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The effects of garlic extract, its application methods and their interaction on growth and yield of potato, *Solanum tuberosum* (L.) Cv. Latonia

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Abstract. The study was conducted in the growing season of 2012–2013 at Al Barjsya area, Al Zubair district, during the period from October 1st 2012 to February 5th 2013, to study the effect of garlic extract, its application methods and their interaction on growth and yield of potato, *Solanum tuberosum* (L.) Cv. Latonia. The experiment was designed according to Randomized Completely Block Design (R. C. B. D.) in a three factorial experiment of 12 treatments resulted from the interaction of: three levels for the first factor (the concentrations of aqueous extract of garlic), two levels for the second factor (the application methods of garlic extract) and three replicates for each experimental unit. The results showed that the garlic extract concentration (250 mL L^{-1}) was significantly better than (0 and 125 mL L^{-1}) for most studied characteristics, whether for vegetative growth or for yield (quantitatively and qualitatively), in exception, the dry matter percentage of leaves was non-significantly affected. For the application methods, it was of a significant effect for all studied characteristics, except for both the percentage of dry matter of each leaves and tubers, where the applying to soil method was significantly superior over the spraying method. For the interaction among the first factor and second factor treatments, the effect was significant mostly for all characteristics, except for the dry matter of each leaves and tubers of potato plants and the average of tuber weight, the effect was not significant.
Key Words: *Allium satvium*, applying to soil, spraying, vegetative growth, quantitative and qualitative yield.

Introduction. Potato *Solanum tuberosum* (L.) belongs to the genus *Solanum*, family *Solanaceae*, it is one of the most important vegetable crops in Iraq and all over the world, according to its productivity and planted area (Hawkes 1990). Also, it ranks fourth after wheat, rice and maize concerning the productivity and yield of protein per hectare, in the world (Wien 1997). The importance of this plant (potato) comes from being the cheapest source of starch, besides to its content of vitamin B and different mineral salts (Al Bahhash 2006). The production of potato may be affected by many external factors and the sum of these factors seems to effect the competition on the necessary products of photosynthesis among different sinks inside the plant, which one of them is the tuber primordia, then respectively effects the yield quantity and quality (Hasan et al 2002; Al Bahhash 2006). The garlic extract is the sap of garlic bulb *Allium satvium* (L.), which belongs to the family *Liliaceae*. It is distinguished by containing high amount of amino acids, which contain sulfur element, such as: Cysteine, Methionine (Synge 1971). As well, garlic contains the following materials: volatile oil, allicin, alliin, sugar, iodine and vitamins (Al Rawi & Chakravarty 1964). As mentioned by Abou Hussein et al (1975a,b), the garlic extract has many effects due to its hormonal (Auxin–Like) nature, which has an important role in lateral extension and elongation of cells.

So, because of the relationship between the improvement of quantitative and qualitative characteristics of plants and the external agricultural treatments, where one of these treatments is the application of garlic extract to potato plants (Cv. Latonia), this study was conducted to achieve the following aims:

1. The usage of natural and environment friendly matters, to increase the yield of potato quantitatively and qualitatively by treating the plants with the aqueous extract of garlic, which contains natural compounds and materials.
2. To study the range of quantitative increment of productivity, per area unit.

Material and Method

Location of the study. This study was conducted in the 2012 growing season during the Autumn farm loop at Al Barjsya area, Al Zubair District within the desert lands located at south-east of Basra province. Table 1 shows some physical and chemical properties of the field soil and irrigation water.

Table 1

Physical and chemical properties of the field soil and irrigation water*

Soil Properties		*Values*
Electrical conductivity (EC) (dS m^{-1})		4.67
Potential of hydrogen (pH)		8.07
Total nitrogen (g Kg^{-1})		0.34
Available phosphorous (mg Kg^{-1})		2.7
Organic matter (g Kg^{-1} soil)		0.43
Soil separate	Sand (%)	68
	Silt (%)	21
	Clay (%)	11
Soil Texture		Lomey sand soil
Irrigation water properties	Electrical conductivity (EC) (dS m^{-1})	7.9
	Potential of hydrogen (pH)	7.3

* Samples were analyzed at the laboratories of field crops department, College of Agriculture, University of Basra.

Table 2

Weekly averages of high and low temperature (°C), and the percentage of relative humidity during the season of experiment

Month	*Week*	*High temp. (°C)*	*Low temp. (°C)*	*Relative humidity (%)*
October	1st	41.3	22.9	31.2
	2nd	37.4	23.4	44.9
	3rd	36.2	20.0	36.7
	4th	34.8	19.7	38.5
November	1st	33.6	19.3	57.1
	2nd	33.1	17.1	57.8
	3rd	32.7	16.4	57.9
	4th	32.2	16.5	56.4
December	1st	31.8	17.1	55.9
	2nd	29.8	14.9	55.1
	3rd	22.4	14.7	63.2
	4th	20.6	12.6	61.7
January	1st	18.3	11.7	62.8
	2nd	18.1	9.5	70.2
	3rd	17.9	7.2	70.3
	4th	17.2	4.3	70.6

Agricultural procedures. The tubers (of 40–50 g weight) where planted on October 1st, 2012 after being stimulated for bud growth. The infected, mechanically damaged and big in size tubers where excluded. The planting was done inside 20 m lines, with a distance of 1 m between one line and another and a 30 cm between one planting hole and

another. The irrigation system used was the drip irrigation. All regular agricultural procedures were done in the field in order to product this crop, such as: irrigation, weeding, exporting as well as spraying the plants with protective sprays to control the diseases and insects, especially against early and late blight fungi, by using the fungicide (Intrakole) of (1.5 mL L^{-1}), and against biting insect by using the insecticide (Diaznone) of (1.5 mL L^{-1}), these procedures were done equally for all experimental units (Aboul Ees 2005). On January 25th, 2013, the irrigation had stopped for 10 days before harvesting, then a manual harvesting (hand pulled) was done for the whole field on February 2nd, 2013.

Preparation of the aqueous extract of garlic juice concentrations (0, 125 and 250 mL L^{-1}). Local garlic cultivar was used to prepare the nutrition solution, where the garlic bulb was dismantled into cloves, peeled, cut into small pieces, blended by electrical blender, then the juice was extracted to get 250 mL of garlic juice then mixed with 1 L of distilled water (D.W.), so the highest concentration of garlic extract was prepared and so done to prepare the 125 mL L^{-1} extract with 1 L D.W. in addition to 0 mL L^{-1} concentration (the control).

The chemical composition of the aqueous extract of garlic juice is displayed in Table 3.

Table 3

Important chemicals and minerals per 100 g of garlic juice*

Chemicals & minerals	*Rates*
Water	59.00 g
Calories	149.00 Kcal
Lipids	0.50 g
Carbohydrates	33.07 g
Fiber	2.10 g
Manganese (Mn)	1672.00 mg
Potassium (K)	401.00 mg
Sulphur (S)	70.00 mg
Calcium (Ca)	181.00 mg
Phosphorus (P)	153.00 mg
Magnesium (Mg)	25.00 mg
Sodium (Na)	17.00 mg
Vitamin B_6	1235.00 mg
Vitamin C	31.00 mg
Glutamic acid	0.805 g
Argenine	0.634 g
Aspartic acid	0.489 g
Leucine	0.308 g
Lysine	0.273 g

* http://www.botanical-online.com/medicinalsalliumsativumangles.htm

The date of applying the garlic extract. After 21 days from planting, the applying of the extract was started on October 22nd, 2012 in precise. Where both application methods (applying to soil and spraying the leaves methods) had started at the same dates, the applying was done three times in one week intervals.

Statistical design and analysis of the experiment. The experiment has been designed according to randomized completely block design (R.C.B.D.) as a factorial experiment in two factors represented by 18 factorial treatments (3 × 2 × 3). The first factor, the concentrations of aqueous extract of garlic it was of 3 levels (0, 125, and 250 mL L^{-1}). The second factor was the application methods, it was of 2 levels (applying to soil and spraying the leaves methods), and all levels (experimental units) were in three replicates. The data was analyzed by using the statistical program SPSS program. While for comparing the averages of treatments, the revised lower significant difference

(Revised L.S.D.) was used under 0.05 probability level, according to Al Rawi & Khalaf Allah (2000).

Vegetative growth characteristics. Ten plants were randomly chosen from each experimental unit, they were picked up from the middle (precisely) of each line, this action took place after 95 days from planting. The following indicators of vegetative growth were listed:

Plant height (cm). Measured from the stem – soil attachment point up to the developing top of each plant of the ten plants chosen.

Number of branches/plant. Accounted for the ten chosen plants above, after 95 days from planting, then their average was calculated.

Leaf area (cm^2). Measured according to Morsy & Noor Eddin (1970), where the fourth mature leaf (located near to the developing top of the plant) was cut and weighted by a sensitive balance. Then a limited area (5×5 cm) from this leaf was cut and weighted, thereafter the whole leaf (the 4^{th} leaf above) area was found from the relationship between the whole leaf weight and the limited area weight.

Percentage of dry matter of leaves (%). The 5^{th} leaf of the ten plants was taken from their developing tops, cleaned, weighted and put in an oven under 70°C for 48 h until the weight was stable, this weight was enlisted, then the percentage of the dry matter of leaf was calculated from this equation:

$$\text{Dry matter of leaves (\%)} = \frac{\text{Dry weight of leaves}}{\text{Fresh weight of leaves}} \times 100$$

The yield and its components

Tubers number/plant. Calculated as an average of tubers per one experimental unit divided by plants number in this unit (30 plants), which are planted at the middle of the line, where no samples were taken from both terminals (the begin and the end) of the line.

Average of tuber weight (g). Calculated from dividing the yield weight of one experimental unit by the number of tubers from this unit.

Productivity (ton $hectares^{-1}$). Estimated from dividing the yield of one experimental unit by the area unit.

Percentage of dry weight of tubers (%). Estimated by putting known weight of cut tubers, inside the oven under 70°C for 72 h until the weight become stable, then this percentage was calculated from:

$$\text{Dry matter of tubers (\%)} = \frac{\text{Dry weight of tubers}}{\text{Fresh weight of tubers}} \times 100$$

Percentage of starch in tubers (%). Measured by determination of the quantity of reduced sugars, using the reduced acid (3,5-dinitrosalsalic acid). According to Al Ogaidi (2002) from the following equation:

$$\text{Starch in tubers (\%)} = \text{(\%) Reduced sugar} \times 96$$

Percentage of total soluble solid (T.S.S.) of tubers (%). Measured in some drops of fruit juice, by using the hand refractometer (A.O.A.C 1980).

Results and Discussion

Effect of aqueous extract of garlic, its application methods and their interaction on some characteristics of vegetable growth. Vegetable growth is one of the most important indicators for biological action of plant, for it is the sum of the interaction between the environment and the genetic structure, which denote the field behavior of plant, then predict the yield (Al Marsoomy 1999).

Plant height (cm). The determination of plant height is an indicator of plant strength, this engenders either by increasing the length of phalanxes or by increasing the number of knots. Usually, the increment of vegetative growth leads to an increment of plant height, flowers number and finally the yield under suitable conditions for growth (Al Juboory 2001).

Table 4 show a significant effect of garlic extract in increasing the plant height with increasing the concentration of the extract, it was noted that the significant superiority was by using the 250 mL L^{-1}, which gave an average height of 38.78 cm, while the control plants gave the least height of 35.67 cm. These results are in accordance with those found by Hussein (2002), where the spraying of garlic extract (2.5 mL L^{-1}) on to the Biet Alpha hybrid cucumber plants gave a significant superiority to increase the plant height.

For the application methods of the garlic extract, it was noted that the applying to soil method was significantly better (38.45 cm) than the spraying one (36.44 cm). While for the interaction between the extract concentrations and their application methods, there was a significant superiority of the interaction treatment (250 mL L^{-1} extract with applying to soil method) of (40.23 cm), over the control plants (35.67 cm) with both methods, which it was of the least height among treatments, but the treatment (40.23 cm) was non-significantly differ from the rest of treatments.

Table 4

Effect of garlic extract, its application methods and their interaction on the potato plant height (cm)

Extract concentration (mL L^{-1})	*Application methods*		*Average of extract concentration*
	Spraying	*To soil*	
0	35.67	35.67	35.67
125	36.32	39.46	37.89
250	37.33	40.23	38.78
Application methods average	36.44	38.45	-
R.L.S.D. (0.05) for garlic extract concentration = 1.17	R.L.S.D. (0.05) for application methods = 1.91		R.L.S.D. (0.05) for interaction = 3.67

Number of branches/plant. Data in Table 5 indicated that there is no significant effect of garlic extract on this characteristic.

Table 5

Effect of garlic extract, its application methods and their interaction on the number of branches/plant in potato

Extract concentration (mL L^{-1})	*Application methods*		*Average of extract concentration*
	Spraying	*To soil*	
0	2.79	2.79	2.79
125	2.97	3.42	3.20
250	2.99	3.51	3.25
Application methods average	2.92	3.24	-
R.L.S.D. (0.05) for garlic extract concentration = N.S.	R.L.S.D. (0.05) for application methods = 0.11		R.L.S.D. (0.05) for interaction = 0.57

However, for the application method, it showed a significant superiority of applying to soil method (3.24 branch/plant) over spraying method (2.92 branch/plant). While the effect of interaction, it was noted that the interaction treatment (250 mL L^{-1}, with applying to soil method, of 3.51 branch/plant), significantly did not differ from all treatment except

the control plant with both methods of application of (2.79 branch/plant) it was significantly different, where the control was of the least number of branches.
The increasing results of branches due to the extract usage agree with Hussein (2002), it might be due to the content of auxin- like compounds in the extract (Table 3), reflected by the increasing characteristics of vegetative growth including branches of the plant (Abou Hussein et al 1975a,b).
Leaf area (cm^2). Data in Table 6 show a significant superiority of the garlic extract concentration of 250 mL L^{-1} (285.1 cm^2) over 125 mL L^{-1} (265.1 cm^2) and control plants (223.6 cm^2), the latest was the least leaf area. The results might be due to the content of garlic extract of nutrients, vitamins and some other compounds, which encourage the production of plant hormones such as gibberellins and cytokinins, and eventually lead to an increase in leaf area. These results are in agreement with Hussein (2002) when she used the garlic extract in different concentrations (0, 2.5, 5.0, and 7.5 mL L^{-1}) on cucumber, where this led to an increment in leaf area.

For the lonely effect of application method, the data in the Table 6 refer to a significant superiority of applying to soil method (279.3 cm^2) over the spraying method (236.5 cm^2).

The interaction effect too, had a significant effect on this characteristic, so as noted, it's treatment of 250 mL L^{-1} applying to soil was the most effective treatment (316.5 cm^2) among all others (125 mL L^{-1} and control) where the control with both methods enriched lower leaf area (223.6 cm^2).

Table 6

Effect of garlic extract, its application methods and their interaction on the leaf area (cm^2) of potato plant

Extract concentration (mL L^{-1})	*Application methods*		*Average of extract concentration*
	Spraying	*To soil*	
0	223.6	223.6	223.6
125	232.3	297.8	265.1
250	253.7	316.5	285.1
Average of application methods	236.5	279.3	-
R.L.S.D. (0.05) for garlic extract concentration = 11.93	R.L.S.D. (0.05) for application methods = 30.16		R.L.S.D. (0.05) for interaction = 17.67

Percentage of leaf dry matter (%). Data's from Table 7 statistically indicates to non-significant effect of the three factors on this characteristic.

Table 7

Effect of garlic extract, its application methods and their interaction on the percentage of the leaf dry matter (%)

Extract concentration (mL L^{-1})	*Application methods*		*Average of extract concentration*
	Spraying	*To soil*	
0	12.37	12.37	12.37
125	12.43	12.63	12.53
250	12.67	12.91	12.79
Average of application methods	12.49	12.64	-
R.L.S.D. (0.05) for garlic extract concentration = N.S.	R.L.S.D. (0.05) for application methods = N.S.		R.L.S.D. (0.05) for interaction = N.S.

The yield and its components

Number of tubers/plant. Data in Table 8 show that the extract concentration of 250 mL L^{-1} (6.72 tuber/plant) was non-significantly different from the 125 mL L^{-1}, while both significantly differed from the control plants (5.67 tubers/plant). This increase might be due to the content of aqueous extract of garlic, which is rich in nutrients as displayed in Table 3. The availability of these nutrients for the plant in sufficient qualities was necessary for its growth and precisely concerning to their role in increasing the division and extending the cells, beside to improving the performance of plant growth regulators, which are interfere in the extending and elongation of the cells, or it might be due to the existence of auxin– like materials within the garlic extract, so when the extract applied, especially of high concentration to the plants, the plant hormones content (auxin) will increase in the plant, causing an increase in vegetative growth characteristics, which one of them was increasing plant height, leaf number and branches number, reflected on increasing fruit number/plant (Abou Hussein et al 1975a,b). These results are with in accordance with those reported by Mengel & Arneke (1982) and Al Obaidi (1996).

Regarding to the application methods alone, the data in Table 8 indicated a significant superiority of the applying to soil method (6.67 tuber/plant) over the spraying method (5.88 tuber/plant).

For interaction, it was noted that its treatment (250 mL L^{-1} garlic extract with applying to soil method) had an average of 7.37 tuber/plant and it was significantly higher than all other interaction treatments, and the least number of tubers were at the control plants within both methods (on average 5.67 tuber/plant).

Table 8

Effect of garlic extract, its application methods and their interaction on the number of tuber/plant in potato

Extract concentration (mL L^{-1})	*Application methods*		*Average of extract concentration*
	Spraying	*To soil*	
0	5.67	5.67	5.67
125	5.91	6.97	6.44
250	6.06	7.37	6.72
Average of application methods	5.88	6.67	-
R.L.S.D. (0.05) for garlic extract concentration = 0.77	R.L.S.D. (0.05) for application methods = 0.67		R.L.S.D. (0.05) for interaction = 1.07

Average of tuber weight (g). For the garlic extract concentration only, there was a significant superiority (250 mL L^{-1}) of 110.8 g over both concentration (125 mL L^{-1} with 100.3 g) and the least value in control plants (93.8 g), where the latest two had non-significant difference between them (Table 9). These results suggests effect of the garlic extract (Table 3), that includes materials, vitamins and hormones, which if they become available in sufficient qualities will be the main reason to improve the growth of plants, especially their role in increasing the division and extending of the cells, as well as enhancement of the performance of plant regulators inside the plant, which directly participate in the extending and elongation of cells. Or the reason of these results might be the content of garlic extract of the auxin– like substances, so the original content of the auxins in the plants will increase, when there plants were sprayed with the garlic extract, especially the high concentration of the extract, subsequently this will be reflected on the characteristics of vegetative growth, which one of them is the average of tuber weight (Abou Hussein et al 1975a,b). These results are in accordance with reports by Mengel & Arneke (1982) and Al Obaidi (1996).

The singular effect of application method is indicated in Table 9, where the applying to soil method is significantly more effective (106.3 g) comparing with spraying method (97.0 g). But concerning the interaction alone it was statistically non-significant.

Table 9

Effect of garlic extract, its application methods and their interaction on the average of tuber weight (g) in potato

Extract Concentration (mL L^{-1})	*Application methods*		*Average of extract concentration*
	Spraying	*To soil*	
0	93.8	93.8	93.8
125	93.9	106.7	100.3
250	103.3	118.3	110.8
Average of application methods	97.0	106.3	-
R.L.S.D. (0.05) for garlic extract concentration = 8.67	R.L.S.D. (0.05) for application methods = 7.13		R.L.S.D. (0.05) for interaction = N.S.

Productivity (ton $hectares^{-1}$). Data in the Table 10 showed a significant superiority of garlic extract concentration of 250 mL L^{-1} (27.88 ton $hectares^{-1}$) over both 0 and 125 mL L^{-1}, where the least productivity was shown by the control (20.52 ton $hectares^{-1}$). These results may be due to the natural content of garlic extract of auxin– like substances (Table 3), which gave rise to increments of these plant regulators in the plant after the spraying of garlic extract, especially in the case of high concentrations of extract. This increment should be reflected on the measurements of vegetative growth including plant height, leaves number, and last increase the total yield of plant (Abou Hussein et al 1975a,b).

The singular effect of application methods of garlic extract referred to a significant superiority of applying to soil method (26.63 ton $hectares^{-1}$) over the spraying method (23.48 ton $hectares^{-1}$). This result is in agree with Abou Hussein et al (1975a,b), when he studied the squash plants after spraying them with garlic extract, where the yield quality was enhanced, so the researchers found that the garlic extract had a similar effect on plants just like auxins.

For the interaction alone, the treatment with 250 mL L^{-1} garlic extract applying to soil method (30.32 ton $hectares^{-1}$) was significantly highest than the rest of the treatments (except the 125 mL L^{-1} with the same applying methods was non-significantly different). While the least productivity was observed in the control plants for both application methods (20.52 ton $hectares^{-1}$).

Table 10

Effect of garlic extract, its application methods and their interaction on the productivity (ton $hectares^{-1}$) in potato

Extract concentration (mL L^{-1})	*Application methods*		*Average of extract concentration*
	Spraying	*To soil*	
0	20.52	20.52	20.52
125	24.48	29.04	26.76
250	23.44	30.32	27.88
Average of application methods	23.48	26.63	-
R.L.S.D. (0.05) for garlic extract concentration = 1.06	R.L.S.D. (0.05) for application methods = 2.73		R.L.S.D. (0.05) for interaction = 3.03

Percentage of dry matter in tubers (%). As seen in Table 11, no statistical significance appeared for the singular effect of garlic extract concentrations, the application method, or even for the interaction between them on the percentage of dry matter in tubers of potatoes.

Table 11

Effect of garlic extract, its application methods and their interaction on the percentage of dry matter in tubers of potato (%)

Extract concentration (mL L^{-1})	*Application methods*		*Average of extract concentration*
	Spraying	*To soil*	
0	17.80	17.80	17.80
125	18.17	18.21	18.19
250	18.33	18.52	18.43
Average of application methods	18.10	18.18	-
R.L.S.D. (0.05) for garlic extract oncentration = N.S.	R.L.S.D. (0.05) for application methods = N.S.		R.L.S.D. (0.05) for interaction = N.S.

Percentage of starch in tubers (%). The singular effect of garlic extract concentrations (Table 12) it was significant. Where its concentration of 250 mL L^{-1} (12.45%) was non-significantly different from 125 mL L^{-1} (11.57%), but significantly different from the control plant, which was of the minimum percentage of starch (9.13%).

For the application methods of extract, the applying of soil method was significantly superior (11.59%) over the spraying method (10.50).

The interaction treatment of 250 mL L^{-1} with applying to soil method (13.18%) resulted the highest content of starch, which didn't differ significantly from the 125 mL L^{-1} (same method), while was significantly different from the rest of treatments. The control (0 mL L^{-1}) showed the least starch percentage in tubers with both methods (9.13%).

Table 12

Effect of garlic extract, its application methods and their interaction on the percentage of starch in tubers on potato plants (%)

Extract concentration (mL L^{-1})	*Application methods*		*Average of extract concentration*
	Spraying	*To soil*	
0	9.13	9.13	9.13
125	10.67	12.47	11.57
250	11.71	13.18	12.45
Average of application methods	10.50	11.59	-
R.L.S.D. (0.05) for garlic extract oncentration = 1.09	R.L.S.D. (0.05) for application methods = 0.81		R.L.S.D. (0.05) for interaction = 0.97

Percentage of total soluble solids (T.S.S.) in tubers (%). Data in Table 13 show a significant difference in the singular effect of garlic extract concentration only, where the 250 mL L^{-1} (8.79%) significantly differ from 0 and 125 mL L^{-1} (6.93 and 8.22%) respectively.

Table 13

Effect of garlic extract, its application methods and their interaction on the percentage of T.S.S. in tubers in potato (%)

Extract concentration (mL L^{-1})	*Application methods*		*Average of extract concentration*
	Spraying	*To soil*	
0	6.93	6.93	6.93
125	7.92	8.52	8.22
250	8.67	8.91	8.79
Average of application methods	7.84	8.12	-
R.L.S.D. (0.05) for garlic extract concentration = 0.33	R.L.S.D. (0.05) for application methods = N.S.		R.L.S.D. (0.05) for interaction = N.S.

This result was in accordance with that found by Hussein (2002), who sprayed garlic extract in 2.5 mL L^{-1} concentration on cucumber plants, which led to highest increment in T.S.S. in fruits.

For the application methods and for the interaction treatments there was no significant difference in the content of T.S.S.

Conclusions. From this study it may be concluded that the application of the aqueous extract of garlic in concentration of 250 mL L^{-1} gives the highest effect on most characteristics of vegetative growth and yield, where it increased the plant height, number of branches, leaf area, number of tubers, weight of tubers, productivity, percentage of starch, percentage of dry matter and T.S.S. of tubers, due to the sum of contents of garlic extract substances, which are natural and environmentally safe.

For the singular effect of the application methods of extract, the applying to soil method was superior over and more effective than the spraying method on the leaves of the plant. So we recommend to use the aqueous extract of garlic to be applied to soil, in order to improve the growth and yield of potato crop or other field crops (that succeeded to be planted in Basra conditions) besides to the economic or strategic crops. As well as another types of plant extracts may be used to improve the growth and yield of field crops.

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