EFFECT OF ORGANIC AND MINERAL FERTILIZERS AND AGRICULTURAL SULFUR ON CONCENTRATION OF N,P AND K IN SOIL AND POTATO TUBERS

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ABSTRACT

A field experiment was carried out to investigate the effect of different levels of organic and mineral fertilizers and agricultural sulfur on availability of N,P and K in soil and their concentrations in potato tubers. The experiment was carried out in the College of Agricultural Engineering Sciences - University of Baghdad, during 2021 by adding three levels of organic fertilizer (Poultry manure) 0, 5, and 10 Mg ha^{-1}, and their symbols were OM_0, OM_1, and OM_2, respectively. three levels of mineral fertilizer 0, 50 and 100% of the fertilizers recommendation, their symbols were C_0, C_1, and C_2 respectively. three levels of agricultural sulfur 0, 1000, and 2000 kg ha^{-1}, their symbols are S_0, S_1, and S_2 respectively. Randomize complete block design was used with factorial experiment using three replicates. The results showed an increase in soil of available nitrogen, phosphorus and potassium with levels of organic, mineral fertilizers and agricultural sulfur. The results showed that the treatment $OM_2S_2C_2$ achieved the highest mean of 62.87, 35.62 and 313.24 mg for N,P and K kg^{-1} soil, respectively, compared to the control treatment $OM_0S_0C_0$, which gave the lowest mean of 28.7, 9.3, 262.56 mg kg^{-1} soil for N,P and K, respectively. The results also showed an increase in the concentrations of nitrogen, phosphorus and potassium in potato tubers. The treatment $OM_2S_2C_2$ achieved the highest mean of 1.29, 0.47, 1.56 % for N,P and K, respectively, compared to the control treatment $OM_0S_0C_0$, which gave the lowest mean of 0.99, 0.25, 1.02% for N,P and K, respectively.

Key words: poultry manure, nutrients availability, integrated management, responsible use and consumption, Iraq

تاثير إضافة مستويات مختلفة من السماد العضوي والمعدني والكبريت الزراعي في تركيز N و P و K في التربة ودرنات البطاطا

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المستخلص

أجريت تجربة حقلية في أحد حقول كلية علوم الهندسة الزراعية- جامعة بغداد لمعرفة تأثير إضافة مستويات من السماد العضوي والمعدني و الكبريت الزراعي في جاهزية مغذيات N و P و K في التربة وتراكيزها في درنات البطاطا. تمت إضافة ثلاثة مستويات من السماد العضوي (سماد الدواجن) 0 و5 و10 ميكاغرام هـ$^{-1}$ ورمز لها OM_0 وOM_1 وOM_2 على التتابع وثلاثة مستويات من السماد المعدني 0 و50 و100% من التوصية السمادية ورمز لها C_0 وC_1 وC_2 بالتتابع وثلاثة مستويات من الكبريت الزراعي 0 و 1000و 2000 كغم هـ$^{-1}$ وأعطيت الرموز S_0 و S_1 وS_2 بالتتابع. أستخدم تصميم القطاعات العشوائية الكاملة وبثلاثة مكررات في تجربة عاملية. أظهرت النتائج زيادة في جاهزية النتروجين والفسفور والبوتاسيوم في التربة، إذ حققت معاملة التداخل الثلاثي $OM_2S_2C_2$ أعلى متوسط بلغ 62.87 و 35.62 و 313.24 ملغم كغم$^{-1}$ تربة لكل من N و P و K بالتتابع قياسا بمعاملة المقارنة $OM_0S_0C_0$ التي أعطت أقل متوسط 28.7 و 9.3 و 262.56 ملغم كغم$^{-1}$ تربة لكل من N و P و K بالتتابع. أظهرت النتائج ايضا زيادة في تراكيز النتروجين والفسفور والبوتاسيوم في درنات البطاطا، وحققت معاملة التداخل الثلاثي $OM_2S_2C_2$ أعلى متوسط بلغ 1.29 و0.47 و1.56% لكل من N وP و K بالتتابع قياسا بمعاملة المقارنة $OM_0S_0C_0$ التي أعطت أقل متوسط 0.99 و 0.25 و 1.02 % لكل من N وP وk بالتتابع.

الكلمات المفتاحية: سماد الدواجن، جاهزية المغذيات، الادارة المتكاملة، الاستخدام والاستهلاك المسؤولان، العراق

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INTRODUCTION

The dry and semi-arid soils of Iraq are characterized by a high percentage of carbonate minerals, a high pH, and a low content of organic matter, that negatively reflected in the availability of nutrients in the soil and the growth of crops (1, 8), However, this problem can be solved by using organic fertilizers, which provide the plant with nutrients and are environmentally safe when compared to mineral fertilizers, also increase the efficiency of use of chemical fertilizers (3, 5, 6). Providing plants with nutrients is necessary to achieve the highest agricultural production, which has increased the use of chemical fertilizers (2, 7, 35, 37). One of the difficulties faced by those interested in agriculture to achieve sustainable agriculture and increase productivity is developing long-term plans and strategies to reduce the use of mineral fertilizers, as improving their use will give a greater chance of polluting the soil, water and air, Therefore, the world has turned towards clean agricultural technologies to reduce sources of pollution as much as possible (4, 32 34, 36). But, organic fertilizer alone does not provide the nutritional requirements of high-yielding crops because of the slow release of nutrients from organic sources and its low content, Therefore, interest in integrated nutrient management began by adding organic fertilizers jointly with mineral fertilizers that release nutrients quickly (14, 30). Natalli *et al*.(26) mentioned that organic fertilization has many advantages compared to mineral fertilization, as it improves some of the mineral, physical, fertility and biological properties of the soil, It reduces reliance on mineral fertilizers, and makes the plant less susceptible to pests and disease. Growing world population and the increase in the demand for food with the presence of determinants of agricultural production, has become a great concern in raising production through the use of mineral fertilizers (N, P and K) (27). Sulfur plays an important role in photosynthesis, respiration, and building the structure of the cell membrane in plants, Because animals cannot synthesize S-containing amino acids, So the rotation of S between plants and the environment is of great importance for the nutrition and health of humans and animals (18, 19, 24). The current study aimed to evaluate effect of adding different levels of organic and mineral fertilizers and agricultural sulfur on the availability of N,P and K and their concentrations in potato tubers.

MATERIALS AND METHODS

A field experiment was conducted in field of the College of Agricultural Engineering Sciences - University of Baghdad at Al-Jadriya area in the spring season 2021 in loam soil. The process of preparing the soil for cultivation were carried out by conducting orthogonal plowing, smoothing and leveling operations. Soil samples were taken from a depth of (0 - 30 cm) from different locations in the field. They were mixed well, air dried and smoothed with a wooden tool and passed through a sieve with a diameter of 2 mm. some physical, mineral and fertility properties required in the study were estimated according to the references mentioned in (Table 1). The field was divided into three blocks and each block into 27 experimental units with an area of 4 m^2 and each experimental unit into three lines, the distance between line and another was 0.75 m, and a distance between experimental units was 0.75m and 1 m between the blocks. The study used poultry manure (Table 2) (31). The study included addition three levels of decomposing poultry manure, which are OM_0 without addition, OM_1 (10 Mg ha^{-1}) and OM_2 (20 Mg ha^{-1}), and three levels of mineral fertilizer NPK, which are C_0 without addition and C_1 half of the fertilizer recommendation 150 N, 45 P, 100 K kg ha^{-1} and C_2 adding the complete fertilizer recommendation 300 N, 90 P, 200 K kg ha^{-1} (9), and three levels of agricultural sulfur S_0 without addition, S_1 1000 kg ha^{-1} and S_2 2000 kg ha^{-1}. Agricultural Sulfur was added by mixing it with the soil two months before planting for control treatments, and one week after the emergence of plants, organic and mineral fertilizers and agricultural sulfur mixed together were added, for a period 75 days before planting for the purpose of completing the decomposition of organic fertilizer and oxidation of agricultural sulfur in one batch by making an incision along the lines In the form grooves 5 cm below the plants and then covered with soil.

Table 1. Some mineral, physical and fertility properties of the study soil before planting

No	Properties		Value	Unit	Reference
1	pH $_{(1:1)}$		7.45		
2	EC $_{(1:1)}$		1.76	ds m^{-1}	
3	CEC		23.70	$Cmol_{+}kg^{-1}$ soil	(28)
4	SOM		22.82		
5	Carbonate minerals		249.0	g kg^{-1} soil	
6	Gypsum		10.41		
7	Cations	Ca^{2+}	4.32		
		Mg^{2+}	2.21		
		Na^{+}	2.94		
		K^{+}	1.50	mmol L^{-1}	
8	Anions	Cl^{-}	4.20		
		SO_4^{2-}	3.91		(28)
		HCO_3^{-}	6.90		
		CO_3^{2-}	Nil		
9	Available nutrients	N	48.28		
		P	18.13	mg kg^{-1} soil	
		K	285.0		
10	Bulk density		1.33	Mg m^{-3}	(13)
11	Particle size distribution	Sand	366.0		
		Silt	458.0	g kg^{-1} soil	(13)
		Clay	176.0		
12	Texture	Loam			

factorial experiment was used with three factors, the treatments were distributed according to the randomized complete block design (RCBD) with three replicates, so that the total number of experimental units became 81 in the soil and in the tubers at harvest time the concentrations of N, P, and K. were estimated after washing, cleaning, cutting, and drying the samples in an experimental units. the concentrations of N, P, and K in the tubers were estimated electric oven at a temperature of 65°Cuntil the weight stabilized. Nitrogen in tubers estimated according to (11). The results of the experiment were analyzed statistically according to the (29) program, and the arithmetic means were compared using the least significant difference (L.S.D) with a probability level of 0.05.

Table 2. Some Properties of poultry manure in the study

Properties	value	unit
pH $_{1:5}$	6.8	–
EC $_{1:5}$	6.3	dS m^{-1}
OC	41	%
N $_{total}$	2.3	%
P $_{total}$	1.4	%
K $_{total}$	1.2	%
C/N Ratio	17.8	

RESULTS AND DISCUSSION

Effect of organic and mineral fertilizers and agricultural sulfur on N, P and K in the soil after harvest: The results of Table (3) show that the effect of the triple interaction organic and mineral fertilization and agricultural sulfur was showed a significant superiority on the soil content of available nitrogen, as the triple interaction treatment ($OM_2S_2C_2$) excelled over all treatments, which gave the highest mean of available nitrogen in the soil, reached to 62.87 mg N kg^{-1} soil, achieving an increase of 119.06%, compared to the control treatment ($OM_0S_0C_0$) which gave the lowest mean of available nitrogen in the soil, reached to 28.70 mg N kg^{-1} soil, followed by the triple interaction treatment ($OM_2S_2C_1$) which also had a significant effect and gave an increase in the concentration of available nitrogen in the soil, with an mean of 54.39 mg N kg^{-1} soil, achieving an increase of 89.51% compared to the control treatment ($OM_0S_0C_0$). The results of Table (4) show that the effect of the triple interaction of organic and mineral fertilization and agricultural sulfur was significant on the soil content of available phosphorus, as the triple interaction treatment ($OM_2S_2C_2$) excelled over all treatments, which gave the highest mean of available phosphorus in the soil, reached to 35.62 mg p kg^{-1} soil, achieving an increase of 283.01%, compared to the control treatment ($OM_0S_0C_0$), which gave the lowest mean of available phosphorus in the soil, reached to 9.30 mg p kg^{-1} soil, followed by the triple interaction treatment ($OM_2S_1C_2$), which also had a significant effect and gave an increase in the concentration of available phosphorus in the soil, with an mean of 31.41 mg p kg^{-1} soil, which achieved an increase of 237.74% compared to the control treatment ($OM_0S_0C_0$). The results in Table (5) show that the effect of the triple interaction between organic and mineral fertilization and agricultural sulfur was significant on the soil content of available potassium, as the interaction treatment ($OM_2S_2C_2$) outperformed all treatments, which gave the highest mean of available potassium in the soil, reached to 313.24 mg K kg^{-1} soil, achieving an increase of 19.30%, compared to the control treatment ($OM_0S_0C_0$), which gave the lowest mean of available potassium in the soil, reached to 262.56 mg K kg^{-1} soil, followed by the triple interaction treatment ($OM_2S_1C_2$), which also had a significant effect and gave an increase in the concentration of available potassium in the soil, with a mean of 308.54 mg K kg $^{-1}$ soil, which achieved an increase of 17.51% compared to the control treatment ($OM_0S_0C_0$).

Table 3. Effect different levels of organic and mineral fertilizers and agricultural sulfur on N in the soil after harvest

organic fertilizer	agricultural Sulfur	mineral fertilizer C_0	C_1	C_2	OM * S
OM_0	S_0	28.70	31.87	35.34	31.97
	S_1	32.19	35.45	39.88	35.84
	S_2	37.01	40.41	45.73	41.05
OM_1	S_0	31.77	35.65	39.25	35.56
	S_1	36.55	39.81	44.42	40.26
	S_2	41.44	46.09	51.71	46.41
OM_2	S_0	35.98	44.62	48.54	43.05
	S_1	41.74	47.59	53.99	47.77
	S_2	46.51	54.39	62.87	54.59
			LSD 7.33		LSD 4.23
			OM * C		
organic fertilizer		C_0	C_1	C_2	mean of organic fertilizer
OM_0		32.63	35.91	40.32	36.29
OM_1		36.59	40.52	45.13	40.74
OM_2		41.41	48.87	55.13	48.47
			LSD 4.23		LSD 2.44
			C * S		
agricultural Sulfur		C_0	C_1	C_2	mean of agricultural Sulfur
S_0		32.15	37.38	41.04	36.86
S_1		36.83	40.95	46.10	41.29
S_2		41.65	46.96	53.44	47.35
			LSD 4.23		LSD 2.44
			mineral fertilizer		
mineral fertilizer		C_0	C_1	C_2	
mean of mineral fertilizer		36.88	41.76	46.86	
			LSD 2.44		

Table 4. Effect different levels of organic and mineral fertilizers and agricultural sulfur on P in the soil after harvest

organic fertilizer	agricultural Sulfur	mineral fertilizer			OM * S
		C_0	C_1	C_2	
OM_0	S_0	9.30	12.95	15.54	12.60
	S_1	10.67	15.92	17.58	14.73
	S_2	12.12	18.41	19.61	16.71
OM_1	S_0	10.85	16.75	19.72	15.77
	S_1	13.17	19.36	23.64	18.72
	S_2	15.34	24.75	28.80	22.96
OM_2	S_0	13.76	23.85	27.77	21.79
	S_1	16.42	26.11	31.41	24.65
	S_2	20.25	30.49	35.62	28.79
			LSD 2.81		LSD 1.62
			OM * C		
organic fertilizer		C_0	C_1	C_2	mean of organic fertilizer
OM_0		10.69	15.76	17.58	14.68
OM_1		13.12	20.28	24.06	19.15
OM_2		16.81	26.82	31.60	25.08
			LSD 1.62		LSD 0.94
			C * S		
agricultural Sulfur		C_0	C_1	C_2	mean of agricultural Sulfur
S_0		11.30	17.85	21.01	16.72
S_1		13.42	20.46	24.21	19.37
S_2		15.90	24.55	28.01	22.82
			LSD 1.62		LSD 0.94
			mineral fertilizer		
mineral fertilizer		C_0	C_1	C_2	
mean of mineral fertilizer		13.54	20.95	24.41	
			LSD 0.94		

Table 5. Effect different levels of organic and Mineral fertilizers and agricultural sulfur on the availability of K in the soil after harvest

organic fetrilizer	agricultural Sulfur	mineral fertilizer			OM * S
		C_0	C_1	C_2	
OM_0	S_0	262.56	267.09	277.61	269.09
	S_1	267.09	273.85	286.93	275.96
	S_2	275.74	279.44	292.58	282.59
OM_1	S_0	270.19	282.31	289.76	280.75
	S_1	275.12	288.72	295.04	286.29
	S_2	284.25	294.22	304.39	294.29
OM_2	S_0	280.48	292.00	300.11	290.86
	S_1	286.71	299.15	308.54	298.13
	S_2	296.10	305.07	313.24	304.80
			LSD 7.28		LSD 4.20

OM * C

organic fertilizer	C_0	C_1	C_2	mean of organic fertilizer
OM_0	268.47	273.46	285.70	275.88
OM_1	276.52	288.42	296.40	287.11
OM_2	287.76	298.74	307.29	297.93
		LSD 4.20		LSD 2.43

C * S

agricultural Sulfur	C_0	C_1	C_2	mean of agricultural Sulfur
S_0	271.08	280.47	289.16	280.23
S_1	276.31	287.24	296.83	286.79
S_2	285.37	292.91	303.40	293.89
		LSD 4.20		LSD 2.43

mineral fertilizer

mineral fertilizer	C_0	C_1	C_2
mean of mineral fertilizer	277.58	286.87	296.47
		LSD 2.43	

The results in tables (3,4,5) that the treatments of organic and mineral fertilization and agricultural sulfur were significantly superior in the concentration of available N,P and K in the soil, The increase in the availability of these nutrients may be attributed to the role of poultry waste in increasing the activity of microorganisms in the root zone that depend on organic matter as an energy source for it to carry out its vital activity and increase the mineralization of organic matter and release these nutrients into the soil, which enhances soil fertility and its ability to preserve on fertilizers and providing them to the plant, which is positively reflected in most plant properties (20,17). this result is agree with the findings of other researchers (5, 21, 30) that adding organic fertilizers led to an increase in the concentrations of these nutrients in the soil after harvest, due to the role of organic matter in contributing to the addition of nutrients to the soil, including nitrogen, phosphorus and potassium. moreover, The organic manure added as poultry waste had a significant effect on increasing the concentrations of nutrients in the soil. This increase is attributed to the content of poultry waste added from it and the release of nutrients in available forms into the soil when the organic manure biodegrades, which varied according to the amount added. In addition to the presence of high organic matter in the soil before planting, which decomposed as a result of fertilizer additions to the soil and released the elements N, P and K. These results are consistent with (25, 27). With regard to mineral fertilization, it had a significant effect in increasing the values of nitrogen, phosphorus and potassium in the soil, as the addition of mineral fertilizer by 50% or 100% of the fertilizer recommendation (NPK) increased the concentration of available nitrogen, phosphorus and potassium in the soil compared to the control treatment, this increase is due to the addition of Mineral fertilizers that contain these nutrients (32,10). Also, the addition of agricultural sulfur to the soil has an important role to reducing the pH of soil, improving the state of soil fertility, nutrients equilibrium in it, and increasing their availability for uptake by plants, all of these factors led to improved plant growth (33,15).

Effect of organic and mineral fertilizers and agricultural sulfur on the concentration of N,P and K% in tubers

The results of Table (6) show effect of the triple interaction of organic and mineral fertilization and agricultural sulfur was significant on the nitrogen content of the tubers, as the triple interaction treatment ($OM_2S_2C_2$) outperformed all treatments, which gave the highest mean tuber nitrogen content 1.29% achieving an increase of 30.30%, compared to the control treatment ($OM_0S_0C_0$) which gave the lowest mean of nitrogen in the tubers 0.99%, followed by the triple interaction treatment ($OM_2S_2C_1$), which also had a significant effect and gave an increase in the nitrogen content of the tubers at a mean of 1.25%, achieving an increase of 26.26% compared to the control treatment ($OM_0S_0C_0$). Table (7) show effect of the triple interaction of organic and mineral fertilization and agricultural sulfur was significant on the phosphorus content of the tubers, as the triple interaction treatment ($OM_2S_2C_2$) outperformed all treatments, which gave the highest mean tuber phosphorus content 0.47% achieving an increase of 88.00% compared to the control treatment ($OM_0S_0C_0$) which gave the lowest mean of phosphorus in the tubers 0.25%, followed by the triple interaction treatment ($OM_2S_2C_1$), which also had a significant effect and gave an increase in the phosphorus content of the tuber an mean of 0.45%, achieving an increase of 80.0 % compared to the control treatment ($OM_0S_0C_0$).

Table 6. Effect organic and mineral fertilizers and agricultural sulfur on the concentration of N% in tubers

organic fertilizer	agricultural Sulfur	mineral fertilizer C_0	C_1	C_2	OM * S
OM_0	S_0	0.99	1.05	1.10	1.05
	S_1	1.03	1.10	1.13	1.09
	S_2	1.08	1.12	1.18	1.13
OM_1	S_0	1.05	1.12	1.16	1.11
	S_1	1.12	1.17	1.19	1.16
	S_2	1.15	1.20	1.23	1.19
OM_2	S_0	1.11	1.17	1.22	1.17
	S_1	1.17	1.23	1.24	1.21
	S_2	1.22	1.25	1.29	1.25
			LSD 0.24		LSD 0.14
			OM * C		
organic fertilizer		C_0	C_1	C_2	mean of Organic fertilizer
OM_0		1.03	1.09	1.14	1.09
OM_1		1.11	1.16	1.19	1.16
OM_2		1.17	1.22	1.25	1.21
			LSD 0.14		LSD 0.08 LSD_{OM}
			C * S		
agricultural Sulfur		C_0	C_1	C_2	mean of agricultural Sulfur
S_0		1.05	1.11	1.16	1.11
S_1		1.11	1.17	1.19	1.15
S_2		1.15	1.19	1.23	1.19
			LSD 0.14		LSD 0.08 LSD_S
			mineral fertilizer		
mineral fertilizer		C_0	C_1	C_2	
mean of Mineral fertilizer		1.10	1.16	1.19	
			LSD 0.08		

Table 7. Effect organic and mineral fertilizers and agricultural sulfur on the concentration of P % in tubers

organic fertilizer	agricultural Sulfur	mineral fertilizer			OM * S
		C_0	C_1	C_2	
	S_0	0.25	0.27	0.31	0.28
OM_0	S_1	0.26	0.29	0.33	0.30
	S_2	0.28	0.32	0.35	0.32
	S_0	0.32	0.34	0.37	0.35
OM_1	S_1	0.34	0.36	0.39	0.37
	S_2	0.36	0.39	0.41	0.39
	S_0	0.38	0.40	0.43	0.40
OM_2	S_1	0.41	0.43	0.44	0.43
	S_2	0.42	0.45	0.47	0.45
			LSD 0.09		LSD 0.05
			OM * C		
organic fertilizer		C_0	C_1	C_2	mean of Organic fertilizer
OM_0		0.26	0.30	0.33	0.30
OM_1		0.34	0.37	0.39	0.37
OM_2		0.41	0.43	0.45	0.43
			LSD 0.05		LSD 0.03
			C * S		
agricultural Sulfur		C_0	C_1	C_2	mean of agricultural Sulfur
S_0		0.32	0.34	0.37	0.34
S_1		0.34	0.36	0.39	0.36
S_2		0.35	0.39	0.41	0.39
			LSD 0.05		LSD 0.03
			mineral fertilizer		
mineral fertilizer		C_0	C_1	C_2	
Mean of Mineral fertilizer		0.34	0.36	0.39	
			LSD 0.03		

The results of table (8) showed effect of the triple interaction of organic and mineral fertilization and agricultural sulfur was significant on the potassium content of the tubers, as the triple interaction treatment ($OM_2S_2C_2$) outperformed all treatments, which gave the highest mean tuber potassium content 1.56 % achieving an increase of 52.94% compared to the control treatment ($OM_0S_0C_0$) which gave the lowest mean of potassium in the tubers 1.02 %, followed by the triple interaction treatment ($OM_2S_2C_1$), which also had a significant effect and gave an increase in the potassium content of the tubers at an mean of 1.51%, achieving an increase of 48.04% compared to the control treatment ($OM_0S_0C_0$).

The results of tables (6,7,8) show a significant superiority of the triple interaction of organic and mineral fertilization and agricultural sulfur in the percentages of N,P, and K in potato tubers, The reason for this increase in nutrients concentrations in the tubers may be due to the increase nutrients availability in the soil solution as a result of organic and mineral fertilization and agricultural sulfur, Also available nutrients contribute to building a good root and shoot system for the plant, thus increasing the amount of nutrients and increasing the absorption of them, and they accumulate in the vegetative part, which helps the plant to carry out its vital activities, which results in a quantity of manufactured materials in the leaves and to provide transport factors for these materials to the tubers, thus increasing their concentration in tubers. This was confirmed by the fact that fertilization has a role in stimulating the growth of the root and vegetative system of the plant, and then increasing its absorption and concentration in tubers (1,22).

Table 8. Effect organic and mineral fertilizers and agricultural sulfur on the concentration of K % in tubers

organic fertilizer	agricultural Sulfur	mineral fertilizer C_0	C_1	C_2	OM * S
	S_0	1.02	1.09	1.14	1.09
OM_0	S_1	1.11	1.17	1.22	1.17
	S_2	1.19	1.28	1.33	1.27
	S_0	1.09	1.13	1.19	1.14
OM_1	S_1	1.23	1.30	1.34	1.29
	S_2	1.32	1.38	1.44	1.38
	S_0	1.17	1.22	1.28	1.23
OM_2	S_1	1.35	1.41	1.46	1.41
	S_2	1.42	1.51	1.56	1.50
			LSD 0.10		LSD 0.06
			OM * C		
organic fertilizer		C_0	C_1	C_2	mean of organic fertilizer
OM_0		1.11	1.18	1.23	1.17
OM_1		1.22	1.27	1.33	1.27
OM_2		1.32	1.38	1.44	1.38
			LSD 0.06		LSD 0.03
			C * S		
agricultural Sulfur		C_0	C_1	C_2	mean of agricultural Sulfur
S_0		1.10	1.15	1.21	1.15
S_1		1.23	1.29	1.34	1.29
S_2		1.31	1.39	1.45	1.38
LSD $_{S*C}$			0.06		LSD 0.03
			mineral fertilizer		
mineral fertilizer		C_0	C_1	C_2	
mean of Mineral fertilizer		1.21	1.28	1.33	
			LSD 0.03		

These results agree with (3,8,12) who indicated that the addition of organic and mineral fertilizers affected the tubers content of N,P, and K, and that its concentrations in tubers increased with the levels of fertilizer addition to the soil. In addition adding sulfur reduces the pH soil, increases the availability of nutrients, improves the physiological process within the plant, and thus increases the absorption of these nutrients by tubers, in addition to its important role in the process of degrading carbohydrates, liberating energy and forming fridoxin which participates in the process of nitrate reduction, It is also one of the most important components of the nitrate chain, Electron transport in the first photosynthetic system of the carbon synthesis process, which works to increase the vegetative growth of plants (16, 23).

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