EFFECT OF FOLIAR FERTILIZATION ON YIELD OF SOME POTATO VARIETIES[1]

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ABSTRACT

Factorial experiment within RCBD with three replications were carried out in Babylon Governorate at two sites (L1 and L2) during the autumn season of 2017-2018 to study the response of three potato varieties (Rivera, Arizona and Burren) to four spraying treatments of foliar fertilizers. The foliar fertilizers treatments were: (F1) high potash (NPK, 0-5-30), (F2) nutrient solution (N 7%, 5% P, K 7%, 0.5% Mg, K-humate 0.5% and micro elements) at 10 ml/L, (f3) half the quantity of both fertilizers, as well as (F4) control (spraying with distill water only). The spraying was applied twice: after 45 days of planting (tubers formation stage) and then 14 days later (tubing expansion stage). The results showed that Burren variety was superior in plant yield and the total yield (469.5 g, 468.7 g and 24.88 $t.ha^{-1}$ and 20.29 $t.ha^{-1}$) respectively. The highest potash fertilizer achieved the highest yield of plant and the marketing yield (441.0 g, 439.9 g and 20.81 $t.ha^{-1}$, 21.84 $t.ha^{-1}$) respectively. The interaction between cultivars and spraying treatments had a significant effect on percentage of dry matter and starch. Burren variety with high potash fertilizer gave the highest dry matter (18.33 and 18.25 %) for both locations, respectively.

Keywords: Potato varieties, Foliar fertilization, High potash fertilizer.

تأثير التسميد الورقي في حاصل بعض اصناف البطاطا [2]

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الخلاصة :

نفّذت لتجربة عاملية وفق تصميم القطاعات العشوائية الكاملة بثلاثة مكررات في محافظة بابل بموقعين (L1 و L2) خلال الموسم الخريفي 2017-2018 ، لدراسة استجابة ثلاثة اصناف بطاطا (ريفيرا و ارزونا و بورين) لأربع معاملات رش بالاسمدة الورقية هي مقارنة ، رش سماد عالي البوتاس (N-P-K، 0-5-30) والمحلول المغذي (N 7% و 5p% و K 7% و Mg 0.5% و K-humate 0.5% و العناصر الصغرى) او رش نصف الكمية من كلا السمادين . كان الرش لمرتين: بعد 45 يوماً من الزراعة (مرحلة تكوين الدرنات) وبعدها بـ 14 يوماً (مرحلة اتساع الدرنات). و بينت النتائج تفوق الصنف بورين بأعلى حاصل للنبات الواحد والحاصل الكلي بلغ 469.5 و468.7 غم نبات$^{-1}$ و24.88 و 20.29 طن هـ$^{-1}$ للموسمين بالتتابع . كما حقق سماد عالي البوتاس أعلى حاصل للنبات الواحد و الحاصل التسويقي بلغ 441.0 و 439.9 غم نبات$^{-1}$ و 20.81 و 21.84 طن ه$^{-1}$ بالتتابع . كان للتداخل بين الاصناف ومعاملات التسميد الورقي تأثير معنوي ، وتفوق تداخل الصنف بورين مع رش السماد عالي البوتاس في النسبة المئوية للمادة الجافة بلغت 18.33 و 18.25% بالتتابع .

كلمات مفتاحية : أصناف بطاطا ، تسميد ورقي ، سماد عالي البوتاس.

[1] Part of M.Sc. thesis of the second author

[2] البحث مستل من رسالة ماجستير للباحث الثاني

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INTRODUCTION:

Potato (*Solanum tuberosum* L.) is one of the most common family plants in the world (Solanaceae), with 75-90% of the world's daily food. Potato tubers are rich in amino acids. They contain 18 amino acids out of 20, which gives it good nutritional value (Muthoni and Nyamongo, 2009). The area of potato cultivation in Iraq in 2016 was 7947 ha in 2016, with a production of 190702 tons and a consumption of 24 $t.ha^{-1}$ (annual statistical group, 2017). Potato planting in spring and autumn in the same year in Iraq. Spring season was higher in production compared to autumn season. In order to increase the production, it is necessary to increase the cultivated area and increase the productivity. This requires the selection of the best varieties suitable for the environmental conditions of the region. It is influenced by many factors, including its response to the environmental conditions and thus its genetic expression (Haase et al., 2005), and to apply the best methods of soil service principally fertilization. The addition of chemical fertilizer to the soil constitutes a high proportion of production costs, and the extravagance in adding it caused a great damage to the environment and human (Kande and Adediran, 2004). Foliar fertilization is one of the most important methods of further processing of plant nutrients and maintaining the nutritional balance within the plant (Dkhil et al., 2011). Potato tuber composition is the critical period for the plant's need for nutrients. Tubers become the largest reservoir of nutrients and the available nutrients in vegetative parts or absorbent by root parts may be insufficient. This requires the rapid processing of nutrients by foliar fertilization. The experiment aims to reduce the amount of soil fertilizer and compensated with foliar fertilizers, and its effect on three commercial varieties of potatoes grown in Iraq under the conditions of the southern region of Babylon province.

MATERIALS AND METHODS

The experiment was carried out during the autumn season of 2017-2018 in two locations, [Al-Basira village (L1) and Al-Nakhilah village (L2) to study the response of three potato varieties (Rivera, Arizona and Burren) to four treatments of foliar fertilization. The treatments were, High potash (NPK, 0-5-30) at 10 ml. L^{-1} , nutrient solution (N 7%, P5%, K 7%, Mg0.5%, K-humate0.5%, with micro elements) at 10 ml. L^{-1}, and spraying with half-concentration of both fertilizers, as well as control treatment (sprayed with distilled water). Randomized Complete block design (RCBD) with three replications was used. Table (1) shows some physical and chemical properties of the field soil in both locations. Chemical fertilizer (NPK, 20-20-20) at the rate of 400 kg. ha^{-1} was applied uniformly to all the field . The field is divided into three replicates each containing 12 experimental units with a distance of 1 m between each of them. Each experimental unit contained 4 ridges 75 cm apart and 2.5 m along. The tuber seed of the three varieties was planted on 15/9/2017 at a distance of 25 cm between the tuber and the other. The spraying was done after 45 days of planting (tuber formation) followed by the second spraying after 14 days (tubing expansion stage). Plant and soil managements (irrigation and weed control) were added as recommended (Matlub, et al. 1989). Tubers were taken off on 5/1/2018.

After the emergence of tuber maturation, ten plants were taken from the middle lines to determine plant tubers number, the mean weight of the tuber (g), plant yield and the marketing tuber yield , the percentage of dry matter and starch in the tubers (AOAC, 1970). The data were statistically analyzed using the Genstat program. The averages were tested according to $LSD_{0.05}$ test (Steel and Torrie ,1981).

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Table 1: Some physical and chemical characteristics of two local soils.

Characteristics		Al-nakhala locale	Al-bsaira locale	Units
pH		**7.5**	**7.4**	-
EC		**3.4**	**2.2**	$dS.m^{-1}$
N (available)		**31.30**	**22.73**	$mg.kg^{-1}$
P (available)		**7.11**	**6.14**	$mg.kg^{-1}$
K (available)		**91**	**107**	$mg.kg^{-1}$
0rganic matter		**1.2**	**1.1**	%
Soil separators	**Sand**	**350**	**480**	$g.kg^{-1}$
	Silt	**530**	**450**	$g.kg^{-1}$
	Clay	**120**	**70**	$g.kg^{-1}$
Soil texture		Medium loam	Medium loam	

RESULTS AND DISCUSSION

Number of tubers (tuber-1)

Table (2) showed that varieties caused a significant effect on the average number of tubers per plant. Burren variety (V3) gave the highest numbers were (4.946 and 6.747) for the two sites respectively. This result may be due to the varieties genetic variation and their genetic expression within the environmental conditions of the region (Haile, 2009). Spraying treatments caused a significant effect on plant tubers number and spraying with high potash gave the highest tubers number (4.8 and 6.3) for both sites respectively, while the control treatment (F0) gave the lowest average number of tubers reached (4.2 and 6.0) for both sites respectively. This is due to the fact that spraying high potash fertilizer improving vegetative growth characteristics, which reflected on yield (Hosseini et al, 2017), and plays a major role in increasing photosynthesis and the amount of carbohydrates which reflected in increasing the number of tubers formed (Belanger et al., 2002 and El-Enany, 2005).

Table (2a): Effect of varieties and foliar fertilizers on plant tuber No. (Al-Bsairah).

Varieties / Foliar fert.	(V1) Rivera	(V2) Arizona	(V3) Burren	Means of foliar fert.
F0 (control)	**4.237**	**3.697**	**4.583**	**4.172**
F1 (high K)	**4.927**	**4.333**	**5.247**	**4.836**
F2 (nutrient sol.)	**4.343**	**3.910**	**4.913**	**4.389**
F3 (both fert.)	**4.700**	**4.150**	**5.040**	**4.630**
Means of var.	**4.552**	**4.022**	**4.946**	
$LSD_{0.05}$	**Var.= 0.0727 int.=n.s.**			**0.0840**

Table (2b): Effect of varieties and foliar fertilizers on plant tuber No. (Al-Nakhailah).

Varieties / Foliar fert.	Varieties			Means of foliar fert.
	(V1) Rivera	(V2) Arizona	(V3) Burren	
F0 (control)	**5.942**	**5.426**	**6.636**	**6.001**
F1 (high K)	**6.432**	**5.646**	**6.695**	**6.257**
F2 (nutrient sol.)	**6.644**	**5.819**	**6.886**	**6.450**
F3 (both fertilizers)	**6.599**	**5.819**	**6.772**	**6.394**
Means of varieties	**6.404**	**5.676**	**6.747**	
$LSD_{0.05}$	**Var.= 0.2124 int.=n.s.**			**0.2452**

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Average tuber weight (g)

Table (3) showed a significant effect of the varieties on tuber weight (g). Arizona (V2) achieved the highest average tuber weight (97.31 and 60.05) for both sites respectively. This may be due to the fact that the crop yield components are controlled by the genetic traits of the variety, or the reason may be due to the environmental conditions and its effect on the varieties. Spraying treatments caused a significant effect on plant tuber weight and spraying with high potash gave the highest tuber weight (92.15 and 60.66) for both sites respectively, while the control treatment (F0) gave the lowest average tuber weight reached (84.45 and 53.84) for both sites respectively. This was due to the effect of nutrient on increasing growth, which caused a positive effect on increasing the efficiency of photosynthesis and thus increased the photosynthesis process net, which is later transferred to the tubers and increases their weight. (Jasim et al., 2013).

Table (3a): Effect of varieties and foliar fertilizers on tuber weight (Al-Bsairah).

Varieties / Foliar fert.	(V1) Rivera	(V2) Arizona	(V3) Burren	Means of foliar fert.
F0 (control)	**72.89**	**94.07**	**86.38**	**84.45**
F1 (high K)	**78.17**	**99.54**	**98.73**	**92.15**
F2 (nutrient sol.)	**78.89**	**98.88**	**95.78**	**91.18**
F3 (both fertilizers)	**78.54**	**96.73**	**97.52**	**90.93**
Means of varieties	**77.12**	**97.31**	**94.60**	
$LSD_{0.05}$	**Var.= 4.603 int.=n.s.**			**5.315**

Table (3b): Effect of varieties and foliar fertilizers on tuber weight (Al-Nakhailah).

Varieties / Foliar fert.	(V1) Rivera	(V2) Arizona	(V3) Burren	Means of foliar fert.
F0 (control)	**52.16**	**56.62**	**52.73**	**53.84**
F1 (high K)	**58.50**	**64.15**	**59.35**	**60.66**
F2 (nutrient sol.)	**53.42**	**58.04**	**56.59**	**56.02**
F3 (both fertilizers)	**56.95**	**61.38**	**58.41**	**58.91**
Means of varieties	**55.26**	**60.05**	**56.77**	
$LSD_{0.05}$	**Var.= 1.671 int.=n.s.**			**1.929**

Spraying treatments caused a significant effect on tuber weight compared to control treatment. The treatment (F1) gave the highest tuber weight (92.15 and 60.66 g) for both sites respectively, while control treatment (F0) gave lowest average tuber weight (84.45 and 53.84) gm for both sites respectively. This may be due to the positive role of potassium in increasing plant growth and this has a positive effect in the increase of processed food, as well as the role of potassium and other elements in stimulation of enzymes, and enhancing transport of these carbohydrates to the tubers (Stark et al, 2004). This effect was clear because soil content of nutrients was within critical limits (Table 1).

Plant yield (g)

Table (4) showed that there were significant differences in the average yield of plant. The Burren (V3) achieved the highest mean of the plant yield (469.5 and 468.7 g) for both sites respectively. This is due to the different genotypes of the cultivars and the effect of the surrounding environmental conditions on the genetic expression of these cultivars (Uphoff et al., 2015).

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Table (4a): Effect of varieties and foliar fertilizers on plant yield (Al-Bsairah).

Varieties / Foliar fert.	(V1) Rivera	(V2) Arizona	(V3) Burren	Means of foliar fert.
F0 (control)	**308.8**	**348.3**	**395.8**	**350.9**
F1 (high K)	**388.6**	**428.7**	**505.5**	**441.0**
F2 (nutrient sol.)	**339.7**	**389.1**	**485.2**	**404.7**
F3 (both fert.)	**369.0**	**401.3**	**491.4**	**420.6**
Means of var.	**351.5**	**391.9**	**469.5**	
$LSD_{0.05}$	**Var.= 22.36 int.=n.s.**			**25.81**

Table (4b): Effect of varieties and foliar fertilizers on plant yield (Al-Nakhailah).

F0 (control)	**308.8**	**348.3**	**395.8**	**350.9**
F1 (high K)	**388.6**	**428.7**	**502.4**	**439.9**
F2 (nutrient sol.)	**339.7**	**389.1**	**485.2**	**404.7**
F3 (both fertilizers)	**339.7**	**401.3**	**491.4**	**420.6**
Means of varieties	**351.5**	**391.9**	**468.7**	
$LSD_{0.05}$	**Var.= 22.72 int.=n.s.**			**26.24**

Spraying fertilizers caused a significant effect on plant yield compared to control treatment. The treatment (F1) gave the highest plant yield reaching (441.0 and 439.9 g), while F0 gave the lowest average plant yield (350.9 and 350.9) g for both sites respectively. This is due to the fact that potassium is an important factor affected growth and yield of potato (Abd El -latif et al, 2011) and had a positive effect in increasing the average number of tubers and tuber weight (table 2 and 3) which was reflected in increasing plant yield.

Marketing yield ($t.ha^{-1}$)

Table (5) showed that varieties caused a significant effect on the marketable tubers yield. Burren variety (V3) achieved the highest marketable yield (24.10 and 19.15 $t.ha^{-1}$) for both locations respectively. This results was due to the genetic differences of varieties. Foliar fertilizer treatments cased a significant effect, and high potash (F1) gave the highest marketable tubers yield (22.41 and 19.20 $t.ha^{-1}$) in both locations respectively. While control treatment (F0) gave the lowest average (17.77 and 16.13) $t.ha^{-1}$ in both locations respectively. This increase in marketing yield may be attributed to the effective role of potassium in improving vegetative growth, increasing the transport of carbohydrate from sink to source (tubers), and potassium role in increasing nitrogen uptake that affected the growth process and yield (Kaiser et al. 2016).

Table (5a): Effect of varieties and foliar fertilizers on marketable yield (Al-Bsairah).

Varieties / Foliar fert.	(V1) Rivera	(V2) Arizona	(V3) Burren	Means of foliar fert.
F0 (control)	**15.57**	**17.70**	**20.03**	**17.77**
F1 (high K)	**19.54**	**21.76**	**25.93**	**22.41**
F2 (nutrient sol.)	**17.16**	**19.62**	**24.96**	**20.58**
F3 (both fertilizers)	**18.79**	**20.32**	**25.48**	**21.53**
Means of varieties	**17.76**	**19.85**	**24.10**	
$LSD_{0.05}$	**Var.= 1.173 int.=n.s.**			**1.354**

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Table (5b): Effect of varieties and foliar fertilizers on marketable yield (Al-Nakhailah).

Varieties / Foliar fert.	(V1) Rivera	(V2) Arizona	(V3) Burren	Means of foliar fert.
F0 (control)	**16.98**	**14.02**	**17.41**	**16.13**
F1 (high K)	**19.70**	**16.08**	**21.83**	**19.20**
F2 (nutrient sol.)	**18.47**	**15.86**	**18.46**	**17.59**
F3 (both fertilizers)	**19.36**	**15.42**	**18.93**	**17.90**
Means of varieties	**18.62**	**15.34**	**19.15**	
$LSD_{0.05}$	**Var.= 0.789 int.=n.s.**			**0.911**

Total tubers yield ($t.ha^{-1}$)

Table (6) showed that there was a significant effect of the varieties on total tubers yield, and Burren variety (V3) achieved the highest total tubers yield (24.88 and 20.29) $t.ha^{-1}$ for both locations respectively. This is due to its high efficiency in converting photosynthesis products from source to sink (Makaraviciute, 2003). Spraying treatments caused a significant effect on total tubers yield compared to control treatment which gave the lowest total yield of (18.60 and 17.11) $t.ha^{-1}$ for both locations respectively. High potash treatment (F1) was superior (23.37 and 20.25 $t.ha^{-1}$) for both locations respectively, compared to F2. This result was due to foliar fertilizer recoup plant needed to the fertilizer by quickly provided with nutrients.

Table (6a): Effect of varieties and foliar fertilizers on total tuber yield (Al-Bsairah).

Varieties / Foliar fert.	(V1) Rivera	(V2) Arizona	(V3) Burren	Means of foliar fert.
F0 (control)	**16.37**	**18.46**	**20.97**	**18.60**
F1 (high K)	**20.59**	**22.72**	**26.79**	**23.37**
F2 (nutrient sol.)	**18.00**	**20.63**	**25.72**	**21.45**
F3 (both fertilizers)	**19.55**	**21.27**	**26.05**	**22.29**
Means of varieties	**18.63**	**20.77**	**24.88**	
$LSD_{0.05}$	**Var.= 1.185 int.=n.s.**			**1.368**

Table (6b): Effect of varieties and foliar fertilizers on total tuber yield (Al-Nakhailah).

Varieties / Foliar fert.	(V1) Rivera	(V2) Arizona	(V3) Burren	Means of foliar fert.
F0 (control)	**17.84**	**15.00**	**18.48**	**17.11**
F1 (high K)	**20.63**	**17.10**	**23.03**	**20.25**
F2 (nutrient sol.)	**19.30**	**16.48**	**19.87**	**18.55**
F3 (both fertilizers)	**20.26**	**16.57**	**19.78**	**18.87**
Means of varieties	**19.51**	**16.29**	**20.29**	
$LSD_{0.05}$	**Var.= 0.818 int.=n.s.**			**0.945**

The superiority of high potassium fertilizer is due to the potassium which plays an important role in increasing the efficiency of photosynthesis and increasing its output and moving towards sink (Wang, et al., 2013). Or due to the effect of potassium in the composition of carbohydrates and enzyme activity, including Kinases, which stimulate the formation of proteins and the formation of ATP, which needs to fill the sieve tubes with high molecular weight photosynthesis products and then transferred to the tubers (Rao and Rao, 2000).

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Percentage of dry matter in tubers (%)

Table (7) showed that varieties caused a significant effect on tubers dry matter (%). Arizona variety (V2) gave the highest percentage of dry matter in the tubers (16.958 and 17.799) %, in both locations significantly compared to other two varieties. This is due to the differences in genetic factors of the varieties (Tekalign and Hammes, 2005). Foliar fertilizers gave highest ratio of tuber dry matter compared to control treatment, and spraying high potash fertilizer (F1) gave the highest tuber dry matter (17.510 and 17.554)% for both sites respectively compared to control (F0) which gave the lowest percentage (14.776 and 16.117 %) in both locations respectively. This is due to potassium, which caused an increase in the efficiency of photosynthesis, its activation of the enzymes activity and its helping in transferring the photosynthesis products to the tubers (Bhaia, 2001). The interaction between the varieties and spray treatments caused significant effect on tubers dry matter (%) in Al-Bsairah location only, where the combination of F1 × V2 gave the highest average of tubers dry matter (18.333%).

Table (7a): Effect of varieties and foliar fertilizers on tuber dry matter (Al-Bsairah).

Varieties / Foliar fert.	Varieties			Means of foliar fert.
	(V1) Rivera	(V2) Arizona	(V3) Burren	
F0 (control)	**14.450**	**15.477**	**14.400**	**14.776**
F1 (high K)	**16.933**	**18.333**	**17.263**	**17.510**
F2 (nutrient sol.)	**15.367**	**16.857**	**16.663**	**16.296**
F3 (both fertilizers)	**16.167**	**17.167**	**16.873**	**16.736**
Means of varieties	**15.729**	**16.958**	**16.300**	
$LSD_{0.05}$	**0.5928 Var.= 0.2964 int.=**			**0.3422**

Table (7b): Effect of varieties and foliar fertilizers on tuber dry matter %(Al-Nakhaiah).

Varieties / Foliar fert.	(V1) Rivera	(V2) Arizona	(V3) Burren	Means of foliar fert.
F0 (control)	**15.482**	**16.998**	**15.869**	**16.117**
F1 (high K)	**17.347**	**18.248**	**17.069**	**17.554**
F2 (nutrient sol.)	**17.264**	**18.124**	**16.852**	**17.413**
F3 (both fertilizers)	**17.139**	**17.825**	**16.842**	**17.269**
Means of varieties	**16.808**	**17.799**	**16.658**	
$LSD_{0.05}$	**Var.= 0.4558 int.= n.s.**			**0.5264**

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