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Effect of potassium and biological fertilization on vegetative growth characteristics of two potatoes cultivars (Solanum tuberosum L.)

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Abstract---This experiment was carried out during the spring growing season 2021 in the research field of the Faculty of Agriculture and Forestry / University of Mosul / Tourist Forestry Zone, to study the response of three factors in the vegetative growth traits of the potato varieties. The first factor included two varieties of potatoes (Taurus and Universa), the second factor included bio-fertilizer (Trichoderma fungi) with two levels and only once (5 $g.m^2$, without addition), and the third factor included potassium fertilizer as sulfate potassium at four levels (0, 100, 200, 300 $kg.ha^{-1}$). The results were as follows: The treatment of the cultivar Taurus gave the highest significant values in plant height, leafy area, number of aerial stems, relative content of chlorophyll in the leaves and percentage of dry matter in the leaves a value of 96.18 $cm.Plant^{-1}$, 5918.6 $cm^2.Plant^{-1}$, 3.41 $steem.Plant^{-1}$, 23.58 and 17.88% respectively. The treatment of bio-fertilization at a concentration of 5 $g.m^2$ was given the highest significant values in the relative content of chlorophyll in the leaves at a value of 22.35. The treatment of potassium fertilization at 300 $kg.ha^{-1}$ was given the highest values in plant height and leafy area with a value of 98.98 $cm.plant^{-1}$ and 6814.8 $cm^2.plant^{-1}$ respectively.

Keywords---trichoderma, bio-fertilizer, potassium sulfate, potatoes.

Introduction

Potato (*Solanum tuberosum* L.) is one of the plants of the Solanaceae family. It is an important tuber crop locally and globally. It is considered the daily food for

more than 75-90% of the world because it contains food and energy (Van Gijessel, 2005). Each 100 gm of potato tubers contains 79.8 gm of water, 76 calories, 2.1 g protein, 0.1 g fat, 17.1 g carbohydrates, 0.5 g fiber, 0.9 g ash and 7 mg calcium (Hassan, 2003). The production of the potato crop is affected by several factors, including the suitability of the variety to the area, which in turn affects the yield, both quantitatively and qualitatively (Hassan et al., 2002). Bio-fertilizers are one of the topics that have received great attention in recent years, either by adding them to the soil or spraying them on the vegetative total of vegetable crops. (Ghamriny etal., 1999) and that Trichoderma fungus is one of the most biological control agents, as it works to combat pathogenic plant fungal pests and works on colonizing the root perimeter of the plant and therefore it provides protection for the plant (Anand, Reddy, 2009). Many noted that potassium fertilization is of great importance for the potato crop. And an important role in enhancing enzyme activity and protein synthesis, as potassium fertilization leads to an increase in vegetative growth (Paufetti, 2004) and potassium deficiency negatively affects the growth and yield of plants (Hassan, 1988), and many researchers emphasized that adding potassium fertilizers to the soil Or spraying the vegetative system with it reflects positively on the growth and yield of the plant, especially for crops that need this element in a high degree, such as the potato crop (Bahia, 2001). The study aims to show the effect of potassium and biological fertilization on the vegetative growth characteristics of two potato cultivars

Materials and Methods

The experiment was carried out in the research field of the College of Agriculture and Forestry/Mosul University/Tourist Forest Area during the spring growing season 2021, to show the response of potato cultivars (Taurus and Universa) to potassium and bio-fertilization. The soil of the field was plowed using a triple plow, two orthogonal plows, smoothed, leveled and cut into three blocks. The number of experimental units in each blocks was 16 experimental units, and in the experiment contain 48 experimental units (16 * 3), urea fertilizer was added (46% N) at a rate of 400 kg. ha^{-1} and super triple phosphate (48%) p_2o at a rate of 600 $kg.ha^{-1}$ (Al-Obaidi, 2005). The tubers of Taurus and Universa were planted at a depth of 12-15 cm, and at a distance of 30 cm between one tuber and another. The tubers were planted on 24/2/2021, and the number of tubers for each plant was 7 tubers and in the experimental unit 21 tubers. The experiment was designed according to the Randomized Complete Block Design (RCBD) in a system of split –split plots cultivars where placed in the main plots, bio-fertilizer in subplots and Potassium in sub sub plots and in three replications. The experiment included the following factors:

- First factor: (cultivars) Taurus and Universa.
- Second factor: included the bio-fertilizer Trichoderma fungus at two levels and for one time only (ground addition) the first level is 5 $g.m^2$ and the second level without addition.

The third factor: Potassium fertilizer as potassium sulfate at four levels (ground addition) The first level is 100 kg. ha^{-1} The second level is 200 kg. ha^{-1} third level is 300 kg. ha^{-1} The fourth level compared to without potassium sulfate .Bio-fertilization and potassium fertilization were added in the first stage, a week after

the completion of germination on 7/4/2021. As for the second stage, the plants were treated with potassium fertilizers with the beginning of the flowering phase on 20/4/2021, after 115 days of planting the tubers, the harvest was done on 9/9 6/2021 and study the characteristics of the following vegetative growth.

- Plant height (cm. Plant $^{-1}$).
- Leaf area (cm^2.Plant^{-1}).
- The number of aerial stems (stem. Plant^{-1}).
- The relative content of chlorophyll in the leaves (SPAD).
- Percentage of dry matter in the leaves (%).

The data were statistically analyzed according to the SAS system, 2017, according to the design used by Duncan's polynomial test under the probability level of 0.05 (Al-Rawi and Khalaf Allah, 2000).

Results and Discussion

The results of Table (1) show that the cultivar Taurus was significantly superior compared to the cultivar Universa and reached (96.18 cm.plant) in this trait. (300 kg.Ha-1) of potassium fertilizer significantly as compared to all treatments and gave the highest values (98.98 cm.Plant-1). In the bilateral interaction between the cultivars and the bio-fertilizer, the non-fertilized and bio-fertilized in Taurus cultivar gave a significant superiority over the Universa cultivar at both levels. As for the interaction between the cultivars and potassium fertilizer, the treatment of Taurus cultivar and the fertilizer at the level of (300 kg.Ha-1) gave a significant superiority over all other treatments with a value of (104.12 cm.plant-1) the highest plant height (100.33 cm. Plant-1) founded in the interaction between non bio-fertilizer and potassium at(300 kg. Ha-1) level. In triple interaction between the three factors, the non-biologically fertilized with Taurus cultivar and fertilized with potassium fertilizer at a level of (300 kg. Ha-1) showed a significant superiority of (105.08 cm. Plant-1) relative to all other interactions except for the interaction of the same non-biologically fertilized cultivar that was fertilized with potassium fertilization at a level of (200 kg. Ha-1) where it reached (102.66 cm. Plant-1).

Table 1
Effect of cultivar, bio-fertilizer and potassium and the interference between them on the plant height (cm. plant^{-1})

Cultivar	Bio-fertilizer levels g. m^2	Potassium levels kg. ha^{-1}				cultivar X Bio-fertilizer	Average effect of cultivar
		without addition	100	200	300		
Taurus	without addition	91.12 b-d	86.41 d-f	102.66 a	105.08 a	96.32 a	96.18 a
	Addition 5 g. m^2	89.62 c-e	102.14 a	89.28 c-e	103.16 a	96.05 a	
Universa	without addition	86.03 d-g	82.37 fg	86.70 d-f	95.58 b	87.67 b	87.12 b

	Addition 5 g. m²	85.87 e-g	81.16 g	87.16 c-f	92.08 bc	86.57 b	
cultivar X potassium	Taurus	90.37 c	94.27 b	95.97 b	104.12 a	Average effect of bio-fertilizer	
	Universa	85.95 d	81.77 e	86.93 d	93.83 b		
bio-fertilizer X potassium	without addition	88.57 de	84.39 f	94.68 bc	100.33 a	91.99 a	
	Addition 5 g. m²	87.75 e	91.65 cd	88.22 e	97.62 ab	91.31 a	
Average effect of potassium		88.16 c	88.02 c	91.45 b	98.98 a		

* The averages that share the same alphabetic letter for each factor and each interference do not differ significantly among themselves according to Duncan's polynomial test at the probability level (P≤ 0.05).

It is noticed from the results of Table (2) that the significant superiority of the cultivar Taurus over the cultivar Universa in the characteristic of the leaf area was (5918.6 $cm^2.plant^{-1}$) Potassium fertilizer showed significant differences among them, where all treatments showed a significant superiority over the control treatment, while the treatment of potassium fertilizer at the concentration (300 kg. Ha^{-1}) gave a significant superiority over the rest of the treatments (6814.8 $cm^2.plant^{-1}$). Taurus and the bio-fertilizer (5 $g.m^2$) were significantly superior to the unfertilized and composted cultivar Universa, as it gave (6010.5 $cm^2.Plant^{-1}$). As for the treatment of the dual interaction between the cultivars and the potassium fertilizer, the treatment of the cultivar Taurus with potassium fertilization was characterized by a high level (300 $kg.Ha^{-1}$) on the rest of the treatments, where it was significantly superior and gave the highest values (9737.9 cm^2. $Plant^{-1}$) in the characteristic of leaf area. In the interaction between biological and potassium fertilization, the biological with potassium fertilizer at a level of (300 kg. Ha^{-1}) also outperformed over all other treatments, with a value of (7127.0 cm^2. $plant^{-1}$) for this trait. In the triple interaction of the three factors of the study, the biologically fertilized with Taurus cultivar and the potassium fertilized at the level (300 $kg.Ha^{-1}$) showed a significant superiority of (10415.0 cm^2. $Plant^{-1}$) in the case of leaf area

Table 2
Effect of cultivar, bio-fertilizer and potassium and the interference between them on the leaf area (cm^2. $plant^{-1}$)

Cultivar	Bio-fertilizer levels g. m²	Potassium levels kg. ha^{-1}				cultivar X Bio-fertilizer	Average effect of cultivar
		without addition	100	200	300		
Taurus	without addition	3912.4 c-f	5012.2 b-e	5321.5 bc	9060.7 a	5826.7 a	5918.6 a
	Addition 5 g. m²	2956.5 ef	6038.3 b	4632.4 b-f	10415.0 a	6010.5 a	

Universa	without addition	3116.9 d-f	2848.2 f	3767.9 c-f	3944.3 c-f	3419.3 b	3667.9 b
	Addition 5 g. m^2	2830.8 f	5170.5 b-d	3825.3 c-f	3839.0 c-f	3916.4 b	
cultivar X potassium	Taurus	3434.5 d	5525.2 b	4977.0 bc	9737.9 a	Average effect of bio-fertilizer	
	Universa	2973.8 d	4009.4 cd	3796.6 cd	3891.7 cd		
bio-fertilizer X potassium	without addition	3514.7 de	3930.2 de	4544.7 cd	6502.5 ab	4623.0 a	
	Addition 5 g. m^2	2893.6 e	5604.4 bc	4228.8 de	7127.0 a	4963.5 a	
Average effect of potassium		3204.2 c	4767.3 b	4386.8 b	6814.8 a		

* The averages that share the same alphabetic letter for each factor and each interference do not differ significantly among themselves according to Duncan's polynomial test at the probability level (P≤ 0.05).

The results of Table (3) indicate that the plants of the cultivar Taurus significantly outperformed the other cultivar Universa with a value of (3.41 stems.$Plant^{-1}$), while there were no significant differences for the treatments of the effect of biological and potassium fertilization on the number of aerial stems. In the bilateral interaction between the two cultivars and bio-fertilizer it was found that the non-biologically fertilized with Taurus cultivar did not differ significantly from the rest of the treatments except for the unfertilized cultivar Universa, which differed significantly with it and gave the lowest values (3.02 stems.$plant^{-1}$). The results did not give any significant differences in the interaction between cultivars and potassium fertilizer in the number of aerial stems, as well as in interaction between bio and potassium fertilizer. The results of the triple interaction between the cultivars , biological and potassium fertilization showed that the highest value was for the non-biologically fertilized with Taurus cultivar and potassium fertilized at the level of (300 kg.Ha^{-1}) (3.75 stems.$Plant^{-1}$), which did not differ significantly with most treatments of this interaction.

Table 3
Effect of cultivar, bio-fertilizer and potassium and the interference between them on the aerial stems number (stem. $plant^{-1}$)

Cultivar	Bio-fertilizer levels g. m^2	Potassium levels kg. ha^{-1}				cultivar X Bio-fertilizer	Average effect of cultivar
		without addition	100	200	300		
Taurus	without addition	3.39 Ab	3.41 ab	3.33 ab	3.75 a	3.47 a	3.41 a
	Addition 5 g. m^2	3.55 Ab	3.41 ab	3.44 ab	3.00 ab	3.35 a	
Universa	without addition	2.99 Ab	2.75 b	3.33 ab	2.99 ab	3.02 b	3.15 b

	Addition 5 g. m^2	3.24 Ab	2.99 ab	3.33 ab	3.55 ab	3.28 ab	
cultivar X potassium	Taurus	3.47 A	3.41 a	3.39 a	3.38 a	Average effect of bio-fertilizer	
	Universa	3.12 A	2.87 a	3.33 a	3.27 a		
bio-fertilizer X potassium	without addition	3.19 A	3.08 a	3.33 a	3.37 a	3.24 a	
	Addition 5 g. m^2	3.40 A	3.20 a	3.39 a	3.28 a	3.32 a	
Average effect of potassium		3.29 A	3.14 a	3.36 a	3.32 a		

* The averages that share the same alphabetic letter for each factor and each interference do not differ significantly among themselves according to Duncan's polynomial test at the probability level (P≤ 0.05).

From the results of Table (4), it was found that Taurus cultivar was superior to the cultivar Universa in the content of chlorophyll in leaves (23.58), and the plants treated with bio-fertilization were significantly superior to the non-biologically-fertilized plants with a value of (22.35), while the potassium fertilization treatments did not show any significant differences in this characteristic and that the highest value at the level of (300 kg. ha-1) was (21.90). In the bilateral interaction between the cultivars and the biological fertilization, the treatment of Taurus variety and the bio-fertilizer (5 g.m2) gave a significant superiority over all other treatments with a value of (25.07). As for the bilateral interaction between cultivars and potassium fertilization, the treatments of the variety Taurus were significantly superior to the treatments of the cultivar Universa for all levels. In the bilateral interaction between the two types of biological and potassium fertilization, the biological and potassium fertilized treatment at the high level (300 kg.ha-1) showed the highest values (22.77), and it differed significantly only with the potassium treatment at the level (100 $kg.ha^{-1}$) and the non-biologically fertilized in the relative content of chlorophyll in the leaves, it reached (18.85) and in the triple interaction of the three study factors, the results of the table indicate that the cultivar Taurus with bio=fertilizer (5 g. m^2) and the potassium fertilization at the level (200 kg. ha-1) were significantly superior to most of the other interactions with a value of (26.78) .

Table 4
Effect of cultivar, bio-fertilizer and potassium and the interference between them on the content of chlorophyll in leaves (SPAD)

Cultivar	Bio-fertilizer levels g. m^2	Potassium levels kg. ha^{-1}				cultivar X Bio-fertilizer	Average effect of cultivar
		without addition	100	200	300		
Taurus	without addition	22.68 a-d	21.19 b-e	22.91 a-d	21.61 a-e	22.10 b	23.58 a

	Addition 5 g. m^2	22.68 a-d	24.66 a-c	26.78 a	26.13 ab	25.07 a	
Universa	without addition	19.81 c-e	16.50 e	16.44 e	20.43 c-e	18.30 c	18.96 b
	Addition 5 g. m^2	19.65 c-e	20.86 c-e	18.61 de	19.40 c-e	19.63 c	
cultivar X potassium	Taurus	22.68 Ab	22.93 ab	24.85 a	23.87 a	Average effect of bio-fertilizer	
	Universa	19.73 Bc	18.68 c	17.53 c	19.92 bc		
bio-fertilizer X potassium	without addition	21.25 Ab	18.85 b	19.68 ab	21.02 ab	20.20 b	
	Addition 5 g. m^2	21.17 Ab	22.76 a	22.70 a	22.77 a	22.35 a	
Average effect of potassium		21.21 A	20.80 a	21.19 a	21.90 a		

* The averages that share the same alphabetic letter for each factor and each interference do not differ significantly among themselves according to Duncan's polynomial test at the probability level (P≤ 0.05).

The results of Table (5) indicate that there are significant differences between the cultivars, where the treatment of Taurus cultivar was significantly superior to the other variety with a value of (17.88), while there were no significant differences in the levels of biological and potassium fertilization for the percentage of dry matter in the leaves,. In the bilateral interaction between the cultivars and the biological fertilization, the non-biologically fertilized with Taurus cultivar was significantly superior to the Universa cultivar and gave the highest value (17.97). In the bilateral interaction between cultivars and potassium fertilization, the cultivar Taurus with a high level of potassium (300 $kg.ha^{-1}$) showed a significant difference of (19.00) as it differed with all other treatments except for the treatment of the same cultivar at the level (200 $kg.ha^{-1}$) where it did not differ significantly with it. The interaction between biological and potassium fertilization, we did not notice any significant differences between treatments for all levels, and in the triple interaction, the cultivar Taurus, which was not biologically fertilized and fertilized with potassium fertilizer at a level of (300 $kg.ha^{-1}$) gave highest values in this trait reached (19. 05).

Table 5
Effect of cultivar, bio-fertilizer and potassium and the interference between them on the percentage of dry matter in the leaves (%)

Cultivar	Bio-fertilizer levels g. m^2	Potassium levels kg. ha^{-1}				cultivar X Bio-fertilizer	Average effect of cultivar
		without addition	100	200	300		
Taurus	without addition	18.47 a-c	16.22 b-d	18.14 a-c	19.05 a	17.97 a	17.88 a
	Addition	15.73	17.74	18.75	18.95	17.79	

	5 g. m^2	Cd	a-c	ab	ab	ab	
Universa	without addition	15.72 Cd	15.90 cd	16.36 a-d	14.19 d	15.55 c	16.13 b
	Addition 5 g. m^2	17.42 a-c	16.33 a-d	16.16 b-d	16.98 a-c	16.72 b	
cultivar X potassium	Taurus	17.10 Bc	16.98 bc	18.45 ab	19.00 a	Average effect of bio-fertilizer	
	Universa	16.57 C	16.12 c	16.26 c	15.59 c		
bio-fertilizer X potassium	without addition	17.10 A	16.06 a	17.25 a	16.62 a	16.76 a	
	Addition 5 g. m^2	16.58 A	17.04 a	17.46 a	17.97 a	17.26 a	
Average effect of potassium		16.84 A	16.55 a	17.36 a	17.29 a		

* The averages that share the same alphabetic letter for each factor and each interference do not differ significantly among themselves according to Duncan's polynomial test at the probability level (P≤ 0.05).

Conclusions

We conclude from the study that Taurus cultivar was significantly superior in plant height, leaf area, number of aerial stems, relative content of chlorophyll in leaves and percentage of dry matter in leaves, and that the use of bio-fertilization level of 5 $g.m^2$ led to significant increases in the relative content of chlorophyll in leaves. Use of potassium fertilization 300 $kg.ha^{-1}$ cause a significant increase in plant height and leaf area°.

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