EFFECT OF FOLIAR APPLICATION WITH CALCIUM, MAGNESIUM AND FERTILIZING WITH HUMIC ACID ON GROWTH , YIELD, AND STORAGE ABILITY OF POTATO TUBERS.

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ABSTRACT

Two experiments were carried out, the first at the College of Agriculture - University of Baghdad during spring season 2017 Everest cv. class (Elite) was used to study the effect of foliar application of calcium and magnesium and addition of humic acid to the soil on potato growth and yield, The layout of the experiment was factorial within RCBD design using three replicates. Calcium and Magnesium sprayed with concentrations (0, 500, 1000 mg.L^{-1}), while the humic acid was added to the soil with (0, 0.75 gm.m^{2}), The second experiment included storage of tubers produced from the spring season, with to study the effect of field treatments on improving the storability of the tubers. The results showed that the treatment of calcium spray was superior a concentration of 1000 mg.L^{-1} in plant height, leaf area, weight of tuber, plant yield and protein % in tubers after storage and reduced the percentage of damaged in tubers stored by 1.57%. The magnesium spray treatment with 1000 mg. L^{-1} exceeded the number of leaves, leaf area, number of tubers per plant, plant yield, the accumulation of dry matter and the percentage of protein in the stored tubers. Humic acid with 0.75 gm.m^{2} was superior in the plant height , the tuber weight and the single plant yield , the concentration of dry matter and the protein percentage in the stored tubers produced. The interaction treatment (500 mg.L^{-1} calcium + 0.75 gm^{2} of Humic acid + 0 mg.L^{-1} of Mg) was superior in the single plant yield which 1.28 kg.plant^{-1}.

Keywords: ***Solanum tuberosum*** **L., weight loss, damage, microelements, foliar.**

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تأثير رش الكالسيوم والمغنيسيوم والتسميد بحامض الهيومك في النمو والحاصل والقابلية الخزنية لدرنات نباتات البطاطا.

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المستخلص

نفذت تجربتان، الأولى حقلية في كلية الزراعة– جامعة بغداد للموسم الربيعي 2017، استعمل فيها تقاوي البطاطا صنف ايفرست (EVEREST) رتبة Elite، بهدف دراسة تأثير رش الكالسيوم والمغنيسيوم وإضافة حامض الهيومك إلى التربة في نمو وحاصل البطاطا، نفذ البحث كتجربة عاملية (3×3×2) ضمن تصميم القطاعات الكاملة المعشاة بثلاثة مكررات رش الكالسيوم والمغنيسيوم بثلاثة تراكيز 0 و500 و1000 ملغم لتر$^{-1}$ وحامض الهيومك بمستويين 0 و0.75 غم م$^{-2}$. أما التجربة الثانية فتضمنت خزن درنات البطاطا المنتجة من العروة الربيعية لمعرفة تأثير المعاملات الحقلية أعلاه في تحسين القابلية الخزنية للدرنات. أظهرت النتائج تفوق معاملة رش الكالسيوم بتركيز 1000 ملغم لتر$^{-1}$ في زيادة ارتفاع النبات والمساحة الورقية ومعدل وزن الدرنة وحاصل النبات الواحد والنسبة المئوية للبروتين في الدرنات بعد الخزن وقللت النسبة المئوية للتلف في الدرنات المخزنة إلى 1.57%. وتفوقت معاملة رش المغنيسيوم بتركيز 1000 ملغم لتر$^{-1}$ في زيادة عدد الأوراق والمساحة الورقية ومتوسط عدد الدرنات في النبات وحاصل النبات الواحد وتركيز المادة الجافة والبروتين في الدرنات المخزونة. وتفوق حامض الهيومك بمعدل 0.75 غم م$^{-2}$ في زيادة ارتفاع النبات ومعدل وزنة الدرنة وحاصل النبات الواحد وتركيز المادة الجافة والبروتين في الدرنات المخزنة. وتفوقت معاملة التداخل 500 ملغم لتر$^{-1}$ كالسيوم + 0.75 غم م$^{-2}$ حامض هيومك + 0 ملغم لتر$^{-1}$ مغنيسيوم في زيادة حاصل النبات الواحد إلى 1.28 كغم نبات$^{-1}$.

كلمات دالة: *Solanum tuberosum* L.، الفقد بالوزن، التلف، العناصر الصغرى، الرش.

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INTRODUCTION

Potato crop (*Solanum tuberosum* L.) is one of the most important vegetable crops in the world with the second stage after the grain crops and it is agood and cheap source of energy. It plays an important role in the food security of many countries of the world (7). Several studies were carried out to improve the growth of potato plants to increase its production per unit area, sachas using many types of fertilizers, which is an important to ensure the crop need of nutrients, but excessive use led to a decrease in the quality of the crop and pollution of the surface and groundwater which causes' a negative effect on the global climate (23), Calcium is an essential element of plant growth, the two processes of cell division and elongation require this element . Calcium also enters in the middle lamella structure in the cellular as calcium bactate. Also, it contribute in phosphatidic acid formation which enters in the composition of cell membranes and improving its effectiveness and its various activities (13). Calcium increases vegetative growth of potato such as plant height and number of leaves (11), as well as its role in improving quality characters of the tubers especially protecting the tubers from damaged during storage period (24). Potato crop consumed large amounts of calcium when compared to other elements such as nitrogen, phosphorus, potassium and magnesium (12). Magnesium is one of the essential elements in plant nutrition because of its significant influence in the process of carbon representation as the magnesium ion occupies the center of the molecule of chlorophyll. Chlorophyll contains 2.7% of magnesium is an essential component, and helps in the formation of many organic compounds such as sugars, fats and oils (14). Huber and Jones, (15) found that plant nutrition with magnesium increases its resistance to many diseases by increasing the resistance of its tissues to degradation by enzymes. Humic acids are a group of humic substances extracted from the soil by alkaline solutions and some other solvents as a dark brown solutions that play an important role in soil fertility and plant nutrition (17), and help to increase nutrient availability (18) . Abu-Zinada and Sekh-Eleid (2) showed that the mineral fertilizer used could be reduced to 50% by the use $20kg.ha^{-1}$. Also adding this fertilizer to the soil led to reduce the loss of nitrogen fertilizers (10). This study aims to estimation the possibility of improving the growth and productivity of potato plants and improving the storability by spraying it with calcium and magnesium and adding the humic acid to the soil.

MATERIALS AND METHODS

Field experiment was carried out at the research station of the College of Agriculture, University of Baghdad- Al-Jadreya in spring season 2017, to study the effect of foliar application with different concentrations of calcium(0, 500, 1000), magnesium(0, 500, 1000) and the addition two levels of humic acid to the soil on growth(0, 0.75 g. m^{-2}), production and storability of potato tubers c v. Everest (Class Elite), which certified by the Ministry of Agriculture, Tillage, preparation and leveling were performed. A factorial experiment within RCBD and three replications were used. Each replicate content of 18 experimental units (treatments). Tubers were planted in plots with dimensions 2.5 m length and 1 m width. The experimental unit was planted with 20 tuber, 10 tubers at each side of the plot, with a depth of 10 - 12 cm and the distances between tubers 0.25 m. Calcium and magnesium elements was sprayed at the vegetative stage with three times, the first spray after 40 days of planting, second and third application was after 40 days between then. The addition of the humic to the soil was done in three time, the first after 40 days of planting and two weeks between every addition and other. The granular humic acid of each experimental unit was dissolved in 5 liters of water and added manually by a water jug to the plots to ensure that all plants received the fertilizer evenly. The humic acid composition shows in Table 1. Data was analysed using analysis of vceriance and the means compared by least significant differences (LSD) with level (0.05)(6).

Storage Experiment: A storage experiment was carried out with the production of field experiments using the same design that used in the field experiment by taking a randomized sample of tubers (5 kg) after the drying process and packaged with meshed plastic bags and stored at a temperature of 4 ± 2 ° C and humidity 85-90% until the end of the storage period (90 days from harvesting).

Studied characters

The length of the plant (cm) was measured by measuring the length of the plant stem in the end of the season from the contact area of the stem with the soil to the top of the plants, selected randomly. Number of the leaves per plant (leaf.plant^{-1}) in the selected plants. The leaf area of the plant was measured using the Digimizer program(20). The weight mean of the tuber calculated by dividing total weight of tubers of experimental unit on number of total tubers, the number of tubers per plant calculated by diving the total tubers of experimental unite on number of plants per experimental unite. The single plant yield (kg.plant^{-1}) calculated by diving total yield of experimental unite on number of plants per experimental unite. The percentage of dry matter in tubers after storage was calculated according to the following equation: % dry matter = (dry weight of tubers / wet weight) x 100. The Protein percentage was calculated In the tubers after storage based on wet weight as follows: Percentage of protein based on wet weight = (percentage of protein based on dry weight X percentage of dry matter) / 100. The percentage of protein based on dry weight in tubers = % nitrogen in tubers X 6.25 (9). The microbial damage after storage was calculated according to the following equation: Percentage of microbial damage = (weight of damaged tubers / total weight of treatment) × 100 (22). The weight loss% was calculated according to the following equation: Percentage of weight loss = (Weight of treatment at the beginning of storage – treatment weight at the end storage) / (weight of treatment at the beginning of storage) × 100 (3).

RESULTS AND DISCUSSION

Plant height (cm): Results in Table 2 shows significant superiority plants of the Ca_2 treatment which led to increasing the height of the plant to 113.85 cm while the plants at control produced the lowest plant height, (110.57 cm). Magnesium Mg_1 plants produced the highest plant height (113.89 cm), while the control had 110.44 cm, The H_1 plants gave the heights plant, (113.72 cm) while control gave a minimum height 111.22 cm. The interaction H_1Ca_1 had highest plant height 114.30 cm compared to the control, which gave a minimum value 108.26 cm. The combination H_1Mg_2 recorded the highest plant height (114.26 cm), while the control plants, produced lowest plant height (108.22 cm). The treatment of Ca_2Mg_2 had the highest plant height (116.61 cm). In the case of the third order interaction among calcium, magnesium and humic acid, had a significant effect on plant height. The treatment $H_0Ca_2Mg_2$ was significantly superior by increasing the plant height to (118.56 cm).

Number of leaves per plant (leaf.plant^{-1})

Results in Table 2 shows that the calcium spraying had a significant effect to the number of leaves plant^{-1}. Plants Ca_1 had the largest number of leaves plant^{-1} (43.37 leaf.plant^{-1}) while, the Ca_0 (control) gave the lowest number of leaves plant^{-1} (36.48 leaf.plant^{-1}). Plants Mg_2 produced the highest number of plant leaves (45.04 plant.leaf^{-1}), while the control lowest number (36.94 leaf.plant^{-1}) obtained from Mg_1 treatment, which did not differ significantly from the plants Mg_0. Results shows that the addition of humic acid resulted in a significant difference in the studied traits. The highest (41.09 leaf.plant^{-1}) obtained from plants H_0 compared to the lowest (38.41 leaf.plant^{-1}) from plants of the H_1. The treatment H_0Ca_1 led to increase in the number of leaves plant^{-1} to 45.74 . The treatment of H_1Ca_0 produced the lowest number of leaves plant^{-1} (36.37 leaf.plant^{-1}), the interaction treatment H_0Mg_2 leds to increase the number of leaves (49.04 leaf.plant^{-1}) compared to the treatment H_0Mg_1, which recorded the lowest (35.89 leaf plant^{-1}). The plants under Ca_1Mg_2 excelled by giving the highest value of leaves plant^{-1} (52.72 Leaf.plant^{-1}) while the control plants produced the lowes (34.50 leaf.plant^{-1}). The interaction $H_0Ca_1Mg_2$ had highest rate of leaves number plant^{-1} (60 leaves plant^{-1}) compared to the interaction treatment $H_0Ca_1Mg_1$, which gave the lowest value 33.22 leaf.plant^{-1}.

Leaf area of the plant (dm^2 plant $^{-1}$)

Results of Table 2 shows a significant increases in the leaf area of the potato plants using Ca_2. It was 132.17 dm^2 the plants order control produced 100.54 dm^2.plant^{-1}. The Mg_2

treatment had the highest leaf area (140.72 dm^2). The H_0Ca_2 increased the leaf area to 142.82 $dm^2.plant^{-1}$ compared to the treatment of H_0, which gave the lowest leaf area $plant^{-1}$ (99.22 dm^2). Plants at the H_0Mg_2 was superior in leaf area (154.77 $dm^2.plant^{-1}$). Third order interaction treatment $H_0Ca_1Mg_2$ produced the highest leaf area (178.17 $dm^2.plant^{-1}$) compared to the control treatment which gave the lowest leaf area (74.42 $dm^2.plant^{-1}$).

Weight of the tuber ($gm.tuber^{-1}$)

Table 3 shows that the plants at the Ca_2 produced the highest weight of tubers (123.18 $gm.tuber^{-1}$), but the control plants gave the lowest weight of tuber (107.25 $gm.tuber^{-1}$). Plants using Mg_1 or Mg_2 treatments had the highest tuber weight (116.62 and 116.44 $gm.tuber^{-1}$) respectively, while the lowest tuber weight obtained from the control which produced (112.23 $gm.tuber^{-1}$). The treatment H_1 produced the highest value of tuber weight (121.00 $gm.tuber^{-1}$) but the control plants (109.20 $gm.tuber^{-1}$). The second order interaction H_1Ca_2 exceeded by produced the highest value of tuber weight (128.61 $gm.tuber^{-1}$). Third order interaction ($H_1Ca_2Mg_1$) produced the heaviest weight of tuber (140.35 $gm.tuber^{-1}$).

Number of tubers per plant ($tuber.plant^{-1}$): Results of Table 3 indicates that the plants at the Ca_1 leds to significantly increases in number of tubers $plant^{-1}$, which gave 9.58 $tuber.plant^{-1}$ compared to the treatment of Ca_2 which produced the lowest number of tubers (8.98 $tuber.plant^{-1}$). Addition of humic acid resulted in a significant effect to the number of tubers (9.45 $tuber.plant^{-1}$) when treatment without humic acid produced (9.16 $tuber.plant^{-1}$ obtained). The second order interaction H_1Ca_1 produced the largest number of tubers (9.79 $tuber.plant^{-1}$),while the H_1Ca_2 had the lowest number of tubers $plant^{-1}$ (8.69 $tuber.plant^{-1}$). The plants at the Ca_1Mg_1 produced highest number of tubers (9.91 $tuber.plant^{-1}$) compared to the treatment of Ca_2Mg_1 which gave 8.54 $tuber.plant^{-1}$. The interaction of $H_1Ca_1Mg_1$ leads to significantly increases number of tubers $plant^{-1}$ (11.15 $tuber.plant^{-1}$) compared to the lowest number of tubers (8.32 tuber $plant^{-1}$) which obtained from the plants under interaction $H_0Ca_2Mg_1$.

Plant yield ($kg.plant^{-1}$): Results in Table 3 shows that the treatments of Ca_2 and Ca_1 were superior in plant yield and produced 1.10 $kg.plant^{-1}$. The Mg_2 treatment produced plant yield (1.10 $kg.plant^{-1}$) compared to the control which had 1.03 $kg.plant^{-1}$. The addition of humic acid increased the plant yield (1.10 kg $plant^{-1}$) compared to the control which produced the lowest plant yield (1.03 $kg.plant^{-1}$). The treatment of H_1Ca_1 was superior in highest yield (1.16 $kg.plant^{-1}$). Compared to the control plants gave the lowest yield (0.97 $kg.plant^{-1}$). The interaction treatment of H_1Mg_1 gave highest plant yield was 1.14 $kg.plant^{-1}$, while the control gave the lowest plant yield (1.00 $kg.plant^{-1}$). The interaction Ca_2Mg_2 and Ca_2Mg_1 gave the highest values (1.12 $kg.plant^{-1}$) for both of them, while the control produced the lowest plant yield (0.91 $kg.plant^{-1}$). The third order interaction $H_1Ca_1Mg_0$ had the highest plant yield (1.28 $kg.plant^{-1}$).

Dry matter percentage in tubers after storage (%): Results in Table 4 shows that the Ca_1 leads to increases in the percentage of dry matter in the stored tubers to 18.75% compared to the control which had 17.38%. The Mg_2 achieved the highest percentage (18.49%) compared to the Mg_1 which gave the lowest percentage (17.43%). Application of humic acid leads to a significant increases in this percentage (18.38%) compared to the control which had (17.85%), the interaction H_1Ca_1 produced the highest (19.24%), while the control had (16.95%), The H_1Mg_2 produced (19.17%) compared to treatment H_1Mg_1 which gave the lowest (17.32%). The treatment of Ca_2Mg_0 recorded the highest percentage of dry matter (19.35%) compared to the control which gave the lowest percentage (16.72%). The third interaction $H_0Ca_2Mg_0$ leads to increase the percentage of dry matter to 20.19%.

Protein percentage in tubers after storage

Results in Table 4 shows that the best treatment was Ca_2 with the highest percentage of protein in tubers after storage which gave 1.42% compared to control which produced the lowest (1.23%). The treatment Mg_2 exceeded by giving the highest value reached 1.42% compared to the treatment Mg_1 which gave the lowest percentage 1.30% , The highest percentage of 1.47% which obtained from humic compared to the control, using produced the lowest (1.23%). The treatment of H_1Ca_1 and H_1Ca_2 gave 1.53% and 1.51%, respectively compared with the lowest value 1.12% which obtained from control. The H_1Mg_2 gave 1.57% which was higher than H_0Mg_1 and gave 1.21%. The interaction Ca_2Mg_2 gave highest percentage (1.51%), compared to control which gave the lowest percentage 1.20%. The third order interaction had $H_1Ca_2Mg_2$ and $H_1Ca_1Mg_2$ highest percentage of protein in the tubers reached 1.65% and 1.64%, respectively, compared to 1.03% which obtained from control plants.

Damage percentage in stored tubers

Results in Table 5 shows that the plants order Ca_2 caused decrease, the percentage of damage in the stored tubers to 1.57%, compared to the control treatment which produced 2.70%. The plants Mg_2 produced the lowest damage rate in stored tubers of 1.79% compared to the treatment of the control which gave the highest percentage of damage (2.53%). Addition of humic acid was superior by decreases percentage of damage in stored tubers to 1.81% compared to control which gave 2.45%. The treatment of H_1Ca_2 decreased damage percentage of tubers to 1.38% compared to the control which gave the highest percentage of damage (3.22%). The treatment of H_1Mg_2 was superior by decrease tubers damage percentage to 1.57% compared to the control which gave 3.06% , The second order interaction (Ca_2Mg_2) decreased the damage tubers percent to 1.44% compared to control which increases (3.78%). The interaction of $H_1Ca_2Mg_1$ gave the lowest damage rate (1.22%) compared with the control treatment which gave the highest damage rate 4.75%.

Percentage of weight loss in stored tubers

Results in Table 5 shows that the treatment of Ca_1 decreased the percentage of weight loss in the stored tubers to 4.14% compared to the control which gave highest percent of weight loss (5.43%). The treatment of Mg_2 exceeded by gave the percentage of weight loss reached 4.35% compared to control treatment which gave 5.39%, The H_1 gave the lowest percent was 4.56% compared to the control which gave 5.01%. The treatment of H_0Ca_1 gave the lowest weight loss rate 3.98% compared to the control with the highest loss of weight in the stored tubers reached 5.90%. The treatment H_1Mg_2 gave the lowest weight loss percent 4.12% % compared to control treatment which gave the highest percent (5.69%). The treatment Ca_1Mg_2 had the lowest percent (3.75%) compared to control which had the highest percentage of lost (6.64%). The third order interaction $H_0Ca_1Mg_2$ achieved lowest percent in weight loss was 3.42% compared to control which gave the highest percentage (7.76%). The reason of the increase in the indices of vegetative growth characters when foliar application with calcium may be due to its importance in growth, because the acquisition of cellular division and elongation of cells requires this element, and it has a role in the process of photosynthesis and increase the accumulation of carbohydrates, which leads to improve the vegetative growth of plants (16 , 4). The increase in the vegetative growth characters of plants when foliar application with magnesium is attributed to its main role in the plant's biological activities. It enters in the formation of the chlorophyll molecule and helps in the formation of other pigments such as carotene and zanthophyll and activates a number of enzymes and coenzymes that contribute to carbohydrate metabolism and this leads to increase of vegetative growth (5, 19). The increase in the character of vegetative growth when adding humic acid to the soil can be attributed to the role of humic acid in increasing cellular division and cell elongation and its effect on many of the plant's biological processes such as respiration, carbonation and protein synthesis, as well as its role in increasing the nutrient availability which in turn leads to an increase of vegetative growth of plants (8, 25). The reason of the increase in quantitative and quality traits when foliar application with calcium may be due to the role of calcium in increasing vegetative character (Table 2), which in turn leads to an increase in the process of photosynthesis and the accumulation of carbohydrate. Calcium transfers the products of photosynthesis from the places of manufacture in the leaves to the places stored in the tubers (sinks) and other parts of the plant, which is reflected positively on the yield and its quantity and quality, and may be due to magnesium role in the activation of photosynthesis processes in the plant, such as carbon representation respiration and creation of carbohydrates in the leaves and moving to the tubers, which contributes to increasing the total yield per plant and total yield and improving quality characters. The increase in quantitative and qualitative characters when fertilizing by addition of humic acid to the soil may be due to the supply of plants with significant amounts of nutrients as well as the improvement of physical, chemical and biological character of the soil, increasing the soil's ability to retain moisture and reducing the and improve their ventilation and increase the activity of microorganisms, which increases the availability of nutrients and their absorption by the plant root and the positive reflection on the yield quantity (1, 21). The reason of the reduction in the percentage of damage and weight loss of stored tubers when spraying calcium and magnesium may be due to the role of these elements in strengthening the cell wall. Magnesium oxide with calcium bactate is involved in the adhesion of cellulose fiber when building the cellular wall, thus increasing its resistance to damage and thus reducing weight loss (13), or perhaps because the nutrition of plants with magnesium and calcium improve the nutritional status of plants by increasing the products of photosynthesis and their accumulation in the plant and its transfer to storage places in the tubers, which improves its storability and reduce the percentage of damage and thus reduces the percentage of lost weight. It may be due to the reduction of damage and loss of weight when adding the humic acid to its high content of potassium (5) who shows that the nutrition of plants in potassium increases its resistance to disease, especially fungal and bacterial diseases by activating many enzymes and its contribution to the construction of proteins and carbohydrates which are necessary to metabolic reactions, also it increases the strength of the cell wall and protection it from being penetrated by pathogens.

Table 1. Components of the humic acid

No	%	%
1	Moisture	10-12
2	Water Solubility	99.8
3	Potassium Humate	85
4	Water-soluble K_2O	11
5	Water insoluble common compounds	>0.1
6	Dry substances	88-90
7	N	0.8
8	Fe	1
9	Other materials	15
10	Cation-exchange capacity (CEC)	<400 Meg $100g^{-1}$

Table 2. Effect of foliar application with calcium, magnesium and fertilizing with humic acid on vegetative growth of potato

Treatments		Plant height (cm)				Number of leaves (leaf.plant^{-1})				Leaf area (dm^2.plant^{-1})			
		Mg_0	Mg_1	Mg_2	H*Ca	Mg_0	Mg_1	Mg_2	H*Ca	Mg_0	Mg_1	Mg_2	H*Ca
	Ca_0	101.22	112.11	111.44	108.26	35.33	33.45	41	36.59	74.42	101.73	121.51	99.22
H_0	Ca_1	113.11	116.22	105.67	111.67	44	33.22	60	45.74	104.67	110.28	178.17	131.04
	Ca_2	110.33	112.33	118.56	113.74	35.67	41	46.11	40.92	121.34	142.5	164.62	142.82
	Ca_0	110.78	114	113.89	112.89	33.67	36.78	38.67	36.37	97.6	101.34	106.61	101.85
H_1	Ca_1	112.45	116.22	114.22	114.3	35	42.56	45.44	41	108.1	123.73	136.89	122.91
	Ca_2	114.78	112.44	114.67	113.96	39.89	34.67	39	37.85	119.64	108.36	136.55	121.52
L.S.D 0.05			6.12		3.54		3.19		1.84		9.52		5.50
Ca_0		106	113.06	112.67	110.57	34.5	35.11	39.83	36.48	86.01	101.53	114.06	100.54
Ca_1		112.78	116.22	109.94	112.98	39.5	37.89	52.72	43.37	106.38	117.01	157.53	126.97
Ca_2		112.56	112.39	116.61	113.85	37.78	37.83	42.55	39.39	120.49	125.43	150.58	132.17
L.S.D 0.05			4.33		2.50		2.25		1.30		6.73		3.89
H_0		108.22	113.55	111.89	111.22	38.33	35.89	49.04	41.09	100.14	118.17	154.77	124.36
H_1		112.67	114.22	114.26	113.72	36.19	38	41.04	38.41	108.45	111.14	126.68	115.42
L.S.D 0.05			3.54		2.04		1.84		1.06		5.50		3.17
Mg		110.44	113.89	113.07		37.26	36.94	45.04		104.3	114.66	140.72	
L.S.D 0.05			2.50				1.30				3.89		

Table 3. Effect of foliar application with calcium, magnesium and fertilizing with humic acid on single plant and its components

treatments		Tuber weight (gm.tuber^{-1})				Number of tubers per plant (tuber.plant^{-1})				Single pant yield (kg.plant^{-1})			
		Mg_0	Mg_1	Mg_2	H*Ca	Mg_0	Mg_1	Mg_2	H*Ca	Mg_0	Mg_1	Mg_2	H*Ca
	Ca_0	98.44	98.89	102.49	99.94	9.13	10.08	9.93	9.72	0.90	0.99	1.02	0.97
H_0	Ca_1	102.91	115.00	111.86	109.92	9.27	8.67	10.15	9.36	0.95	1.00	1.13	1.03
	Ca_2	119.84	120.21	113.18	117.74	9.52	8.32	9.97	9.27	1.13	1.00	1.13	1.09
	Ca_0	101.60	122.35	119.72	114.56	9.15	8.43	9.37	8.98	0.93	1.03	1.12	1.03
H_1	Ca_1	132.57	102.93	123.97	119.82	9.62	11.15	8.62	9.79	1.28	1.15	1.07	1.16
	Ca_2	118.05	140.35	127.44	128.61	8.57	8.77	8.75	8.69	1.01	1.23	1.11	1.12
L.S.D 0.05			6.00		3.47		0.61		0.35		0.08		0.05
Ca_0		100.02	110.62	111.10	107.25	9.14	9.26	9.65	9.35	0.91	1.01	1.07	1.00
Ca_1		117.74	108.97	117.91	114.87	9.44	9.91	9.38	9.58	1.11	1.07	1.10	1.10
Ca_2		118.94	130.28	120.31	123.18	9.04	8.54	9.36	8.98	1.07	1.12	1.12	1.10
L.S.D 0.05			4.24		2.45		0.43		0.25		0.06		0.03
H_0		107.06	111.37	109.17	109.20	9.31	9.02	10.02	9.45	1.00	1.00	1.09	1.03
H_1		117.41	121.88	123.71	121.00	9.11	9.45	8.91	9.16	1.07	1.14	1.10	1.10
L.S.D 0.05			3.47		2.00		0.35		0.20		0.05		0.02
Mg		112.23	116.62	116.44		9.21	9.24	9.46		1.03	1.07	1.10	
L.S.D 0.05			2.45				n. s				0.03		

Table 4. Effect of foliar application with calcium, magnesium and fertilizing with humic acid on quality of tubers after storage

treatments		% of dry matter in tubers after storage				% of protein in tubers after storage			
		Mg_0	Mg_1	Mg_2	H*Ca	Mg_0	Mg_1	Mg_2	H*Ca
	Ca_0	16.16	17.53	17.15	16.95	1.03	1.16	1.15	1.12
H_0	Ca_1	18.25	18.35	18.18	18.26	1.22	1.25	1.29	1.25
	Ca_2	20.19	16.77	18.11	18.36	1.40	1.22	1.37	1.33
	Ca_0	18.26	16.79	18.40	17.81	1.37	1.28	1.42	1.35
H_1	Ca_1	19.23	18.51	19.97	19.24	1.49	1.47	1.64	1.53
	Ca_2	18.51	16.66	19.14	18.10	1.50	1.40	1.65	1.51
L.S.D 0.05			1.06		0.61		0.08		0.05
Ca_0		17.21	17.16	17.77	17.38	1.20	1.22	1.29	1.23
Ca_1		18.74	18.43	19.08	18.75	1.35	1.36	1.46	1.39
Ca_2		19.35	16.72	18.63	18.23	1.45	1.31	1.51	1.42
L.S.D 0.05			0.75		0.43		0.06		0.03
H_0		18.20	17.55	17.81	17.85	1.22	1.21	1.27	1.23
H_1		18.66	17.32	19.17	18.38	1.45	1.38	1.57	1.47
L.S.D 0.05			0.61		0.35		0.05		0.03
Mg		18.43	17.43	18.49		1.33	1.30	1.42	
L.S.D 0.05			0.43				0.03		

Table5. Effect of foliar application with calcium, magnesium and fertilizing with humic acid on percentage of damage and weight loss after storage

treatments		% of damage in stored tubers				% of weight loss in stored weight			
		Mg_0	Mg_1	Mg_2	H*Ca	Mg_0	Mg_1	Mg_2	H*Ca
H_0	Ca_0	4.75	2.78	2.11	3.22	7.76	4.91	5.05	5.90
	Ca_1	2.49	2.29	2.39	2.39	3.79	4.73	3.42	3.98
	Ca_2	1.93	1.79	1.55	1.75	5.51	4.63	5.28	5.14
H_1	Ca_0	2.81	2.47	1.29	2.19	5.52	4.95	4.39	4.96
	Ca_1	1.62	1.92	2.09	1.88	4.60	4.20	4.09	4.30
	Ca_2	1.58	1.22	1.32	1.38	5.17	4.28	3.87	4.44
L.S.D 0.05			0.18		0.11		0.97		0.56
Ca_0		3.78	2.63	1.70	2.70	6.64	4.93	4.72	5.43
Ca_1		2.06	2.10	2.24	2.13	4.19	4.47	3.75	4.14
Ca_2		1.75	1.51	1.44	1.57	5.34	4.45	4.58	4.79
L.S.D 0.05			0.13		0.07		0.68		0.39
H_0		3.06	2.29	2.02	2.45	5.69	4.75	4.58	5.01
H_1		2.00	1.87	1.57	1.81	5.10	4.48	4.12	4.56
L.S.D 0.05			0.11		0.06		0.56		0.32
Mg		2.53	2.08	1.79		5.39	4.62	4.35	
L.S.D 0.05			0.07				0.39		

REFERENCES

1. Abow EL- Maged, M. M.; A. M. El-Bassiony and Z. F. Fawzy .2006. Effect of organic manure with or without chemical fertilizer on growth quality of some varieties of broccoli plants. J. Appl. Sci. Res. 2(10): 791- 798

2. Abu-Zinada, I. A. ; K. S. Sekh-Eleid. 2015. Humic Acid to decrease fertilization rate on potato (*Solanum tuberosum* L.) American Journal of Agriculture and Forestry. 3(5): 234-238

3. Al-Dhubaebi, M. H. M. S. 2000. Effect of Spraying with Maleic Hydrazide, Micronutrients and Storage Methods in Improving the *alum cepa* L. M. Sc. Thesis - Department of Horticulture - College of Agriculture - University of Baghdad. pp: 122

4.Alhatib, A. A. 2007. Soil Fertility and Fertilization Basics. College of Agriculture. Alexandria University. Daralkutub for Publishing. pp: 509

5.Alnaimi, S. N. 2011. Principles of Plant Nutrition. Ministry of Higher Education and Scientific Research. University of Al Mosul. College of Agriculture and Forestry. pp: 1440

6. Al-Rawi, K. M. and A. Khalaf Allah. 2000. Design and Analysis of Agricultural Experiments. University of Al Mosul. college of Agriculture and Forestry. Iraq. pp: 488

7. Alsayed, S. F. 2009. Production of Cold Season Vegetables in Desert Lands. College of Agriculture - Cairo University. Egyptian Library for Printing and Publishing. pp: 783

8. Alwan, J. M. and R. I. A. Al-Hamdani. 2012. Organic Agriculture and Environment. College of Agriculture and Forestry - University of Mosul. pp: 273

9. Alzahawi, S.M.A. 2007. Effect of Various Organic Fertilizers and Soil Coverage in the Growth, Production and Quality of Potatoes. M. Sc. Thesis. College of Agriculture - University of Baghdad. pp: 88

10. Chen, X. ; M. Kou; Z. Tang; A. Zhang and H. Li .2017. The use of humic acid urea fertilizer for increasing yield and utilization of

nitrogen in sweet potato . Plant Soil Environ. 63(5): 201–206.
11. Chowdhury, R. S. 2017. Effect of Calcium, Magnesium, Sulphur, Zinc and Boron on Growth and Yield of Potato(cv. Kufri Jyoti). Thesis submitted. Uttar Banga Krishi Viswavidyalaya. pp:1- 88
12. Fiţ, E. M. and M. C. Hangan. 2010. The effect of differential fertilization upon desirée and ostara potatos production on districambosol soil. Research Journal of Agricultural Science, 42(3), 137-142
13. Hassan, A. A. 2016. Fertilization of Vegetable Crops 1st ed. Series of Technology and Physiology of Vegetables. College of Agriculture - Cairo University. Daralkutub for Publishing. pp: 601
14. Havlin, J. L.;J. D. Beaton;S. L.Tisdale and W. L. Nelson. 2005. Soil Fertility and Fertilizers: 7th ed. An Interoductionon Nutrient Management .New jersey. pp: 205
15. Huber, D. M. and J. B. Jones. 2013. The role of magnesium in plant disease. Plant and Soil, 368(1-2), 73-85.
16. Kafi, M.; W. S. Stewart and A. M. Borland. 2003. Carbohydrate and Proline contents in leaves, roots and apices of salt-tolerant and salt sensitive wheat cultivars (*Triticum aestivum*). Russian Journal of Plant Physiology, 50(20): 155-162
17. Nebbioso, A.; G. Vinci; M. Drosos; R. Spaccini and A. Piccolo. 2015. Unveiling the molecular composition of the unextractable soil organic fraction (humin) by humeomics. Biology and fertility of soils, 51(4), 443-451
18. Ouni, Y.; T. Ghnayaa; F. Montemurro; C. Abdellya and A. Lakhdara. 2014. The role of humic substances in mitigating the harmful effects of soil salinity and improve plant productivity. Int. J. Plant Prod. 8, 353–374
19. Rehm, G. 2008. Calcium and Magnesium : The Secondary Cousins . Article , University of Minnesota . pp: 1 – 7.
20. Sadik, S. K. ; A. A. AL-Taweel and N. S. Dhyeab. 2011. New computer program for estimating leaf area of several vegetable crops. American-Eurasian Journal of Sustainable Agriculture, 5(2):304-309
21. Selim, E. M.; A. A. Mosa and A. M. EL-Ghamry. 2009. Evaluation of humic substances fustigation through surface and subsurface drill irrigation systems on potato grown order Egyptian sandy soil conditions Agric. Water management. 96: 1218-1222
22. Taha, A. J. 1995. The Effect of fertilizing with Potassium, Calcium and Temperature on Improving the Storability of Garlic. M. Sc. Thesis. Department of Horticulture. College of Agriculture. Baghdad University. pp:137.
23. Tilman, D.; C. Balzer; J. Hill and B. L. Befort. 2011. Global food demand and the sustainable intensification of agriculture. Proceedings of the National Academy of Sciences, 108(50), 20260-20264
24. Waterer, D. 2005. Calcium Nutrition of Potatoes, Problems and Potential Solutions. Manitoba Agri.pp: 1-3
25. Zandonadi, D.; L. Canells and A. Facanha. 2007. Indolacetic and humic acids induce lateral root development through a concerted plasmalemma and tonoplast H+ pumps activation. Planta, 225(6), 1583-1595.