University of Thi-Qar Journal of agricultural research
Thi-Qar Journal of agricultural research
ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226

Response of potato varieties (*Solanum tuberosum* L.) to foliar application of calcium, magnesium and humic acid

Rawafid H. AL-Obaidi
Department of Field Crops, College of Agriculture, University of Basrah, Iraq.
E-mail: rawafid.qasim@uobasrah.edu.iq

Abstract

A field experiment was conducted in 2025-2026 during the autumn season at the farm of Al-Faris Station, located 25 km southwest of Basrah Province / Al-Zubair District, Iraq, in a sandy loam soil, to study the effect of foliar spraying with four combinations of calcium and magnesium fertilizers (0, 2g L^{-1} $MgSO_4$, 4g L^{-1} Ca $(NO_3)_2$ and 4g L^{-1} Ca $(NO_3)_2$ + 2g L^{-1} $MgSO_4$) and three concentrations of humic acid (0,2,and 4gL^{-1}) on growth , yield and quality of three varieties of potato, (Burren, Almonda and Arnova) .In a Randomized Complete Block Design (R.C.B.D.) with three replications, the split plots arrangement was used. The results showed that the variety Almonda was superior in the tuber yield with averages of 33.36 Mg h^{-1}.Fertilization treatment (4g L^{-1} Ca $(NO_3)_2$ + 2g L^{-1} $MgSO_4$) gave the highest tuber yield reached 35.55 Mg ha^{-1}.Also Spraying humic acid(2 gL^{-1}) achieved the highest tuber yield (33.97 Mg h^{-1}). The interaction between the study factors showed a significant advantage in most of the studied traits, The interaction Almonda variety when treated with 2,and 4gL^{-1} of humic acid and 4g L^{-1} Ca $(NO_3)_2$ + 2g L^{-1} $MgSO_4$ gave the maximum yield reached 39.78 Mg ha^{-1}.

Keywords : ***potato , calcium, magnesium, humic acid, chlorophyll content, yield, starch***

I. Introduction

The potato crop (*Solanum tuberosum* L.) is one of the world's greatest vegetable crops for its high nutritional content and vital role in human food security (Zhang *et al.*, 2017). Potatoes are a healthy food that is low in energy but high in starch, vitamins and antioxidants such flavonoids, carotenoids, phenolic acids, and protein (Mehdi *et al.*, 2008). According to data, Iraq produced 189.40 thousand tons of potatoes in the spring and fall of 2024 on an estimated 33 thousand dunum of land, with an average production of 5742.20 kilograms per dunum (Directorate of Agricultural Statistics,2024). Foliar nutrition management is considered an effective agricultural process because it gives nutrients direct to plant tissues, increases nutrient uptake efficiency, and decreases losses caused by soil application. Calcium is not only necessary for structural strength ,it is in charge of several vital plant processes, such as the activation of enzymes involved in photosynthesis, energy transfer, nutrient uptake and regulates cell elongation, which is essential for the growth of long roots that ensure plants can get enough nutrients, also serves as a messenger molecule, balancing negative ions within the cell and encouraging regular communication among plant cells (White and Broadley,2003). Singh *et al.,* (2024) found that spraying with calcium nitrate and magnesium sulfate at a concentration of 2% improved growth characteristics and yield for two potato varieties and severe magnesium deficiency can reduce the yield of tubers up to 15%. Magnesium is another crucial ingredient in the production of potatoes, it is an essential mineral element for photosynthesis because it is as a key component of chlorophyll forms the center of chlorophyll and regulates numerous activities linked to photosynthesis and the synthesis of assimilates in plants. (Chen *et al.,* 2018), its absence has a detrimental impact on the culinary qualities of potatoes and stunts their growth and development (Gerendás and Führs ,2013) . One organic fertilizer that is safe for the environment is humic acid because chemical fertilizers have a negative effect on both the environment and the health of people (Hartwigson and Evans,2000). Humic acid used directly can increase plant metabolism, enhance its ability to absorb nutrients, and improve its resistance to environmental stress, all of which lead to improved vegetative growth and higher

production .El-Sayed Hameda *et al*., (2011) found that the application of humic acid improved the vegetative traits, tuber weight and quantity, other study also show that foliar spraying Potato with humic acid increased the yield by 33.38% when compared to a control. Foliar application of humic acid can stimulate plant metabolism, improve nutrient absorption, and enhance tolerance to environmental stress, which ultimately contributes to better vegetative growth and increased yield (Man-hong *et al*.,2020).
In order to improve crop productivity and quality under local environmental conditions, this study is to evaluate the impact of foliar spraying with calcium, magnesium, and humic acid on the growth and yield of various potato cultivars.

II.Materials and Methods

The experiment was laid out in 2025-2026 during the autumn season at the farm of Al-Faris Station, located 25 km southwest of Basra Province / Al-Zubair District, Iraq, (longitude 47°.42` East and latitude 30°.23` North) in a sandy loam soil its results are shown in Table (1), The main objective is to study effect of foliar spraying with four combinations of calcium and magnesium: Control(F0) , $MgSO_4$ 2g L^{-1} (F1), $Ca(NO_3)_2$ 4g L^{-1}(F2) and Ca $(NO_3)_2$ 4g L^{-1}+ $MgSO_4$ 2g L^{-1} (F3), and three concentrations of humic acid:control (H0), 2gL^{-1}(H2) and 4gL^{-1}(H1) on the growth , yield and quality of three varieties of potato, (Burren(V1), Almonda (V2) and Arnova (V3).In a Randomized Complete Block Design (R.C.B.D.) with three replications, the split plots arrangement was used. A total of 108 (3×4×3*3) experimental units. After the tubers were planted at a depth of 10–12 cm, a 20 cm covering of field soil was applied to the plants. NPK 20-20-20 compound fertilizer was added at a rate of 300 kg dunam^{-1} (Matloub *et al.,* 1989). The tubers were planted whole as an autumn crop on 1st/October, the harvesting was carried out on 15th/February/ 2026. Magnesium, calcium, and humic acid were sprayed on the plants in two stages: once 45 days after they sprouted, and again 15 days later. Many traits were studied, total chlorophyll content**,** plant height, stem number plant^{-1}, tuber weight, number of tubers per plant, plant yield, total yield of tubers, and some qualitative characteristics of tubers including the percentage of dry matter (%) (A.O.A.C.,1970), starch content (%) according to Nourian *et al*., (2003) . The data was statistically analyzed using the GenStat program, at a 0.05 probability level, the least significant differences (L.S.D) test was used between the means of the components and their interactions (Al-Rawi and Khalafallah, 2000).

Table (1) Some Analytical properties of the soil

Soil properties	
E.C 1:1	6.86 d S.m-¹
pH	7.19
Available N	25.20 mg kg-¹
Available P (mg kg-¹)	5.70 mg kg-¹
Available K (mg kg-¹)	111.90 mg kg-¹
Organic matter	0.54%
Sand	80.99%
Loam	11.87%
Clay	7.14%
Soil texture	Sandy loam

III. Results and discussion

Total chlorophyll content (mg g^{-1}) :

The content of chlorophyll in leaves differs significantly by humic acid , fertilizer concentrations and all interactions except the varieties and the interaction between varieties and fertilizers (Table 2). The high concentration of humic acid (H2) had a higher value (55.88mg g^{-1}) at par with H1(53.56 mg g^{-1}), while the control(H0) had the lowest value (46.26mg g^{-1}). This is due to the role of humic acid in

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.9858

Table 2. Effect of Humic acid and Ca, Mg on total chlorophyll content of leaves ($mg\ g^{-1}$) of potato varieties

Humic acid $g\ L^{-1}$	Fertilizers $g\ L^{-1}$	Varieties V1	V2	V3	H×F
H0	F0	38.27	46.23	41.07	41.86
	F1	44.81	44.73	47.39	45.64
	F2	45.92	47.85	50.57	48.11
	F3	51.12	48.31	48.17	49.20
H1	F0	50.81	49.97	42.89	47.89
	F1	55.84	51.73	54.27	53.95
	F2	53.51	56.20	49.78	53.16
	F3	55.43	50.17	51.72	52.44
H2	F0	52.63	60.11	52.91	55.22
	F1	59.00	55.82	52.88	55.90
	F2	55.41	56.75	57.71	56.62
	F3	50.73	61.93	53.65	55.44
Mean V		51.12	52.48	50.25	
		V1	V2	V3	Mean F
V × F	F0	47.22	52.09	45.63	48.31
	F1	53.21	50.78	51.17	51.72
	F2	51.63	53.58	52.69	52.63
	F3	52.42	53.49	49.82	51.91
		V1	V2	V3	Mean H
	H0	45.02	45.66	48.11	46.26
	H1	53.89	53.61	53.17	53.56
	H2	54.43	55.90	54.31	55.88

LSD P≤ 0.05	V	F	H	V × H	V×F	H×F	V×F×H
	NS	3.374	4.123	5.487	NS	6.425	9.973

promoting the absorption of nutrients, especially nitrogen, iron and magnesium, which are essential for the formation of chlorophyll (Ferrara and Brunetti,2010). Spraying with calcium and magnesium (F2) achieved the highest chlorophyll content (52.63 $mg\ g^{-1}$) at par with F2nd F4, while the control (F0), gave the lowest(48.31 $mg\ g^{-1}$) .Calcium supports photosynthetic activity and membrane stability, whereas magnesium is a structural element of the chlorophyll molecule. Thus, these nutrients can be applied directly to improve chlorophyll production (Chowdhury ,2017). The highest chlorophyll content (55.90mg g^{-1}) was produced by V2×H2 while the lowest was found by V1×H0 (45.02 $mg\ g^{-1}$), As for the interaction between humic and fertilizer concentrations, H2 ×F2 gave the highest value(56.62 $mg\ g^{-1}$), while the lowest was achieved in H0×F0 (41.86 $mg\ g^{-1}$). The interaction V2×H2×F3 gave the highest chlorophyll content reaching 61.93 $mg\ g^{-1}$, it did not differ significantly from most combinations at high concentrations of humic acid and fertilizers for both varieties V1 and V2, on the other hand the lowest chlorophyll content was found in V1×H0×F0 interaction, reaching 38.27 mg^{-1}.

Plant height (cm)

The results of Table 3 clearly show that plant height was significantly influenced by varieties, humic acid spraying, Ca and Mg concentrations, and their interactions. With an average plant height of 65.41 cm, variety V2 excelled the other varieties, while V3 had the lowest plant height (59.38 cm). Genetic variables that regulate hormone activity, growth pattern, and internode length, as well as each variety's reaction to the environment and its strategy for allocating nutrients between vegetative development

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.9858

and tuber formation, may be the main cause of the variation in height among potato varieties (Zhao *et al.*,2023). This result conforms to the findings of Al-Sahaf *et al.* (2018), Hussain *et al.* (2019), and Al-Obaidi and Abelwaheed (2021). The results of table 3 also showed that foliar application of humic acid (H2) led to an increase in plant height by an average of 67.06cm, while the treatment(H0) gave 58.38cm. Because humic acid includes cyclic phenolic compounds that have an action similar to that of plant hormones, it has a greater ability to stimulate growth by accelerating plant cell division and elongation, which raises the plants height (Nardi *et al*.,2016).

Table 3 shows that treatment F3 achieved the highest plant height of 64.88 cm, at par with F2 (62.70cm), compared to treatment F0, which recorded the lowest height of 57. 62cm.By improving cell division and cell wall development, increasing chlorophyll synthesis and photosynthetic efficiency, and encouraging nutrient uptake and vegetative growth, foliar application of calcium and magnesium can increase plant height (Mengel and Kirkby, 2002; Taiz *et al.*, 2015).

The interaction between fertilizers and humic acid was also found to have significant effects on plant height. Interaction showed that H2×F3 performed better and resulted in the highest plant height (73.21cm) However, H0×F0 produced the shortest plant height (53.21cm). As for the dual interaction between the varieties and the fertilizer, Table 2 shows that the combination V1×F3 achieved the highest plant height with an average of 71.49 cm, while the combination V3×F0 gave the lowest plant height with an average of 54.42 cm. The results indicated that the interaction between variety V1 with H2 and recorded the highest average height of 68.98cm, at par with V2×H2 (68.54cm), while the interaction V3×H0 gave the lowest (55.28 cm). The interactionsV2×H2×F3 gave the maximum plant height reached 78.45 cm at par with V3×H2×F3(72.37cm) while the lowest average was recorded in V3×H0× F0 (48.63cm).

Table 3. The effect of Humic acid and Ca, Mg on plant height (cm) of potato varieties

Humic acid g L^{-1}	Fertilizers g L^{-1}	Varieties			H×F
		V1	V2	V3	
H0	F0	53.33	57.67	48.63	53.21
	F1	54.00	58.87	57.17	56.68
	F2	61.17	63.17	58.27	60.87
	F3	62.20	69.00	57.03	62.74
H1	F0	58.23	62.70	54.33	58.42
	F1	60.90	62.00	60.87	61.26
	F2	60.71	66.92	60.64	62.76
	F3	73.76	70.73	61.17	68.55
H2	F0	61.88	61.50	60.30	61.23
	F1	68.30	67.40	61.70	65.80
	F2	67.13	66.51	60.07	64.57
	F3	68.82	78.45	72.37	73.21
Mean V		62.54	65.41	59.38	
		V1	V2	V3	Mean F
V × F	F0	57.81	60.62	54.42	57.62
	F1	61.07	62.76	59.91	61.25
	F2	63.00	65.57	59.54	62.70
	F3	71.49	59.64	63.52	64.88
V × H		V1	V2	V3	Mean H
	H0	57.68	62.18	55.28	58.38
	H1	63.37	65.57	59.25	62.73

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 *https://doi.org/10.54174/utjagr.9858*

	H2		**68.98**	**68.54**	**63.67**		**67.06**
LSD≤0.05	**V**	**F**	**H**	**V × H**	**V×F**	**H×F**	**V×F×H**
	3.99	**2.63**	**2.35**	**5.83**	**5.41**	**4.29**	**8.72**

Number of branches (branch plant^{-1})

Results revealed that foliar application of humic acid, fertilizers of calcium and magnesium and all interactions had a significant effect on number of branches, whereas the varieties had no significant effect on this trait(Table 4).The highest concentration of humic acid (H2) gave the maximum number of branches (6.29 branch plant^{-1}) with no significant differences with H1 concentration (6.04 branch plant^{-1}), while the minimum branches were found in control (5.56 branch plant^{-1}). This may be due to the role of humic acid in stimulating cell elongation and division, which is reflected in improved plant growth, as well as increasing the chlorophyll content in the leaves and increasing plant height (Tables 2 and 3), which led to an increase in the number of branches. The same table revealed that the maximum number of branches recorded 6.88 branch plant^{-1} for the F3 concentration with an increased percentage 37.60% compared to the control which record the minimum number (5.00 branch plant^{-1}), This is for fertilizer spray has enhanced plant growth, and its high concentration was superior as it provides elements that enter numerous vital enzymes, increasing plant height (Table 3 and, consequently, the number of branches.

Table 4. The effect of Humic acid and Ca, Mg on number of branches (branch plant^{-1}) of potato varieties

Humic acid g L^{-1}	**Fertilizers g L^{-1}**	**Varieties**			**H×F**
		V1	**V2**	**V3**	
H0	**F0**	**4.13**	**4.41**	**5.43**	**4.66**
	F1	**5.90**	**5.34**	**5.00**	**5.41**
	F2	**6.16**	**4.87**	**5.63**	**5.55**
	F3	**6.43**	**6.70**	**5.77**	**6.30**
H1	**F0**	**4.87**	**5.53**	**4.91**	**5.10**
	F1	**6.27**	**5.67**	**5.46**	**5.80**
	F2	**5.97**	**6.51**	**6.11**	**6.20**
	F3	**6.83**	**7.12**	**6.93**	**6.96**
H2	**F0**	**6.33**	**5.43**	**6.21**	**5.99**
	F1	**5.76**	**7.16**	**4.63**	**5.85**
	F2	**5.34**	**6.51**	**6.37**	**6.07**
	F3	**7.15**	**8.48**	**6.07**	**7.23**
Mean V		**5.92**	**6.14**	**5.71**	
		V1	**V2**	**V3**	**Mean F**
V × F	**F0**	**5.11**	**5.44**	**4.47**	**5.00**
	F1	**5.98**	**6.03**	**5.01**	**5.67**
	F2	**5.92**	**5.91**	**6.04**	**5.96**
	F3	**6.81**	**7.56**	**6.26**	**6.88**
V × H		**5.55**	**6.03**	**6.29**	
		V1	**V2**	**V3**	**Mean H**
	H0	**5.66**	**5.57**	**5.44**	**5.56**
	H1	**5.98**	**6.30**	**5.83**	**6.04**
	H2	**6.21**	**6.83**	**5.82**	**6.29**

University of Thi-Qar Journal of agricultural research
Thi-Qar Journal of agricultural research
ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.9858

LSD≤0.05	V	F	H	V × H	V×F	H×F	V×F×H
	N .S	0.53	0.42	0.69	0. 90	0.86	1.52

The interaction H2 ×F3 gave the highest number branches (7.23 branch plant^{-1}) at par with H1 ×F3 (6.96 branch plant^{-1}) while the interaction of H0 × F0 gave the lowest (4.66 branch plant^{-1}) .The highest branches of plant was observed for the variety V2at F3 fertilizer concentration (7.56 branch plant^{-1}) at par with V1×F3 ,while the lowest was in the control treatment for the V3 variety(4.47 branch plant^{-1}).The data also show that the interactions V2× H2 produced the highest branches of 6.83 branch plant^{-1} with no significant differences with V1× H2 and V2 × H1, while, the interaction V3×H0 gave the lowest (5.44 branch plant^{-1}). The interactionsV2×H2×F3 andV1×D1×N3 gave the maximum (8.48 branch plant^{-1}), while the lowest average was recorded in V1×H0× F0 (4.13 branch plant^{-1})

The number of tubers (tuber plant^{-1})

The number of tubers per plant is significantly impacted by the foliar application of fertilizers and humic acid as well as all interactions. However, no significant effect was observed for the varieties (Table 5). The foliar spray treatment of humic acid(H2) showing the highest number of tubers reached 11.92 tuber plant^{-1}, compared to the lowest number appeared in the treatments H1 which gave 9.88 tuber plant^{-1}. This may be due to the role of humic acid in stimulating enzymatic reactions and activating vital processes, which increases the number of branches (Table 4) and consequently the number of tubers. An increase in the number of tubers per plant was reported with increasing concentrations of Ca and Mg (F3) reached 11.53 tuber plant-1 at par with F2(10.71 tuber plant^{-1}) comparison to control which gave 9.83 tuber plant-1. Increasing the number of branches in this treatment may have significantly affected the number of tubers. Significant interaction was found between the foliar spraying of humic acid with Ca and Mg concentrations (Table 5).

Table 5. The effect of Humic acid and Ca, Mg on the number of tubers (tuber plant^{-1}) of potato varieties

Humic acid g L^{-1}	Fertilizers g L^{-1}	Varieties			H×F
		V1	V2	V3	
H0	F0	10.67	8.70	9.13	9.50
	F1	9.17	9.57	10.38	9.71
	F2	9.53	11.52	9.47	10.17
	F3	10.27	12.10	11.40	11.26
H1	F0	8.81	8.97	10.33	9.37
	F1	8.10	10.23	10.62	9.65
	F2	10.00	11.12	9.54	10.22
	F3	10.15	11.36	9.47	10.33
H2	F0	11.27	11.82	8.83	10.64
	F1	11.92	13.30	11.73	12.32
	F2	13.74	12.62	9.81	12.06
	F3	14.00	12.71	12.14	12.95
Mean V		10.64	11.17	10.24	
		V1	V2	V3	Mean F
V × F	F0	10.24	9.83	9.43	9.83
	F1	9.17	11.03	11.06	10.42
	F2	10.76	11.77	9.59	10.71
	F3	11.42	12.14	11.02	11.53
V × H		V1	V2	V3	Mean H

University of Thi-Qar Journal of agricultural research
Thi-Qar Journal of agricultural research
ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.9858

	H0		**9.91**	**10.47**	**10.21**		**10.20**
	H1		**9.22**	**10.45**	**9.97**		**9.88**
	H2		**12.48**	**12.64**	**10.64**		**11.92**
LSD≤0.05	**V**	**F**	**H**	**V × H**	**V×F**	**H×F**	**V×F×H**
	N.S	**1.250**	**1.887**	**2.123**	**2.120**	**2.374**	**3.785**

The results indicated that Interaction H2 × F3 had the highest average number of tubers, reaching 12.95 tuber plant-[1] with no differences between the same concentration of humic with all concentrations of fertilizers whereas the lowest values were found by H1×F0 (9.37 tuber plant^{-1}). varieties x fertilizers interaction had a significant effect, V2 × F3 had the highest number of tubers reaching 12.14 tuber plant^{-1}, while the interaction V1 × F1 gave the lowest number (9.17 tuber plant^{-1}).The highest tubers per plant found in V2 variety treated with humic acid(H2) reached 12.64 tuber plant-1 ,In contrast, the interaction V1×H1 gave the lowest number of tubers (9.22 tuber plant^{-1}) at par with some interactions .The interactionsV1×H2×F3 excelled with the highest number of tubers, which reached 14.00 tuber plant^{-1}, and it did not differed significantly from many interactions compared to (V2 ×H0 × F0) which gave the lowest tuber number of 8.70 tuber plant^{-1} (Table 5).

Tubers weight (g)

Data presented in table 6 demonstrated that variety V2 was superior at the other cultivars which gave the highest tuber weight of 127.35g, while variety V1 gave the lowest 117.65 g. Genetic variation in photosynthetic efficiency and the distribution of photosynthetic products between the vegetative parts and the tubers are the main causes of the variance in tuber weight across varieties, incredibly probable that the V2 variety has a better genetic capacity to carry and store carbohydrates produced in the leaves more effectively, leading to bigger tubers. These findings are consistent with those published by, Shayaa and Hussien (2019) , Al-Obaidi and Abelwaheed (2021) .

Different humic acid concentrations have significant effects on the tubers weight reaching the highest rate of 126.13g When sprayed with H1 at par with H2(126.10g), While the treatment H0 gave the lowest weight 0f 111.93 g (Table 6). It could be due to the humic acid ability to supply and make available the necessary nutrients for improved plant growth and, consequently, an increase in the plant tuber weight (Yadava *et al.*,2024). Table 6 showed that the weight of plant tubers was significantly affected by the concentration of fertilizer applied. The highest values of weight of tubers were recorded with the highest fertilizer concentration of F3 and F2 (130.90 and 129.20g). On the other hand, the lowest weight of tubers was detected with the lowest concentration F0 (104.87g). This may be attributed to the fact that spraying the plants with calcium and magnesium led to an increase in several physiological processes within them, such as carbohydrate metabolism, which in turn led to an increase in tuber weight (Duwadi *et al.*,2022).

Table 6. The effect of Humic acid and Ca, Mg on tuber weight(g) of potato varieties

Humic acid g L^{-1}	**Fertilizer g L^{-1}**	**Varieties**			**H×F**
		V1	**V2**	**V3**	
H0	**F0**	**101.20**	**98.30**	**115.50**	**105.00**
	F1	**116.50**	**127.50**	**95.20**	**113.07**
	F2	**108.10**	**129.40**	**98.80**	**112.10**
	F3	**119.70**	**134.40**	**97.60**	**117.23**
H1	**F1**	**104.70**	**119.30**	**117.40**	**113.80**
	F2	**111.50**	**127.60**	**125.10**	**121.40**
	F3	**122.40**	**132.30**	**134.30**	**129.67**
	F4	**131.50**	**142.80**	**148.10**	**140.80**

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.9858

H2	F0	112.50	112.40	115.30	113.40
	F1	99.00	125.70	122.30	115.67
	F2	136.80	141.30	137.40	138.50
	F3	147.90	137.20	135.90	140.33
Mean V		117.65	127.35	120.24	
		V1	V2	V3	Mean F
V × F	F0	106.10	96.50	112.00	104.87
	F1	107.40	128.60	117.40	117.80
	F2	126.60	139.40	121.60	129.20
	F3	133.00	130.20	129.50	130.90
V × H					Mean H
	H0	111.40	123.60	100.80	111.93
	H1	128.20	125.90	124.30	126.13
	H2	126.90	132.40	119.00	126.10

LSD (P≤0.05)	V	F	H	V× H	V×F	H×F	V×F×H
	9.61	10.58	10.32	15.63	18.19	17.58	31.05

Table 6 data demonstrated that the interaction between various humic acid and fertilizer concentrations mostly affected the weight of potato tubers. The results showed that Interaction H1× F4 had the highest average tubers weight reaching 140.80g at par with the interactions H2×F2 and H2×F3, whereas the lowest values were found by H0 ×F0 (105.00g). Varieties that spraying with Ca &Mg fertilizers interaction had a significant effect(Table 6).The interaction V2 × F2 had the highest tuber weight reaching 139.40g at par with some interactions, while the interaction V2 × F0 gave the lowest number (96.50g).The highest tubers weight of plant found in V2 variety treated with humic acid (H2) reached 132.40g, whereas the interaction V3×H0 gave the lowest tuber weight (100.80g).The interaction V3×H1×F3 excelled with the highest tubers weight, which reached 148.10g, with no significant difference from most interactions, whereas the interaction (V3 ×H0 × F1) which gave the lowest (95.20g) .

Tuber yield (Mg ha^{-1})

Humic acid g L^{-1}	Fertilizer g L^{-1}	Varieties			H×F
		V1	V2	V3	
H0	F0	17.25	20.13	19.34	17.57
	F1	23.28	31.17	27.00	26.81
	F2	31.11	34.65	32.14	32.63
	F3	32.17	36.28	30.21	32.89
H1	F0	22.18	29.01	28.19	24.79
	F1	27.32	32.54	32.45	29.44
	F2	35.19	36.12	33.87	34.06
	F3	37.21	39.78	34.89	37.29
H2	F0	24.36	27.57	25.14	25.69
	F1	33.42	35.26	25.39	31.36
	F2	37.15	38.19	34.39	36.58
	F3	37.78	39.59	36.98	38.12
Mean V		29.87	33.36	30.00	
		V1	V2	V3	Mean F
V × F	F0	22.48	25.82	25.36	24.55
	F1	26.68	30.56	28.74	28.66
	F2	31.58	34.78	34.12	33.49
	F3	34.89	36.87	34.89	35.55

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.9858

V × H							**Mean H**
	H0		**24.36**	**25.54**	**27.13**		**25.68**
	H1		**28.81**	**33.87**	**29.32**		**30.67**
	H2		**33.03**	**36.32**	**32.56**		**33.97**
LSD≤0.05	**V**	**F**	**H**	**V× H**	**V×F**	**H×F**	**V×F×H**

The results in Table 7 indicate the significant effect of varieties, fertilizer, humic acid, and all interactions on this trait. Variety V2 achieved the highest tuber yield of 33.36 Mg ha^{-1}, increased by 11.68% compared to V1, which recorded the lowest average yield of 29.87 Mg ha^{-1}, The superiority of the V2 variety is due to its higher tuber weight and the variation in total potato yield among different varieties may be attributed to their genetic diversity and the resulting physiological .Spraying with humic acid (H2)resulted in an average increase in tuber yield of 33.97 Mg ha^{-1}, representing 32.44% increase over the control , which yielded a total yield of 25.68 Mg ha^{-1} (Table 6). Table 7 shows the superiority of treatment F3, achieving the highest total yield of 35.55Mg ha^{-1} at par with F2 and an increase of 44.81% over treatment F0, which gave the lowest yield of 24.55 Mg ha^{-1}.

Table 7. The effect of Humic acid and Ca, Mg on tuber yield (Mg ha^{-1}) of potato varieties

The increase in tuber yield when spraying with Ca and Mg, and humic acid fertilizers is attributed to their positive effects on yield components, the number of tubers and tuber weight (Tables 5 and 6), which is reflected positively in the increased yield. Interaction showed that H2×F3 resulted in the highest yield of tubers (38.12 Mg ha^{-1}) However, H0×F0 produced the lowest yield (17.57 Mg ha^{-1}).

As for the interaction between varieties and the fertilizers, table 7 shows that the combination V2×F3 achieved the highest tuber yield of 36.87 Mg ha^{-1}, while the combination V1×F0 gave the lowest yield (22.48 Mg ha^{-1}). The results indicated that the interaction between variety V2 with H2 recorded the highest yield of 36.32 Mg ha^{-1}, at par with some interactions, while the interaction V1×H0 gave the lowest (24.36 Mg ha^{-1}).

The interaction V2×H1×F3 gave the maximum yield, reaching 39.78 Mg ha^{-1}, while the lowest was found in V1×H0× F0 (17.25 Mg ha^{-1}).

Dry matter (%)

The results of table (8) showed that the varieties, spraying with fertilizers, humic acid and their interactions differed significantly in dry matter content of tubers, as the V2 variety gave the highest mean of 25.72%, while the V3 variety gave the lowest (22.39%). This may be attributed to the difference in the genetic variations of the varieties, in terms of the strength of vegetative growth, and the efficiency of starch deposition inside the tubers, which led to the accumulation of carbohydrates manufactured in the photosynthesis process, and their transfer to storage in the tubers, which increased the content of dry matter in the tubers (Hassan, 1999).

Table 8. The effect of Humic acid and Ca, Mg on Dry matter (%) of potato varieties

University of Thi-Qar Journal of agricultural research
Thi-Qar Journal of agricultural research
ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.9858

Humic acid g L^{-1}	Fertilizer g L^{-1}	Varieties V1	Varieties V2	Varieties V3	H×F
H0	F0	18.06	20.88	17.51	18.82
	F1	21.90	23.92	19.33	21.72
	F2	22.56	25.69	22.14	23.46
	F3	23.84	24.98	21.32	23.38
H1	F0	21.76	22.86	21.47	22.03
	F1	25.95	26.53	20.86	24.45
	F2	28.19	28.16	22.63	26.33
	F3	28.45	30.00	24.59	27.68
H2	F0	21.47	23.69	21.92	22.36
	F1	25.54	23.98	23.89	24.47
	F2	25.63	28.00	26.44	26.69
	F3	26.64	30.17	26.58	27.80
Mean V		24.17	25.72	22.39	
		V1	V2	V3	Mean F
V × F	F0	20.43	22,42	20.39	21.08
	F1	24.44	23.91	21.03	23.13
	F2	24.96	25.33	23.74	24.68
	F3	25.35	26.79	23.86	25.33
V × H					Mean H
	H0	19.89	22.46	23.06	21.80
	H1	23.17	24.42	25.23	24.27
	H2	22.85	25.95	24.70	24.50

LSD $P \leq 0.05$	V	F	H	V × H	V×F	H×F	V×F×H
	1.06	1.49	1.08	1.68	2.43	2.63	4.20

The data on dry matter content in tubers was also significantly improved by spraying with humic acid (Table 8).The maximum content was found with the concentration of H2 reached 24.50% at par with H1(24.27%),while non-sprayed treatment (H0) gave the lowest rate 21.80% .This is attributed to its role in improving nutrient absorption and stimulating plant physiological activity, which led to increased photosynthetic efficiency and the accumulation of carbohydrates and starch in tubers, and this was reflected in the high dry matter content(Yadava *et al.*,2024).

As the table 8 shows, treatment F3 was superior in terms of dry matter content in tubers, as it achieved the highest average of 25.33%, with an increase of 20.16% over treatment F0, which gave the lowest dry matter percentage in tubers of 21.08%. This is due to the role of both calcium and magnesium fertilizers in affecting many vital activities that take place within the plant, and thus is reflected in the amount of compounds manufactured in the leaves and the transfer of the excess of them to the tubers to become part of their dry matter.

The interaction H2×F3 gave the highest dry matter content (27.80%), while the interaction H0×F0 gave the lowest (18.82%) ,it is also clear from the results the interactions V2× F3, V1× F3 and V2× F2 achieved the highest dry matter content of 26.79 ,25.35 and 25.33% respectively with no differences between them , while V3×F0 gave the lowest value (20.39%). It is clear from the data of table 8 that the response of the varieties to the foliar application of humic acid differed significantly for dry matter content, as the interaction between the V2 ×H2 gave the highest dry matter content of 25.95%, and did not differ significantly from some interactions , while V1 ×H0 gave the lowest value of 19.89% .The interactionsV2×H2×F3 gave the maximum dry matter content (30.17%), with no differences with some interactions ,while the lowest value was found in V3×H0×F0 (17.51%).

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 *https://doi.org/10.54174/utjagr.9858*

Starch content %

The starch content in the potato tubers of varieties varied significantly (Table 9).The varietyV2 had the maximum total starch (19.17%) followed by V1 (17.80%), whereas variety V1had the lowest value of starch content in tuber (16.98%).The difference in starch content between potato varieties may be attributed to the fact that it is a polygenic trait, which affects how starch is synthesized and accumulated within the tuber and how these genes respond to the surrounding environmental conditions (Li *et al.,* 2024).According to Uppal (1999), the amount of starch was proportionate to the dry matter. Given that starch is primarily responsible for the dry matter composition of potato tubers (Dean and Thornton, 1992).It can be seen(Table 9) that the increase in calcium and magnesium fertilizer increased starch content, the highest content was produced by plants treated with high level of fertilizers (F2) at par with F3 reached 18.67 and 17.82% respectively ,while the least content was produced by the control treatment (16.56%).

Table 9. The effect of Humic acid and Ca, Mg on Starch (%) of potato varieties

Humic acid g L^{-1}	Fertilizer g L^{-1}	Varieties			H×F
		V1	V2	V3	
H0	F0	16.85	15.68	13.27	15.27
	F1	18.08	19.40	16.63	18.04
	F2	17.22	19.76	16.10	17.69
	F3	18.28	20.98	19.32	19.53
H1	F0	16.98	17.21	14.07	16.07
	F1	18.84	17.78	15.67	17.43
	F2	16.61	19.45	19.29	18.45
	F3	20.32	20.65	19.77	20.25
H2	F0	15.60	18.23	16.56	16.80
	F1	17.42	19.32	17.00	17.91
	F2	18.88	20.76	17.22	18.95
	F3	18.45	20.79	18.86	19.37
		17.80	19.17	16.98	
	Mean V	V1	V2	V3	Mean F
V × F	F0	16.48	18.33	14.86	16.56
	F1	18.12	18.89	16.45	17.82
	F2	18.91	19.00	18.11	18.67
	F3	19.45	19.67	18.98	18.37
V × H					Mean H
	H0	16.09	16.72	18.26	17.02
	H1	18.15	18.19	18.47	18.27
	H2	17.11	18.33	19.68	18.37

LSD P≤0.05	V	F	H	V × H	V×F	H×F	V×F×H
	0.81	1.29	N.S	1.95	2.07	2.43	3.77

Moreover, the humic acid had no significant effect on starch content. The interaction between H1×F3 was superior, as it gave the highest starch content of 20.25% at par with many interactions, compared with control treatment, which gave 17.25%.The interaction of varieties and fertilizers were significant, when treating V2 with F3, the starch content reached 19.67% at par with the most interactions, the lowest starch content at untreated V3 variety which gave 14.86%(Table 9).Also the same table indicated that the variety V3 when treated with humic concentration H2 gave the highest starch content of 19.68%compared V1×H0 which gave16.09%.the triple interaction between the treatments were significant, interaction V2×H2×F3 gave the highest starch content reaching 20.79%, compared with V3×H0×F0 which gave the lowest value reached 13.27%.

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 *https://doi.org/10.54174/utjagr.9858*

IV.Conclusion

Treatments with calcium nitrate, magnesium sulfate and humic acid had a major impact on potato growth ,yield parameters. It can be concluded that The Almonda variety can be successfully cultivated with spraying $4gL^{-1}$ of humic acid and $4g\ L^{-1}$ Ca $(NO3)_2$ + $2g\ L^{-1}$ $MgSO_4$ which might be regarded as the ideal concentrations to achieve the greatest growth , yield and quality.

V.References

A.O.A.C., (1970). Association of Official Analytical Chemists. Official Method of Analysis, 12th. End. Ed. Washington.1016.337.

Al-Obaidi ,R.H. and Abelwaheed, A. H.(2021). Evaluation of the response of five varieties of potato plant (*Solanum tuberosum* L.) For saline stress under the conditions of Basra, IOP Conf. Series: Earth and Environmental Science 761 , 012065 , doi:10.1088/1755-1315/761/1/012065

Al-Rawi, K. M. and Khalaf Allah, A. M. (2000). Design and Analysis of Agricultural Experiments. College of Agriculture and Forestry. University of Mosul – Iraq.

Al-Sahaf, F. H.; Al-Mharib, M. Z. and Mahmood, A. H. (2018). Growth and production of three potato cultivars as affected by organic foliar nutrition. Kufa J. Agric. Sci., 10(4): 12–25.

Chen ZC, Peng WT, Li J, Liao H (2018). Functional dissection and transport mechanism of magnesium in plants. Semin Cell Dev Biol 74:142–152.

Chowdhury, R.S. (2017). Effect of calcium, magnesium, Sulphur, zinc and boron on growth and yield of potato (cv.Kufri Jyoti). M.Sc. Thesis Uttar Banga Krishi Vishwavidyalaya, India.

Dean, B.B. & R.E. Thornton. 1992. The specific gravity of potatoes. Extension Bulletin 1541, Washington State University, Cooperative Extension, Pullman, W.A. Directorate of Agricultural Statistics. Ministry of Agriculture. Secondary Crops and Vegetable Production Report, Central Statistical Organization - Iraq, 2024.

Directorate of Agricultural Statistics. Ministry of Agriculture. Secondary Crops and Vegetable Production Report, Central Statistical Organization - Iraq, 2024.

Duwadi, A., Shrestha, A. K., & Pudasainy, D. P. (2022). Effect of foliar application of different nutrients on growth, yield, and quality of potato (*Solanum tuberosum* L.) in Sankhu, Kathmandu, Nepal. *Journal of Agriculture and Forestry University*, 61-69. https://n9.cl/9lrqyo

El-Sayed Hameda, E.A.; Saif-El-Dean A.; Ezzat ,S. & El-Morsy A.H.A.(2013). Responses of productivity and quality of sweet potato to phosphorus fertilizer rates and application methods of the humic acid. International Research Journal of Agricultural Science and Soil Science, 1(9): 383-393.

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.9858

Ferrara ,G. and Brunetti, G. (2010).Effects of the times of application of a soil humic acid on berry quality of the table grape (*Vitis vinifera* L.) Italia. Spanish J. of Agric.Res.8(3):817-822.

Gerendás, J.; Führs, H. (2013). The significance of magnesium for crop quality. Plant Soil, 368 : 101-128 .

Hartwigson, J.A., and Evans, M.R. Humic acid seed and substrate treatments promote seedling root development. Hort Sci., 35: 1231- 1233.

Hassan, A. A.(1999). Potato Production. Vegetable Crops Series: Production Technology and Advanced Agricultural Practices. First Edition, Arab Publishing House. Arab Republic of Egypt, P.P: 446

Hussain, S.; Rehman, A.; Hussain, M.; and Ali, M. (2019). Impact of cow manure compost on soil fertility and crop yield: A review. Journal of Environmental Science and Agriculture, 12(2): 45-53.

Li, H.; Brouwer, H.; Del Pup, E.; Lieshout , N.; Finkers ,R.; W.C ; Bachem ,B & Visser ,V. G. F.(2024). Allelic variation in the auto-tetraploid potato: genes involved in starch and steroidal glycoalkaloid metabolism as a case study. BMC Genomics, 1:24.

Man-hong,Y; Z. Lei, X. Sheng-tao, B. Neil, B; McLaughlin & L.Jing-hui (2020). Effect of water-soluble humic acid applied to potato foliage on plant growth, photosynthesis characteristics and fresh tuber yield under different water deficits. Sci Rep 10, 7854.

Matloub, Adnan Nasser; Sultan, Izz al-Din Muhammad; and Abdul, Karim Saleh (1989). *Vegetable Production*, Part II. Higher Education Press, University of Mosul, Republic of Iraq.

Mehdi, M.,; Saleem, T.; Rai, H.K.; Mir, M.S. and Rai, G. (2008). Effect of nitrogen and FYM interaction on yield and yield traits of potato genotypes under Ladakh condition. Potato J 35(3-4).

Mengel, K. and E. A. Kirkby (1982). Principles of plant nutrition. 3rd ed. Int. Potash. Inst. Bern Switzerland .

Nardi, S.; Pizzeghello, D.; Schiavon, M., and Ertani, A. (2016). Plant biostimulants: physiological responses induced by protein hydrolyzed-based products and humic substances in plant metabolism. Scientia Agricola, 73, 18-23.

Nourian, F., Ramaswamy, H. S., & Kushalappa, A. C. (2003). Kinetics of quality change associated with potatoes stored at different temperatures*. LWT - Food Science and Technology, 36(1), 49-65

Shayaa , A. H. ; & Hussien W. A. (2019) . Effect of the Neem leaves and extract and organic fertilizer in the production and quality of two Potato cultivars. Iraqi J. of Agri. Sci. , 50(1):275- 285.

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.9858

Singh, N; Sharma, R.; Kumar, D & Verma, J.(2024). Effect of calcium and magnesium nutrition on vegetative growth and tuber yield of potato (*Solanum tuberosum* L.) Environment Conservation Journal. 25 (1):144-155

Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). Plant Physiology and Development ,Sixth Edition, Sinauer Associates, Inc. Publishers Sunderland, Massachusetts U.S.A;P.888.

Uppal, D.S. 1999. Quality traits and chipping performance of newly released potato varieties. J. Indian Potato Assoc. 26:139-142.

White, P .J. and Broadley ,M.R.(2003). Calcium in Plants. Annals of Botany, 92,(4) : 487–511, https://doi.org/10.1093/aob/mcg164

Yadava, L. P., Singh, J., Srivastava, D., Singh, S. P., Mishra, P. K., & Singh, H. D. (2024). Effect of humic acid and vermicompost on growth and yield of potato (Solanum tuberosum L.) cv. Chipsona-1. Plant Archives.24(1) :93-100

Zhang, H.; Xu, F.; Wu, Y.; Hu, H.; Dai, X.(2017) .Progress of potato staple food research and industry development in China. J. Integr. Agric. 16(12): 2924-2932

Zhao,L.; Meiling Z.; Sirong, J.; Xiaorui, D.; Ke, D.; Tiancang, N.; Jian Wa.; Zhiqiang, X. and Fang W.(2023). Insights into the Genetic Determination of the Autotetraploid Potato Plant Height, Genes 2023, 14, 507:1-11.