76a | 13.05a |
| **$V_3$** | 418.14b | 1383.56b | 30.22b | 12.13b |

*Mean which have at least once common letter are not significant different at the 5% level using (DMRT).
$F_1$: 150 kg.ha$^{-1}$ urea fertilizer, $F_2$: 150 kg.ha$^{-1}$ urea fertilizer with 5 t.ha$^{-1}$ vermicompost, $F_3$: 5 t.ha$^{-1}$ vermicompost.
$V_1$: Rashid, $V_2$: Bahous 99, $V_3$: Aba 99.

It seems that the increase in height in the combined treatments of nitrogen fertilizer and vermicompost is due to the role of vermicompost in providing low-use elements, which are used in the synthesis of indole acetic acid, carbohydrate metabolism, nitrogen metabolism, as part of the structure of enzymes or as cofactors. Regulators play a very important role in a large number of enzymes (Cakir, 2005). On the other hand, the use of vermicompost increases the organic matter and the activity of soil microorganisms, which causes the supply of nutrients and nitrogen from organic to mineral form and the availability of these elements during the growth period and height increase (Habibi and Majidian, 2011). According to Arguello *et al*. (2006), vermicompost increased the height of the plant, and this increase was attributed to the ability of vermicompost to stimulate the activity of beneficial soil microbes and its ability to increase the absorption of high-use mineral elements and micronutrients, and its consequence in improving the photosynthesis process. On the other hand, Azarpoor *et al*. (2012) reported that nitrogen interaction with vermicompost increased seed yield and plant height. As Mahmoodi nezhad dezfully *et al*. (2016) found out that one of the important reasons that can be counted for the effect of biological fertilizer in increasing the height of the plant is that the use of these fertilizers along with chemical fertilizers led to an increase in the length of the internodes, which can be related to stimulating the production of plant hormones produced by biofertilizers, which was consistent with the results of this research.

### 4.2. *Seed yield and its components*

#### 4.2.1. *Number of spikes per unit area*

The number of spikes per unit area under the influence of different levels of combined nitrogen fertilizer and vermicompost was significant at the five percent probability level, and the varitys and their interaction were significant at the one percent probability level (Table 2). The highest number of spikes per square meter with an average of 395.02 was attributed to the application of supplying half of the plant's fertilizer in the form of chemical and the rest in the form of vermicompost, and the lowest number with an average of 316.35 was allocated to providing the plant's fertilizer in the form of vermicompost (Table 3). Among the agricultural varitys, the varity Bahous 99 had the highest number of spikes per square meter with an average of 400.14 spikes and it produced 22.5% more spikes compared to Rashid varity (310.23) (Table 3). The results of the interaction of the treatments showed that the highest number of spikes per square meter with an average of 402.15 in the treatment of half of the plant fertilizer in the form of chemical and the rest of vermicompost and the Bahous 99 and the lowest number with an average of 308.5 from the application of vermicompost fertilizer and Rashid was obtained (Fig. 1).

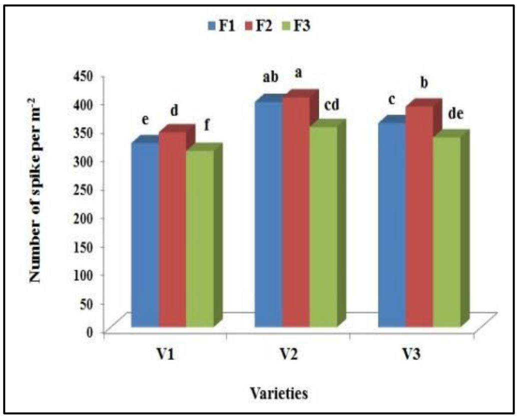


**Fig.1.** Mean comparison interaction effect combined urea fertilizer and vermicompost and varities on number of spike on m$^{-2}$. Mean which have at least once common letter are not significant different at the 5% level using (DMRT). $F_1$: 150 kg.ha$^{-1}$ urea fertilizer, $F_2$: 150 kg.ha$^{-1}$ urea fertilizer with 5 t.ha$^{-1}$ vermicompost, $F_3$: 5 t.ha$^{-1}$ vermicompost. $V_1$: Rashid, $V_2$: Bahous 99, $V_3$: Aba 99.

It seems that because of the flexibility in the use of production conditions and production potential, the varity of Bahous 99 was able to produce more number of spikes per unit area than the varity of Rashid. On the other hand, vermicompost fertilizer and nitrogen cause the development of growth indices which are the primary need for the growth and development of yield components such as the number of spikes, the number of seeds per spike and the1000 seed weight. Applying a balanced amount of nitrogen fertilizer in the plant produces a favorable number, size and length of spikes in the plant, which ultimately produces a larger number of spikes and heavier seeds at the end of the growth stage (Yaghoubian *et al*., 2017). Various researches have shown that vermicompost fertilizer significantly increases the amount of carbon in the soil, increases absorbable nitrogen in the soil, and increases the population and activity of beneficial soil microorganisms and provides plant access to nutrients (Nitrogen, phosphorus, and potassium), these factors collectively improve the vegetative and reproductive growth of plants (Sarwar *et al*., 2009). In this regard, Seimarizadeh *et al*. (2022) stated that by increasing the consumption of vermicompost, the supply of water and nutrients for the plant increased and the number of spikes per square meter increased. On the other hand, Biri *et al.* (2016) reported that the use of vermicompost and nitrogen fertilizers had a positive and significant effect on the number of panicles in the plant and seed yield, so that the use of these organic fertilizers had an effect equal to half of the nitrogen fertilizer used. Other researchers such as Javanmard *et al*. (2015) have also pointed out the positive role of nitrogen fertilizer and vermicompost in increasing number of spikes per square meter, which was consistent with results of this study.

4.2.2. *Number of seed per spike*

The number of seeds per spike under the influence of different levels of combined nitrogen fertilizer and vermicompost and varieties and their interaction was significant at the 1% of probability level (Table 2). The highest number of seeds per spike (with an average of 36.03) is from the application of supplying half of the plant's fertilizer in the form of chemical and the rest in the form of vermicompost, and the lowest number (with an average of 31.58) is due to providing the plant's fertilizer entirely the form of vermicompost was allocated (Table 3). Among the agricultural varitys, the varity Bahous 99 had the highest number of seeds per spike with an average of 37.15 and compared to Rashid varity, it had more seeds per spike by 16.5% (Table 3). The results of the interaction of the combination of nitrogen fertilizer and vermicompost and varieties showed that the highest number of seeds per spike with an average of 38.25 was treated with half of the fertilizer consumed by the plant in the form of chemical and the rest with vermicompost and the Bahous 99 and the lowest number with an average of 30 seeds was obtained from the application of vermicompost fertilizer and Rashid varity (Fig. 2).

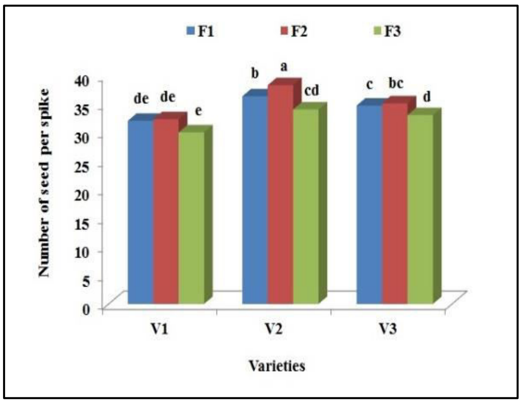


**Fig.2.** Mean comparison interaction effect combined urea fertilizer and vermicompost and varities on number of seed per spike. Mean which have at least once common letter are not significant different at the 5% level using (DMRT). $F_1$: 150 kg.ha$^{-1}$ urea fertilizer, $F_2$: 150 kg.ha$^{-1}$ urea fertilizer with 5 t.ha$^{-1}$ vermicompost, $F_3$: 5 t.ha$^{-1}$ vermicompost. $V_1$: Rashid, $V_2$: Bahous 99, $V_3$: Aba 99.

It seems that the Bahous 99, having a longer spike length due to the better use of environmental conditions and the potential to produce more dry matter, produced more leaves and stems compared to the Rashid varity, as a result, with a higher photosynthetic capacity, it was able to increase the number of seeds per spike (Zahedian *et al*., 2015). The positive effect of nitrogen on the leaf area index and the durability of the leaf area causes the period of materialization and seed filling to become longer (Alazamani, 2014). Also, the use of vermicompost increased the organic matter and the activity of soil microorganisms, which caused the supply of nutrients and nitrogen from organic to mineral form and the availability of these elements during the growth period and increased the number of seeds per spike (Abera *et al*., 2019). According to the reports of Biari *et al*. (2008), the use of organic and nitrogen fertilizers significantly increases the number of seeds in the row. They attributed the reason for this to the increased absorption of nutrients required by the plant due to the use of organic fertilizers combined with chemicals. In this regard, Shahrasbi *et al*. (2019) reported that increasing the consumption of nitrogen fertilizer, while removing nitrogen limitations for the plant, increases the photosynthetic and production efficiency of the plant and ultimately leads to an increase in the number of seeds per spike. On the other hand, Aslam *et al*. (2019) reported that the use of vermicompost as a rich source of organic matter, in addition to providing better nutrients, by improving the physical conditions of the soil, reducing evaporation and maintaining moisture, is more than other treatments prevents from deficiency of plant nutrients in sensitive stages of plant growth and causes an increase in the number of seeds per wheat spike. As Kahanizadeh and Mojaddam (2015) reported that the application of vermicompost and urea fertilizer significantly affected the yield and yield components as well as the quality characteristics of the seed. These results are similar to the findings of other researchers who showed that nitrogen fertilizer and vermicompost increase the number of seeds per spike (Sohail *et al*., 2018; Aslam *et al*., 2019).

4.2.3. *1000 seed weight*

The effect of different levels of combined nitrogen fertilizer and vermicompost and varitys and their interaction on the 1000 seed weight was significant at the 1% of probability level (Table 2). The highest 1000 seed weight (40.16 gr) was attributed to the application of supplying half of the plant fertilizer in the form of chemical and the rest in the form of vermicompost, and lowest one (34.77 gr) was for supply of vermicompost (Table 3). Among the ural varitys, Bahous 99 had the highest 1,000 seed weight with an average of 39.21 grams, which was 11% more than Rashid varity (35.02 grams) (Table 3). The highest 1000 seed weight (41.23 gr) was obtained for treatment of half of the fertilizer used by the plant in the form of chemicals and the rest with vermicompost and Bahous 99, and lowest one (33.8 gr) was for application of vermicompost fertilizer and Rashid varity (Fig. 3).

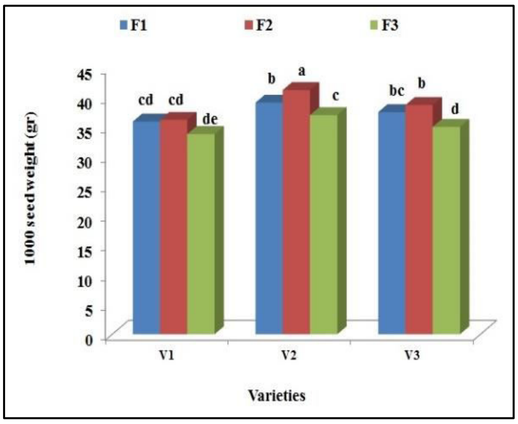


**Fig.3.** Mean comparison interaction effect combined urea fertilizer and vermicompost and varities on number of 1000 seed weight. Mean which have at least once common letter are not significant different at the 5% level using (DMRT). $F_1$: 150 kg.ha$^{-1}$ urea fertilizer, $F_2$: 150 kg.ha$^{-1}$ urea fertilizer with 5 t.ha$^{-1}$ vermicompost, $F_3$: 5 t.ha$^{-1}$ vermicompost. $V_1$: Rashid, $V_2$: Bahous 99, $V_3$: Aba 99.

The 1000 seed weight depends on the genetic characteristics of each varity. So that in the present study, the Bahous 99 significantly produced the highest weight of 1000 seeds (gr) compared to the Rashid varity. Vermicompost fertilizer has a lower apparent specific weight due to the presence of worm-shaped pellets, which increases porosity, ventilation and water permeability in the soil. The use of vermicompost in sustainable agriculture, in addition to increasing the support and activity of beneficial soil microorganisms, has worked to supply nutrients needed by plants such as nitrogen, phosphorus, and soluble potassium, and it seems to have improved the weight of seeds in the plant (Toulabi *et al*., 2021). In this regard, Khanizadeh and Mojaddam (2015) stated that the improvement of the 1000 seed weight at the highest level of nitrogen fertilizer and vermicompost may be due to the gradual release of nutrients and especially nitrogen available to the plant. On the other hand, Biari *et al*. (2008) reported that the 1000 seed weight increases if organic and chemical fertilizers are used. In this regard, Seimarizadeh *et al*. (2022) stated that by increasing the consumption of vermicompost, the supply of water and nutrients for the plant increased and 1000 seed weight increased. The results of this experiment were consistent with results of Aslam *et al*. (2022) and Biri *et al*. (2016) in direction of increasing seed weight in case of providing nutrients through use of organic fertilizers such as vermicompost combined with chemical fertilizers.

4.2.4. *Seed yield*

The seed yield under the influence of different levels of integration of fertilizers and varitys and their interaction was significant at the 1% of probability level (Table 3-4). The highest seed yield with an average of 450.21 grams per square meter was attributed to the application of providing half of the plant's fertilizer in the form of chemical and the rest in the form of vermicompost, and the lowest seed yield with an average of 401.37 grams per square meter was allocated to providing the plant's fertilizer in the form of vermicompost. (Table 2). Among the varitys, the highest seed yield belonged to the Bahous 99 varity with an average of 462.05 grams per square meter and the lowest seed yield belonged to the Rashid varity with an average of 391.57 grams per square meter (Table 3). The highest seed yield with an average of 468.11 grams per square meter was obtained from the treatment of half of the fertilizer used by the plant in the form of chemicals and the rest with vermicompost and the Bahous 99 varity, and the lowest seed yield with an average of 394.2 grams per square meter was obtained from the application of vermicompost fertilizer and the Rashid varity (Fig. 4). This result shows that in terms of seed production and yield components, the Bahous 99 had more ability to increase the yield, which was consistent with the results of Mokhtari *et al.* (2016) in wheat plant. Based on the results, the use of vermicompost in the soil alone is not able to provide nitrogen, so it is necessary to add nitrogen fertilizers to the vermicompost.

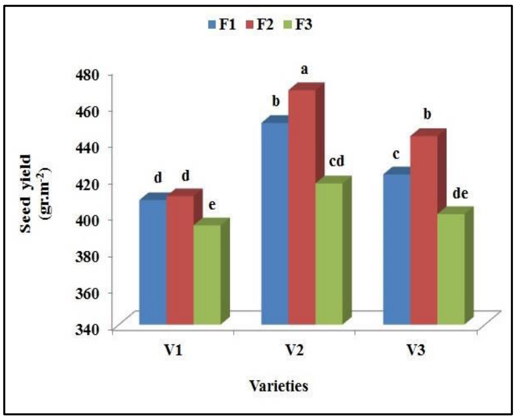


**Fig.4.** Mean comparison interaction effect combined urea fertilizer and vermicompost and varities on number of seed yield. Mean which have at least once common letter are not significant different at the 5% level using (DMRT). $F_1$: 150 kg.ha$^{-1}$ urea fertilizer, $F_2$: 150 kg.ha$^{-1}$ urea fertilizer with 5 t.ha$^{-1}$ vermicompost, $F_3$: 5 t.ha$^{-1}$ vermicompost. $V_1$: Rashid, $V_2$: Bahous 99, $V_3$: Aba 99.

Nitrogen deficiency causes premature aging of leaves by lowering the leaf area index and disrupting protein synthesis and degradation, and especially by affecting the ribolose bisphosphate carboxylase, it has a negative effect on the photosynthesis process of the plant, and finally the leaf surface, seed yield, seed weight, seed number and other yield components are significantly reduced (Biri *et al.*, 2016). Also, the presence of vermicompost organic materials provided optimal conditions for photosynthesis and as a result more plant growth, because with the decomposition of vermicompost, the growth and development of the root increases and the growth of aerial organs also increases, and finally the strengthening of vegetative growth, especially reproductive growth. It directly increased plant yield.

In this regard, Javanmard *et al*. (2015) reported that the highest yield of wheat seed was obtained in the treatment of 7 tons per hectare of vermicompost + 100% chemical fertilizer. In another study, it was found that the absorption of nitrogen by plants in soils containing vermicompost and organic fertilizers increased compared to the control, which was attributed to the increase in soil nitrogen as a result of the use of organic fertilizers (Eghball *et al*., 2004). According to the reports of Habibi and Majidian (2011), the combined treatment of biological and chemical nitrogen fertilizer caused a significant increase in yield and yield components. As Seimarizadeh *et al*. (2022) reported that at different levels of vermicompost fertilizer, the highest seed yield (2593 $kg.ha^{-1}$) was obtained when 20 $t.ha^{-1}$ of vermicompost was used and the lowest yield (1566 $kg.ha^{-1}$) was obtained when no vermicompost was used. The results of other researchers such as Ma *et al*. (2019) and Toulabi *et al*. (2021) were in line with the results of this research.

4.2.5. *Biological yield*

The effect of different levels of fertilizer combination and varitys and their interaction on the biological yield of was significant (Table 2). The highest biological yield with an average of 1405.32 grams per square meter was attributed to the application of providing half of the plant fertilizer in the form of chemical and the rest in the form of vermicompost, and the lowest biological yield with an average of 1365.4 grams per square meter was allocated to the provision of plant fertilizer in the form of vermicompost. (Table 3). Among the varitys, the highest biological yield was obtained from the Bahous 99 varity with an average of 1410.36 grams per square meter and the lowest biological yield from the Rashid varity with an average of 1371.88 grams per square meter (Table 3). The results of the interaction of the treatments showed that the highest biological yield with an average of 1427.47 grams per square meter was treated with half of the plant fertilizer in the form of chemicals and the rest as vermicompost and the Bahous 99 and the lowest biological yield with an average of 1363.8 grams per square meter was obtained from the application of vermicompost fertilizer and Rashid (Fig. 5).

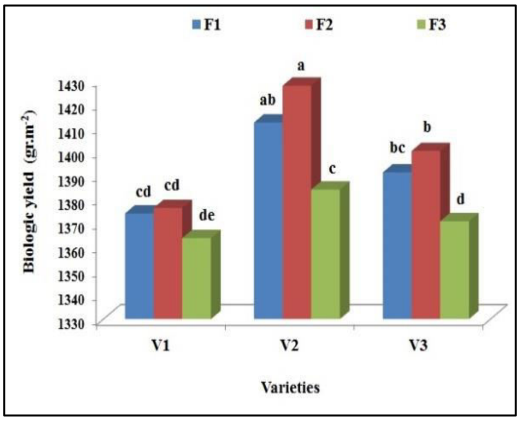


**Fig.5.** Mean comparison interaction effect combined urea fertilizer and vermicompost and varities on number of biologic yield. Mean which have at least once common letter are not significant different at the 5% level using (DMRT). $F_1$: 150 $kg.ha^{-1}$ urea fertilizer, $F_2$: 150 $kg.ha^{-1}$ urea fertilizer with 5 $t.ha^{-1}$ vermicompost, $F_3$: 5 $t.ha^{-1}$ vermicompost. $V_1$: Rashid, $V_2$: Bahous 99, $V_3$: Aba 99.

It seems the high potential of the Bahous 99 in conditions of using nitrogen fertilizer and vermicompost compared to other varieties in the use of current resources and other factors that increase photosynthetic production and assimilates, leads to more growth of plant organs and it was characterized by increasing biomass and seed yield through increasing the number of seeds and their weight (Zahedian *et al*., 2015). Also, application of nitrogen fertilizer and vermicompost by increasing efficiency and absorption of nitrogen caused more growth of aerial organs and consequently increased biological yield. The use of organic fertilizers other than molecular nitrogen fixation causes the production of auxin, which causes an increase in lethal threads and absorption of nutrients and as a result increases the biological yield of the plant, Aslam *et al*. (2019) and Anan (2009) also reported similar results. Nitrogen consumption affects the growth, production power of the leaf area and the photosynthetic capacity of the plant, in such a way that the amount of photosynthesis in the leaf area decreases with the decrease of the nitrogen level, which will further reduce the growth and development, biological yield and biomass production(Alam *et al*., 2007). Manyuchi *et al*. (2013) stated that the use of vermicompost increases the organic matter and activity of soil microorganisms, which causes the supply of nutrients and nitrogen from organic to mineral form and the availability of these elements during the growth period and the increase in seed and biological yield is consistent with the results of this research.

4.2.6. *Harvest index*

The harvest index was significantly influenced by varitys and different levels of chemical fertilizer and vermicompost, although the interaction effect of the treatments on this trait was not significant (Table 2). The results showed that the highest harvest index with an average of 32.03% belonged to provide half of the plant fertilizer in chemical form and the rest in the form of vermicompost, and the lowest harvest index with an average of 29.39% was allocated to the supply of plant fertilizer in the form of vermicompost (Table 2). Among the varitys studied, the highest harvest index was obtained from the Bahous 99 varity with an average of 32.76% and the lowest harvest index from the Rashid varity with an average of 13% (Table 3). In this study, the varity of Bahous 99, having more photosynthetic power and consequently high biological yield and the optimal distribution pattern of photosynthetic materials between vegetative and reproductive organs, had a higher harvest index. In this regard, Awan *et al*. (2017) stated that the existence of genetic differences between the varitys studied was one of the possible reasons for the difference in harvest index among the varitys. The important point in these results is that the combined use of nitrogen fertilizer and vermicompost has a far greater effect on the harvest index than the treatment of using nitrogen fertilizer and vermicompost alone. Nitrogen affected the distribution of dry weight of the plant and the allocation of more dry matter and the increase of seed yield caused an increase in the harvest index, and these results were consistent with the findings of Yaghoubian *et al*. (2017). In this regard, Habibi and Majidian (2011) reported that the combined treatment of biological and chemical fertilizers increased the harvest index. The presence of organic materials such as vermicompost provided optimal conditions for photosynthesis and as a result more plant growth. Because with the decomposition of vermicompost, root growth and development increases and the growth of aerial organs also increases, and finally, the strengthening of vegetative growth, especially reproductive growth, had a direct effect on increasing plant yield and harvest index (Amyanpoori *et al*., 2015). Aslam *et al*. (2019) stated that vermicompost fertilizer, in addition to increasing the biological yield and harvest index, improved the physical and chemical characteristics of the soil, which confirmed the results of this research.

4.3. *Seed protein content*

The effect of different levels of combined nitrogen fertilizer and vermicompost and varitys on seed protein percentage was significant (Table 2). The highest percentage of seed protein with an average of 12.8% belonged to provide half of the plant fertilizer in the form of chemical and the rest in the form of vermicompost, and the lowest percentage of seed protein with an average of 10.6% was allocated to the supply of plant fertilizer in the form of vermicompost (Table 3). The highest percentage of seed protein was obtained from the Bahous 99 varity with an average of 13.05% and the lowest percentage was obtained from the Rashid varity with an average of 26% (Table 3). The amount of protein in wheat seed depends on the genetic potential of each varity and environmental conditions. It seems that the Bahous 99, due to its superior genetic potential and flexibility in using environmental conditions, was able to allocate more protein than the other two varieties (Ranjbar and Alavi Fazel, 2018). The increase of seed protein in the treatment of combining nitrogen fertilizer with vermicompost can be due to the mineralization process of residues and the release of nitrogen in the soil and appropriate moisture. Nitrogen is the primary and essential element for making proteins, so the higher the amount of this element in the plant, the higher the amount of protein synthesis (Biri *et al*., 2016). Toulabi *et al*. (2021) stated that vermicompost increased the percentage of seed protein. The research results of Khanizadeh and Mojaddam (2015) indicate that simultaneously with the increase of vermicompost from zero to 8 tons per hectare, seed protein increased, so that the highest seed protein from the 8 tons per hectare treatment and the lowest seed protein from the control treatment (no use) was obtained. It seems that with the increase of soil nitrogen, more amount of this element is absorbed by the plant and its excess accumulates in the form of protein in the seed for vegetative growth and seed formation, which was consistent with the results of this research.

## 5. CONCLUSION

The effect of combining nitrogen fertilizer and vermicompost and varitys was effective on plant height, seed yield, number of spikes, number of spikes per square meter, 1000 seed weight, biological yield and seed protein percentage. The characteristics of seed yield, number of spikes, number of spikes per square meter, 1000 seed weight, leaf area index, biological yield and harvest index were significantly influenced by the interaction of nitrogen fertilizer and vermicompost and varitys. The yield and yield components were also influenced by the combination of nitrogen fertilizer and vermicompost and varitys. The results showed that the highest seed yield (468.11 $gr.m^{-2}$) and biological yield (1427.47 $gr.m^{-2}$) were obtained from the combined treatment of nitrogen fertilizer and vermicompost and Bahous 99. Considering that the use of vermicompost in the soil alone is not able to provide nitrogen, it is necessary to add nitrogen fertilizers to vermicompost. Nitrogen deficiency causes premature aging of leaves by lowering LAI as well as disrupting protein synthesis and degradation, and ultimately leaf area, seed yield, seed weight, seed number and other yield components are significantly reduced. Adding organic materials such as vermicompost to the soil provided optimal conditions for photosynthesis and as a result more plant growth. Because with the decomposition of vermicompost, the growth and development of roots increases and the growth of aerial organs also increases, and finally, the strengthening of vegetative growth, especially the reproductive growth, had a direct effect on increasing the quantitative and qualitative yield of the wheat plant. The results of this research showed that the use of vermicompost fertilizer along with nitrogen chemical fertilizer can reduce the consumption of nitrogen chemical fertilizer in addition to producing sufficient crops, which significantly contributes to the health of the environment and is an important strategy in the direction of movement towards sustainable agriculture. Therefore, in order to achieve the maximum quantitative and qualitative yield, it is suggested to cultivate the wheat plant of Bahous 99 varity with the combined application of nitrogen fertilizer and vermicompost in Amareh region in southern Iraq.

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## FOOTNOTES

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