# EFFECT OF ORGANIC FERTILIZER AND BORON FOLIAR ON QUANTITATIVE AND QUALTITATIVE TRAITS POTATO FOR PROCESSING

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**ABSTRACT**

**A field experiment was carried out at University of Baghdad, College of Agricultural Engineering Sciences during fall season of 2020 and spring season of 2021. This study was aimed evaluate the effect of the organic fertilizer and boron foliar on the yield of potatoes for processing. The factorial experiment (5*4) within RCBD and three replicates. The organic fertilizer as palm peat at four levels (0, 12, 24 and 36 ton. ha$^{-1}$) in addition to the chemical fertilizer recommendation treatment. Boron at four Concentrations 0, 100, 150 and 200 mg. L$^{-1}$ . The results revealed significant different among 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$^{-1}$ in the leaves area (105.65 and 159.63 dm$^2$ plant$^{-1}$ for both seasons, respectively), the tubers number, yield and TSS reached 13.78 tubers. plant$^{-1}$, 9.27 tubers. plant$^{-1}$ and 833.3 g. plant$^{-1}$ 1122.2 g. plant$^{-1}$ and 6.67, 5.43% respectively. While the highest tubers dry weight recorded the significant value at the application of 36 ton. ha$^{-1}$ with foliar application of boron at 150 mg. L$^{-1}$ reached 21.30 and 26.02% for both seasons, respectively. Also, starch and the specific density of tubers were increased (14.98 and 19.19%) and (1.085 and 1.108%) for both seasons, respectively.**

**Key words: *Solanum tuberosum* L, waste management, Iraqi palms, fronds residues, recycling,**

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## تاثير السماد العضوي والرش بالبورون في صفات كمية ونوعية البطاطا الخاصة للتصنيع

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**المستخلص:**

أُجري تحربة حقلية في كلية علوم الهندسة الزراعية, جامعة بغداد للموسم الخريفي2020 وللموسم الربيعي 2021 تهدف الدراسة تاثير اضافة السماد العضوي والرش بالبورون في نمو وانتاجية البطاطا الخاصة للتصنيع، نفذت كتجربة عاملية (5*4) ضمن تصميم القطاعات الكاملة المعشاة RCBD و بثلاث مكررات, اضيف السماد العضوي (مخلفات 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.لتر$^{-1}$ . اظهرت النتائج تفوق معنوي لمعاملة اضافة السماد العضوي بالمستوى 24 طن.هكتار$^{-1}$ والرش بالبورون بتركيز 100 ملغم.لتر$^{-1}$ في المساحة الورقية للنبات (105.65 و 159.63 دسم$^2$. نبات$^{-1}$ للموسمين على التتابع) وفي عدد الدرنات للنبات وفي حاصل النبات فقد بلغت في الموسم الخريفي 13.78 درنة.نبات$^{-1}$ و 833.3غم.نبات$^{-1}$ وفي الموسم الربيعي 9.27 درنة.نبات$^{-1}$ و 1122.2غم.نبات$^{-1}$ على التتابع وفي TSS فقد بلغ 6.67 و 5.43% للموسمين على التتابع في حين كانت اعلى نسبة مئوية للمادة الجافة في الدرنات في المعاملة بالسماد العضوي بالمستوى 36 طن.هكتار$^{-1}$ والرش بالبورون بالتركيز 150ملغم.لتر$^{-1}$ حيث بلغت 21.30 و 26.02 % للموسمين على التتابع وكذلك النشا والكثافة الظاهرية للدرنات فقد زادتا (14.98 و 19.19%) و (1.085 و 1.108%) للموسمين على التتابع.

**كلمات مفتاحية: *Solanum tuberosum* L, ادارة النفايات, نخيل العراق, متبقيات السعف, تدوير، نشا البطاطا**

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## INTRODUCTION

Potato *Solanum tuberosum* L. is considered the most important starch crop in the world. wide is essential food for more than a billion people around the world, and it has various health benefits that makes it more important as a basic food component for many of the world's population (3, 27). The improvement of potato quality in Iraq is therefore a priority to ensure food security (22, 24, 25). From the notion of sustainability; the use of recyclable organic fertilizers and Natural substances in agriculture has been increasingly popular in Iraq in recent decades (1, 9, 10, 11, 45, 46, 47). Organic fertilizers are more desirable to apply rather than chemical fertilizers due to the cost, the ability to improve the soil structure, and texture, which increases the soil ability to retain water and stimulates root growth. The sources of organic fertilizers vary whether from plant or animal, as they improve the soil content of organic matter, which is positively reflected on the optimal growth of plants and yield quality (4, 5, 8, 12, 26). Iraqi is famous of the abundance of its date palms. Dead fronds can be recycled to create organic fertilizer due to their high annual production. Majul and Jassim (39) mentioned that the application of rice and palm fronds residues to potato gave the highest rate of total yield reached 37.65 and 37.60 tons. $ha^{-1}$ 38.61 and 38.55 tons. $ha^{-1}$ respectively. Micronutrients, plays an important role in many vital and physiological processes within the plants (6). Boron is one of the most important micro-nutrients for the production of high-quality crops. (17, 21). The lack of boron leads to a defect in the roots growth and bud tissues and a severe decrease in the productivity of the crops; the cases of boron deficiency are more prevalent all over the world and the deficiency is treated either by the foliar or soil application (40, 44). El Dissoky and Abdel-kadar (31) recorded that the foliar application of boron at levels 0, 30, 60, and 90 mg. $L^{-1}$ were significantly affected the vegetative growth characteristics of potato plants, where the level of 60 mg. $L^{-1}$ recorded the highest values of leaves area reached 1946 and 1960 $dm^2$. $Plant^{-1}$. El-Hadidi et al. (32) showed that the foliar application of boron at a rate of 100 ppm had improved potato yield and tubers quality, as the yield reached 17.78 tons. $ha^{-1}$ and the tubers weight (230.00 g. $tuber^{-1}$), starch content (18.82%), and carbohydrate content (37.80%). Ewais et. al (33) recommended the foliar application of boron at a concentration of 100 mg $L^{-1}$ as it improved the most of tuber's characteristics, where the rate of specific density was 1.090, starch content (18.82%), carbohydrate content (34.57), protein percent (17.58%), and tuber's yield (16.77 tons. $ha^{-1}$), and average tuber weight (154.67 g. $plant^{-1}$). This research was aimed to evaluate the possibility of improving the yield and quality of potatoes for processing by the application of organic fertilizers and boron foliar application.

## MATERIALS AND METHODS

Field experiment was carried out in University of Baghdad - College of Agricultural Engineering Sciences - research station A during the fall season of 2020 and spring season of 2021 to evaluate the role of organic fertilizer and foliar application of boron in the growth and yield of 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 land was divided into three blocks, and each of was divided into 20 experimental units with an area of 1.875 $m^2$. In the fall season, it was included two lines with a length of 1.25 m and a width of 0.75 m. In the spring season, it included lines with a length of 2.5 m and a width of 0.75 m. The tubers were planted on 16/9/2020 for the fall season and on 17/ 1/ 2021 for the spring season, on each side, with 0.25 m between each plant, with an average of 10 plants per experimental unit. All agricultural operations were performed for all experimental units. The factorial experiment included two factors, the first is the application of organic fertilizer with a symbol O (palm frond waste) at four levels in addition to the treatment of the application of chemical fertilizer according to the approved recommendation (14). Half of the chemical fertilizer recommended 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 bulking), as follows: $O_0$ the chemical fertilizer recommendation, $O_{0½}$ control treatment,$O_{12}$ organic fertilizer at a concentration of 12 ton.ha$^{-1}$, $O_{24}$ organic fertilizer at a concentration of 24 ton. ha$^{-1}$, and $O_{36}$ organic fertilizer at a concentration of 36 ton ha$^{-1}$. The second factor was the foliar application of boron (boric acid 17.4%) 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 was applied in two stages, the first after 45 days of planting (vegetative growth) (on 3/11/2020 for the fall season) (on 17/3/2021 for the spring season), and the second was after 60 days (tuber growth) (on 22 /11/2020 for the fall season) (on 6/4/2021 for the spring season), the factorial experiment (4×5) was carried out within the RCBD design with three replicates, with 60 experimental units. The results were analyzed using the Genstat software and the averages were compared using the least significant difference test (L.S.D.) at a probability level of 5% (16). The following characteristics were measured: leaves area (dm$^2$ plant$^{-1}$), tubers number (tuber. plant$^{-1}$), tuber's weight (g. tuber$^{-1}$). plant's yield (kg. plant$^{-1}$). TSS (%). The tuber's percent of dry matter (%). the starch (%).The specific density (%).The protein (%) was estimated by the Kjeldahl method using Microkjeldahl device. The total carbohydrates (%).

## RESULTS AND DISCUSSION

### 1- Plant's growth and yield

Results in Table 1 reveal a significant increases with the application of organic fertilizer at the level of $O_{24}$ in the leaves area reached 92.54 and 138.22 dm$^2$. plant$^{-1}$ for both seasons, respectively. Also significant increases were recorded in the tuber's number, reached 10.60 tubers for the fall season, while the level of organic fertilizer $O_{36}$ in the spring season recorded a significant increases in the tuber's number, reached 8.59 tubers. Plant$^{-1}$, also the treatment of $O_{24}$ recorded the highest tuber's weight for the fall season reached 65.00 g. tuber$^{-1}$, which significantly did not differed from $O_{36}$ and $O_0$. While the highest tuber's weight in the spring season was recorded by the treatment of the complete fertilizer recommendation $O_0$, reached 121.08 g. tuber$^{-1}$, the increase in the number of tuber or tuber weight was reflected on the plant's yield. The treatment of $O_{36}$ in the spring season gave the highest plant's yield reached 1018.3 g. plant$^{-1}$, which did not differed significantly from the level of $O_{24}$, which had increased the plant's yield in the fall season reached 677.8 g. Plant$^{-1}$. Also, the treatment of $O_{36}$ had increased the tuber's dry matter (18.79 and 23.20% for both seasons, respectively), while the control ($O_{0½}$) had the lowest values for all traits (49.98 and 102.65 dm$^2$. Plant$^{-1}$). (8.33 and 6.88 tuber. plant$^{-1}$), (56.03 and 106.30 g. tuber$^{-1}$), (477.6 and 732.5 g. plant$^{-1}$) and (13.75 and 20.03%) for both seasons, respectively. The increases in leaves area could be attributed to the role of organic fertilizers that applied to the soil, as they increase the availability of nutrients to facilitate their absorption by the plant, these nutrients encourage the cell division and elongation. This is reflected on the an the increases of leaves area, where nitrogen and phosphorous enter the composition of proteins, enzymes and nucleic acids that stimulate the formation of cytokinins, which encourages cell division (30, 34, 36, 37, 49), The reason for the tuber's number increases could be due to the role of the application organic fertilizers in improving the chemical and physical characteristics of the soil by increasing the soil's water retention as it provides ideal conditions for the root's growth as well as an increase in the activity and preparation of micro-organisms. This increases the nutrients availability and absorption by the plant (43), including the macro-nutrients (nitrogen, phosphorous and potassium), which was increased the shoots number and thus the tuber's number of the plant. Yield increase is due to the increase in the tuber's number and weight. Which was positively reflected on the yield (50, 51). While the foliar application of boron at the concentration of $B_{100}$ recorded a significant increases in the leaves area reached 87.91 and 134.48 dm$^2$.plant$^{-1}$, and the tuber's number (11.16 and 8.25 tubers. plant$^{-1}$), the tuber weight (63.10 and 114.55 g. tuber$^{-1}$), which led to a significant differences in the

yield of one plant, reached 702.7 and 944.2 g. plant$^{-1}$. It also led to a significant increases in the tuber's content of dry matter reached18.36 and 20.87% for both seasons respectively, compared to the control ($B_0$) that recorded the lowest values (68.12 and 117.23 dm$^2$. plant$^{-1}$), (8.37 and 7.53 tuber. plant$^{-1}$), (62.28 and 108.93 g. tuber$^{-1}$), (523.6 and 825.8 g. plant$^{-1}$) and (15.14 and 20.89%) for both seasons, respectively. This is attributed to the role of boron that improves physiological and biochemical processes through activating meristematic tissues, increasing cell division and elongation, and increasing the production and effectiveness of growth regulators, as well as its role in regulating auxin in plants, processing, and production of growth, which is positively reflected on the vegetative parameters of the plant (17, 20, 28, 42). The foliar application of boron has improved the physiological processes and encouraged the shoots growth, which was reflected the tuber's number, This is attributed to the role of boron in activating the plant's ability in photosynthesis and its participation in a number of metabolic pathways, as it leads to the activation of some enzymes, increased photosynthesis and the building of proteins and nucleic acids (23, 29, 35, 37). The results in Table (2) indicate a significant effect of the interaction between organic fertilization and the foliar application of boron on the leaves area at the treatment of $O_{24}B_{100}$ reached 105.65, and 159.63 dm. plant$^{-1}$ for both seasons respectively, results also indicated a significant increases in the tuber's number, which was reflected in a significant increase in the plant's yield, as it reached 13.78 tuber. plant$^{-1}$ and 833.3 g. plant$^{-1}$ during the fall season, and 9.27 tuber. plant$^{-1}$ and 1122.2 g. plant$^{-1}$ in the spring season respectively, while both treatment $O_{24}B_{150}$ in the fall season and the treatment $O_{12}B_{150}$ in the spring season recorded a significant increases in the tuber weight reached 76.37 and 134.73 g. tuber$^{-1}$, respectively. While the highest tubers content of dry matter was recorded by the treatment of $O_{36}B_{150}$ reached 21.30 and 26.02% for both seasons respectively, which did not significantly differ from five of the interactions in the spring season, including $O_{24}B_{100}$. While the lowest numbers were recorded in the control ($O_{0½}$ $B_0$), as the leaves area was 43.74 and 86.55 dm$^2$. Plant$^{-1}$, the tuber's number was 6.44 and 6.13 tuber. Plant$^{-1}$, the tuber weight was 51.62 and 92.69 g. Tuber$^{-1}$, and the plant's yield was 332.9 and 568.3 g. plant$^{-1}$, and the tuber's content of dry matter reached 12.27 and 16.82% for both seasons, respectively.

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

| Treatment | Leaf area (m$^2$. plant$^{-1}$) | | No. of tubers (tuber. plant$^{-1}$) | | Weight of tuber(g.tuber$^{-1}$) | | Yield of plant (Kg plant$^{-1}$) | | Dry weight % tubers | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 |
| $O_0$ * | 79.18 | 126.67 | 9.31 | 6.89 | 64.76 | 121.08 | 606.5 | 829.6 | 16.55 | 20.96 |
| $O_{0½}$ | 49.98 | 102.65 | 8.33 | 6.88 | 56.03 | 106.30 | 477.6 | 732.5 | 13.75 | 20.03 |
| $O_{12}$ | 89.09 | 126.51 | 9.93 | 8.19 | 57.33 | 112.40 | 566.7 | 911.9 | 17.70 | 21.88 |
| $O_{24}$ | 92.54 | 138.22 | 10.60 | 8.06 | 65.00 | 118.95 | 677.8 | 957.3 | 17.29 | 22.19 |
| $O_{36}$ | 84.11 | 131.40 | 9.90 | 8.59 | 64.00 | 118.70 | 635.1 | 1018.3 | 18.79 | 23.20 |
| L.S.D $_{0.05}$ | 2.33 | 6.09 | 0.76 | 0.51 | 5.30 | 6.09 | 54.91 | 60.21 | 1.48 | 1.67 |
| $B_0$ | 68.12 | 117.23 | 8.37 | 7.53 | 62.28 | 108.93 | 523.6 | 825.8 | 15.14 | 20.89 |
| $B_{100}$ | 87.91 | 134.48 | 11.16 | 8.25 | 63.10 | 114.55 | 702.7 | 944.2 | 18.36 | 20.87 |
| $B_{150}$ | 80.77 | 125.24 | 9.20 | 7.19 | 62.23 | 119.16 | 572.6 | 859.9 | 16.81 | 22.62 |
| $B_{200}$ | 79.13 | 123.42 | 9.73 | 7.92 | 58.09 | 119.31 | 572.0 | 932.9 | 16.96 | 22.23 |
| L.S.D $_{0.05}$ | 2.08 | 5.45 | 0.68 | 0.45 | N.S | 5.45 | 49.11 | 53.86 | 1.32 | 1.49 |

***$O_0$ 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 2. Effect of the interaction between organic fertilization and spraying with boron on growth and yield traits of the artificial potato plant (Fontane) planted in the fall season 2020 and (Sinora) in the spring season 2021.**

| Interaction | Leaf area ($m^2$. $plant^{-1}$) | | No. of tubers (tuber. $plant^{-1}$) | | Weight of tuber(g.$tuber^{-1}$) | | Yield of plant (Kg $plant^{-1}$) | | Dry weight % tubers | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 |
| $O_0$ $B_0$ | 66.24 | 130.00 | 9.28 | 7.37 | 64.00 | 110.49 | 591.7 | 812.7 | 15.10 | 19.66 |
| $O_0$ $B_{100}$ | 79.42 | 134.21 | 9.78 | 6.90 | 65.86 | 117.85 | 646.3 | 813.3 | 18.67 | 20.33 |
| $O_0$ $B_{150}$ | 91.09 | 120.59 | 6.61 | 7.00 | 61.49 | 114.29 | 406.3 | 800.0 | 16.16 | 21.50 |
| $O_0$ $B_{200}$ | 79.97 | 121.90 | 11.56 | 6.30 | 67.69 | 141.70 | 781.7 | 892.3 | 17.26 | 22.47 |
| $O_{0½}$ $B_0$ | 43.74 | 86.55 | 6.44 | 6.13 | 51.62 | 92.69 | 332.9 | 568.3 | 12.27 | 16.82 |
| $O_{0½}$ $B_{100}$ | 54.32 | 108.22 | 9.33 | 7.40 | 62.98 | 109.92 | 588.1 | 809.6 | 14.84 | 20.45 |
| $O_{0½}$ $B_{150}$ | 52.32 | 105.25 | 10.56 | 7.00 | 61.70 | 108.81 | 654.2 | 761.7 | 14.70 | 20.86 |
| $O_{0½}$ $B_{200}$ | 49.53 | 110.59 | 7.00 | 6.97 | 47.83 | 113.79 | 335.0 | 790.6 | 13.21 | 21.97 |
| $O_{12}$ $B_0$ | 74.73 | 118.75 | 7.94 | 8.17 | 61.18 | 106.65 | 482.5 | 870.3 | 16.66 | 20.69 |
| $O_{12}$ $B_{100}$ | 97.39 | 128.59 | 10.78 | 8.47 | 58.34 | 103.15 | 638.3 | 865.0 | 19.01 | 21.12 |
| $O_{12}$ $B_{150}$ | 94.72 | 131.11 | 11.17 | 7.33 | 56.59 | 134.73 | 633.3 | 986.7 | 17.54 | 22.17 |
| $O_{12}$ $B_{200}$ | 89.51 | 127.58 | 9.83 | 8.80 | 52.20 | 105.08 | 512.5 | 925.8 | 17.61 | 23.55 |
| $O_{24}$ $B_0$ | 86.42 | 124.53 | 7.61 | 7.47 | 65.76 | 112.52 | 496.7 | 837.1 | 15.57 | 23.39 |
| $O_{24}$ $B_{100}$ | 105.65 | 159.63 | 13.78 | 9.27 | 60.63 | 121.12 | 833.3 | 1122.2 | 18.31 | 23.31 |
| $O_{24}$ $B_{150}$ | 83.94 | 139.18 | 9.50 | 6.83 | 76.37 | 124.22 | 722.1 | 848.7 | 15.33 | 22.56 |
| $O_{24}$ $B_{200}$ | 94.18 | 129.53 | 11.50 | 8.67 | 57.24 | 117.94 | 659.3 | 1021.4 | 19.95 | 19.48 |
| $O_{36}$ $B_0$ | 69.47 | 126.29 | 10.56 | 8.50 | 68.85 | 122.31 | 714.2 | 1040.9 | 16.09 | 23.91 |
| $O_{36}$ $B_{100}$ | 102.76 | 141.76 | 12.11 | 9.20 | 66,69 | 120.73 | 807.5 | 1110.7 | 21.00 | 19.22 |
| $O_{36}$ $B_{150}$ | 81.77 | 130.07 | 8.17 | 7.80 | 55.00 | 113.73 | 447.1 | 887.3 | 21.30 | 26.02 |
| $O_{36}$ $B_{200}$ | 82.44 | 127.49 | 8.78 | 8.87 | 65.47 | 118.05 | 571.7 | 1034.3 | 16.77 | 23.67 |
| $L.S.D_{0.05}$ | 4.66 | 12.18 | 1.52 | 1.02 | 10.61 | 12.19 | 109.82 | 120.42 | 2.96 | 3.33 |

**2- Yield characteristics**

The results in Table (3) reveal a significant differences with the organic fertilizer treatment at the level of $O_{24}$ in the total soluble solids (TSS) ( 5.83 and 4.82%) for both seasons, respectively. Also, the same level of fertilization was recorded the significant tuber's content of carbohydrates for both seasons (21.40 and 18.20%) respectively, and the tuber's content of protein during the fall season (14.09%). Whereas the treatment of $O_{36}$ was significantly increased the tuber's content of starch, reached 12.75 and 16.68% for both seasons, respectively. The tuber's content of protein for the spring season was 8.18%, and the same level was significantly increased the specific density of tubers, which were 1.073 and 1.094% for both seasons, respectively, compared to the control that were fertilized with half the chemical fertilizer recommendation ($O_{0½}$), which recorded the lowest values for all studied traits including TSS (5.31 and 4.38%), starch (8.26 and 13.85%), carbohydrates (18.68 and 14.98%), protein (19.83 and 7.26%) and Specific density (1,049 and 1.079%) for both seasons, respectively. This can be due to the role of organic fertilizers (palm frond residues) that applied to the soil, which plays a role in preparing plants with sufficient quantities of nutrients. Thus, the nutritional value of industrial potatoes increases, especially by increasing its starch content and specific density (15, 20). The differences in the tuber's dry matter leads to an increase in the total soluble solids T.S.S, and this ratio is one of the traits that indicate a high nutritional value of the crops and an increase in their storage capacity (2, 7, 8, 13). The dry matter is the final product of the metabolism processes, where the dry matter accumulates in the storage areas (tubers), and their increases in the tubers leads to an increase in the starch percent, protein and the necessary nutrients included in the composition of the tuber. The TSS and specific density are important quality criteria that determine the quality of industrial potatoes for making potato chips and frankincense (18, 19, 48). The foliar application of Boron was significantly affected the qualitative characteristics of potato tubers, as concentration of $B_{100}$ led to a significant increase in TSS for both seasons (5.85 and 4.87%), starch, and carbohydrates in tubers for the fall season (12.37 and 21.03%, respectively). Also, the concentration of $B_{150}$

had a significant increases in both starch and protein of the tubers of the spring season (16.16 and 7.93 %, respectively), while Boron at concentration of $B_{200}$ recorded the highest value for carbohydrates% in the spring season and protein% in the fall season, reaching 17.65 and 13.08%, respectively. While specific density was increased significantly at the concentration of $B_{100}$ in the fall season and at the concentration of $B_{150}$ in the spring season (1.071 and 1.091%, respectively) , The lowest values for the yield qualitative TRAITs were recorded by the control ($B_0$) which were represented by TSS (5.38 and 4.41%), starch (9.49 and 14.62%), carbohydrates (19.23 and 15.12%), protein (11.71 and 7.52%), and specific density (1.056 and 1.083) for both seasons, respectively. The foliar application of boron led to an improvement in the yield parameters, which can be due to the role of boron in the process of transferring sugar molecules within the plant. Boron also has a role in the formation of protein through the processes of building nucleic acids, DNA, and RNA. It also has a role in activating plant hormones and improving many physiological and biochemical processes during the growth process, including cell division, and elongation, and the accumulation of carbohydrate and proteins, and their transfer to storage areas within the plant, which is positively reflected on the yield characteristics (38, 41). The interaction between organic fertilization and the foliar application of boron had a significant effect on the quality characteristics of tubers (Table 4). The interaction of $O_{24}B_{100}$ treatment revealed a significant increases in TSS, which amounted to 6.67 and 5.43 for both seasons respectively, in carbohydrates (19.77%) and protein in the fall season(%15.48) , While the interaction treatment of $O_{36}B_{100}$ led to a significant increases in carbohydrates during the fall season (22.87%) and protein in the spring season(%8.46), As for starch and the specific density of tubers, these parameters were increased significantly by the treatment of $O_{36}B_{150}$ for both seasons (14.98 and 19.19%) and (1.085 and 1.108%), respectively. While the lowest values of quality traits were found in control ($O_{0½}$ $B_0$) which were represented by TSS (5.00 and 4.17%), starch (6.94 and 10.99%), carbohydrates (15.90 and 12.90%), protein (9.39 and 6.89%) and specific density (1.042 and 1.064%) for both seasons, respectively.

**Table 3. Effect of organic fertilization and spraying with boron on quality indicators of yield for artificial potato plant (Fontane) planted in the fall season 2020 and (Sinora) in the spring season 2021.**

| Treatment | TSS % | | Starch % | | Carbohydrates % | | Protein % | | Specific density % | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 |
| $O_0$ * | 5.66 | 4.73 | 10.75 | 14.68 | 19.12 | 16.08 | 11.79 | 7.68 | 1.063 | 1.084 |
| $O_{0½}$ | 5.31 | 4.38 | 8.26 | 13.85 | 18.68 | 14.98 | 10.83 | 7.26 | 1.049 | 1.079 |
| $O_{12}$ | 5.74 | 4.76 | 11.78 | 15.50 | 20.79 | 16.87 | 12.81 | 7.78 | 1.068 | 1.088 |
| $O_{24}$ | 5.83 | 4.82 | 11.41 | 15.77 | 21.40 | 18.20 | 14.09 | 7.85 | 1.066 | 1.089 |
| $O_{36}$ | 5.64 | 4.79 | 12.75 | 16.68 | 20.50 | 17.36 | 12.78 | 8.18 | 1.073 | 1.094 |
| L.S.D $_{0.05}$ | 0.32 | 0.27 | 1.32 | 1.48 | 0.98 | 0.95 | 0.56 | 0.08 | 0.007 | 0.008 |
| $B_0$ | 5.38 | 4.41 | 9.49 | 14.62 | 19.23 | 15.12 | 11.71 | 7.52 | 1.056 | 1.083 |
| $B_{100}$ | 5.85 | 4.87 | 12.37 | 14.60 | 21.03 | 16.40 | 12.76 | 7.77 | 1.071 | 1.083 |
| $B_{150}$ | 5.61 | 4.79 | 10.98 | 16.16 | 20.06 | 17.63 | 12.28 | 7.93 | 1.063 | 1.091 |
| $B_{200}$ | 5.71 | 4.71 | 11.11 | 15.81 | 20.07 | 17.65 | 13.08 | 7.78 | 1.065 | 1.089 |
| L.S.D $_{0.05}$ | 0.29 | 0.24 | 1.18 | 1.33 | 0.88 | 0.85 | 0.50 | 0.07 | 0.006 | 0.007 |

***$O_0$ 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. Effect of the interaction between organic fertilization and spraying with boron on quality indicators of yield for artificial potato (Fontane) planted in the fall season 2020 and (Sinora) in the spring season 2021**

| Interaction | TSS % | | Starch % | | Carbohydrates % | | Protein % | | Specific density % | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 | Full 2020 | Spring 2021 |
| $O_0$ $B_0$ | 5.67 | 4.33 | 9.46 | 13.52 | 17.45 | 14.93 | 10.56 | 7.52 | 1.056 | 1.077 |
| $O_0$ $B_{100}$ | 5.70 | 4.57 | 12.64 | 14.03 | 20.60 | 14.83 | 11.67 | 7.85 | 1.073 | 1.080 |
| $O_0$ $B_{150}$ | 5.00 | 4.87 | 9.51 | 15.16 | 18.40 | 17.47 | 11.63 | 7.60 | 1.056 | 1.086 |
| $O_0$ $B_{200}$ | 6.27 | 5.17 | 11.38 | 16.02 | 20.04 | 17.10 | 13.29 | 7.73 | 1.066 | 1.091 |
| $O_{0½}$ $B_0$ | 5.00 | 4.17 | 6.94 | 10.99 | 15.90 | 12.90 | 9.39 | 6.89 | 1.042 | 1.064 |
| $O_{0½}$ $B_{100}$ | 5.17 | 4.07 | 9.22 | 14.23 | 19.93 | 13.50 | 11.39 | 7.13 | 1.055 | 1.081 |
| $O_{0½}$ $B_{150}$ | 5.73 | 5.10 | 9.10 | 14.59 | 20.05 | 16.53 | 11.15 | 7.33 | 1.054 | 1.083 |
| $O_{0½}$ $B_{200}$ | 5.33 | 4.20 | 7.77 | 15.58 | 18.84 | 17.00 | 11.38 | 7.69 | 1.047 | 1.088 |
| $O_{12}$ $B_0$ | 5.20 | 5.00 | 10.85 | 14.44 | 21.47 | 15.57 | 11.58 | 7.56 | 1.063 | 1.082 |
| $O_{12}$ $B_{100}$ | 5.67 | 4.97 | 12.94 | 14.83 | 20.97 | 15.83 | 12.69 | 7.50 | 1.074 | 1.084 |
| $O_{12}$ $B_{150}$ | 6.10 | 4.57 | 11.63 | 15.76 | 21.03 | 17.73 | 13.65 | 8.21 | 1.067 | 1.089 |
| $O_{12}$ $B_{200}$ | 6.00 | 4.50 | 11.69 | 16.99 | 19.70 | 18.33 | 13.33 | 7.83 | 1.068 | 1.096 |
| $O_{24}$ $B_0$ | 5.37 | 4.27 | 9.87 | 16.85 | 22.53 | 15.90 | 14.00 | 7.73 | 1.058 | 1.095 |
| $O_{24}$ $B_{100}$ | 6.67 | 5.43 | 12.32 | 16.77 | 20.80 | 19.77 | 15.48 | 7.92 | 1.071 | 1.095 |
| $O_{24}$ $B_{150}$ | 5.70 | 5.13 | 9.67 | 16.11 | 21.96 | 18.73 | 12.65 | 8.19 | 1.057 | 1.091 |
| $O_{24}$ $B_{200}$ | 5.60 | 4.43 | 13.78 | 13.36 | 20.31 | 18.40 | 14.23 | 7.58 | 1.079 | 1.077 |
| $O_{36}$ $B_0$ | 5.67 | 4.30 | 10.34 | 17.31 | 18.82 | 16.30 | 13.02 | 7.88 | 1.060 | 1.098 |
| $O_{36}$ $B_{100}$ | 6.03 | 5.30 | 14.71 | 13.13 | 22.87 | 18.07 | 12.56 | 8.46 | 1.084 | 1.075 |
| $O_{36}$ $B_{150}$ | 5.53 | 4.30 | 14.98 | 19.19 | 18.87 | 17.67 | 12.35 | 8.31 | 1.085 | 1.108 |
| $O_{36}$ $B_{200}$ | 5.33 | 5.27 | 10.95 | 17.09 | 21.45 | 17.40 | 13.19 | 8.08 | 1.063 | 1.096 |
| L.S.D $_{0.05}$ | 0.65 | 0.54 | 2.64 | 2.97 | 1.96 | 1.91 | 1.13 | 0.16 | 0.014 | 0.016 |

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