Plant Archives Vol. 20, Supplement 2, 2020 pp. 131-139 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

THE EFFECT OF ORGANIC RESIDUES AND SPRAYING OF POTASSIUM AND ZINC ON SOME GROWTH CHARACTERISTICS AND YIELD OF POTATO

Noora Hade Najem[1], Fadhil Hussain Al-Sahaf [1*] and Hussien Jawad Albayati[2]

[1]Department of Horticulture and Landscape gardening, Faculty of Agriculture, University of Kufa, Iraq.
[2]Department of Horticulture and Landscape gardening, Faculty of Agriculture, University of Mosul, Iraq.
* Corresponding author. E-mail address: fadhilh.alsahaf@uokufa.edu.iq.

Abstract

A field experiment was conducted in Babylon province in 2018 spring season to examine the effect of adding organic residues (poultry dung, rice residues and palm fronds residues), spraying of zinc sulphate and potassium sulphate on some growth characteristics and yield of potato. Results showed significant effect of rice residues in comparison with control treatment in both plant height (97.81 cm) and leaf area (38.074 cm^2. $plant^{-1}$). While poultry dung treatment was significantly higher in the number of air stems (2.652), leaf content of total chlorophyll(45.704 mg.100gm^{-1} soft weight), tubers number (14.00 tuber.$plant^{-1}$)and total yield of tubers (59.67 ton /h^{-1}) compare to control. Zinc sulphate treatment at concentration of 0.4 (gm.L^{-1}) was significant in comparison with control and growth characteristics and yield of potato plants were as follows: plant height (96.08 cm), the number of air stems (2.389 tuber.$plant^{-1}$), leaf area (36.944 cm^2. $plant^{-1}$), leaf content of total chlorophyll (45.704 mg.100gm^{-1} soft weight), total tubers number (13.417 tuber.$plant^{-1}$) and total yield of tubers (53.03 ton /h^{-1}). Potassium sulphate treatment also showed significant effect at concentration of 5.0 (gm.L^{-1}) in all studied characteristics compare to control treatment.

Keywords **:** Organic residues, leaf feeding, potassium sulphate, zinc sulphate

Introduction

Potato (*Solanum tuberosum* L.) is a vegetable plant belonging to Solanaceae under *Solanum* genus that comprises more than 2000 species. Potatoes are annual plants, eudicots and most cultivated worldwide and consumed as a tuber crop (Hassan, 1999). After wheat, riceand maize potato is become the fourth in terms of yield and consumption. The planted area of this crop is 19089.328 h globally and total of 381,682,144 ton productivity, while the area that growing by potato in Iraq has reached 25.745 h with average productivity of 15.6 ton/h and total yield 402302 ton (FAO, 2017). These statistics is clearly indicating the reduction of potato yield in Iraq in comparison with other countries. The organic fertilization is considered as an important method to provide plants with essential nutrient requirements without any negative effect on the environment. In addition, it improves the structure of soil and makes nutrients ready for plants (Cook, 1972). Thus, current study is conducted due to the major roll of potassium and zinc elements in physiological processes inside plant by spraying those nutrients on leafs of potato plants. This research aims to increase potato yield and improve tubers by adding organic residues and spraying of zinc and potassium sulphate.

Materials and Methods

The experiment was conducted in two farms, the first one located in Keffel, Babylon province in 2017 first spring season and the second farm in Debla South of Babylon province in 2018second spring season. Potato seeds of SYLVANA cultivar for first spring season were planted in 1/2/2017 and for second spring season in 8/1/2018 on rows and the distance between these rows was 75 cm and between tubers was 25 cm. The total tubers in each row were 32 and the experimental unit area was 7.5m^2(1 meter was left between each experimental unit to prevent the transportation between treatments). The experiment was designed using RCBD and the organic residues were put in the main plot. 36 treatments were applied in this experiment with three replicates for each treatment. The least significant difference (L.S.D.) was used to compare means at 5% level of significance (P>0.05) (Al Rawi and Khalafala, 2000).

Soil samples were taken from 0-30 cm depth of soil surface and analyzed in soil laboratory, Faculty of Agriculture, University of Kufa (Table 1). While the chemical and physical characteristics of adding fertilizers were analysed in laboratories of Green University of Al Qasim (Table 2).

Table 1 : Chemical and physical characteristics of field soil.

Soil characteristics	Standard Unit	Spring season 2017	Spring season 2018
PH	-		7.7
EC	dS.m^{-1}		2.2
N	%		1.4
P	%		0.33
K	%		0.13
Organic material	%		1.07
Sand	%		22
Silt	%		54
Clay	%		24
Soil texture	-		

Table 2 : Chemical and physical characteristics of added fertilizers in this study.

Soil characteristics	Palm fronds fertilizer	Rice residuesfertilizer	Poultry dungfertilizer
PH	7.4	6.18	7
EC(Ds.m^{-1})	5.148	4.11	9.5
N%	1.46	0.96	0.71
P%	0.454	0.083	1.311
K+%	2.89	2.147	2.5
Organic material	68.7	12.14	65

All added fertilizers in this study were obtained from National Centre of Organic Agriculture, Najaf, Ministry of Agriculture and added to soil 10 days before planting potato tubers by sawing and mixing these fertilizers very well with soil as a first factor. The average use of palm fronds and rice residues fertilizers was 20 ton.h^{-1} and 2 ton.h^{-1} for poultry dung fertilizer. The second factor was spraying potato leafs with potassium sulphate (SO_4K_2) using three levels of concentrations (0, 2.5 and 5 gm.L^{-1}). The third factor was spraying potato leafs with zinc sulphate using three levels of concentrations (0, 2.5 and 5 gm.L^{-1}). After 45 days of planting, plants were sprayed by both potassium and zinc sulphate in tuber initiation stage then spraying was don twice every 15 days and the following plant characteristics were recorded:

1- **Plant height (cm):** 5 plants were chosen randomly from the middle rows and plant height was recorded.
2- **Air stems number (stem.plant^{-1}):** 5 plants were chosen randomly to calculate the number of air stems for each experimental unit.
3- **Leaf area (cm^2.plant^{-1}):** 30 discs of leafs were taken then put in oven at 70^{O}C to dry it. Then the dry weight and leaf area were calculated using the procedure of Watson and Watson (1953).
4- **Leafs content of total chlorophyll (mg.100g soft weight):** Goodwin (1976) method was used to estimate total chlorophyll in leafs.
5- **The average of total tubers number (tuber.plant^{-1}):** The total number of tubers for each plant was calculated as follows:
The average of total tubers number = the average of total number of tubers for each plant/total number of plants.
6- **The number of marketable tubers (tuber.plant^{-1}):** The average of marketable tubers was calculated using the above method after excluding infected and deformed tubers (Al-Musawi, 2014).
7- The average of marketing tuber weight (gm): calculated as follows:
The average of marketing tuber weight=marketing yield/ number of marketable tubers
8- **Marketing yield (kg.h^{-1}):** calculated by divided marketable plants in the experimental unit on the total number of plants.
9- **Total tubers yield (ton.h^{-1}):** total yield = total yield of the experimental unit/experimental unit area.

Results and Discussion

Plant height (cm): Results of Table 3 for the first season showed that adding organic residues had significant effect on plant height. Poultry dung treatment gave greater plant height 97.81 cm in comparison with control treatment 88.00 cm. Zinc sulphate treatment had also significant effect on the plant height 96.08cm at 0.4 gm.L^{-1} concentration while control treatment gave 87.97cm. Potassium sulphate at 5 gm.L-1 increased plant height to 95.64 cm compare to 90.25 cm in control. In the second season, poultry dung treatment increased height to 67.21 cm compare to 60.34 cm in control. Zinc sulphate treatment at 0.2 gm.L^{-1} gave the highest 63.44 cm, whereas 0.4 gm.L^{-1} concentration gave 62.34 cm. The increasing rate of plant height may occur due to promotion of organic residues to enhance plant peaks to produce Auxins which increase the height (Shraqy and Kader, 1985). Organic fertilizers play the major roll in vegetative growth by improving soil characteristics which lead to make micro and macro elements ready for plants (Al-Obaydy, 2008). This result is in agreement with Al-Sultany (2015) and Al-Sharefy (2015) who reported that the uses of organic fertilizers lead to increasing plant height. The increasing of plant height in first season happened due to the use of zinc and potassium sulphate that lead to improve plant metabolism and plant growth (Al-Sahaf, 1989).

Air stems number (stem.plant^{-1}): Table 4 results of first season showed significant effect in the average number of air stems in poultry dung treatment that reached 2.652 stem. plant^{-1} compare to 1.904 stem.plant^{-1} in control treatment. Zinc sulphate treatment at 0.4 gm.L^{-1} concentration also gave better average of stems number 2.389 in comparison with the control which gave 2.133 stem.plant^{-1}. Potassium sulphate treatment was not significant in air stems number. The second season results showed greatest and significant effect in both palm fronds and poultry dung residues treatments that reached 2.82 and 2.81 respectively compare to 1.92 in control while, there were no significant effect in Potassium and zinc sulphate treatments. The increasing number of air stems occurred due to the size of tubers that lead to increasing sprouts number and vegetative growth (Arsenaut and Christie, 2004). The adding of organic residues was increased air stems number compare to control which is in agreement with previous studies by (Pang and Letey, 2000; Haraldsen *et al*., 2000; Sharif Hossien *et al*., 2003).

Leaf area (cm.plant^{-1}): Table 5 results for the first season showed that rice residues had significant effect in leaf area which reached 38.074 cm.plant^{-1}. Zinc sulphate treatment had great size of leafs at 0.4gm.L^{-1} concentration in comparison with control 30.667 cm.plant^{-1}. While potassium sulphate treatment had significant effect on leaf area at 5.00 gm.L^{-1} concentration where it reached 35.444 cm.plant^{-1} compare to 32.639 in control. In the second season, poultry dung treatment showed significant effect in leaf area 33.701cm.plant^{-1} in comparison with control which recorded the lowest leaf area 29.762 cm.plant^{-1}. Zinc sulphate treatment at 0.4 gm.L^{-1}concentrations showed higher value of leaf area 33.664 cm.plant^{-1} compare with 29.659 in control. While the potassium sulphate treatment at 5.00gm.L^{-1} concentration recorded 32.371 cm.plant^{-1} and increased leaf area significantly compare to control treatment which recorded the lowest leaf area 31.202 cm.plant^{-1}. Organic

fertilizers contain many nutrients such as nitrogen, phosphor and potassium that are ready for absorption due to microorganisms' activities and lead to increase leaf area (Al Zahawy, 2007).

Leaf content of total chlorophyll (mg.100gm^{-1} soft weight): Results of adding poultry dung showed significant effect in leaf content of total chlorophyll as it reached 45.704 mg.100gm^{-1} soft weight compare to control treatment which recorded the lowest value 32.259 mg.100gm^{-1} soft weight (Table 6). Zinc sulphate treatment was also significant at 0.4 gm.L^{-1} concentration and gave highest level of chlorophyll 44.639 mg.100gm^{-1} soft weight compare to 37.444 mg.100gm^{-1} soft weight in control. Potassium sulphate treatment showed significant level of chlorophyll 43.306 mg.100gm^{-1} soft weight at 5.00 gm.L^{-1} concentration in comparison with 40.306 mg.100gm^{-1} soft weight. In the second season results, poultry dung treatment gave the highest level of chlorophyll 34.459 mg.100gm^{-1} soft weight compare to 31.308 mg.100gm^{-1} soft weight in control. Zinc spraying treatment was also gave significant level of chlorophyll at 0.4 concentration where reached 33.459 mg.100gm^{-1} soft weight. Potassium sulphate treatment in the second season was also showed significant level of chlorophyll at 2.5 gm.L^{-1}concentration and gave 32.992 mg.100gm^{-1} soft weight compare to 32.706 mg.100gm^{-1} soft weight in control. The increasing level of chlorophyll in potato leafs after adding poultry dung may occurred due to providing of nitrogen and magnesium by the organic residues (Table 2) which has a major role in chlorophyll molecule (ADDISCOTT, 1974). In addition, zinc sulphate contributes in many biological processes such as oxidation and formation of amino acid (Tryptophan) that consists of IAA Auxin (Tsui, 1984) which contributes in chlorophyll formation and producing energy and construction of nucleic, amino and fatty acids (AlNaamy, 2011).

Total tubers number (tuber.plant^{-1}): Table 7 results showed that there was significant effect of adding poultry dung where the total tubers number reached 14.00 tuber.plant^{-1} in comparison with 10.204 tuber.plant^{-1} in control treatment. Zinc sulphate treatment gave the highest number of tubers 13.417tuber.plant^{-1} at 0.4 gm.L^{-1} compare to 10.597 in control. While potassium sulphate treatment gave a total tuber number of 12.972 tuber.plant^{-1}at 5.00 gm.L^{-1}compare to 11.500 in control.In the second season results, poultry dung treatment gave 13.241 tuber.plant^{-1} compare to 7.815 tuber.plant^{-1} in control. Zinc spraying treatment was also gave 13.625 tuber.plant^{-1} at 0.4 concentration compare to 8.250 tuber.plant^{-1}in control. Potassium sulphate treatment in the second season was also showed significant tuber number at 5 gm.L^{-1} concentration and gave 11.931 tuber.plant^{-1} compare to 10.153tuber.plant^{-1}in control. Organic fertilizers play the major roll in vegetative growth by improving soil characteristics which lead to absorb water and nutrients elements ready for plants (Grandy *et al*., 2002) in addition to decrease lost elements by heavy irrigation (Tisadle *et al*., 1993).

6-**The number of marketable tubers (tuber.plant^{-1}):** Table 8 results showed that there was significant effect of adding poultry dung where the number of marketable tubers reached 8.667 tuber.plant^{-1}in comparison with 5.907 tuber.plant^{-1} in control treatment. Zinc sulphate treatment gave the highest number of marketabletubers 8.083 tuber.plant^{-1} at 0.4 gm.L^{-1} compare to 5.625 in control. While potassium sulphate treatment gave a number of 7.722 tuber.plant^{-1}at 5.00 gm.L^{-1} compare to 6.306 in control. In the second season results, poultry dung treatment gave 7.778 tuber.plant^{-1} compare to 4.426 tuber.plant^{-1} in control. Zinc spraying treatment was also gave 7.903 tuber.plant^{-1} at 0.4 concentration compare to 4.597 tuber.plant^{-1} in control. Potassium sulphate treatment in the second season was also showed significant number of marketable tubers at 5 gm.L^{-1} concentration and gave 6.806 tuber.plant^{-1} compare to 5.778 tuber.plant^{-1} in control. Organic residues play the major roll in vegetative growth such as plant height, the number of air stems, chlorophyll level and leaf area which reflected inprovidingnutrients in tubers and increase the number of marketable tubers (Mikitzel and Knowles, 1990).

The average weight of marketable tuber (gm.plant^{-1}): Table 9 results for the first season showed that there was significant effect of adding poultry dung where the number of marketable tubers reached 121.59 gm.plant^{-1} in comparisons with 97.04gm.plant^{-1}in control treatments. Zinc sulphate treatment gave the highest average weight of marketable tubers 114.42gm.plant^{-1}at 0.4 gm.L^{-1} compare to 106.14 in control. While potassium sulphate treatment gave average weight of 114.72 gm.plant^{-1}at 5.00 gm.L^{-1} compare to 106.36 in control. In the second season results, poultry dung treatment gave 77.11gm.plant^{-1} compare to 66.48gm.plant^{-1} in control. Zinc spraying treatment was also gave 78.47gm.plant^{-1} at 0.4 concentration compare to 68.32gm.plant^{-1} in control. Potassium sulphate treatment in the second season was also showed significant average weight of marketable tubers at 5 gm.L^{-1} concentration and gave 6.806 gm.plant^{-1} compare to 5.778 gm.plant^{-1}in control. The average weight of marketable tubers was higher in the first season than the second season and this may because decreasing number of tubers which lead to increase the average weight of marketable tubers in addition to low breath rate of plant parts at the increasing volume stage in the end of season which provides an excess on nutrients that stored in tubers (Hassan, 1999).

Marketing yield (kg.plant^{-1}): The first season results showed that there was significant effect of adding poultry dung where the marketing yield reached 1065 kg.plant^{-1} in comparisons with 0.573kg.plant^{-1} in control treatments (Table 10). Zinc sulphate treatment gave the highest marketing yield 0.941 kg.plant^{-1} at 0.4 gm.L^{-1} compare to 0.603 in control. While potassium sulphate treatment gave marketing yield of 904 kg.plant^{-1} at 5.00 gm.L^{-1} compare to 679 in control. In the second season results, poultry dung treatment gave 0.605kg.plant^{-1}compare to 0.279 kg.plant^{-1}in control. Zinc spraying treatment was also gave 0.626kg.plant^{-1} at 0.4 concentration compare to 0.318 kg.plant^{-1} in control. Potassium sulphate treatment in the second season was also showed significant marketing yield at 5 gm.L^{-1} concentration and gave 0.521 kg.plant^{-1}compare to 0.421 kg.plant^{-1}in control. The reason for increasing marketing yield when adding organic residues may due to contents of organic fertilizers which has many nutrients that provide perfect growth conditions and reflect on the increasing of marketing yield (Botteau, 2004).

The total yield of tubers (ton.h^{-1}): Results of first season showed that there was significant effect of adding poultry dung where the total yield of tubers reached 59.67 ton.h^{-1}in

comparisons with 32.89 ton.h^{-1}in control treatments (Table 11). Zinc sulphate treatment gave the highest total yield 53.03 ton.h^{-1}at 0.4 gm.L^{-1} compare to 34.88 in control. While potassium sulphate treatment gave total yield of 51.01 ton.h^{-1} at 5.00 gm.L^{-1} compare to 39.04 in control. In the second season results, poultry dung treatment gave 35.68 ton.h^{-1} compare to 17.98 ton.h^{-1}in control. Zinc spraying treatment was also gave 37.48 ton.h^{-1} at 0.4 concentration compare to 19.13 ton.h^{-1}in control. Potassium sulphate treatment in the second season was also showed significant total yield at 5 gm.L^{-1} concentration and gave 31.30 ton.h^{-1} compare to 25.27 ton.h^{-1}in control. The significant increasing in organic fertilizer treatments occurred due to improvement of chemical and physical characteristics of soil when these fertilizers added which lead to more vegetative growth and increasing yield in the experimental unit (Al Zahawi, 2007; Al Muhammady, 2009). Organic residues was decreased pH value in soil which makes nutrients elements ready for plants in addition to produce hormones, Auxins and Gibberellins that promote plant growth and productivity (Al-Sahaf, 1994).

Table 3 : The effect of zinc and potassium and their interaction on plant height.

Second spring season				First spring season				Treatments	
Interaction of residues × zinc sulphate	**Potassium sulphate g.L^{-1}**			**Interaction of residues zinc × sulphate**	**Potassium sulphate g.L^{-1}**			**Zinc sulphate g.L^{-1}**	**Organic residues**
	5	**2.5**	**control**		**5**	**2.5**	**Control**		
60.21	60.23	60.30	60.10	84.67	86.00	84.33	83.67	**Control**	**Control**
60.28	60.30	60.27	60.27	89.00	90.33	88.67	88.00	**0.2**	
60.52	60.57	60.57	60.43	90.33	92.67	90.67	87.67	**0.4**	
65.47	64.27	64.50	67.63	88.89	90.33	90.00	86.33	**Control**	**Poultry dung 2 ton.ha^{-1}**
69.33	67.20	70.40	70.40	94.78	99.00	94.67	90.67	**0.2**	
66.83	64.27	65.73	70.50	97.78	103.00	98.33	92.00	**0.4**	
62.06	62.30	61.97	61.90	92.22	98.00	91.33	87.33	**Control**	**Rice residues 20ton.ha^{-1}**
62.38	62.23	62.60	62.30	100.00	102.00	99.33	98.67	**0.2**	
62.97	63.17	63.13	62.60	101.22	102.00	102.00	99.67	**0.4**	
61.63	61.57	61.93	61.40	86.11	88.67	86.00	83.67	**Control**	**Palm fronds residues 20ton.ha^{-1}**
61.76	61.70	61.63	61.93	95.22	98.33	95.33	92.00	**0.2**	
62.23	62.33	62.33	62.03	95.00	97.33	94.33	93.33	**0.4**	
2.521	n.s			1.020	1.880			LSD	
Effect of organic residues	62.10	62.95	63.46	**Effect of organic residues**	95.64	92.92	90.25	**Effect of potassium sulphate**	
	0.857				0.571			LSD	
60.34	60.37	60.38	60.27	88.00	89.67	87.89	86.44	**Control**	**Interaction of residues ×potassium sulphate**
67.21	65.24	66.88	69.51	93.81	97.44	94.33	89.67	**Poultry dung 2 ton.ha^{-1}**	
62.47	62.57	62.57	62.27	97.81	100.67	97.56	95.22	**Rice residues 20ton.ha^{-1}**	
61.87	61.87	61.97	61.79	92.11	94.78	91.89	89.67	**Palm fronds residues 20ton.ha^{-1}**	
2.439	2.629			0.567	1.042			LSD	
Effect of zinc sulphate				**Effect of zinc sulphate**					
62.34	62.09	62.17	62.76	87.97	90.75	87.92	85.25	**Control**	**Interaction of zinc sulphate potassium × sulphate**
63.44	62.86	63.72	63.72	94.75	97.42	94.50	92.33	**0.2**	
62.14	62.58	62.94	63.89	96.08	98.75	96.33	93.17	**0.4**	
0.664	n.s			0.563	n.s			LSD	

Table 4 : The effect of adding organic residues and spraying potassium and zinc sulphate and their interaction on air stems numbers of potato plants.

Second spring season				First spring season				Treatments	
Interaction of residues ×zinc sulphate	Potassium sulphate g.L^{-1}			Interaction of residues zinc sulphate×	Potassium sulphate g.L^{-1}			Zinc sulphate g.L^{-1}	Organic residues
	5	2.5	control		5	2.5	control		
1.88	2.00	1.86	1.80	1.867	1.867	1.933	1.800	control	Control
1.88	1.86	2.00	1.80	1.889	1.933	1.867	1.867	0.2	
2.00	2.00	2.00	2.00	1.956	1.933	2.000	1.933	0.4	
2.55	2.73	2.53	2.40	2.444	2.467	2.467	2.400	control	Poultry dung 2 ton.ha^{-1}
2.93	3.00	3.00	2.80	2.667	2.667	2.467	2.867	0.2	
2.95	2.93	2.93	3.00	2.844	2.867	2.733	2.933	0.4	
2.26	2.33	2.20	2.26	2.022	2.133	2.000	1.933	control	Rice residues 20ton.ha^{-1}
2.48	2.60	2.46	2.40	2.267	2.400	2.200	2.200	0.2	
2.80	2.80	2.80	2.80	2.378	2.400	2.333	2.400	0.4	
2.80	2.80	2.80	2.80	2.200	2.267	2.333	2.000	control	Palm fronds residues 20ton.ha^{-1}
2.86	2.86	2.86	2.86	2.400	2.400	2.467	2.333	0.2	
2.82	2.80	2.86	2.80	2.378	2.400	2.333	2.400	0.4	
0.068	0.122				n.s			LSD	
Effect of organic residues	2.56	2.52	2.47	Effect of organic residues	2.311	2.261	2.256	Effect of potassium sulphate	
	0.037				n.s			LSD	
1.92	1.95	1.95	1.86	1.904	1.911	1.933	1.867	control	Interaction of residues ×potassium sulphate
2.81	2.88	2.82	2.73	2.652	2.667	2.556	2.733	Poultry dung 2 ton.ha^{-1}	
2.51	2.57	2.48	2.48	2.222	2.311	2.178	2.178	Rice residues 20ton.ha^{-1}	
2.82	2.82	2.84	2.82	2.326	2.356	2.378	2.244	Palm fronds residues 20ton.ha^{-1}	
0.051	0.074			0.095	0.140			LSD	
Effect of zinc sulphate				Effect of zinc sulphate					
2.37	2.46	2.35	2.31	2.133	2.183	2.183	2.033	control	Interaction of zinc sulphate potassium × sulphate
2.54	2.58	2.58	2.46	2.306	2.350	2.250	2.317	0.2	
2.64	2.63	2.65	2.65	2.389	2.400	2.350	2.417	0.4	
0.032	0.060			0.058	n.s			LSD	

Table 5. The effect of adding organic residues and spraying potassium and zinc sulphate and their interaction on leaf area.

Second spring season				First spring season				Treatments	
Interaction of residues ×zinc sulphate	Potassium sulphate g.L^{-1}			Interaction of residues zinc sulphate×	Potassium sulphate g.L^{-1}			Zinc sulphate g.L^{-1}	Organic residues
	5	2.5	control		5	2.5	control		
29.081	30.253	28.620	28.370	28.000	29.667	27.667	26.667	Control	Control
30.311	31.290	30.360	29.283	31.556	31.667	31.667	31.333	0.2	
29.893	30.593	29.937	29.150	32.667	33.000	32.333	32.667	0.4	
30.963	32.397	30.763	29.730	31.444	32.333	32.333	29.667	Control	Poultry dung 2 ton.ha^{-1}
34.150	34.837	34.133	33.480	33.556	34.667	33.000	33.000	0.2	
35.991	36.140	35.910	35.923	37.222	41.667	38.000	32.000	0.4	
29.407	29.290	29.317	29.613	33.778	36.667	33.667	31.000	Control	Rice residues 20ton.ha^{-1}
31.487	32.623	31.333	30.503	39.222	40.667	39.333	37.667	0.2	
33.392	33.540	33.503	33.133	41.222	41.667	41.000	41.000	0.4	
29.183	28.963	28.623	29.963	29.444	31.667	30.333	26.333	Control	Palm fronds residues 20ton.ha^{-1}
31.197	32.690	31.093	29.807	33.333	34.333	33.667	32.000	0.2	
35.381	35.837	34.840	35.467	36.667	37.333	34.333	38.333	0.4	
0.631	1.043			0.941	1.516			LSD	
Effect of organic residues	32.371	31.536	31.202	Effect of organic residues	35.444	33.944	32.639	Effect of potassium sulphate	
	0.302				0.433			LSD	
29.762	30.712	29.639	28.934	30.741	31.444	30.556	30.222	Control	Interaction of residues ×potassium sulphate
33.701	34.458	33.602	33.044	34.074	36.222	34.444	31.556	Poultry dung 2 ton.ha^{-1}	
31.429	31.818	31.384	31.083	38.074	39.667	38.000	36.556	Rice residues 20ton.ha^{-1}	
31.920	32.497	31.519	31.746	33.148	34.444	32.778	32.222	Palm fronds residues 20ton.ha^{-1}	
0.326	0.562			0.547	0.842			LSD	
Effect of zinc sulphate				Effect of zinc sulphate					
29.659	30.226	29.331	29.419	30.667	32.583	31.000	28.417	Control	Interaction of zinc sulphate potassium × sulphate
31.786	32.860	31.730	30.768	34.417	35.333	34.417	33.500	0.2	
33.664	34.028	33.547	33.418	36.944	38.417	36.417	36.000	0.4	
0.354	0.541			0.512	0.779			LSD	

Table 6 : The effect of adding organic residues and spraying potassium and zinc sulphate and their interaction on leaf content of total chlorophyll.

Second spring season				First spring season				Treatments	
Interaction of residues ×zinc sulphate	Potassium sulphate g.L^{-1}			Interaction of residues zinc sulphate×	Potassium sulphate g.L^{-1}			Zinc sulphate g.L^{-1}	Organic residues
	5	2.5	control		5	2.5	control		
31.162	30.944	31.229	31.313	30.111	31.333	30.000	29.000	control	Control
31.254	31.178	31.402	31.181	33.333	35.000	33.667	31.333	0.2	
31.508	31.288	31.579	31.655	33.333	34.000	33.667	32.333	0.4	
33.729	34.377	34.465	32.344	40.889	40.667	41.333	40.667	control	Poultry dung 2 ton.ha^{-1}
34.312	34.246	34.280	34.410	47.889	50.000	47.333	46.333	0.2	
35.443	35.483	35.447	35.400	48.333	51.667	47.667	45.667	0.4	
32.510	32.608	32.507	32.416	39.444	40.667	39.333	38.333	control	Rice residues 20ton.ha^{-1}
32.321	32.220	32.490	32.254	47.222	49.333	48.000	44.333	0.2	
32.288	32.385	32.237	32.241	49.111	49.333	49.000	49.000	0.4	
32.419	32.462	32.279	32.515	39.333	40.667	39.667	37.667	control	Palm fronds residues 20ton.ha^{-1}
32.967	33.462	33.056	32.384	45.889	48.000	47.333	42.333	0.2	
34.599	34.499	34.937	34.361	47.778	49.000	47.667	46.667	0.4	
0.331	0.473			1.133	1.571			LSD	
Effect of organic residues	32.929	32.992	32.706	Effect of organic residues	43.306	42.056	40.306	Effect of potassium sulphate	
	0.124				0.404			LSD	
31.308	31.137	31.404	31.383	32.259	33.444	32.444	30.889	control	Interaction of residues ×potassium sulphate
34.495	34.702	34.730	34.052	45.704	47.444	45.444	44.222	Poultry dung 2 ton.ha^{-1}	
32.373	32.404	32.411	32.303	45.259	46.444	45.444	43.889	Rice residues 20ton.ha^{-1}	
33.328	33.474	33.424	33.087	44.333	45.889	44.889	42.222	Palm fronds residues 20ton.ha^{-1}	
0.237	0.290			0.890	n.s			LSD	
Effect of zinc sulphate				Effect of zinc sulphate					
32.455	32.598	32.620	32.147	37.444	38.333	37.583	36.417	control	Interaction of zinc sulphate potassium × sulphate
32.714	32.777	32.807	32.557	43.583	45.583	44.083	41.083	0.2	
33.459	33.414	33.550	33.414	44.639	46.000	44.500	43.417	0.4	
0.163	0.234			0.520	0.752			LSD	

Table 7 : The effect of adding organic residues and spraying potassium and zinc sulphate on the average of total tubers number.

Second spring season				First spring season				Treatments	
Interaction of residues ×zinc sulphate	Potassium sulphate g.L^{-1}			Interaction of residues zinc sulphate×	Potassium sulphate g.L^{-1}			Zinc sulphate g.L^{-1}	Organic residues
	5	2.5	Control		5	2.5	Control		
5.222	5.667	5.667	4.333	8.833	9.500	9.000	8.000	Control	Control
8.389	9.000	8.333	7.833	10.556	10.833	10.667	10.167	0.2	
9.833	10.500	9.833	9.167	11.222	12.167	11.500	10.000	0.4	
10.667	12.333	10.833	8.833	12.222	13.000	12.000	11.667	Control	Poultry dung 2 ton.ha^{-1}
13.833	14.833	13.500	13.167	14.444	15.333	14.333	13.667	0.2	
15.222	15.667	15.000	15.000	15.333	16.667	15.667	13.667	0.4	
8.778	9.667	8.667	8.000	10.611	11.167	10.000	10.667	Control	Rice residues 20ton.ha^{-1}
11.889	13.333	11.667	10.667	12.167	13.500	11.000	12.000	0.2	
15.056	15.333	15.000	14.833	13.444	14.167	12.667	13.500	0.4	
8.333	9.333	8.333	7.333	10.722	11.667	10.500	10.000	Control	Palm fronds residues 20ton.ha^{-1}
10.889	12.167	11.167	9.333	12.722	13.167	13.000	12.000	0.2	
14.389	15.333	14.500	13.333	13.667	14.500	13.833	12.667	0.4	
0.824	n.s			n.s	n.s			LSD	
Effect of organic residues	11.931	11.042	10.153	Effect of organic residues	12.972	12.014	11.500	Effect of potassium sulphate	
	0.310				0.365			LSD	
7.815	8.389	7.944	7.111	10.204	10.833	10.389	9.389	Control	Interaction of residues ×potassium sulphate
13.241	14.278	13.111	12.333	14.000	15.000	14.000	13.000	Poultry dung 2 ton.ha^{-1}	
11.907	12.778	11.778	11.167	12.074	12.944	11.222	12.056	Rice residues 20ton.ha^{-1}	
11.204	12.278	11.333	10.000	12.370	13.111	12.444	11.556	Palm fronds residues 20ton.ha^{-1}	
0.585	n.s			0.701	0.854			LSD	
Effect of zinc sulphate				Effect of zinc sulphate					
8.250	9.250	8.375	7.125	10.597	11.333	10.375	10.083	Control	Interaction of zinc sulphate potassium × sulphate
11.250	12.333	11.167	10.250	12.472	13.208	12.250	11.958	0.2	
13.625	14.208	13.583	13.083	13.417	14.375	13.417	12.458	0.4	
0.410	n.s			0.436	n.s			LSD	

Table 8 : The effect of adding organic residues and spraying potassium and zinc sulphate and their interaction on the number of marketable tubers.

Second spring season				First spring season				Treatments	
Interaction of residues ×zinc sulphate	Potassium sulphate g.L^{-1}			Interaction of residues zinc sulphate×	Potassium sulphate g.L^{-1}			Zinc sulphate g.L^{-1}	Organic residues
	5	2.5	control		5	2.5	control		
3.111	3.333	3.333	2.667	4.389	4.833	4.667	3.667	control	Control
4.667	5.000	4.667	4.333	6.444	6.833	7.000	5.500	0.2	
5.500	6.000	5.333	5.167	6.889	7.500	7.167	6.000	0.4	
6.056	6.833	5.833	5.500	7.111	8.000	7.000	6.333	control	Poultry dung 2 ton.ha^{-1}
8.111	8.833	8.000	7.500	8.889	10.000	8.667	8.000	0.2	
9.167	9.500	9.000	9.000	10.000	11.333	10.000	8.667	0.4	
4.667	5.000	4.667	4.333	5.722	6.167	5.333	5.667	control	Rice residues 20ton.ha^{-1}
6.667	7.667	6.667	5.667	7.056	7.833	6.667	6.667	0.2	
8.778	9.000	8.833	8.500	7.667	8.167	7.333	7.500	0.4	
4.556	5.000	4.667	4.000	5.278	5.667	5.167	5.000	control	Palm fronds residues 20ton.ha^{-1}
6.000	6.667	6.000	5.333	6.944	7.833	7.000	6.000	0.2	
8.167	8.833	8.333	7.333	7.778	8.500	8.167	6.667	0.4	
0.426	n.s				n.s			LSD	
Effect of organic residues	6.806	6.278	5.778	Effect of organic residues	7.722	7.014	6.306	Effect of potassium sulphate	
	0.175				0.265			LSD	
4.426	4.778	4.444	4.056	5.907	6.389	6.278	5.056	control	Interaction of residues ×potassium sulphate
7.778	8.389	7.611	7.333	8.667	9.778	8.556	7.667	Poultry dung 2 ton.ha^{-1}	
6.704	7.222	6.722	6.167	6.815	7.389	6.444	6.611	Rice residues 20ton.ha^{-1}	
6.241	6.833	6.333	5.556	6.667	7.333	6.778	5.889	Palm fronds residues 20ton.ha^{-1}	
0.332	n.s			0.562	0.658			LSD	
Effect of zinc sulphate				Effect of zinc sulphate					
4.597	5.042	4.625	4.125	5.625	6.167	5.542	5.167	control	Interaction of zinc sulphate potassium × sulphate
6.361	7.042	6.333	5.708	7.333	8.125	7.333	6.542	0.2	
7.903	8.333	7.875	7.500	8.083	8.875	8.167	7.208	0.4	
0.197	n.s			0.275	n.s			LSD	

Table 9 : The effect of adding organic residues and spraying potassium and zinc sulphate and their interaction on the average weight of marketable tuber.

Second spring season				First spring season				Treatments	
Interaction of residues ×zinc sulphate	Potassium sulphate g.L^{-1}			Interaction of residues zinc sulphate×	Potassium sulphate g.L^{-1}			Zinc sulphate g.L^{-1}	Organic residues
	5	2.5	control		5	2.5	control		
63.00	63.67	63.33	62.00	97.56	97.33	98.00	97.33	control	Control
65.22	66.67	64.67	64.33	96.78	94.67	97.67	98.00	0.2	
71.22	73.33	71.00	69.33	96.78	101.00	97.33	92.00	0.4	
72.78	73.67	73.00	71.67	116.33	121.67	115.33	112.00	control	Poultry dung 2 ton.ha^{-1}
75.67	78.00	75.33	73.67	125.00	127.00	128.33	119.67	0.2	
82.89	85.33	83.00	80.33	123.44	120.67	126.00	123.67	0.4	
69.33	72.33	69.67	66.00	108.00	113.33	108.33	102.33	control	Rice residues 20ton.ha^{-1}
74.33	75.67	74.00	73.33	111.78	123.33	111.67	100.33	0.2	
81.00	83.33	81.67	78.00	118.33	122.00	119.67	113.33	0.4	
68.17	72.00	68.50	64.00	102.67	108.67	104.33	95.00	control	Palm fronds residues 20ton.ha^{-1}
74.67	76.00	74.33	73.67	114.22	122.33	111.00	109.33	0.2	
78.78	80.00	78.67	77.67	119.11	124.67	119.33	113.33	0.4	
1.220	2.122			3.421	5.446			LSD	
Effect of organic residues	75.00	73.10	71.17	Effect of organic residues	114.72	111.42	106.36	Effect of potassium sulphate	
	0.630				1.550			LSD	
66.48	67.89	66.33	65.22	97.04	97.67	97.67	95.78	control	Interaction of residues ×potassium sulphate
77.11	79.00	77.11	75.22	121.59	123.11	123.22	118.44	Poultry dung 2 ton.ha^{-1}	
74.89	77.11	75.11	72.44	112.70	119.56	113.22	105.33	Rice residues 20ton.ha^{-1}	
73.87	76.00	73.83	71.78	112.0	118.56	111.56	105.89	Palm fronds residues 20ton.ha^{-1}	
0.798	n.s			2.605	3.379			LSD	
Effect of zinc sulphate				Effect of zinc sulphate					
68.32	70.42	68.62	65.92	106.14	110.25	106.50	101.67	control	Interaction of zinc sulphate potassium × sulphate
72.47	74.08	72.08	71.25	111.94	116.83	112.17	106.83	0.2	
78.47	80.50	78.58	76.33	114.42	117.08	115.58	110.58	0.4	
0.635	n.s			1.617	n.s			LSD	

Table 10 : The effect of adding organic residues and spraying potassium and zinc sulphate and their interaction on marketing yield.

Second spring season				First spring season				Treatments	
Interaction of residues ×zinc sulphate	Potassium sulphate g.L^{-1}			Interaction of residues zinc sulphate×	Potassium sulphate g.L^{-1}			Zinc sulphate g.L^{-1}	Organic residues
	5	2.5	control		5	2.5	control		
0.196	0.212	0.211	0.165	0.428	0.470	0.457	0.357	control	Control
0.304	0.333	0.301	0.278	0.622	0.646	0.683	0.538	0.2	
0.392	0.440	0.378	0.358	0.669	0.757	0.697	0.552	0.4	
0.441	0.503	0.426	0.394	0.825	0.973	0.807	0.696	control	Poultry dung 2 ton.ha^{-1}
0.614	0.689	0.602	0.552	1.113	1.268	1.112	0.958	0.2	
0.760	0.810	0.747	0.723	1.257	1.441	1.260	1.072	0.4	
0.324	0.361	0.324	0.285	0.620	0.697	0.581	0.581	control	Rice residues 20ton.ha^{-1}
0.496	0.580	0.493	0.415	0.792	0.965	0.745	0.668	0.2	
0.711	0.750	0.721	0.662	0.907	0.995	0.877	0.850	0.4	
0.311	0.360	0.319	0.256	0.541	0.616	0.537	0.472	control	Palm fronds residues 20ton.ha^{-1}
0.448	0.506	0.446	0.392	0.797	0.958	0.776	0.655	0.2	
0.643	0.706	0.655	0.569	0.929	1.058	0.974	0.755	0.4	
0.031	n.s			0.075	n.s			LSD	
Effect of organic residues	0.521	0.468	0.421	Effect of organic residues	0.904	0.792	0.679	Effect of potassium sulphate	
	0.012				0.029			LSD	
0.297	0.328	0.297	0.267	0.573	0.625	0.612	0.482	control	Interaction of residues ×potassium sulphate
0.605	0.667	0.591	0.556	1.065	1.227	1.060	0.908	Poultry dung 2 ton.ha^{-1}	
0.510	0.563	0.513	0.454	0.773	0.885	0.734	0.699	Rice residues 20ton.ha^{-1}	
0.468	0.524	0.473	0.406	0.756	0.877	0.762	0.627	Palm fronds residues 20ton.ha^{-1}	
0.023	0.029			0.047	0.062			LSD	
Effect of zinc sulphate				Effect of zinc sulphate					
0.318	0.359	0.320	0.275	0.603	0.689	0.595	0.526	control	Interaction of zinc sulphate potassium × sulphate
0.466	0.527	0.460	0.409	0.831	0.959	0.829	0.705	0.2	
0.626	0.676	0.625	0.578	0.941	1.063	0.952	0.807	0.4	
0.014	n.s			0.040	n.s			LSD	

Table 11 : The effect of adding organic residues and spraying potassium and zinc sulphate and their interaction on the total yield of tubers.

Second spring season				First spring season				Treatments	
Interaction of residues ×zinc sulphate	Potassium sulphate g.L^{-1}			Interaction of residues zinc sulphate×	Potassium sulphate g.L^{-1}			Zinc sulphate g.L^{-1}	Organic residues
	5	2.5	control		5	2.5	control		
11.70	12.68	12.69	9.72	25.27	27.59	26.70	21.53	Control	Control
18.68	20.21	18.63	17.21	35.41	36.60	38.41	31.22	0.2	
23.56	26.28	23.00	21.40	38.00	42.90	39.52	31.57	0.4	
26.07	29.66	25.48	23.06	46.76	54.58	45.74	39.96	Control	Poultry dung 2 ton.ha^{-1}
36.46	40.71	35.67	33.00	62.32	70.49	62.35	54.13	0.2	
44.52	47.72	43.67	42.17	69.93	79.72	70.22	59.84	0.4	
19.97	23.00	19.66	17.26	35.68	39.87	33.51	33.65	Control	Rice residues 20ton.ha^{-1}
30.29	35.27	29.96	25.64	45.01	54.49	42.04	38.49	0.2	
42.77	45.07	43.28	39.96	51.49	56.27	49.65	48.55	0.4	
18.80	21.73	19.25	15.41	31.79	36.05	31.48	27.84	Control	Palm fronds residues 20ton.ha^{-1}
27.16	30.43	27.37	23.70	45.59	53.97	44.63	38.17	0.2	
39.06	42.89	39.66	34.64	52.71	59.64	55.00	43.47	0.4	
1.805	n.s			3.982	n.s			LSD	
Effect of organic residues	31.30	28.19	25.27	Effect of organic residues	51.01	44.94	39.04	Effect of potassium sulphate	
	0.660				1.578			LSD	
17.98	19.72	18.11	16.11	32.89	35.70	34.88	28.11	Control	Interaction of residues ×potassium sulphate
35.68	39.37	34.94	32.74	59.67	68.26	59.44	51.31	Poultry dung 2 ton.ha^{-1}	
31.01	34.44	30.97	27.62	44.06	50.21	41.74	40.23	Rice residues 20ton.ha^{-1}	
28.34	31.68	28.76	24.58	43.36	49.89	43.71	36.49	Palm fronds residues 20ton.ha^{-1}	
1.395	1.636			2.518	3.357			LSD	
Effect of zinc sulphate				Effect of zinc sulphate					
19.13	21.77	19.27	16.36	34.88	39.52	34.36	30.75	Control	Interaction of zinc sulphate potassium × sulphate
28.15	31.66	27.91	24.89	47.08	53.89	46.86	40.50	0.2	
37.48	40.49	37.40	34.54	53.03	59.63	53.60	45.86	0.4	
0.842	n.s			2.104	n.s			LSD	

Conclusion

This study was confirmed that the using of organic residues (poultry dung, rice residues and palm fronds residues), spraying of zinc sulphate and potassium sulphate was significant in most studied characteristics such as vegetative growth of potato plant, yield and quality.These fertilizers were promoted the providing of nitrogen and magnesium which has a major role in chlorophyll molecule. In addition, zinc sulphate contributes in many biological processes such as oxidation and formation of amino acid which contributes in producing energy and construction of nucleic, amino and fatty acids. Moreover, improve chemical and physical characteristics of soil when these fertilizers added which lead to more vegetative growth and increasing yield in the experimental unit

References

Addiscott, T.M. (1974). Potassium and the distribution of calcium and magnesium in potato plants. J. Sci. Food, 25: 1173 –1183.

Al-Muhammady, O.H.M. (2009). The use of animal fertilizers and whey as a method of organic farming and its impact on the growth and yield of potato. Ph.D. thesis, Baghdad University, Iraq.

AL-Musawi, A.E.M. (2014). The effect of the number of mineral-organic fertilizer on the growth and yield of potato(*Solanum tuberosum* L.) and *Zea mays* var saccharta under the nested farming system. Ph.D. thesis, Technical College, Musayyib University, Iraq.

AlNaamy, S.A.N. (2011). Principles of plant nutrition. Dar Ibn Al-Atheer for printing and publishing,University of Mosul, Iraq, 1440.

Alobady, Abd Al Munaem Saaed Kaleel Hayawi (2005). Physiological studies in improving growth, yield, seed production and reducing watwr stress on potato(*Solanum tuberosum* L.). Ph.D. Thesis. University of Mosul, Iraq.

AlRawi, K.M. and Abd AlAzez, M.K. (2000). Design and analysis of agricultural experements. Second edition, Dar Alketub for printingand publishing, University of Mosul, Iraq.

Al-Sahaf, F.H. (1989). Applied plant nutrition. Baghdad University, Iraq, 259.

Al-Sahaf, F.H. (1994). Native The effect of the number of spraying with nutrient solution (Alnahraen) on the growth and yield of potato (Estima cultivar). Iraqi Journal of Agricultural Sciences 25(1).

Al-Sharefy, M.J.H. (2015). The effect of organic and chemical fertilizer on growth characteristics and yield of potato (*Solanum tuberosum* L.) Dezi cultivar. Euphrates Journalof Agricultural Sciences, 1(2): 50-53.

AlSultany, A.N.A. (2015). The effect of organic and humic acid levels on growth characteristics and yield of potato. Master thesis, Green University of Al Qasim, Iraq.

Al-Zahawi, S.M.A. (2007). The effect of organic fertilizers and soil coverage on growth, production and quality of potato.Master thesis, Baghdad University, Iraq.

Arsenaut, W.J. and Christie, B.R. (2004). Effect of whole seed tuber size and pre-plant storage conditions on yield and tuber size distribution of russet Burbank. Amer. J. Potato, 10(3): 302–307.

Boiteau, G. (2004). Assessing CPB (Colorado Potato Beetle) control option and N fertility in organic potato production. Organic Agric. Center of Canada.

Cook, G.W. (1972). Fertilizer for maximum yield . Richard Clay (The Chaucer Press) Ltd. Bungay. Suffolk., Great Britain, 457.

FAO (2008). http:// www.fao. Org /Potato 2008/ ar/potato/ factosheet.html

Goodwin, T. (1976). Chemistry and Biochemistry of Plant pigments. 2nd ed. Academic Press. New York. San Francisco. USA., 373.

Grandy, A.S.; Porter, G.A. and Erich, M.S. (2002). Organic amendment and rotation crop effect on the recovery of soil organic matter and aggregation in potato cropping systems. Soil Sci. Am. J., 66: 1311–1319.

Haraldsen, T.K.; Asdal, A.; Grasdalen, C.; Nesheim, L. and Ugland, T.N. (2000). Nutrient balances and yields during conversion from convetional to organic cropping systems on silt loam and clay soils in Norway. Biol. Agric. Hortic., 17: 229-246

Hassan, A.A.A. (1999). The production of potato, vegetabels crops series,production and agricultural practices. First edition, Arab publishing house, Egypt, pp 446.

Mikitzel, L.J. and Knowles, N.R. (1990). Effect of potato seed-tuber age on plant establishment and amelioration of age-linked effects with auxin. Plant Physiol., 93: 967-975.

Pang, X.P. and Letey, J. (2000). Oragnic farming: challeng of timing nitrogen availability to crop nitrogen requirements. Soil Sci. Amer. J., 64: 247-253.

Sharaqi, M.M. and Abd-Alhady, K. (1985). Plant physiology. Arabic group for publishing.

Sharif Hossain, A.B.; Hakim, M.A. and Justus., M. (2003). Effect of manure and fertilizers on the growth and yield of potato Pakistan Journal of Biological Sciences, 6(14): 1243-1246.

Tsui, A.S.A. (1984). Multiple-constituency framework of managerial reputational effectiveness.

Watson, D.J. and Watson, M.A. (1953). Comprative Physiological studies on the growth of yield crops. 111. Effect of infection with beet yellow. Annals of Applied Biology.