SPRAYING NANO CHITOSAN LOADED WITH NPK, NETTEL AND GREEN TEA EXTRACTS AS A TOOL FOR IMPROVEMENT POTATO PRODUCTIVITY

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ABSTRACT

This study was aimed to evaluate the effect of spraying nano chitosan loaded with NPK fertilizer and nettle leaf and green tea extracts on the growth and productivity of potato for the spring and fall seasons of 2021.It was conducted at private farm in Wasit Governorate, Iraq, as a factorial experiment (5 × 5) within randomized complete block design using three replicates. The first factor included spraying with four concentrations of chitosan nanoparticles loaded with NPK fertilizer 0, 10. 15 and 20% in addition to chemical fertilization treatment, the second factor was spraying nettle leaf extract 25 and 35 gL^{-1} and green tea extract with 2 and 4 $g.L^{-1}$, in addition to the control treatment, spraying with distilled water only. The results showed a significant superiority of the interaction between spraying with Nano chitosan loaded with NPK at a concentration of 15% and spraying green tea extract at a concentration of 4 g L^{-1} significantly in producing the highest plant height 62.77 and 60.86 cm, number of main stems of the plant 4.45 and 4.36 stem for the both seasons respectively and mean of tuber weight (111.0 g $tuber^{-1}$) for the spring season which increased the productivity of tuber yield (56.3 and 51.6 in ton ha^{-1} for both seasons, respectively).

Keywords: *Solanum tuberosum* L, foliar application, Nano elements, plant extracts, tuber yield.
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الرش بالكيتوسان النانوي المحمل NPK ومستخلص القريص والشاي الاخضر كأداة لتحسين الانتاجية للبطاطا

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المستخلص

يهدف البحث تقييم تأثير الرش بالكيتوسان النانوي المحمل NPK والرش بمستخلص القريص والشاي الاخضر في نمو وانتاجية البطاطا للموسمين الربيعي والخريفي 2021. نفذ تجربة حقلية محافظة واسط كتجربة عاملية (5*5) ضمن تصميم القطاعات الكاملة المعشاة و بثلاث مكررات تضمن العامل الاول الرش بأربع تراكيز من جسيمات الكيتوسان النانوية المحملة بالأسمدة NPK (0, 10, 15 و 20 % اضافة الى معاملة التسميد الكيميائي) اما العامل الثاني فقد تضمن الرش بمستخلص أوراق القريص بتركيزين 25 و 35 غم.لتر$^{-1}$ ومستخلص الشاي الاخضر بتركيزين 2 و 4 غم لتر$^{-1}$ فضلاً عن معاملة القياس الرش بالماء المقطر فقط . اظهرت النتائج تفوق معنوي لمعاملة التداخل بين الرش بجسيمات الكيتوسان النانوية المحملة بالأسمدة NPK بالتركيز 15% مع رش مستخلص الشاي الاخضر بالتركيز 4 غم لتر$^{-1}$ في اعطاء اعلى قيمة لارتفاع النبات بلغت 62.77 و 60.86 سم, عدد للسيقان الرئيسة بلغت 4.45 و 4.36 ساق نبات$^{-1}$ للموسمين على الترتيب وفي معدل وزن الدرنة (111.0 غم) للموسم الربيعي وبالتالي زيادة الانتاجية لحاصل الدرنات (56.3 و 51.6 طن هكتار$^{-1}$ لكلا الموسمين على الترتيب)

الكلمات المفتاحية: *Solanum tuberosum* L, الرش الورقي, عناصر ثانوية, مستخلصات نباتية, حاصل النبات
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INTRODUCTION

Potato (*Solanum tuberosum* L.) is the most important crop in agricultural production that mainly contributes to the economic profitability and food security of Iraq. Consequently, our local society has a great need to increase its production capacity (6, 7, 23) in particular; potato varieties for processing (20, 21, 41, 42). The addition of Nano fertilizers is an efficient way was applied to several crops and improved their growth and productivity as in tomato (43), broccoli (37), date palm (31) and bread wheat (2, 25). Elshamy *et al*.(28) found that when spraying chitosan nanoparticles loaded with NPK with three concentrations (10%-50%-100%) on potato, it led to a significant increase in growth and production for all concentrations compared to the untreated plant, foliar application at a concentration of 10% was excelled other concentrations in the highest stem length, root length, fresh and dry weight of vegetative growth, leaves content of total chlorophyll, number of tubers per plant, yield per plant, average tuber weight, leaves, total carbohydrates and TSS. Natural extracts are considered as one of the promising bio stimulants due to their high effectiveness to become a new generation suitable for use in sustainable agriculture (8, 13, 14, 15). Plant extracts can be prepared by using any part of the plant such as seed sprouts (10, 11, 12, 40) roots, leaves (38, 39) , either individually or in mixtures (30). Salman and Abdulrasool (38) found that when spraying Coconut water led to improve vegetative growth and yield of broccoli plants. Nettle *Urtica dioica* L. is one of the oldest sources of plant fibers and has recently been used as a substitute for synthetic fibers in the textile and clothing industry (44) and can be grown in polluted areas to reduce the risks of pollutants to humans and the environment (36). Garmendia *et al.* (29) found that fermenting nettle and using it as an organic fertilizer sprayed on potato plants led to differences in growth .The results showed that the application of a double dose of the recommended (300 L ha^{-1}) of nettle extract led to an increase in plant height, number of leaves, and total chlorophyll content, excelled on the other levels. Abdulraheem and Estefo, (3) found in a study on the effect of foliar application of extracts of some plants on the growth and yield of two pea cultivars, Nettle leaf extract was excelled than others (nettle seed extract, fenugreek seed extract, and licorice root extract) in producing the highest means for plant height, number of leaves, chlorophyll content, number of pods, and seed yield for both cultivars compared to other extracts treatments and control treatment. Maricic et al.(33) notes in a field experiment on green bean plants, fertilization using two types of nettle extract, the first type, is a short-term extract and it was prepared by soaking 183 g of wild nettle plant in 10 liters of water for 24 hours, the short-term extract was foliar application and the long-term extract was added through the soil, The results showed that the foliar application with nettle extract is almost equivalent to the ground fertilization with nettle extract and both types It had a positive effect on the growth traits (plant height and leaves area) compared with the control treatment. *Camellia sinensis* L. green tea is an interesting plant extract, Spraying with Compost tea extract led to an increase in the total crop production in the first year by 21.9% and in the second year by 16.3% due to the increases in the number of fruits and leaves area for pepper plant (45). Dahshan *et al*. (27) noted that spraying green tea extract at three levels (0.1, 0.2, 0.3)% gave a positive effect on yield and tuber content of nitrogen, phosphorus and potassium for potato plants Burren cultivar. Abd-Alrahman and Aboud (1) was extracted compost tea by adding 10 L of water to a liter of compost they found that foliar application compost tea extract (20L fed^{-1})with yeast extract at a concentration of 6 g L^{-1} on sweet pepper plants grown in containers filled with perlite and peat moss medium (1:1 V/V).) led to a significant increase in the vegetative growth traits (plant length, number of branches for each plant, and number of leaves , leaves area, fresh and dry weight of leaves), yield traits (fruit diameter, fruit length, fruit weight, and total yield) and leaf content of nitrogen, potassium, phosphorus, and vitamin C for both seasons, respectively, compared to the control treatment. The study was aimed to evaluate the response of potato growth and yield to foliar application with Nano chitosan loaded with mineral fertilizer

NPK and spraying with nettle leaf extracts and green tea.

MATERIALS AND METHODS

The experiment was conducted at private farm in Wasit Governorate (32.92°N, 44.77°E) and about 55 km south of Baghdad / Iraq. With studying the effect of foliar application with Nano chitosan loaded with NPK fertilizer and nettle leaf extracts and green tea on the growth and productivity of potatoes for the spring and fall seasons of 2021.The Burren hybrid potato plant, rank Elite, of Dutch origin, was used. At the end of the season, part of the tubers produced from the spring season 2021 were stored in refrigerator at a temperature of 4 °C, and later used as tubers for the fall season 2021. A furrows was used with a width of 0.75 m, then the furrows was divided into experimental units which included a 5 m long furrow in the spring season 2021 and a 2.5 m long furrow in fall 2021 season, an area of 3.75 m^2. Planting conducted at a distance of 0.25 m between tubers, an average of 20 plants per experimental unit for both seasons. The tubers were planted on January 19, 2021 for the spring season, and for the autumn season, on September 17, 2021. The tubers of the same hybrid of rank A produced from the spring planting of the same field experiment, not treated with the experimental treatments, were planted and stored in refrigerated private warehouses for the period from May 22, 2021 to September 9, 2021 at a temperature of 4 °C ± 2 °C. Nano Chitosan (factor I) were prepared in laboratory according to the mentioned method Maricic et al.(33) and Corradini et al. (26). It included foliar application with four concentrations of Nano chitosan loaded with NPK (17) in addition to chemical fertilization treatment as fallow: C100% = ground addition complete chemical fertilizer, C50% ground addition half of the chemical fertilizer recommendation plus Spray with distilled water only (control treatment), NanoNPK1, NanoNPK2 and NanoNPK3, Nano chitosan loaded with NPK fertilizer at a concentrations 10, 15 and 20% respectively. Foliar application was conducted in three stages, the first after the completion of emergence, the second during the vegetative growth and the third during tuber growth. Half of the chemical fertilizer recommendation was added to the foliar application treatments with Nano chitosan, and the fertilizer recommendation for the potato crop was adopted according to AL Khadimy (9) (300 N, 300 P_2O_5 and 300 K_2O). The second factor involved foliar application with nettle leaf extract, symbol N (3) and green tea extract symbol GT (27) with two concentrations for each of them, in addition to the control treatment as follows: C0 (Control) foliar with distilled water , N1 and N2 foliar with nettle leaf extract at a concentration 25 and 35 $g.L^{-1}$ respectively, GT1 and GT2 foliar with green tea extract at a concentration 2 and 4 $g.L^{-1}$ respectively, foliar application was done with two time, after 45 and 60 days of planting. The experiment was conducted for both seasons as a factorial experiment with two factors (5 × 5) within the randomized complete block design (RCBD) with three replicates, The results were analyzed using analysis of variances and means compared using LSD level 0.05 (16). Ten plants were taken randomly from each experimental unit at the end of the season to calculate the traits for both seasons, plant height (cm), number of main stems per plant (stem), number of total leaves (leaf of $plant^{-1}$), and leaves' total chlorophyll content. (mg 100 g $F.W.^{-1}$) and the dry weight of the total vegetative part (g $plant^{-1}$), and measurements the yield of the plants were taken at the harvest that conducted in the spring season on 5/17/2021 (118 days from planting to harvest) and in fall season on 6/1/2022 (111 days from planting to harvest) and measuring total number of tubers (tuber $plant^{-1}$), weight of the tuber ($g.tuber^{-1}$) and the total yield (ton ha^{-1}). The concentration of macro nutrients N, P and K % in leaves were calculated.

RESULTS AND DISCUSSION

Vegetative growth traits

The results show in Table (1) that the foliar treatment of NanoNPK2 at a concentration of (15%) was excelled in its counterparts in producing the highest mean of plant height (58.45 and 57.54 cm), the number of main stems of the plant (4.03 and 3.94 stems) and the number of leaves per plant (56.34 and 53.63 leaf) for both seasons, respectively compared to C50%, which produce the lowest values for the same traits (46.83, 44.37 cm $plant^{-1}$ and 2.90, 2.87 stem $plant^{-1}$ and 41.15,

40.46 leaf plant^{-1} for both seasons, respectively). The NanoNPK2 treatment was significantly superior in producing the highest leaf content of total chlorophyll, which reached 504.4 and 486.3 mg 100g F.W.$^{-1}$ for both season respectively. While the C50% produced the lowest total chlorophyll reached to 419.6 mg 100g F.W.$^{-1}$ for the spring season, and in C100% (385.8 mg 100g F.W.$^{-1}$) for the fall season. The NanoNPK2 supervised in the dry weight of vegetative growth, which reached 49.69 and 46.21 g plant^{-1} for both seasons respectively. While dry weight of vegetative growth in the C50 was reached 32.04 and 30.31 g.plant^{-1} for both seasons respectively. Foliar application with green tea extract GT2 resulted in a significant increase in plant height, number of main stems and number of leaves per plant for both seasons (58.39 and 56.82 cm, 3.68 and 3.63 stem, 55.23 and 53.22 leaf for both seasons respectively, compared to the C0 which produced 50.07 and 48.07 cm plant^{-1}, 3.28 and 3.06 stem plant^{-1} and 41.71 and 40.17 leaves plant $^{-1}$ for both seasons respectively. GT2 resulted in a significantly superior of each of the chlorophyll content and the dry matter of vegetative growth (509.1 and 472.9 mg 100 g F.W. $^{-1}$ and 48.04 and 46.13 g.plant^{-1}) for both seasons respectively. The lowest means were in C0 (430.6 and 407.6 mg of 100 g F.W. $^{-1}$ and 38.39 and 36.36 g.plant^{-1} for both seasons respectively) The interaction between Nano chitosan loaded with NPK and extracts of nettle leaves and green tea (Table 2), showed a significant effect on all vegetative growth traits. NanoNPK2 GT2 was significantly superior than others, producing the highest value of plant height 62.77 and 60.86 cm plant^{-1}, number of main stems of the plant reached 4.45 and 4.36 stem.plant^{-1} total chlorophyll reached 547.3 and 526.7 mg.100g F.W. $^{-1}$, and dry weight of the vegetative part reached 56.21 and 52.18 g plant^{-1} for both seasons, respectively, compared to the lowest means in C0 50% C0 for plant length 39.26 and 36.29 cm plant^{-1} for both seasons, respectively, number of leaves 37.56 leaf plant^{-1} and the leaf content of total chlorophyll 385.7 mg 100gm^{-1} for the spring season and for dry matter 32.04 and 30.31 g. plant^{-1} for both seasons respectively. The lowest mean of the number of main plant stems in C100% C0 was 2.71 and 2.16 stem.plant^{-1} for the both seasons, respectively, and total chlorophyll reached 322.7 mg 100g F.W.$^{-1}$ for the fall season. The increment in vegetative traits under the foliar application with Nano chitosan loaded with NPK can be due to the role of this fertilizer in providing optimal concentrations nutrition of mineral especially N, P and K which is a positive method for rapid response to plant nutrition (34, 35). Using Nano fertilizers based on polymer as a carrier of fertilizers in supplying the plant with nitrogen, potassium and phosphorus to the plant may be improves the nutritional status of the plant and prevents the loss of nutrients in the soil, water and air through direct entry, and avoids the interaction of nutrients with soil, microorganisms, water and air (5). Smallness of the particles loaded with fertilizers played an important role due to their high ability to penetrate cellular walls, stomata openings and wounds on the leaf surfaces with a large entry of nanoparticles into the cytoplasm and may be associated with different organelles in it (2), enhancing the various physiological processes of the plant and raising the efficiency of photosynthesis process and increasing the amount of manufactured materials and activating a number of enzymes. These results are consistent with what was mentioned by Elshamy *et al.* (28) who concluded that foliar Nano chitosan loaded with NPK on potato plants, and is consistent in its general framework with what was reached by (22). The increment in the vegetative growth traits under the foliar application of plant extracts nettle leaf and green tea extract can be due to their role in providing the plant with nutrients, due to their high content of biologically active compounds such as phenols, carotenoids and vitamins and organic acids that act as natural antioxidants, as well as a wide and different spectrum of nutrients that play a vital role in building plant tissues (26). These results are consistent with what was stated by Garmendia *et al.*(29) when using nettle leaf extract on potato plants, and with what was confirmed by (3) on pea plants. And with what was found by (Abdulrasool and AL- Malikshah, (4) when using foliar application with green tea extract on pepper plants.

Table 1. The effect of spraying with chitosan nanoparticles loaded with NPK, nettle leaf extract, and green tea extract on the vegetative growth traits of potato plant planted in the spring and autumn seasons 2021.

Treatments	Plant height (cm)		No. of main stems (stem. plant^{-1})		No. of Leaves (Leaf. plant^{-1})		Chlorophyll mg.100g F.W.$^{-1}$		Dry weight (g plant^{-1})	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Chitosan nanoparticles loaded with NPK fertilizer (%)										
$C_{100\%}$	54.52	51.00	3.17	2.94	44.50	43.32	441.2	385.8	41.63	40.37
$C_{50\%}$	46.83	44.37	2.90	2.87	41.15	40.46	419.6	399.2	36.25	35.29
$NanoNPK_1$	55.85	53.85	3.43	3.31	46.77	45.82	469.4	451.6	44.33	41.81
$NanoNPK_2$	58.45	57.54	4.03	3.94	56.34	53.63	504.4	486.3	49.69	46.21
$NanoNPK_3$	56.73	55.74	3.99	3.87	53.78	50.45	483.6	479.1	46.36	44.51
$LSD_{0.05}$	0.30	0.64	0.03	0.08	1.84	2.59	8.5	3.6	0.10	0.10
Plant extracts (g L^{-1})										
C_0	50.07	48.07	3.28	3.06	41.71	40.17	430.6	407.6	38.39	36.36
N_1	54.39	52.31	3.49	3.44	48.00	47.35	449.8	438.4	43.80	41.50
N_2	53.73	50.01	3.46	3.30	44.64	43.13	443.2	423.5	41.81	40.04
GT_1	56.15	55.29	3.60	3.48	52.96	49.8	485.4	459.6	46.23	44.15
GT_2	58.05	56.82	3.68	3.63	55.23	53.22	509.1	472.9	48.04	46.13
$LSD_{0.05}$	0.30	0.64	0.03	0.08	1.84	2.59	8.5	3.6	0.1	0.1

***C100% = ground addition to the recommendation chemical fertilizer, C50% = ground addition to half of the recommendation chemical fertilizer, Nano CS-NPK_1 = chitosan nanoparticles loaded with NPK fertilizer at a concentration of 10%, Nano CS-NPK_2 = chitosan nanoparticles loaded with fertilizer NPK at a concentration of 15%, Nano CS-NPK_3=chitosan nanoparticles loaded with NPK fertilizer 20%, C0 = control treatment (spray with distilled water only), N1 = 25g L^{-1} nettle leaf extract, N2 = 35g L^{-1} nettle leaf extract, GT1 = Green tea extract at a concentration of 2g L^{-1}, GT2 = green tea extract at a concentration of 4g L^{-1}**

Table 2. Effect of the interaction between spraying with chitosan nanoparticles loaded with NPK and nettle leaf extract, and green tea extract on the vegetative growth traits of potato plant planted in the spring and autumn seasons 2021

Interaction	Plant height (cm)		No. of main stem (stem. plant^{-1})		No. of Leaves (Leaf. plant^{-1})		Chlorophyll mg.100g F.W.$^{-1}$		Dry weight (g. plant^{-1})	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
$C_{100\%}$ C_0	48.06	44.38	2.71	2.16	40.84	38.88	413.1	322.7	36.70	35.91
$C_{100\%}$ N_1	55.98	51.46	3.29	3.28	44.57	44.71	428.4	401.0	42.46	40.53
$C_{100\%}$ N_2	54.82	46.20	3.28	2.71	42.33	40.69	426.3	359.3	39.41	39.17
$C_{100\%}$ GT_1	56.09	55.38	3.26	3.25	46.53	45.31	461.1	420.2	44.24	42.72
$C_{100\%}$ GT_2	57.63	57.59	3.28	3.30	48.25	47.00	477.2	425.7	45.34	43.50
$C_{50\%}$ C_0	39.26	36.29	2.89	2.87	37.56	36.54	385.7	383.4	32.04	30.31
$C_{50\%}$ N_1	46.63	45.52	2.92	2.86	40.07	39.99	400.4	396.2	35.31	34.19
$C_{50\%}$ N_2	45.80	39.81	2.90	2.90	39.43	37.96	398.9	393.6	34.71	33.40
$C_{50\%}$ GT_1	50.03	49.10	2.86	2.84	43.33	42.98	424.6	407.6	39.13	38.51
$C_{50\%}$ GT_2	52.42	51.13	2.93	2.90	45.35	44.80	488.4	415.2	40.08	40.07
$NanoNPK_1$ C_0	53.71	51.74	3.33	2.89	41.50	39.83	430.2	427.7	39.25	37.68
$NanoNPK_1$ N_1	55.97	52.92	3.41	3.38	45.85	45.82	448.6	437.7	45.00	42.00
$NanoNPK_1$ N_2	55.74	52.52	3.39	3.30	43.11	43.11	437.9	431.8	43.53	39.07
$NanoNPK_1$ GT_1	56.03	55.88	3.48	3.44	49.06	47.30	511.3	475.0	46.00	44.20
$NanoNPK_1$ GT_2	57.81	56.18	3.53	3.52	54.31	53.03	518.8	485.9	47.88	46.08
$NanoNPK_2$ C_0	55.00	54.08	3.70	3.66	45.50	43.68	473.0	459.0	42.92	39.58
$NanoNPK_2$ N_1	57.44	56.68	3.93	3.88	57.01	55.37	494.4	480.4	49.20	45.83
$NanoNPK_2$ N_2	56.60	56.65	3.86	3.80	51.27	49.21	480.1	472.7	46.10	44.74
$NanoNPK_2$ GT_1	60.43	59.45	4.22	3.99	63.05	58.35	527.3	492.8	54.00	48.71
$NanoNPK_2$ GT_2	62.77	60.86	4.45	4.36	64.86	61.54	547.3	526.7	56.21	52.18
$NanoNPK_3$ C_0	54.31	53.86	3.78	3.73	43.18	41.90	451.3	445.3	41.02	38.34
$NanoNPK_3$ N_1	55.93	54.99	3.90	3.82	52.51	50.87	477.1	476.7	47.05	44.96
$NanoNPK_3$ N_2	55.68	54.89	3.85	3.79	47.05	44.70	473.0	460.0	45.29	43.82
$NanoNPK_3$ GT_1	58.14	56.65	4.16	3.90	62.81	55.05	502.6	502.4	47.79	46.62
$NanoNPK_3$ GT_2	59.61	58.33	4.23	4.09	63.38	59.71	513.8	511.0	50.67	48.84
$L.S.D_{0.05}$	0.66	1.43	0.07	0.17	4.12	NS	18.9	8.1	0.23	0.23

Concentration of elements in the leaves

It is clear from the results in Table 3 revealed a significant effect of NanoNPK2 in concentration of N% which reached 1.910%, 1.880%, and P% reached to 0.569% and 0.550% for both seasons respectively. Nano NPK1, NanoNPK2 and NanoNPK3, produced K% 1.750, 1.760 and 1.750% respectively in spring season and 1.740, 1.760 and 1.740% respectively for fall season; However no significantly differences was observed between the treatments within both seasons. Compared to the lowest concentrations were in C50% for N% (1.590, 1.570%), for P% (0.485, 0.457%), and for k% (1.600, 1.560%) for both seasons respectively. The foliar application of green tea extract GT2 produced a significant increment in the leaves content of N% (1.830%, 1.810%), P% (0.585%, 0.569%), and K % (1.760%, 1.740%) for both seasons respectively. The results of the interaction between the two study factors (Table 4) had no significant effect on the percentage of nitrogen in the spring season. While for fall season the results showed that the highest N% in NanoNPK2 GT2, NanoNPK2 GT1, and NanoNPK3 GT2, which did not gave a significant differences between them and reached 1.950%, 1.920%, and 1.910%, respectively while C100% C0 produced a significant highest values of N% 1.540%, compared with C50% C0, which had the lowest N% 1.480%. Interaction treatment NanoNPK2 GT2, NanoNPK2 GT1 and NanoNPK3 GT2 for spring season was producing highest P% (0.617%, 0.587%, 0.590%, respectively) with no significant differences between them, C50% C0, which produced the lowest P% reached 0.427%. In fall season the interaction treatment did not show any significant effect on P%. NanoNPK2GT2 treatment was significantly superior in the spring season for K% reached 1.790%, compared to the lowest percentage at C50%N2 reached 1.530%. In fall season NanoNPK2 GT2 treatment was significantly superior at K% amounting to 1.780%, compared to the lowest percentage which was found in C0 50%, (1.500%). The increment in the leaves content of N, P and K can be due to the increase in the concentration of Nano fertilizer, nettle leaf extract and green tea extract and their content of many nutrients required for plant's growth which varies according to the nutrient type and the extract nature and contributed to the plant reaching a good nutritional state, which led to an increase in the plant's efficiency in absorbing and accumulating nitrogen, phosphorus and potassium in the leaves (38), in addition to the role of each element, individually or in combination with another element, in activating many enzymes necessary for the pathways of photosynthesis metabolism and increasing the outputs of all vital processes by building plant tissues, complex compounds, amino acids and proteins (45).

3- Yield and its components

The results in Table 3 indicate that there is a significant increase in the tubers number the plant for the spring and fall seasons, NanoNPK2 producing highest value reached 8.98 and 8.79 tuber plant^{-1} for both seasons, respectively, C100% treatment produced 7.03 and 6.94 tuber Plant ^{1} for both seasons compared to C50% that produced the lowest values reached to 5.74 and 5.61 tubers plant^{-1} for both seasons respectively. The highest means for weight of tuber in spring season was 108.4 g. tuber^{-1} at NanoNPK2, and in fall season at NanoNPK1 (107.8 g.tuber^{-1}), compared to the lowest mean tuber weight 86.1 and 82.6 g tuber^{-1} at C100% for both seasons respectively. These results were reflected on the productivity of the potato plant, the highest average was 51.9 and 49.1 ton ha^{-1} at NanoNPK2 for both seasons respectively.Foliar application with nettle leaf extracts and green tea had a significant effect on the total number of tubers of plant, the highest value at green tea extract GT2 (8.14 and 8.07 tubers .Plant^{-1}) for both seasons respectively. While the lowest values were recorded at C0 reached 7.12 and 6.85 tuber plant^{-1} for both seasons respectively. In the mean of tuber weight foliar with green tea extract at GT1, GT2 and the control treatment C0 did not show a significant difference between them, although the control treatment C0 gave the highest value reached 102.5 g tuber^{-1} for the spring season. Compared to nettle leaf extract at N2 recorded the lowest values reaching 99.9 g tuber^{-1}. The highest total yield was found (44.8 and 42.3 ton ha^{-1})

at GT2 for both seasons, respectively, compared to control C0, which produced the lowest total yield (39.2 and 36.6 ton ha^{-1}) for both seasons respectively. The interaction between the two factors (Table 4) showed a significant effect on the yield and its components. NanoNPK2 GT2 significantly superior on number of tubers per plant (9.51 and 9.39 tubers $plant^{-1}$) for both seasons respectively, Compared to C50%C0 which produced lowest value reached to 5.21 and 5.13 tubers $plant^{-1}$ for both seasons respectively. For the average tuber weight it showed a significant increment (111.0 g. $tuber^{-1}$) at NanoNPK2 GT2, compared to the C100% N2 which producing the lowest value (83.3 $g.tuber^{-1}$) for spring season. While in fall season, the interaction NanoNPK1C0 produced the highest value for tuber weight (112.7 g $tuber^{-1}$) compared to the lowest value (76.8 $g.tuber^{-1}$) at C100%C0. The interaction between the two factors had a significant effect on productivity, NanoNPK2 GT2 showed a significant increase reaching 56.3 and 51.6 ton $hectare^{-1}$ for both seasons respectively. Compared to the lowest productivity at C50%C0, which reached 27.2 ton ha^{-1} in spring season, and at C100%C0 which reached 24.9 ton ha^{-1} in fall season. The increment in the tubers number of plant under the factors of this study may have contributed apparently to the plant in the method of providing the plant with mineral fertilizers, especially N, P and K by adopting Nano polymer technology and creating particles characterized by safe and high penetration specifications of cell walls due to their small size and the occurrence of a kind of food homeostasis within the plant, which directly affected the efficiency of the photosynthesis process and increased the manufacture of energy-rich compounds and the activation of enzymes necessary for vital processes within the plant.This is reflected in the increase in plant tissues, as well as the role of N in building proteins and enzymes that increase plant growth, as well as the participation of nitrogen in the formation of amino acids and the increase in the effectiveness of GA3 gibberellins, which are responsible for the formation of stolons in potato plants, which increases the number of tubers formed (17, 19). In addition to the role of K and P in raising the efficiency of metabolizing carbohydrates manufactured in the leaves and storing them in tubers in the form of starch, which reflected of plant yield by increasing the tubers number of plant, which is positively reflected on increasing the productivity. This result was in agreement with Elshamy *et al.* (28), which showed that spraying with Nano chitosan loaded with nitrogen, phosphorus and potassium contributed to increasing the yield indicators of potato plants, and agreement with mentioned by a Al-Juthery et al in the field of Nano fertilizers (18). The significant increase in the tuber weight may be due to the role of nutrients in providing the plant with nutrients, as they are rich in mineral nutrients, organic and amino acids, vitamins and hormones which were important for the growth, chlorophyll and then increasing the accumulation of carbohydrates and their transfer to the tubers, which increases their weight. The effect of the study factors on increasing the number of tubers and the weight of the tuber was similarly reflected on the plant yield and increased productivity. This results was in agreement by number of researchers (22, 46, 47, 48). We recommend the use of foliar application with chitosan nanoparticles loaded with NPK at a concentration of 15% and green tea extract at a concentration of 4g L^{-1} because their role in improving the vegetative growth of potato plants and increasing plant productivity.

Table 3. Effect of spraying with chitosan nanoparticles loaded with NPK, nettle leaf and green tea extract on the concentration of elements in the leaves and yield traits of potato plant planted in the spring and autumn seasons 2021.

Treatment	% leaves N		P		K		No. of tubers (tuber. plant^{-1})		Weight of tuber(g.tuber^{-1})		Productivity (ton ha^{-1})	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Chitosan nanoparticles loaded with NPK (%)												
$C_{100\%}$	1.63	1.62	0.50	0.48	1.72	1.70	7.03	6.94	86.1	82.6	32.2	30.6
$C_{50\%}$	1.59	1.57	0.49	0.46	1.60	1.56	5.74	5.61	101.0	101.0	30.9	30.2
NanoNPK 1	1.84	1.81	0.51	0.49	1.75	1.74	7.89	7.70	107.3	107.8	45.2	44.2
NanoNPK 2	1.91	1.88	0.57	0.55	1.76	1.76	8.98	8.79	108.4	104.9	51.9	49.1
NanoNPK 3	1.88	1.85	0.55	0.53	1.75	1.74	8.76	8.64	106.2	97.2	49.6	44.7
LSD $_{0.05}$	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.4	1.3	0.2	0.5
Plant extracts (g L^{-1})												
C_0	1.70	1.69	0.47	0.45	1.68	1.65	7.12	6.85	102.5	99.3	39.2	36.6
N_1	1.77	1.73	0.51	0.49	1.71	1.70	7.59	7.42	101.9	99.5	41.5	39.4
N_2	1.74	1.71	0.49	0.46	1.69	1.68	7.62	7.44	99.9	98.3	40.9	39.1
GT_1	1.81	1.79	0.55	0.49	1.74	1.73	7.94	7.90	102.3	98.4	43.5	41.5
GT_2	1.83	1.81	0.59	0.57	1.76	1.74	8.14	8.07	102.4	98.1	44.8	42.3
LSD $_{0.05}$	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.4	NS	0.2	0.5

*C100% = ground addition to the recommendation chemical fertilizer, C50% = ground addition to half of the recommendation chemical fertilizer, Nano CS-NPK_1 = chitosan nanoparticles loaded with NPK fertilizer at a concentration of 10%, Nano CS-NPK_2 = chitosan nanoparticles loaded with fertilizer NPK at a concentration of 15%, Nano CS-NPK_3=chitosan nanoparticles loaded with NPK fertilizer 20%, C0 = control treatment (spray with distilled water only), N1 = 25g L^{-1} nettle leaf extract, N2 = 35g L^{-1} nettle leaf extract, GT1 = Green tea extract at a concentration of 2g L^{-1}, GT2 = green tea extract at a concentration of 4g L^{-1}

Table 4. Effect of the interaction between spraying with chitosan nanoparticles loaded with NPK fertilizer nettle leaf extract, and green tea extract on the chemical and yield traits of potato plant planted in the spring and autumn seasons 2021

Interaction	% leaves N		P		K		No. of tubers (tuber. plant^{-1})		Weight of tuber(g.tuber^{-1})		Productivity (ton ha^{-1})	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
$C_{100\%}$ C_0	1.57	1.54	0.44	0.43	1.66	1.64	6.34	6.08	92.3	76.8	31.2	24.9
$C_{100\%}$ N_1	1.63	1.62	0.47	0.45	1.72	1.71	7.10	7.02	84.2	83.0	31.9	31.1
$C_{100\%}$ N_2	1.61	1.61	0.45	0.43	1.70	1.69	7.14	7.13	83.3	83.1	31.7	31.6
$C_{100\%}$ GT_1	1.66	1.64	0.55	0.52	1.74	1.73	7.22	7.19	84.4	85.1	32.5	32.6
$C_{100\%}$ GT_2	1.69	1.67	0.57	0.57	1.76	1.75	7.36	7.28	86.2	85.2	33.8	33.0
$C_{50\%}$ C_0	1.54	1.48	0.43	0.40	1.57	1.50	5.21	5.13	98.0	99.3	27.2	27.1
$C_{50\%}$ N_1	1.57	1.55	0.46	0.43	1.55	1.53	5.48	5.28	104.0	105.0	30.4	29.6
$C_{50\%}$ N_2	1.55	1.53	0.44	0.41	1.53	1.52	5.82	5.49	96.8	98.4	30.0	28.8
$C_{50\%}$ GT_1	1.64	1.63	0.53	0.50	1.65	1.63	5.78	5.86	106.5	103.2	32.8	32.3
$C_{50\%}$ GT_2	1.67	1.65	0.56	0.54	1.68	1.64	6.43	6.30	99.8	99.3	34.2	33.3
$NanoNPK_1$ C_0	1.76	1.78	0.46	0.44	1.70	1.67	7.60	6.94	106.7	112.7	43.3	41.7
$NanoNPK_1$ N_1	1.85	1.76	0.47	0.47	1.75	1.74	7.91	7.64	104.2	106.0	43.9	43.2
$NanoNPK_1$ N_2	1.83	1.72	0.47	0.46	1.74	1.73	7.94	7.89	107.5	105.1	45.6	44.2
$NanoNPK_1$ GT_1	1.87	1.88	0.55	0.53	1.77	1.76	7.97	8.00	108.7	106.8	46.2	45.6
$NanoNPK_1$ GT_2	1.88	1.90	0.57	0.56	1.78	1.77	8.03	8.02	109.3	108.4	46.8	46.4
$NanoNPK_2$ C_0	1.84	1.82	0.53	0.51	1.73	1.73	8.14	8.07	110.9	108.8	48.1	46.8
$NanoNPK_2$ N_1	1.93	1.87	0.56	0.55	1.76	1.76	8.96	8.92	110.2	103.4	52.6	49.1
$NanoNPK_2$ N_2	1.88	1.85	0.55	0.52	1.73	1.74	8.87	8.34	104.1	106.3	49.3	47.3
$NanoNPK_2$ GT_1	1.95	1.92	0.59	0.57	1.78	1.77	9.40	9.23	105.9	102.7	53.1	50.6
$NanoNPK_2$ GT_2	1.97	1.95	0.62	0.60	1.79	1.78	9.51	9.39	111.0	103.1	56.3	51.6
$NanoNPK_3$ C_0	1.81	1.80	0.51	0.49	1.72	1.71	8.30	8.02	104.8	98.6	46.4	42.2
$NanoNPK_3$ N_1	1.87	1.86	0.55	0.52	1.75	1.74	8.49	8.26	106.8	100.1	48.4	44.1
$NanoNPK_3$ N_2	1.85	1.82	0.54	0.49	1.73	1.72	8.35	8.33	107.6	98.3	47.9	43.7
$NanoNPK_3$ GT_1	1.92	1.87	0.57	0.55	1.76	1.75	9.31	9.23	106.1	94.3	52.7	46.4
$NanoNPK_3$ GT_2	1.95	1.91	0.59	0.58	1.77	1.76	9.36	9.36	105.7	94.5	52.8	47.2
L.S.D $_{0.05}$	N.S	0.04	0.03	N.S	0.05	0.05	0.04	0.10	0.9	2.8	0.3	1.1

REFERENCES

1. Abd-Alrahman, H.A. and F.S. Aboud. 2021. Response of sweet pepper plants to foliar application of compost tea and dry yeast under soilless conditions. Bulletin of the National Research Centre.45:119.

2. Abdel-Aziz, H.M.M.; M.N.A. Hasaneen and A.M. Omer. 2018. Effect of foliar application of Nano chitosan NPK fertilizer on the chemical composition of wheat grains. Egyptian Journal of Botany. 58(1):87-95.

3. Abdulraheem S. M. and J. I. Estefo. 2018. Effect of seeds, leaves, and roots extract plants on growth and yield of pea. Tikrit Journal for Agricultural Sciences. 18 (2): 60 – 67.

4. Abdulrasool, I. J. ., and Al-Malikshah, Z. R. J. 2022. Effect of Adding Fulzyme plus and Spraying with Green Tea Extract on Vegetative Growth and Yield of Pepper cv. California Wonder. Basrah Journal of Agricultural Sciences, 35(2), 302–312. https://doi.org/10.37077/25200860.2022.35.2.23

5. Adisa, I.O.; V.L.R. Pullagurala; J.R. Peralta-Videa; Ch.O. Dimkpa; W.H. Elmer; J.L. Gardea-Torresdey and J.C.White. 2019.'Recent advances in nano-enabled fertilizers and pesticides:A critical review of mechanisms of action', Environmental Science: Nano. 6 (7): 2002 -2030

6. Al-Dulaimi,N.,H.,A and N.,J.,K.,Al-Amri .2020. Impact of *Conocarpus erectus* L. fertilizer, and some micronutrients on growth and production of potato. Iraqi Journal of Agricultural Sciences 51(3):865-873 https://doi.org/10.36103/ijas.v51i3.1041

7. Al-Dulaimi,N.,H.,A and N.,J.,K.,Al-Amri .2020. Stimulation growth and yield of potato by buttonwood pruning residues and spraying several micronutrients. Iraqi Journal of Agricultural Sciences 51(4) : 1048-1057. https://doi.org/10.36103/ijas.v51i4.1083

8. Al-Gebory, K. D. H. and A. M. H. Al-Khafagy. 2011. Effects of some organic fertilizers on growth, productivity and leaf content from N, P, and K elements of onion plant. Kufa Journal for Agricultural Science, 3(1):47-55

9. AL- Khadimy , N. A. S. 2021. Effect of NPK fertilizers application to the soil and foliar application of conventional and Nano-NPK on fertilizer efficiencies and potato yield. Ph. D. Dissertation, Agriculture Engineering Sciences, University of Baghdad. pp: 102.

10. Al-Khafaji, A. M. H. H. and K. D. H. Al-jubouri. 2022. Influence of aqueous extract of barley sprouts, trehalose, and calcium on growth, quality and yield of carrot. Iraqi Journal of Agricultural Sciences, 53(1): 133-140. https://doi.org/10.36103/ijas.v53i1.1517

11. Al-Khafaji, A. M. H. H. and K. D. H. Al-jubouri. 2022. Maximization carrot minerals preserve and antioxidant capacity by foliar application of aqueous barley sprouts extract, trehalose, and calcium. Iraqi Journal of Agricultural Sciences, 53(1):122-132. https://doi.org/10.36103/ijas.v53i1.1515

12. Al-Khafaji, A. M. H. H. and K. D. H. Al-Jubouri. 2022. Enhancing growth and production of carrot plant by spraying aqueous barley sprouts extract, trehalose, and calcium. Journal of Kerbala for Agricultural Sciences, 9(4): 134-144. https://doi.org/10.59658/jkas.v9i4.1069

13. Al-Khafaji, A. M. H. H., and K. D. H. Al-Jubouri. 2023. Upgrading growth, yield, and folate levels of lettuce via salicylic acid and spirulina, vermicompost aqueous extracts, 54(1):235-241. https://doi.org/10.36103/ijas.v54i1.1696

14. Al-Khafaji, A. M. H. H., N. J. K. Al-Amri, and N. H. A. Al-Dulaimi. 2022. Growth, yield, and antioxidant traits of different parts of beetroot as affected by vermicompost and glutathione. Iraqi Journal of Agricultural Sciences, 53(5): 1107-1114. https://doi.org/10.36103/ijas.v53i5.1623

15. Al-Khafagy, A. M. H. and K. D. H. Al-Gebory. 2010. Influences of fertilizers and organic nutrients on growth and seed yield of onion. Diyala Journal of Agricultural Sciences. 2 (2): 64 – 84

16. AL Mohammadi, S. M. and F.H. AL Mohammadi . 2012. Statistics and Experimental Design. Dar Osama for publication and distribution / Amman, Jordan. pp. 376.

17. Al-Issawi, A. K. H. 2015. Effect of praying with Some Growth Regulators, Amino Acids and Chemical fertilizers on growth and production of potato *Solanum tuberosum* L. cv. Burren . M.Sc.thesis. College of Agriculture – Al Anbar University. pp: 109

18. Al-Juthery, H.W.A. and E.H.O. Al-Maamouri. 2020. Effect of urea and Nano-nitrogen fertigation and foliar application of Nano-boron and molybdenum on some growth and yield parameters of potato. Al-Qadisiyah Journal For Agriculture Science. 10(1):253-263.
19. AL-Muhamadi O.H.M. and A. K. AL-Essawi. 2015. The spraying with some nutrients on potato plants *Solanum tuberosum* L.cv. Burren and its effect in growth and production. AL Anbar Journal of Agricultural Sciences, 13 (1): 362 -367
20. Al-Rubaie; A. H. S. and K. D. H. Al-Jubouri. 2023. Effect of tocopherol, trehalose and soil improvement in water productivity and industrial potatoes under water stress. Iraqi Journal of Agricultural Sciences, 54(4):979-995.
https://doi.org/10.36103/ijas.v54i4.1787
21. Al-Rubaie; A. H. S. and K. D. H. Al-Jubouri. 2023. Response of growth and yield of industrial potatoes to soil improvement and spraying with tocopherol and trehalose under water stress. Iraqi Journal of Agricultural Sciences, 54(4):963-978.
https://doi.org/10.36103/ijas.v54i4.1786
22. Al-Zebari,Y.I.; A.MS.Kahlel and S.Y.H. AL-Hamdany.2021. Response of four potato (*Solanum tuberosum* L.) varieties to four nano fertilizers. Earth and Environmental Science.761:012060.
23. Al-Zaidi, M. A. H. and M. A. H. Al-Jumaili. 2022. Impact safe nutrients in raising production and chemical contents of potato. Iraqi Journal of Agricultural Sciences, 53(6):1397-1406.
https://doi.org/10.36103/ijas.v53i6.1655
24. Barreca, D. 2021. Mechanisms of plant antioxidants action. Plants. 10(1):35.
25. Burhan, M.G. and S.A. AL-Hassan. 2019. Impact of nano NPK fertilizers to correlation between productivity, quality and flag leaf of some bread wheat varieties. Iraqi Journal of Agricultural Sciences. 50 (Special Issue):1-7.
26. Corradini, E., M. R. Moura, and L. H. Mattoso. 2010. A preliminary study of the incorporation of NPK fertilizer into chitosan nanoparticles. Express Polymer Letters 4: 509–515.
27. Dahshan, A.M.A.; H.E.M. Zaki; Y.M.M. Moustafa; Y. T. Abdel-Mageed and M. A. M.Hassan. 2018. Effect of some growth regulators and natural extracts on yield and quality of potato. Minia Journal of Agric. Res. and Develop. 38(2): 271-295.
28. Elshamy, M.T.; S.M. Elkhallal; Sh.M. Husseiny and K.Y. Farroh. 2019. Application of nano-chitosan NPK fertilizer on growth and productivity of potato plant. Journal of Scientific Research in Science. 36(1):424-441.
29. Garmendia, A.; M.D. Raigón; O. Marques; M. Ferriol; J. Royo and H. Merle. 2018. Effect of nettle slurry (*Urtica dioica* L.) used as foliar fertilizer on potato (*Solanum tuberosum* L.) yield and plant growth. Peer. Jour. 6: e4729.
30. Godlewska, K.; D. Ronga and I. Michalak . 2021. Plant extracts - importance in sustainable agriculture. Italian Journal of Agronomy.16:1851.
31. Jubeir, Sh.M. and W.A. Ahmed. 2019. Effect of nano fertilizers and application methods on vegetative growth and yield of date palm. Iraqi Journal of Agricultural Sciences. 50(1):267-274.
32. Márcia, R. de Moura., F. A. Aouada and L. H.C. Mattoso. 2008. Preparation of chitosan nanoparticles using methacrylic acid. Journal of Colloid and Interface Science 321: 477–483.
33. Maricic, B.; S. Radman; M. Romic; J. Perkovic; N. Major; B. Urlic; I. Palcic; D. Ban; Z. Zoric and S.G. Ban. 2021. Stinging nettle (*Urtica dioica* L.) as an aqueous plant-based extract fertilizer in green bean (*Phaseolus vulgaris* L.) Sustainable Agriculture.Sustainability.13:4042.
34. Nyawade, S.O.; N.N. Karanja; Ch.K. Gachene; H. I. Gitari; E. Schulte-Geldermann and M. Parker. 2020. Optimizing soil nitrogen balance in a potato cropping system through legume intercropping. Nutr Cycl Agroecosyst, 117: 43-59.
35. Rajasekar, M.; D.U. Nandhini and S. Suganthi. 2017. Supplementation of mineral nutrients through foliar spray-A Review. International Journal of Current Microbiology and Applied Sciences. 6(3):2504-2513.
36. Sadik, S.A. 2019. Production of nettle (*Urtica dioica)*, environmental and economic valuation in conventional farming. Master's thesis. Department of Economics and Management. Agricultural Economics. University of Helsinki. Fenland. pp: 58

37. Salman, A.D. and A.H. Abdulrazzaq. 2022. Effect of cultivation dates and different sources of soil fertilization on vegetative characteristics,quality and yield of broccoli. International Journal of Agricultural and Statistical Sciences.18 (1):165-171.

38. Salman, A. D., and E. J. Abdul Rasool. 2022. Effect of ozone enrichment and spraying with organic nutrient on nutrient and water use efficiency and fertilizer productivity of broccoli plant cultivated hydroponically with modified NFT technology. Iraqi Journal of Agricultural Sciences, 53(2):660-668. https://doi.org/10.36103/ijas.v53i3.1576

39. Salman, A. D., and E. J. Abdul Rasool. 2022. Effect of ozone enrichment and spraying with coconut water and moringa extract on vegetative growth and yield of broccoli plant under hydroponic system with modified NFT technology Iraqi Journal of Agricultural Sciences, 53(2):406-414. https://doi.org/10.36103/ijas.v53i2.1549

40. Salman, A. D. 2023. Effect of aqueous extracts of the sprouted seeds on the quantitative and qualitative yield of the coral lettuce cultured under the modified nutrient solution film NFT system. Revis Bionatura, 8 (2) 80. http://dx.doi.org/10.21931/RB/2023.08.02.80

41. Saaseea, K. G. and N. J. K. Al-a'amry. 2023. Effect of nitrogen, phosphorous and potassium levels on the productivity of industrial potatoes, Iraqi Journal of Agricultural Sciences, 54(6): 1726-1736. https://doi.org/10.36103/ijas.v54i6.1871

42. . Shaker, U. B., and I. J. Abdul rasool. 2023. Role of organic fertilizer and boron foliar application on growth and productivity of potato for processing Iraqi Journal of Agricultural Sciences, 54(5): 1478-1486. https://doi.org/10.36103/ijas.v54i5.1847

43. Turk, H.A.M. and R.M.A. AL-Ubiady. 2022. Effect of spraying with nano-elements and selenium under water stress conditions on vegetative traits and yield of tomato plants. Indian Journal of Ecology. 49(20):10-16.

44. Viotti, C.; K. Albrecht; S. Amaducci; P. Bardos; C. Bertheau; D. Blaudez; L. Bothe; D. Cazaux; A. Ferrarini; J. Govilas; H. Gusovius; T. Jeannin; C. Lühr; J. Müssig; M. Pilla; V. Placet; M. Puschenreiter; A. Tognacchini; L. Yung and M. Chalot . 2022. Nettle, a long-known fiber plant with new perspectives. Materials.15: 4288.

45. Zaccardelli, M.; C. Pane; D. Villecco; A. M.Palese and G. Celano. 2018. Compost tea spraying increases yield performance of pepper (*Capsicum annuum* L.) grown in greenhouse under organic farming system. Italian Journal of Agronomy. 13:991. page:229-234.

46. Zainaldeen, M. A. and I. J. Abdulrasool. 2017. Response growth and production of potato plant var. Rodolof for spraying with gibberellin and nutrients. Euphrates Journal of Agriculture Science. 9 (4):525 – 536.

47. Zainaldeen, M.A. and I.J. Abdulrasool. 2018. Effect of foliar application of gibberellin and nutrients on growth and yield of potato var.‘‘Burren”. Iraqi Journal of Agricultural Sciences. 49(2):279-287.

48. Zainaldeen, M. A. and I. J. Abdul Rasool. 2023. Response of growth and yield of true potato seed plants to foliar application with organic nutrients. Fifth International Conference for Agricultural and Environment Sciences IOP Conf. Ser.: Earth Environ. Sci. 1158 042047. DOI 10.1088/1755-1315/1158/4/042047