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# The Impact of Bio-Organic and N, P, K Fertilizers on the Growth and Yield of Potato

*Duraïd K.A. AL-Taey and Rusul F. AL-Shmary*

## Abstract

Bio-organic agriculture considers the medium- and long-term impact of agricultural interferences on the agro-ecosystem. It aims to produce food while setting an ecological balance to soil fertility. Bio-organic agriculture takes a proactive design as opposed to treating problems after they emerge, so the study was conducted for studying two factors: First: the cultivars (Riviera and Arizona) class A resulting from cultivation of class E imported and cultivated in spring season 2018. The second factor: fertilizer combinations (bio-organic fertilizers compared with traditional chemical fertilizers). Arizona cultivar significantly achieved the highest values, in most of the study parameters compared to Rivera cultivar. Significant differences were observed between the treatments of fertilizer combinations, the treatment (organic fertilizer + bio-fertilizer + 25% chemical fertilizer) significantly achieved the best values compared to the control. Bi-interaction treatment (Arizona cultivar + organic fertilizer + bio-fertilizer + chemical fertilizer 25%) achieved the highest yield per hectare (43.24 tons.ha<sup>-1</sup>).

**Keywords:** Sustainability, Bio fertilizers, Organic compost, Nutrients availability

## 1. Introduction

Potato (*Solanum tuberosum* L.) is considered one of the most important vegetable crops in the world in terms of production and cultivated area, it belongs to the Solanaceae family, which includes about 90 genera and about 2000 species [1, 2]. Cultivated areas of potato crop in Iraq are increasing, however, that the produced quantities do not meet the requirements of the Iraqi consumers. This is due to many of the problems facing the cultivation of the crop in Iraq, the most important of which is soil salinity, which plays an important role in determining productivity [3, 4], where the crop's exposure to salt stress causes a decline the production in most vegetables [5]. Therefore, research has recently tended to study raising the average of growth and production in such, improving the reality of cultivation of this crop in Iraq requires attention to the various agricultural service operations and providing plants with the necessary nutrients. Organic fertilizers are an important way to provide plants with the necessary nutrient requirements and they do not adversely affect the environment [6], where the addition of organic fertilizers to the soil improves their synthetic traits and increases the activity and numbers of microorganisms [7].

Bio-fertilizer is natural substance, which is composed of many strains of bacteria and fungus for decreasing the chemical use in fertilization applications. In addition, bio-fertilizer has a positive role in helping the plants because it contains microorganisms, which are capable of mobilizing nutrient elements from unavailable form to available form through different biological processes [8], also play a role in improving the physical, chemical and biological traits of the soil. Bio-fertilizers are one of the used materials in this field which are natural preparations containing a group of beneficial microorganisms that have an active and effective role in improving soil fertility and supplying plants with part of their nutritional needs; where it maintains the equilibrium of the elements in agricultural lands and converts the elements to the soluble and available form suitable for plant nutrition. It is also involved in the biological resistance for some pests and plant diseases [9, 10]. The concept of integrated fertilization has emerged, which is a combination of chemical, organic and bio-fertilization in order to rationalize the use of chemical fertilizers and compensating them with natural fertilizers for the purpose of increasing yield and improving quality [1].

This study aims to test the response of two potato cultivars to organic and bio-fertilization and their interaction with chemical fertilization for the traits of growth and yield in saline-affected soils.

## 2. Material and methods

The experiment was conducted in a private field of Babylon governorate, located on longitude 44.39 E and latitude 32.3 N during the autumn growing season (2018). Soil samples were taken from different locations and depth for the purpose of conducting some physical and chemical properties as shown in **Table 1**.

Potato tubers for the two cultivars (Arizona and Riviera) class (A) was obtained from the harvest of agricultural season (2018), which was cultivated with the class (E) and stored at 4°C in refrigerated warehouses. Tubers was cultivated on 10/9/2018 on a furrow where the length (2 m), the distance between the furrow (75 cm), 1 m was left between the experimental units and plots.

The NPK fertilizer (15:15:15) was added in two batches before culture and after 45 days of the first addition, with specified rates (25% of the recommendation of fertilizer, 50% from of the recommendation of fertilizer, 100% of the

Soil properties	Values
pH	7.5
EC (dS.m <sup>-1</sup> )	6.23
Organic matter (%)	1.25
Nitrogen (%)	0.33
Phosphorus (%)	0.12
Potassium (%)	1.07
Sand (%)	22
Silt (%)	54
Clay (%)	24
Texture	Silty loam

**Table 1.**  
*Some of the physical and chemical properties of the soil.*

recommendation of fertilizer at a rate of (600 kg.ha<sup>-1</sup> N: 20, P:20,K: 20), bio-fertilizer (a mixture of *Bacillus megaterium* + *Azotobacter chroococcum* + *Fluorescent Pseudomonas*) was added before cultivation according to a recommendation (200 g from bio-fertilizer to 5 L of water). Tubers were directly immersed into this solution for 30 minutes. Bio-fertilizer was obtained from the Ministry of Science and Technology, Laboratories of the Agricultural Research Department in Al-Zafaraniya.

The experiment was conducted based on Randomized Complete Block Design (RCBD), with a split-plot system with two factors, the first factor is cultivars that are symbolized by (V), which is the Main-plot, the second factor is fertilizer combinations that are symbolized by (F) with 8 treatment combinations, which is the sub-plots. Each treatment replicated with three times and the total of experimental units are (48). The significant differences between the treatments were calculated at a significant level of (0.05) for the least significant difference (LSD) using Genstat program.

## 2.1 Study parameters

Plant height (cm), Leaf area (cm<sup>2</sup>.plant<sup>-1</sup>), chlorophyll contents in leaves (SPAD unit), percentage of dry matter of leaves and total yield of tubers (tons.ha<sup>-1</sup>).

## 3. Results and discussion

### 3.1 Plant height

**Table 2** showed that a significant difference between the two cultivars, Arizona cultivar, was recorded the highest value of plant height (48.38 cm) compared to the Riviera cultivar which gave the lowest values (34.82 cm). The treatments of fertilizer combinations F6 (organic fertilizer + bio-fertilizer + 25% chemical fertilizer) achieved the highest value of plant height (45.87 cm) compared to the control treatment which amounted to 37.79 cm. As for the bi-interaction between cultivars and fertilizer combinations as shown in **Table 3**. The treatment (Arizona cultivar + 100% chemical fertilizer) has achieved the highest average amounted to 53.61 cm which did not significantly differ from the treatment (Arizona cultivar + organic fertilizer + bio-fertilizer + 25% chemical fertilizer).

### 3.2 Leaf area (cm<sup>2</sup>.plant<sup>-1</sup>)

The fertilizer combinations had a significant effect, the treatment (organic fertilizer + bio-fertilizer + 25% chemical fertilizer) had recorded the highest average amount to 9448 cm<sup>2</sup>.plant<sup>-1</sup>, and the lowest value at the control treatment which amounted to 5158 cm<sup>2</sup>.plant<sup>-1</sup>. In the bi-interaction between cultivars and fertilizer combinations **Table 3**, the treatment (Arizona cultivar + Organic Fertilizer + Bio-fertilizer + 25% Chemical Fertilizer) gave the highest value of leaf area amounted to 9454 cm<sup>2</sup>.plant<sup>-1</sup>.

### 3.3 Chlorophyll contents in leaves (SPAD unit).

**Table 2** showed the highest value of chlorophyll contents in leaves amounted to 38.21 SPAD compared to the Riviera cultivar, which recorded the lowest value amounted to 35.51 SPAD. As for fertilizer combinations, the treatment (organic fertilizer + bio-fertilizer + 25% chemical fertilizer) recorded the highest value

LSD 0.05	Study factors				
	Plant height cm	Leaf area (cm <sup>2</sup> .plant <sup>-1</sup> )	Chlorophyll content (SPAD)	Percent of dry weight of the leaves	Total yield ton.ha <sup>-1</sup>
V1	48.38	7842.88	38.21	14.98	35.49
V2	34.82	7681	35.51	14.01	31.21
<b>LSD 0.05</b>	<b>2.734</b>	<b>0.311</b>	<b>1.858</b>	<b>0.823</b>	<b>1.553</b>
F1	39.39	6351.50	36.77	14.10	35.62
F2	37.90	5876.50	33.19	13.50	28
F3	41.17	8079.50	37.37	14.76	33.80
F4	45.74	9218.50	37.66	15.56	36.20
F5	40.42	8911.50	37.79	14.40	37.56
F6	45.87	9448	38.70	15.09	40.58
F7	44.50	9052	36.80	14.85	33.50
F8	37.79	5158	36.62	13.67	21.55
<b>LSD 0.05</b>	<b>2.885</b>	<b>1.642</b>	<b>1.576</b>	<b>1.147</b>	<b>1.112</b>

V = Cultivars, V1 Arizona, V2 Rivera; F = Fertilizer combinations, F1, (corn cobs compost), F2 (corn cobs compost Organic fertilizers + bio-fertilizer), F3 (corn cobs compost + chemical fertilizer 25% of recommended fertilizer), F4 (corn cobs compost + chemical fertilizer 25% of recommended fertilizer), F5 (corn cobs compost + bio-fertilizer + chemical fertilizer 50% of recommended fertilizer), F6 (corn cobs compost + bio-fertilizer + chemical fertilizer 25% of recommended fertilizer), F7 (Chemical fertilizer 100% full recommended fertilizer), F8 (Control).

**Table 2.**

Effect of cultivar and fertilizer combinations on the traits of growth and yield of potato plant.

amounted 38.70 SPAD compare with other fertilizer combination treatments, while there was no significant differences among the treatments of bi interactions between cultivars and fertilizers combinations **Table 3**.

### 3.4 Percent of dry weight of leaves

**Table 2** has shown that Arizona cultivar was achieved the highest value of percent of dry weight in leaves amounted to 14.98% compared to the Rivera cultivar which has been recorded the lowest percent of dry weight of leaves amounted to 14.01%.

The results indicated that a significant differences between the fertilizer combination treatments, the treatment (Corn cobs compost + 25% chemical fertilizer) recorded the highest average amounted to 15.56% which did not differ significantly from the treatment (corn cobs compost + bio-fertilizer + 25% chemical fertilizer) which amounted to 15.09%. Differences between bi-interaction treatments did not reach a significant level **Table 3**.

### 3.5 The total yield (tons.ha<sup>-1</sup>)

**Table 2** has indicated that Arizona cultivar has been achieved the highest value of total yield amounted to 35.49 tons.ha<sup>-1</sup> compared to Rivera cultivar which recorded the lowest total yield amounted to 31.21 tons.ha<sup>-1</sup>.

The results in **Table 2** has indicated that Arizona cultivar has achieved the highest value of total yield amounted to 35.49 tons.ha<sup>-1</sup> compared to Rivera cultivar which recorded the lowest total yield amounted to 31.21 tons.ha<sup>-1</sup>. As for fertilizer

Study factors					
LSD 0.05	Plant height cm	Leaf area (cm <sup>2</sup> .plant <sup>-1</sup> )	Chlorophyll content (SPAD)	Percent of dry weight of the leaves	Total yield ton.ha <sup>-1</sup>
V1 F1	46.17	6543	37.63	14.27	37.50
V1 F2	45.54	5965	35.67	14.17	29.65
V1 F3	49.73	8043	38.90	15.35	37.24
V1 F4	49.89	9369	38.41	15.82	39.62
V1 F5	47.31	9056	39.33	15.14	41.35
V1 F6	50.45	9454	40.63	15.33	43.24
V1 F7	53.61	9027	37.40	15.68	33.79
V1 F8	44.31	5286	37.73	14.06	21.55
V2 F1	32.62	6160	35.90	13.94	33.75
V2 F2	30.26	5788	30.70	12.84	26.35
V2 F3	32.60	8116	35.83	14.18	30.35
V2 F4	41.59	9068	36.90	15.3	32.78
V2 F5	33.54	8767	36.25	13.66	33.76
V2 F6	41.29	9442	36.77	14.85	37.92
V2 F7	35.38	9077	36.20	14.03	33.21
V2 F8	31.27	5030	35.50	13.28	21.55
<b>LSD 0.05</b>	<b>4.024</b>	<b>2.177</b>	<b>Non-Significant</b>	<b>Non-Significant</b>	<b>1.662</b>

*Significant at P<0.05, ANOVA; since the 2-way interaction was significant it was used to explain results.*

**Table 3.**  
 Effect of interactions on the traits of yield and growth of potato plant.

combinations treatments recorded a significant difference between them, the treatment (corn cobs compost + bio-fertilizer + 25% chemical fertilizer) achieved the highest value with 40.58 tons.ha<sup>-1</sup>, while the control treatment recorded the lowest value amounted to 21.55 tons.ha<sup>-1</sup>. **Table 3** has shown that Arizona cultivar which was treated with (Corn cobs compost + Bio-Fertilizer + 25% Chemical Fertilizer) gave the highest total yield amounted to 43.24 tons.ha<sup>-1</sup> compared to other treatment.

The results above emphasized that the Arizona cultivar has been achieved the best values compared to Rivera cultivar in all study parameters, may that due to the variation of genetic traits among the cultivars as well as to the response of Arizona cultivar to the factors and conditions of the soil properties more than Riviera.

The superiority of the Arizona cultivar in the plant height, number of leaves, leaves area, led to an increase in the carbon metabolism, and accumulation of carbohydrates, amino acids and finally increased proteins, that elevated the dry matter in leaves, which reflected on total yield.

The mixing of corn cobs compost (compost) and bio-fertilizer raised the nitrogen availability in the Rhizosphere and encouraged the activity of the microorganisms, and elevation of microorganisms activity accompanied by raising the rate of organic phosphorus mineralization, then an increase of phosphorus availability, which had been effected on stimulating co-enzymes and forming chlorophyll [11, 12].

The mineral and bio-fertilizers mixing with the organic matter have a positive role in improving the vegetative traits and providing the elements necessary for plant growth and development, which contributes to increasing the photosynthesis process, thus increasing manufactured carbohydrates, and stored in tubers. These results agree with [13–15], which they found that organic fertilizers have a role in increasing the yield.

This may also due to the role of bio-fertilizers and mineral fertilizers because they contain nutrients such as where they are available to absorption after mineralizing it in the soil due to soil revitalization and this leads to improving vegetative growth, thus an increase in the yield [16, 17].

#### 4. Conclusions

1. The results above have been confirmed the role of cultivars in obtaining an economic yield in response to the surrounding conditions, as the Arizona variety was more suitable in the conditions of the cultivated area.
2. The addition of chemical fertilizer was reduced by 75% through the combination treatment F6 (Corn cobs compost + Bio-Fertilizer + 25% Chemical Fertilizer), which realized the highest yield compare with other combination treatments.

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