ROLE OF ORGANIC FERTILIZER AND BORON FOLIAR APPLICATION ON GROWTH AND PRODUCTIVITY OF POTATO FOR PROCESSING

U. B. SHAKER* **I. J. ABDUL RASOOL**
Researcher **Prof.**
*** Dept. Hort. Landscape Gardening ,Coll. of Agric. Eng. Sci., University of Baghdad**
ula.Bahaa1205a@coagri.uobaghdad.edu.iq eimanjabir@coagri.uobaghdad.edu.iq

ABSTRACT

This research was carried out at University of Baghdad - College of Agricultural Engineering Sciences during the fall season of 2020 and spring season of 2021 in order to evaluate the effect of organic fertilizer and the foliar application of boron on the growth and yield of industrial potatoes (*Solanum tuberosum* L.). Using factorial experiment (5*4) within Randomized Complete Block Design with three replicates, the organic fertilizer (palm fronds peat) was applied at four levels (0, 12, 24, and 36 ton ha^{-1}) in addition to the treatment of the recommended of chemical fertilizer. The foliar application of Boron was applied at four concentrations which were 0, 100, 150 and 200 mg (H_3Bo_3). L^{-1}. The results Revealed a significant increase under the application of organic fertilizer at the level of 24 $ton.ha^{-1}$ and the foliar application of boron at a concentration of 100 mg. L^{-1} ($O_{24}B_{100}$) on plant height, main branches number, and leaves number, which was reflected on the increase of vegetative dry weight and then the yield of potato (63.67 cm and 57.00 cm $plant^{-1}$), (4.89 and 5.22 stem. $plant^{-1}$), (66.50, and 55.67 leaf. $plant^{-1}$), (113.38 and 108.49 g. $plant^{-1}$), (44.17 and 59.48 $ton.ha^{-1}$) for both seasons, respectively. It also recorded a Significant differences in the chemical parameters in the leaves, as Chlorophyll reached (265.51 and 203.12 mg.100 g^{-1} wet weight), N (4.883 and 2.293%), P (0.577 and 0.413%), K (2.467 and 2.660%) and B (65.60 and 63.56 mg. kg^{-1}) for both seasons, respectively.

Key words: *Solanum tuberosum* L, waste management, micronutrients, plant residues, recycling.
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دور السماد العضوي والرش بالبورون في نمو وانتاجية البطاطا الخاصة للتصنيع

علا بهاء شاكر إيمان جابر عبدالرسول
باحث أستاذ
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المستخلص

أُجري البحث في كلية علوم الهندسة الزراعية – جامعة بغداد في الموسم الخريفي2020 والموسم الربيعي 2021 بهدف دراسة تاثير اضافة السماد العضوي والرش بالبورون في نمو وانتاجية البطاطا (*Solanum tuberosum* L.) الخاصة بالتصنيع، نفذ كتجربة عاملية (5*4) ضمن تصميم القطاعات الكاملة المعشاة و بثلاث مكررات , تم اضافة السماد العضوي سعف النخيل باربع مستويات (0, 12, 24 و 36 طن.هكتار$^{-1}$) اضافة الى معاملة اضافة التوصية السمادية الكيميائية وتم رش البورون وبأربعة تراكيز 0, 100, 150 و 200 ملغم H_3Bo_3 .لتر $^{-1}$. اظهرت النتائج تفوق معنوي لمعاملة اضافة السماد العضوي بالمستوى 24 طن.هكتار$^{-1}$ والرش بالبورون بتركيز 100 ملغم.لتر$^{-1}$ ($O_{24}B_{100}$) في طول النبات وعدد الافرع الرئيسة وعدد الاوراق مما انعكس على زيادة الوزن الجاف للمجموع الخضري ومن ثم زيادة الانتاجية لنباتات البطاطا (63.67 و 57.00 سم. نبات$^{-1}$) ,(4.89 و 5.22 ساق.نبات$^{-1}$) ,(66.50 و 55.67 ورقة .نبات$^{-1}$) , (113.38 و 108.49 غم .نبات$^{-1}$) , (44.17 و59.48 طن.هكتار$^{-1}$) للموسمين على التتابع كما انها ادت الى تفوق معنوي في المؤشرات الكيميائية للاوراق فقد بلغ Chlorophyll (265.51 و 203.12 ملغم.100غم وزن طري$^{-1}$) و N (4.883 و 2.293 %) و P (0.577 و 0.413 %) وK (2.467 و 2.660 %) و B (65.60 و 63.56 ملغم.كغم$^{-1}$) للموسمين على التتابع.

الكلمات المفتاحية: *Solanum tuberosum* L, ادارة النفايات, مغذيات صغرى , مخلفات نباتية, اعادة تدوير
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INTRODUCTION

Potato *Solanum tuberosum* L. one of the most important major agricultural crops in the world and Iraq for its production and cultivated area, and constitutes a basic and cheap food for many people. Thus, multiple scholars concentrated on strategies for enhancing its quality and productivity in different environments (21, 22, 23). A growing trend in recent decades has been the use of natural materials and organic fertilizers in agriculture (1, 10, 11, 12, 38, 39, 40,). Considering the locality of the location; Iraq has a particular interest in palm peat due to the prevalence of its wastes. There are many researchers supported using recyclable palm residues in increasing plants yield. Potato plant var. Desiree had an increase in number of main stems, plant height and leaves area when fertilized with palm peat at a level of 32 ton ha^{-1} during the spring season (18). AL-Sultany (19) also revealed that the application of organic fertilizer (compost from palm fronds) to potato plant var. Aladdin at a concentration of 60 ton. ha^{-1} during the fall season significantly increased both the plant height and the number of main stems. Hussein and Abbas (26) revealed that the application of organic fertilizer (palm peat) at different levels with chemical fertilizer gave the highest values of vegetative growth parameters of potato plants, where the vegetative dry weight was 76.08, 57.70 g, and the plant height was 52.20 and 64 87 cm for both seasons, respectively, and the highest leaves content of phosphorous was 0.702 and 0.469% for both seasons, respectively. The nutritional balance is an important factor for the vegetable crops production, even the plant's requirements of micronutrients is usually small quantities. However, it is still important for the growth and development of crops to obtain the best production and optimum quality (6, 15, 20, 29). Also, plants require a small quantity of boron for plant growth compared to other nutrients (3). Tantawi et al. (42) revealed that the foliar application of boron on potato plant at a rate of 11.5% had increased the plant height to 50 cm $plant^{-1}$, leaves number reached 42.3 leaves. $plant^{-1}$, the dry weight reached 32.5%, and total yield reached 15.1 ton. fed^{-1}($4200\ m^2$). Muthanna et al. (31) found that the application of Zn, Mn, Fe, B gave the highest plant height, in the early stage of plant life 60 days and a late stage 90 days, reached 43.16 cm, and 45 cm respectively, and the late stage recorded the highest productivity reached 22.45 ton. ha^{-1}. Thomson et al. (43) mentioned that the foliar application of boron at concentrations 0, 100, 200, 300 ppm on potato plants, Var. Kufri, grown in three regions for two seasons, the concentration of 300 ppm recorded the most significant values in plant height in one of the regions, reached 79.76 cm, compared to the control treatment which was 69.95 cm. Lenk and Das (28) revealed that the foliar application of boron on potato plants was significantly increased the total yield by 18.71% than the chemical fertilizer NPK treatment. Ilyas et.al, (27) found that spraying boron at 0.04% led to significant increased total yield of Autumn Potato Crop reached 18.7 ton.ha^{-1} This research was aimed to evaluate the possibility of improving the growth and productivity of potato crop for industrial through organic fertilization of palm peat and the foliar application of boron.

MATERIALS AND METHODS

Field experiment was conducted at the open field at University of Baghdad - College of Agricultural Engineering Sciences - research station during the fall season of 2020 and the spring season of 2021, in order to evaluate the role of organic fertilizer and the foliar application of boron on the growth and yield of industrial potatoes, the Fontane hybrid potato was planted during the fall season and the Sinora hybrid during the spring season, produced by the Dutch company Agrico, which was obtained from Nahar Al-Awrad Company. The field experiment was divided into three blocks, and each of was divided into 20 experimental units with an area of 1.875 m^2. The tubers were planted on 16/9/2020 for the fall season and on 17/ 1/ 2021 for the spring season, Distance between planting line 0.75 m and 0.25 m between each plant, with an average of 10 plants per experimental unit. All agricultural operations were performed for all experimental units. Factorial experiment within the Randomized complete Block Design with three replicates included two factors, the first is the application of organic fertilizer with a symbol O (palm peat) at four

levels in addition to the treatment of the application of chemical fertilizer according to the approved recommendation by Ali et al. (7). Half of the chemical fertilizer recommendation was applied to all levels of organic fertilizer, and the chemical fertilizer was applied by three portions, the first was during the planting phase, the second was after 45 days of planting (vegetative growth) and the third after 60 days (tuber initiation), as follows: O_0 the chemical fertilizer recommendation, $O_{0½}$ control treatment, O_{12} organic fertilizer at a level 12 ton.ha^{-1}, O_{24} organic fertilizer at a level 24 ton.ha^{-1}, and O_{36} organic fertilizer at a level 36 ton.ha^{-1}. The second factor was the foliar application of boron with a symbol (B) at four concentrations: B_0 control treatment, B_{100} a concentration of 100 mg.L^{-1}, B_{150} a concentration of 150 mg.L^{-1}, and B_{200} a concentration of 200 mg. L^{-1}, the treatment of boron (boric acid 17.4% B) was applied in two stages, the first after 45 days of planting (vegetative growth) (3/11/2020 for the fall season) (17/3/2021 for the spring season), and the second was after 60 days (tuber initiation) (on 22 /11/2020 for the fall season) (on 4/6/2021 for the spring season). The results were analyzed using the Genstat software and the averages were compared using the least significant difference test LSD) at a probability level of 5% (14). The following parameters were measured: Plant height (cm), Number of main stems (stem.plant^{-1}), Leaves number, Dry weight of vegetable growth (g. plant^{-1}), Leaves content of chlorophyll (mg 100 g^{-1} wet weight), The yield (ton.ha^{-1}) the estimation was based on the experimental unit yield by excluding damaged and infected plants, then the yield was applied to the hectare, Leaves content of Nitrogen (%) was measured using a Kjeldahl distillation, Leaves content of phosphorous (%) using ammonium molybdate and ascorbic acid using a spectrophotometer at a wavelength of 620 nm, Leaves content of potassium in the leaves (%) using a flame photometer and Leaves content of boron mg.kg^{-1}

RESULTS AND DISCUSSIONS

1- Vegetative and yield parameters

Results in Table (1) reveal significant difference values under the application of organic fertilizer at the level of O_{24} in the traits of vegetative growth and yield of potato plants for both seasons, as the plant height recorded 57.15, and 53.10 cm, the stems number, 4.52 and 4.47 stems. Plant^{-1}, and the leaves number reached 60.30 and 53.11 leaves. Plant^{-1} for both seasons, respectively. Also, the level O_{36} during the spring season recorded the highest productivity per unit area reached 53.97 ton.ha^{-1}, which did not differ significantly from the level O_{24}, which has increased the yield of the fall season, to 35.93 ton.ha^{-1}, It also has increased the dry weight of the spring season (95.50 g.plant^{-1}) compared to the control treatment ($O_{0½}$), which had the lowest values (43.67 and 45.89 cm.plant^{-1}), (2.79 and 2.83 stems. plant^{-1}) (44.33 and 44.19 leaf. plant^{-1}), (65.8 and 70.31 g. plant^{-1}), (25.31 and 38.83 ton. ha^{-1}) for both seasons, respectively. The vegetative growth increase could be due to the fact that the application of organic fertilizers may stimulate the production of auxins, amino acids and proteins that are important in building chloroplasts and increasing the photosynthesis process. The application of organic fertilizers had increased the leaves content of and chlorophyll, which leads to increase the plant height, the main stems number and leaves area (35, 41) It also provides the plant with sufficient quantities of nutrients, and the increase of these nutrients, including (phosphorous and potassium) in the leaves (Table 3) that leads to an increase in photosynthesis which is reflected on the increase carbohydrates, and thus on the growth by increasing the leaves number in the plant. The role of phosphorous in the leaves is to an increase in the activation of the photosynthesis process as it involved in the composition of a number of organic enzymes such as phosphorylated sugars and the composition of enzymatic chaperones and energy compounds such as adenosine triphosphate, which is important in the process of photosynthesis (24). The role of potassium is to activate a number of enzymes, including oxidation and reduction enzymes, protein synthesis and CO2 representation, that stimulates a number of important vital activities within the plant (44). The application of the macronutrients (nitrogen, phosphorous and potassium) leads to an increase in vegetative growth and then reflected on the plant yield (45, 46). Foliar

application of boron at the concentration B_{100} has significantly increased the plant height, reached 56.03 and 53.03 cm plant^{-1}, the main stems number, reached 4.08, and 4.25 stem. Plant^{-1}, which did not different significantly from B_{150} and B_{200} during the fall season, and leaves number reached 59.0 and 51.64 leaves. Plant^{-1}, dry weight reached 96.44 and 90.84 g. Plant^{-1}, total yield reached 37.24 and 50.04 ton. ha^{-1} for both seasons respectively, compared to the control treatment B_0 in which the lowest values were (48.77 and 49.23 cm. Plant^{-1}), (3.47 and 3.73 stem. plant^{-1}), (50.93 and 48.42 leaf. plant^{-1}), (73.91 and 82.60 g.plant^{-1}), (27.75 and 43.77 ton.ha^{-1}) for both seasons respectively. This could be attributed to the important role of boron in the formation of cell walls and activation of their membranes, its participation in the metabolic system within the plant and stimulates the photosynthetic products transfer to the rest of the plant parts. Also, the effectiveness of boron in the cell membrane lies in the absorption of nutrients such as nitrogen, phosphorous and potassium and their great role in the growth and regulation of the vital activities of the plant (30, 37). Boron also improves physiological and biochemical processes by activating meristematic tissues, increasing cell division and elongation, and increasing the production and effectiveness of growth regulators, which positively affects and increases the plants vegetative growth (7).

Table 1. The effect of organic fertilization and spraying with boron on the vegetative growth and productivity traits of the artificial potato plant (Fontane) planted in the fall season 2020 and (Sinora) in the spring season 2021

Treatment	Plant height (cm)		No. of main stems (stem. plant^{-1})		No. of Leaves (Leaf. plant^{-1})		Dry weight (g plant^{-1})		Total yield (ton ha^{-1})	
	Fall 2020	Spring 2021	Fall 2020	Spring 2021	Fall 2020	Spring 2021	Fall 2020	Spring 2021	Fall 2020	Spring 2021
O_0*	53.58	50.71	3.82	4.17	55.00	51.11	77.61	85.12	32.14	43.97
$O_{0½}$	43.67	45.89	2.79	2.83	44.33	44.19	65.80	70.31	25.31	38.83
O_{12}	55.12	52.11	4.36	4.08	58.11	50.33	94.19	88.34	30.03	48.33
O_{24}	57.15	53.10	4.52	4.47	60.30	53.11	93.88	95.50	35.93	50.74
O_{36}	54.39	53.79	4.19	4.42	57.23	52.72	87.50	93.69	33.66	53.97
L.S.D $_{0.05}$	2.49	2.25	0.40	0.34	2.31	1.93	2.86	5.99	2.91	3.19
B_0	48.77	49.23	3.47	3.73	50.93	48.42	73.91	82.60	27.75	43.77
B_{100}	56.03	53.03	4.08	4.25	59.00	51.64	96.44	90.84	37.24	50.04
B_{150}	53.64	50.86	4.08	3.89	55.69	50.07	84.87	86.60	30.35	45.41
B_{200}	52.70	51.36	4.13	4.11	54.35	51.04	79.97	86.31	30.32	49.44
L.S.D $_{0.05}$	2.23	2.01	0.36	0.29	2.07	1.73	2.56	5.36	2.60	2.85

***O_0 add the recommendation chemical fertilizer, $O_{0½}$ without organic (control) + (add half the recommendation chemical fertilizer), O_{12} organic with a concentration of 12 tons.ha^{-1} + (add half the chemical fertilizer recommendation), O_{24} organic with a concentration of 24 tons.ha^{-1} + (add half the recommendation chemical fertilizer) and organic O_{36} at a concentration of 36 tons.ha^{-1} + (add half of the chemical fertilizer recommendation), B_0 without spraying (control), B_{100} spraying boron at a concentration of 100 mg.l^{-1}, B_{150} spraying boron at a concentration of 150 mg.l^{-1} and B_{200} boron spray at a concentration of 200 mg.L^{-1}**

The interaction between the organic fertilization and the foliar application of boron had a significant effect on the traits of vegetative growth and productivity of the plant (Table 2). The treatment of $O_{24}B_{100}$ revealed a significant increase in plant height, main stems number and leaves number, which was reflected on the dry weight of the vegetative growth and then increased productivity of potato plants (63.67 cm), (57.00 cm. plant^{-1}), (4.89 and 5.22 stem. plant^{-1}), (66.50 and 55.67 leaf. plant^{-1}), (113.38 and 108.49 g. plant^{-1}), and (44.17 and 59.48 ton.ha^{-1}) for both seasons, respectively. While the control treatment ($O_{0½}$ B_0), recorded the lowest values of the mentioned parameters (44.0 cm. plant^{-1} for the spring season), (2.33 stem. plant^{-1} for both seasons), (39.00 and 42.00 leaf. plant^{-1}), (60.07 and 66.47 g. plant^{-1}), (17.65 and 30.12 ton. ha^{-1}) for both seasons, respectively.

Table 2. Effect of the interaction between organic fertilization and spraying with boron on the vegetative growth and productivity traits of the artificial potato plant (Fontane) planted in the fall season 2020 and (Sinora) in the spring season 2021

Interaction	Plant height (cm)		No. of main stem (stem. plant^{-1})		No. of Leaves (Leaf. plant^{-1})		Dry weight (g. plant^{-1})		Total yield (ton. ha^{-1})	
	Fall 2020	Spring 2021	Fall 2020	Spring 2021	Fall 2020	Spring 2021	Fall 2020	Spring 2021	Fall 2020	Spring 2021
O_0 B_0	45.00	51.50	3.67	4.33	50.50	52.11	73.34	89.64	31.36	43.07
O_0 B_{100}	52.25	54.33	3.17	4.45	55.17	53.67	76.34	92.91	34.25	43.11
O_0 B_{150}	59.42	46.67	4.67	3.67	58.67	47.33	92.04	74.71	21.53	42.40
O_0 B_{200}	57.67	50.33	3.78	4.22	55.67	51.33	68.74	83.22	41.43	47.29
$O_{0½}$ B_0	51.67	44.00	2.33	2.33	39.00	42.00	60.07	66.47	17.65	30.12
$O_{0½}$ B_{100}	49.00	46.00	3.00	2.67	49.50	43.44	70.91	68.37	31.17	42.91
$O_{0½}$ B_{150}	45.00	46.11	2.67	3.00	47.33	44.00	68.69	69.69	34.67	40.37
$O_{0½}$ B_{200}	40.33	47.44	3.19	3.33	41.50	47.33	63.64	76.69	17.76	41.90
O_{12} B_0	53.33	47.33	3.67	3.56	54.67	44.22	75.83	79.74	25.57	46.12
O_{12} B_{100}	55.00	53.33	4.56	4.33	60.17	51.44	108.79	83.72	33.83	45.84
O_{12} B_{150}	56.00	54.00	4.55	4.00	59.11	53.11	100.78	97.92	33.57	52.29
O_{12} B_{200}	56.00	53.78	4.67	4.45	58.50	52.56	91.35	91.69	27.16	49.07
O_{24} B_0	53.50	49.67	4.33	4.00	58.00	51.33	85.26	85.17	26.32	44.36
O_{24} B_{100}	63.67	57.00	4.89	5.22	66.50	55.67	113.38	108.49	44.17	59.48
O_{24} B_{150}	53.45	54.00	4.42	4.55	57.61	53.89	82.55	99.61	38.27	44.98
O_{24} B_{200}	58.17	51.22	4.44	4.11	59.08	51.56	94.23	88.74	34.94	54.13
O_{36} B_0	40.33	53.67	3.33	4.45	52.50	52.44	75.05	92.00	37.85	55.17
O_{36} B_{100}	60.22	54.50	4.76	4.56	63.67	54.00	112.68	100.73	42.80	58.87
O_{36} B_{150}	54.33	53.00	4.11	4.22	55.75	52.00	80.27	91.06	23.70	47.03
O_{36} B_{200}	51.33	54.00	4.56	4.44	57.00	52.44	82.01	90.96	30.30	54.82
L.S.D $_{0.05}$	4.99	4.50	0.80	0.67	4.62	3.86	5.73	11.99	5.82	6.38

2- Chemical parameters in the leaves

Results in Table 3 revealed a significant increase by the organic fertilization at level O_{12} during the fall season and at the level of O_{24} during the spring season in the leaves content of Chlorophyll, which recorded 249.11 and 186.26 mg.100 g wet weight^{-1} for both seasons, respectively. The application of organic fertilizer at the level of O_{24} was significantly increased the leaves content of N, P and K, which reached 4.49%, 0.533% and 2.373% in the fall season, respectively, and in the spring season, 2.259%, 0.3933% and 2.625%, respectively. While the level of organic fertilization O_{36} recorded the highest leaves content of boron for the fall season and at the level of O_{24} for the spring season reached 56.65 and 51.60 mg. kg^{-1}, respectively, compared to control treatment ($O_{0½}$), which recorded the lowest values for all parameters which were the leaves content of Chlorophyll (202.23 and 165.98 mg.100g wet weight^{-1}), N (3.813 and 2.102 %), P (0.404 and 0.219%), K (2.234 and 2.498 %), B (47.30 and 36.15 mg.kg^{-1}) for both seasons, respectively. These results could be attributed to the role of organic fertilizers, as the percent of nutrients in the soil increased by the decomposition of organic matter, which increases the nutrients availability for absorption, and reflected on their concentrations in the plant (4, 5, 9, 13). The increase in leaves content of chlorophyll is due to the increase in nitrogen released in the soil as a result of the application of organic fertilizers, which increased the accumulated nitrogen in the plant. Most of the nitrogen in plants is concentrated in the leaves (32, 33, 34). In fact; many researchers emphasized on the positive correlation between potato plant content of N and enhancing growth (2, 8, 16, 17) Also, the foliar application of boron had a significant effect on the chemical parameters of the leaves, the concentration of B_{100} has increased each of Chlorophyll, N and B content in the leaves and for both seasons (243.61 and 187.06 mg.100 g wet weight^{-1}, 4.629, 2.225 %, 61.27 and 50.82 mg. kg^{-1}) respectively. Also, the concentration of B_{200} recorded the highest values of leaves content of P reached 0.477 and 0.334% for both seasons, respectively, and the leaves content of K for the spring season, reached 2.588%, while the control treatment (B_0) recorded the lowest values of Chlorophyll (222.45, 174.12 mg.100 g wet weight^{-1}), N (3.977 and 2.167%), P (0.453 and 0.308%), K (2.317 and 2.560%) and B (36.93 and 29.20 mg. kg^{-1}) for both seasons, respectively. This could be due to the role of boron in the effectiveness of the cell membrane in the absorption of nutrients

and their transfer within the plant. The nutrients increase could be attributed to the role of boron in improving the ion transport system of the plant which increases efficiency of ion absorption (23 and 9). The interaction between organic fertilization and boron had a significant effect on the chemical parameters of the leaves (Table 4). The $O_{24}B_{100}$ treatment revealed a significant increase in all the studied parameters, as Chlorophyll reached (265.51 and 203.12 mg.100 g wet weight^{-1}) and N (4.883 and 2.293%). and P (0.577 and 0.413%), K (2.467 and 2.660%) and B (65.60 and 63.56 mg. kg^{-1}) for both seasons, respectively. While the control treatment ($O_{0½}$ B_0) recorded the lowest values content of Chlorophyll (194.97 and 157.23 mg.100gm wet weight^{-1}), N (3.437 and 2.090%), P (0.363 and 0.207%), and K (2.193 and 2.473 %) and B (30.72 and 21.57 mg. kg^{-1}) for both seasons, respectively. Therefore, we recommend a combination of adding organic fertilizer (24 ton.ha^{-1}) with foliar boron (100 mg.l^{-1}) to increase growth and plant yield.

Table3. Effect of organic fertilization and spraying with boron on Chemical indicators in the leaves of artificial potato plant (Fontane) planted in the fall season 2020 and (Sinora) in the spring season 2021.

Treatment	Chlorophyll mg.100g fresh wt.$^{-1}$		N %		P %		K %		B mg.Kg^{-1}	
	Fall 2020	Spring 2021	Fall 2020	Spring 2021	Fall 2020	Spring 2021	Fall 2020	Spring 2021	Fall 2020	Spring 2021
O_0 *	232.30	177.76	4.302	2.208	0.458	0.313	2.333	2.585	52.91	50.78
$O_{0½}$	202.23	165.98	3.813	2.102	0.404	0.219	2.234	2.498	47.30	36.15
O_{12}	249.11	180.34	4.480	2.194	0.429	0.298	2.340	2.597	55.14	40.71
O_{24}	245.84	186.26	4.490	2.259	0.533	0.393	2.373	2.625	53.32	51.60
O_{36}	233.02	185.48	4.377	2.242	0.497	0.377	2.366	2.587	56.65	46.97
L.S.D $_{0.05}$	3.94	4.97	0.103	0.011	0.013	0.009	0.018	0.023	4.13	2.38
B_0	222.45	174.12	3.977	2.167	0.453	0.308	2.317	2.560	36.93	29.20
B_{100}	243.61	187.06	4.629	2.225	0.473	0.315	2.334	2.578	61.27	50.82
B_{150}	232.96	176.60	4.306	2.201	0.455	0.323	2.332	2.587	60.48	51.38
B_{200}	234.98	178.88	4.259	2.211	0.477	0.334	2.333	2.588	53.57	49.57
L.S.D $_{0.05}$	3.52	4.44	0.092	0.009	0.012	0.009	N.S	0.020	3.69	2.13

***O_0 add the recommendation chemical fertilizer, $O_{0½}$ without organic (control) + (add half the recommendation chemical fertilizer), O_{12} organic with a concentration of 12 tons.ha^{-1} + (add half the chemical fertilizer recommendation), O_{24} organic with a concentration of 24 tons.ha^{-1} + (add half the recommendation chemical fertilizer) and organic O_{36} at a concentration of 36 tons.ha^{-1} + (add half of the chemical fertilizer recommendation), B_0 without spraying (control), B_{100} spraying boron at a concentration of 100 mg.l^{-1}, B_{150} spraying boron at a concentration of 150 mg.l^{-1} and B_{200} boron spray at a concentration of 200 mg.L^{-1}**

Table 4. The effect of the interaction between organic fertilization and spraying with boron on chemical indicators in the leaves of artificial potato leaves (Fontane) planted in the fall season 2020 and (Sinora) in the spring season 2021

Interaction	Chlorophyll mg.100g fresh wt.$^{-1}$		N %		P %		K %		B mg.Kg^{-1}	
	Fall 2020	Spring 2021	Fall 2020	Spring 2021	Fall 2020	Spring 2021	Fall 2020	Spring 2021	Fall 2020	Spring 2021
O_0 B_0	217.22	182.17	4.227	2.163	0.433	0.277	2.333	2.570	42.93	33.30
O_0 B_{100}	219.24	185.23	4.427	2.277	0.497	0.300	2.267	2.587	56.07	55.33
O_0 B_{150}	244.69	168.74	4.317	2.183	0.420	0.333	2.383	2.573	61.48	62.60
O_0 B_{200}	248.07	174.89	4.240	2.210	0.483	0.340	2.350	2.610	51.17	51.90
$O_{0½}$ B_0	194.97	157.23	3.437	2.090	0.363	0.207	2.193	2.473	30.72	21.57
$O_{0½}$ B_{100}	214.92	172.24	4.143	2.093	0.420	0.223	2.240	2.493	54.43	42.53
$O_{0½}$ B_{150}	214.73	160.11	3.837	2.107	0.380	0.210	2.227	2.527	47.17	46.07
$O_{0½}$ B_{200}	204.29	174.33	3.837	2.117	0.453	0.237	2.277	2.500	56.87	34.43
O_{12} B_0	246.11	172.31	4.203	2.190	0.433	0.307	2.353	2.563	42.00	28.50
O_{12} B_{100}	254.34	179.64	4.817	2.173	0.427	0.283	2.357	2.583	53.03	43.80
O_{12} B_{150}	253.57	185.02	4.523	2.207	0.427	0.300	2.290	2.607	75.83	39.13
O_{12} B_{200}	242.41	184.39	4.377	2.207	0.430	0.303	2.360	2.633	49.70	51.40
O_{24} B_0	238.09	175.23	4.207	2.220	0.513	0.360	2.320	2.623	31.93	27.97
O_{24} B_{100}	265.51	203.12	4.883	2.293	0.577	0.413	2.467	2.660	65.60	63.56
O_{24} B_{150}	229.40	188.45	4.410	2.263	0.527	0.390	2.360	2.637	55.60	54.27
O_{24} B_{200}	250.35	178.23	4.460	2.260	0.517	0.410	2.353	2.580	60.13	60.59
O_{36} B_0	215.85	183.66	3.810	2.170	0.520	0.390	2.387	2.570	37.07	34.67
O_{36} B_{100}	264.07	195.05	4.873	2.290	0.447	0.353	2.350	2.567	77.23	48.88
O_{36} B_{150}	222.38	180.66	4.443	2.247	0.520	0.383	2.400	2.593	62.30	54.84
O_{36} B_{200}	229.78	182.57	4.383	2.260	0.500	0.380	2.327	2.617	49.99	49.50
L.S.D $_{0.05}$	7.88	9.93	0.205	0.021	0.027	0.019	0.035	0.045	8.27	4.76

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