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Effect of Potassium and Sulfur-Containing Fertilizers on some Growth Parameters, Chemical Constituents, Protein and Yield of Potato (*Solanum tuberosum* L.) Binella Böhm 52 72 × Sirco Variety

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ABSTRACT

An analysis was completed in the field to consider the impact of potassium (K) and sulfur (S) on potato for ideal yield, quality, and supplement use effectiveness. Medicines included four degrees of potassium (0, 100, 200 and 300 kg K ha^{-1}) and five degrees of sulfur (0, 50, 100, 150 and 200 kg S ha^{-1}) in Split plot configuration having three replications in Kanipanka investigate station, Sulaimani Governorate, Iraqi Kurdistan district under inundated condition. The potassium and sulfur collaboration effectsly affected vegetative development. Leaf territory, No. of stem and secured territory per plant indicated a critical effect of potassium and sulfur application. There was noteworthy negative communication among potassium and sulfur. The all out tuber yield expanded on a normal by 17.5 and 37.63 percent at 200 kg K ha^{-1} and 300 kg K ha^{-1}, individually, when contrasted with no potassium application. Sulfur application significantly affected all out tuber yield, appropriate yield for showcasing and non-reasonable yield for promoting, non-reasonable yield for advertising to add up to yield, tuber number and tuber weight. The all out tuber yield and appropriate yield for advertising are expanded with expanding sulfur application. Concerning the information of compound substance tuber of potato demonstrated that the blend of potassium and sulfur, it saw that most noteworthy percent of K, P, N, Ca and protein substance were 1.60, 0.44, 1.47, 2.84 and 9.19 % enrolled by 300 kg K ha^{-1} × 0 kg S ha^{-1}, 0 kg K ha^{-1} × 100 kg S ha^{-1}, 200 kg K ha^{-1} ×100 kg S ha^{-1}, 300 kg K ha^{-1} ×100 kg S ha^{-1} and 200 kg K ha^{-1} × 200 kg S ha^{-1}, individually.

Keywords: Potato, Chemical Component, Growth and Yield

INTRODUCTION

Potato is connnidered as the fourth most significant nourishment crop after rice, wheat, and maize on the planet. India and China are the biggest potatoes delivering nation on the planet, with yearly creation of 37.3 million tones (Anonymous, 2010). Potato is the most broadly developed nourishment crop after wheat, rice and maize. It is plentiful in nutrient C and potassium, high in protein content, and is about fat free. More potatoes are devoured by the total populace than by some other vegetable (Vanaei *et al*., 2008). Potatoes arrived at Iraq so later in the nineteenth century, however the yield was not planted as a vegetative harvest around then, yet the yield was planted as a vegetative yield in the twentieth century starting (Al-Rawi, 1975). The parity sustenance is a basic part of supplement the executives and assumes a critical job in inc reasing crop creation and it's quality (Rasheed *et al*., 2004). Soil ripeness is one of the main considerations that influence the yield and nature of the potato (Adhikari and Sharma, 2004). Potato is a touchy harvest to application the board of K and S and sums less or more than its prerequisites, or early and late utilization of K and S will influence the quantitative and subjective yield of tuber (Rezaei and Soltani, 1996). Adjusted preparation has end up being a boss in agrarian creation under the distinctive cultivating circumstance and added to almost 50 percent in by and large increment in rural creation (Singh *et al*., 2008). The potato crop requires a decent portion of Nitrogen (N), Phosphorus (P), Sulfur (S) and potassium (K) for ideal creation (Singh and Trehan, 1998). In the serious awkwardness in the N: P: K application proportion and lopsided preparation for N and absence of potash application are very normal among ranchers (Singh and Rai, 2011). Potassium is significant fundamental macronutrients which assume a significant job in development and advancement of potato crop. Potassium application has been ignored by most of ranchers in our nation bringing about ceaseless consumption of soil K (Ladha *et al*., 2003 and Lal *et al*., 2007). Iraq soils are commonly high in absolute K, yet just a little portion of it is available in accessible structure due to dynamic harmonies between interchangeable, non-replaceable and fixed K. With high yield force and high K evacuation, the dirts are getting insufficient in K. Visit K lacks have been seen in crops (Panaullah *et al*., 2006). Regmi *et al*. (2002) proposed that due to deficient K application, K soil unevenness in the farming environment and stagnation of yield will turn out to be increasingly articulated with time. Sulfur is one of the six macronutrients required for legitimate plant improvement, it is a fundamental component in potato development and creation, since it is significant for the arrangement of some basic plant mixes, for example, it assumes basic job in different significant instruments, for example, the development of amino acids,

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proteins, oils; in basic segments of cellular material; and in actuation of specific nutrients and catalysts. Sulfur is basic as an auxiliary segment of some amino acids found in the two plants and creatures, along these lines it is a piece of cosmetics of each living life form. Chlorophyll development likewise is reliant on legitimate Sulfur sustenance. Plants can absorb inorganic sulfur and inc orporate it into natural mixes, while creatures depend altogether on natural wellsprings of sulfur (Malgorzata and Agnieszka, 2008). The current investigation was attempted to build up a manure suggestion for potato and to decide the gainfulness of various mixes of composts on the quality and amount of potato.

MATERIALS AND METHODS

Experimental design

The experiment was conducted at (Kanipanka Agricultural Research Farm, 45° 43' 11'' E, 35° 22' 57'' N 578 m above sea level) in Sulaimani Governorate, Kurdistan Region – Iraq (Fig.1), during the autumn growing season from 14/8/2008 to 5/12/2008 to study the effect of potassium and sulfur on potato tubers (Binella Böhm 52 72 × Sirco cultivar), were brought from the Agrico Company Netherlands, . The experiment was laid out in a Split plot design with three dispersed replications, having 21 treatment combinations of four of levels of potassium (0, 100, 200 and 300 kg K ha^{-1}) in the main plots and five levels of sulfur (0, 50, 100, 150 and 200 kg S ha^{-1}) in the sub plots. Di-ammonium Phosphate ($(NH_4)_2H_2PO_4$) fertilizer which contained (46% P_2O_5 and 18% N) was applied at the same level (300 kg ha^{-1}), for all experimental units to give (206.55g) DAP. After preparing the land (plowing - softening - leveling), the land divided into furrows. The experiment was conducted on the 846.8 m^2 (23.2m X 36.5m). The area of the experimental unit was (2.7 X 2.55 m). The experimental unit contained three straight furrows with length 2.7 m and width 0.85 m. Potato tubers (Binella Böhm 52 72 × Sirco cultivar), obtained from the Agrico Company Netherlands were planted in-furrow at 5 cm depth and distance between two tubers was 30 cm. Plots were irrigated as needed through the growing season. Tubers were then collected by hand, washed, graded by USDA specifications, and weighed.

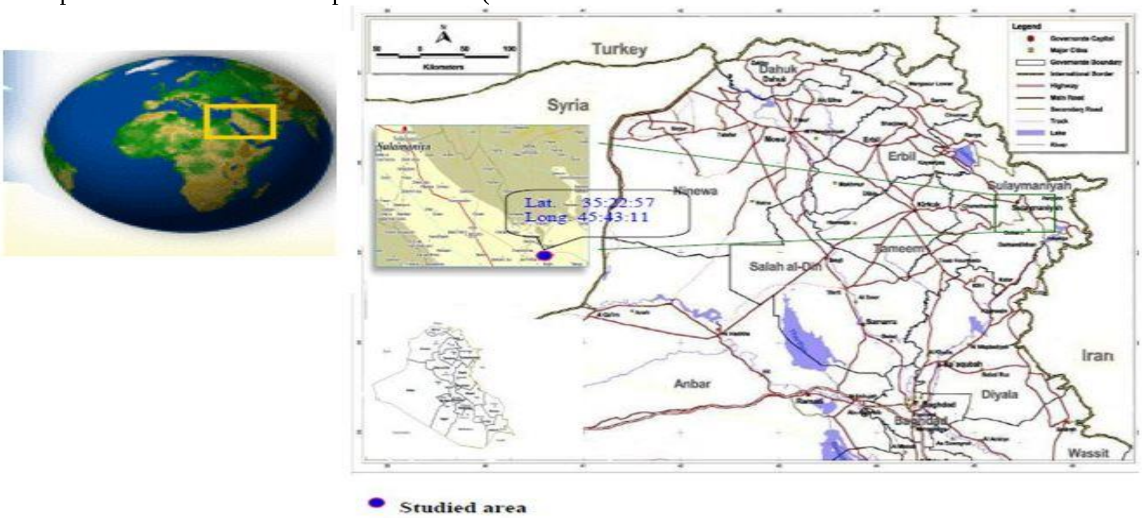

Figure 1. Location of studied area

Soil Analysis

Soil sample was taken from 0-40 cm depth before the commencement the experiment. The collected and prepared soil samples were oven dried at 105 ºC. They were analyzed for different physicochemical properties by adopting the standard procedures and methods employed. The details are presented in Table 1

Studied characters

During the growth period, plant height, leaf area (L45, L60 and L75), Number of stem (NS45, NS60, and NS75) and covered area per plant were recorded at 45, 60 and 75 days after planting. Yield parameters were recorded at harvest.

Chemical constituents

The N, P, Ca and K content of tuber of potato was determined by ICP-AES (Varian, Vista Axiel Simultaneous) as described by Soltanpour and Workman (1981). Tuber Protein content: tubers of five plants samples were milled to determine protein content by Kjeldahl digestion apparatus through determining organic nitrogen (AOAC, 1984).

Table 1. Some physical and chemical properties of the soil used in field experiment.

soil properties		Location
		Kanipanka
Particle Size Distribution (PSD) g kg^{-1}	Sand	100
	Silt	420
	Clay	480
Textural Class		Clay loam
Bulk density *M*g m^{-3}*		1.50
pH		7.33
EC dS m^{-1} At 25 °C		0.49
Cation Exchange capacity (CEC) $cmol_c$ kg^{-1}		34.2
Organic matter (OM) g kg^{-1}		23.33
Soluble ions mmol L^{-1}	Ca^{2+}	1.1
	Mg^{2+}	0.85
	Na^{+}	0.62
	K^{+}	0.186
	HCO_3^{-}	3.29
	SO_4^{2-}	0.79

Data analysis

Statistical analysis JMP7 computer software was used in the statistical analyses of the data obtained in this investigation (JMP, 2007). Ten plants were randomly selected prior to harvest for collecting the data on yield attributes of potato. Collected data were analyzed statistically and the means were separated as per LSD Test.

RESULTS AND DISCUSSION

Growth parameters

Leaf area and number of the stem were not influenced by potassium and sulfur levels. Leaf area ranged from 6.76 to 8.06 L45, 9.75 to 12.64 for L60 and 11.98 to 16.6 for L75. Number of stem varied from 4.51 to 4.93 for NS45, 4.62 to 5.09 for NS60 and 5.35 to 5.55 for NS75 Table (2). Covered area per plant at 45 and 60 days was not affected by potassium application. Application of potassium has a significant effect on the covered area at 75 days compared to control (0 kg K ha^{-1}) (Table 2).

The maximum covered area was recorded under the dose of potassium (300 kg K ha^{-1}) while the minimum covered area was registered by control (0 kg K ha^{-1}). This might be due to the effect of K plays a crucial role in the maintenance of tissue water relation, aids in photosynthesis and enhances N uptake and protein synthesis resulting in better foliage growth (Marschner, 1995). Saha *et al.* (2001) also observed that stems per hill were not influenced by N and K levels. Number of stems/plant is a factor of variety, seed size, and its physiological status; hence, stems per hill were not influenced by potassium levels. Potassium increases leaf expansion particularly at early stages of growth, extends leaf area duration by delaying leaf shedding near maturity. Similarly Sulfur also had not significant effect on leaf area (L), the number of the stem (S) and covered area at 75 days. The covered area at 45 and 60 days increased significantly at 200 kg S ha^{-1} and 150 kg S ha^{-1} (Table 3). The moderate of electro conductivity of medium with moderate of nitrogen content in soil may lead to unchanging of growth parameters.

Table2. Effect of potassium fertilizer (kg ha^{-1}) treatments on growth parameters

Potassium fertilizer levels (kg ha^{-1})	L45 (cm^2)	L60 (cm^2)	L75 (cm^2)	NS45	NS60	NS75	Covered area/ plant (45 days)	Covered area/ plant (60 days)	Covered area/ plant (75 days)
0	6.76	9.75	11.98	4.51	5.09	5.35	13.02	28.4	38.47
100	8.06	10.42	12.62	4.93	4.91	5.49	13.60	30.20	41.36
200	6.82	10.03	12.29	4.80	4.71	5.55	13.3	28.51	40.59
300	7.65	12.64	16.60	4.53	4.62	5.55	13.41	29.23	42.81
LSD	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*3.69*

Table3. Effect of sulfur fertilizer (kg ha^{-1}) treatments on growth parameters

Sulfur fertilizer levels (kg ha^{-1})	L45 (cm^2)	L60 (cm^2)	L75 (cm^2)	NS45	NS60	NS75	Covered area/ plant (45 days)	Covered area/ plant (60 days)	Covered area/ plant (75 days)
0	6.85	10.28	13.01	4.61	4.78	5.28	12.84	28.60	40.53
50	7.57	11.25	14.37	4.44	4.52	5.39	12.98	27.95	40.38
100	7.39	10.35	12.75	4.69	4.80	5.22	13.11	29.59	39.59
150	7.63	10.36	12.23	4.86	5.11	5.83	13.42	30.21	41.30
200	7.18	11.33	14.50	4.86	4.94	5.72	14.23	28.78	42.23
LSD	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*0.77*	*2.00*	*ns*

The K and S connection effectively affected vegetative development. Leaf region, No. of stem and secured zone per plant demonstrated a huge effect of potassium and sulfur application (Table 4). There was huge negative association among K and S. The most extreme worth was recorded by collaboration 100 kg K ha^{-1} × 100 kg S ha^{-1} (L45), 300 kg K ha^{-1} × 200 kg S ha^{-1} (L60), 300 kg K ha^{-1} × 200 kg S ha^{-1} (L75), 200 kg K ha^{-1} × 200 kg S ha^{-1} (NS45), 100 kg K ha^{-1} × 150 kg S ha^{-1} (NS60), 200 kg K ha^{-1} × 200 kg S ha^{-1} (NS75), 200 kg K ha^{-1} × 200 kg S ha^{-1} (Covered territory 45), 100 kg K ha^{-1} × 100 kg S ha^{-1} (Covered region 60) and 300 kg K ha^{-1} × 200 kg S ha^{-1} (Covered zone 75). There is better usage of S is the nearness of K as reflected in an expansion in plant stature (Singh and Trehan, 1998) and yield (Chaddha, *et al*., 2006). Potassium alongside N assumes a significant job in development and yield as it is associated with absorption, transport and capacity time of photosynthesis (Marschner, 1995). Potassium builds leaf extension especially at beginning times of development, expands leaf region length by deferring leaf shedding close to development. K application actuates number of chemicals engaged with photosynthesis, sugar digestion and proteins and aids the translocation of starches from leaves to tubers (Imas and Bansal, 2002). For the most part, the upgrade in plant development might be because of that use of sulfur helps in expanding the plant development consequently expanded the take-up of the supplements at more elevated levels of sulfur. Comparable outcomes had additionally been accounted for by Dabhi *et al*., 2004; Jaggi, 2005 and Fatma *et al*., 2012. Right now, and Sood (2002) and Fatma *et al*., (2012) revealed that sulfur application decidedly influenced every single vegetative character of the onion plant. Conversely Hamilton *et al*., 1998, demonstrated that extra sulfur didn't fundamentally influence plant development

Yield and yield contributing characters

The yield and yield contributing characters of potato contrasted essentially because of utilizing diverse compost of K and S. Absolute Potato yield was 8.98, 9.8, 10.55 and 12.36 Mg ha^{-1} because of the primary impact of 0 kg K ha^{-1}, 100 kg K ha^{-1}, 200 kg K ha^{-1} and 300 kg K ha^{-1}, individually. The complete tuber yield expanded on a normal by 17.5 and 37.63 percent at 200 kg K/ha and 300 kg K/ha individually, when contrasted with no K application. The impact was progressively apparent in the reasonable yield for advertising yield where the appropriate yield for promoting expanded by 19.81 and 41.4 percent at 200 kg K ha-1 and 300 kg K ha^{-1} when contrasted with no K application. K application diminished non-reasonable yield for promoting and non-appropriate yield for advertising to add up to yield. The most noteworthy appropriate yield for advertising and non-reasonable yield for showcasing (11.92 and 0.55 Mg ha^{-1}) was recorded by 300 kg K ha^{-1} and 0 kg K ha^{-1} application while the least appropriate yield for promoting and non-reasonable yield for showcasing (8.43 and 0.38 Mg ha^{-1}) was enrolled by 300 kg K ha^{-1} and 100 kg K ha-1 application. Most extreme number of tubers/plant (11.02) was found from 300 kg K ha^{-1} based manure treatment, and it was factually unique in relation to different medicines. Control plot (0 kg K ha^{-1}) delivered least tubers/plant (7.42). The most noteworthy tuber weight/plant (98.1 g) was recorded from 300 kg K ha-1 treatment and it was factually like 100 kg K ha^{-1} and 200 kg K ha^{-1} treatment. Least tuber weight/plant (89.23 g) was gotten from control treatment (0 kg K ha^{-1}), (Table 5).

Table 4. Effect of potassium and sulfur fertilizer (kg ha^{-1}) combination on growth parameters.

Levels K + S(kg ha^{-1})	L45 (cm^2)	L60 (cm^2)	L75 (cm^2)	NS45	NS60	NS75	Covered area/ plant (45 days)	Covered area /plant (60 days)	Covered area/ plant (75 days)
0 K + 0 S	5.02	8.49	10.89	4.89	5.00	5.66	13.07	26.73	33.50
0 K + 50 S	7.89	10.99	13.17	4.33	4.33	5.11	12.53	25.27	38.83
0 K + 100 S	6.05	7.72	8.97	4.44	4.66	5.22	12.23	29.83	38.13
0 K + 150 S	7.52	9.73	11.81	4.44	4.44	5.22	13.50	30.87	41.50
0 K + 200 S	7.32	11.84	15.07	4.44	4.67	5.55	13.77	29.67	40.40
100 K + 0 S	8.03	10.75	12.17	5.22	5.44	5.44	13.27	30.50	40.10
100 K + 50 S	7.48	10.35	13.29	4.66	4.78	5.22	13.07	30.90	39.90
100 K + 100 S	9.17	11.89	13.56	4.67	4.78	4.89	13.37	33.03	42.43
100 K + 150 S	8.31	9.52	10.61	5.22	5.45	6.22	12.53	30.20	42.70
100 K + 200 S	7.32	9.59	11.84	4.89	5.00	5.66	13.93	26.37	41.67
200 K + 0 S	5.86	8.83	11.79	4.33	4.33	4.78	12.57	26.80	43.27
200 K +50 S	7.44	11.74	15.51	4.44	4.55	5.66	13.40	26.53	40.40
200 K + 100 S	7.07	10.31	13.27	4.77	4.88	5.33	13.40	26.83	38.53
200 K + 150 S	7.32	9.97	11.56	4.99	5.33	5.78	13.67	30.80	39.83
200 K + 200 S	6.42	9.32	10.95	5.44	5.44	6.23	14.97	30.07	40.90
300 K + 0 S	8.47	13.06	17.17	4.00	4.33	5.22	12.47	30.37	45.23
300 K + 50 S	7.49	11.90	15.49	4.33	4.44	5.55	12.90	29.10	42.40
300 K + 100 S	7.28	11.48	15.22	4.89	4.89	5.44	13.43	28.67	39.27
300 K + 150 S	7.37	12.21	14.97	4.78	5.22	6.11	13.97	28.97	41.17
300 K + 200 S	7.66	14.57	20.13	4.66	4.66	5.44	14.27	29.03	45.97
LSD	3.25	6.02	9.16	2.12	2.17	2.13	1.54	3.99	5.78

Table5. Yield parameters of potato as influenced by potassium (kg ha^{-1}) application

Potassium fertilizer levels (kg ha^{-1})	Total Yield (*Mg* ha^{-1})	Suitable Yield for marketing (*Mg* ha^{-1})	Non-suitable Yield for marketing (*Mg* ha^{-1})	Non-suitable Yield for marketing to Total yield	No. of Tuber	Tuber Weight (g)
0	8.98	8.43	0.55	5.33	7.42	89.23
100	9.80	9.42	0.38	3.84	8.59	95.23
200	10.55	10.10	0.45	4.32	9.36	94.08
300	12.36	11.92	0.44	3.56	11.02	98.10
LSD	*0.13*	*0.23*	*0.22*	*1.56*	*0.30*	*4.4*

Moinuddin *et al*. (2005) and Ummar and Moinuddin (2001) additionally demonstrated an expansion in potato tuber yield because of potassium application up to 120 and 200 kg ha-1. Increment in all out yield and the yield of huge tubers because of K preparation may originate from the invigorating impact of potassium on photosynthesis, phloem stacking, and translocation just as the blend of huge atomic weight substances inside capacity organs adding to the fast building of the tubers (Singh, 1999). Upadhyay and Sharma, (1987) and Imas and Bansal (2002) have demonstrated that quick building potato assortments delivering huge size tubers react more to K than the assortments with little size tubers as the use of K is known to expand the tuber size. Sulfur application significantly affected all out tuber yield, the appropriate yield for showcasing and non-reasonable yield for advertising, non-reasonable yield for promoting to add up to yield, tuber number and tuber weight (Table 6).

Table6. Yield parameters of potato as influenced by sulfur (kg ha^{-1}) application

Sulfur fertilizer levels (kg ha^{-1})	Total Yield (*Mg* ha^{-1})	Suitable Yield for marketing (*Mg* ha^{-1})	Non-suitable Yield for marketing (*Mg* ha^{-1})	Non-suitable Yield for marketing to Total yield	No. of Tuber	Tuber Weight (g)
0	9.80	9.34	0.46	4.71	8.70	94.67
50	10.16	9.83	0.33	3.34	8.82	93.87
100	11.01	10.61	0.40	3.87	9.45	93.78
150	10.28	9.61	0.67	5.68	9.33	96.53
200	10.86	10.45	0.41	3.70	9.18	91.94
LSD	*0.10*	*0.13*	*0.23*	*1.26*	*0.51*	*3.78*

The total tuber yields and suitable yield for marketing increased with increasing S application. Total potato yield was 9.8, 10.16, 11.01, 10.28 and 10.86 *M*g ha^{-1} due to the main effect of 0 kg S ha^{-1}, 50 kg S ha^{-1}, 100 kg S ha^{-1}, 150 kg S ha^{-1} and 200 kg S ha^{-1} respectively. Maximum suitable yield for marketing was recorded by 100 kg S ha^{-1} application while the minimum suitable yield for marketing was showed by 0 kg S ha^{-1} application. This effect may be due to a reduction in the soil pH where elemental sulfur is used. Sulfur helps to reduce the level of common and powdery scab. Other recent research conducted at the University of Nebraska has revealed that applications of sulfur gave as much as a 34% increase in yield. This same research has shown that sulfur applications significantly reduce the incidence of common scab on tubers and black scurf.

Table 7. Yield parameters of potato as influenced by potassium and sulfur (kg ha^{-1}) application

Levels K + S (kg ha^{-1})	Total Yield (*Mg* ha^{-1})	Suitable Yield for marketing (*Mg* ha^{-1})	Non-suitable Yield for marketing (*Mg* ha^{-1})	Non-suitable Yield for marketing to Total yield	No. of Tuber	Tuber Weight (g)
0 K + 0 S	8.32	7.90	0.42	5.04	7.10	90.48
0 K + 50 S	9.58	8.82	0.76	7.93	7.16	91.01
0 K + 100 S	9.32	8.81	0.51	5.56	7.75	86.67
0 K + 150 S	8.67	8.82	0.85	5.84	7.30	91.74
0 K + 200 S	9.01	8.80	0.21	2.29	7.19	86.23
100 K + 0 S	9.26	8.80	0.46	4.96	7.79	96.76
100 K + 50 S	9.74	9.65	0.29	0.92	8.32	96.99
100 K + 100 S	10.19	9.80	0.39	3.81	8.62	99.01
100 K + 150 S	9.41	8.95	0.46	4.91	9.01	96.09
100 K + 200 S	10.39	9.91	0.48	4.58	9.21	87.28
200 K + 0 S	9.31	8.93	0.38	4.03	9.40	95.16
200 K +50 S	11.08	10.88	0.22	1.74	9.35	91.04
200 K + 100 S	10.39	9.90	0.49	4.69	9.52	90.12
200 K + 150 S	10.62	9.93	0.69	6.49	9.04	98.57
200 K + 200 S	11.36	10.83	0.53	4.66	9.48	95.50
300 K + 0 S	12.31	11.72	0.59	4.82	9.92	96.26
300 K + 50 S	10.26	9.97	0.29	2.78	10.44	96.45
300 K + 100 S	14.14	13.94	0.20	1.43	11.99	99.80
300 K + 150 S	12.41	11.73	0.68	5.49	11.92	99.71
300 K + 200 S	12.66	12.25	0.41	3.28	10.85	98.75
LSD	*0.20*	*0.26*	*0.23*	*2.52*	*1.02*	*7.57*

The K & S interaction had significant effects on yield. Total yield, the suitable yield for marketing, non-suitable yield for marketing, the Non-suitable yield for marketing to total yield, No. of tuber and tuber weight revealed a significant effect of potassium and sulfur application (Table 7). There was a significant interaction between K and S. The maximum value was recorded by interaction 300 kg K ha^{-1} x100 kg S ha^{-1}, for total yield, the suitable yield for marketing, tuber weight and number of the tuber. There is better utilization of S is the presence of K as reflected in an increase in plant height (Singh and Trehan, 1998) and yield (Chaddha, *et al.*, 2006). Potassium along with N plays a major role in growth and yield as it is involved in assimilation, transport and storage time of photosynthates (Marschner, 1995). The interaction within the two studied factors as soil dressing and their affecting on potato plant growth. Whereas, the recorded data indicate that, the plant height, leaves numbers, the fresh and dry weight of leaves and branches all of them responded no significantly by the interaction treatments. These were completely similar in both experimental seasons, except the dry weight of branches (two seasons), and totally fresh and dry weight of whole plant (only in 2nd season). In spite the no significantly results, it could be concluded that generally foliar spraying of sulfur at a higher level, i.e. 6000 ppm with addition bio-sulphur at the highest level, i.e. 450 kg/fed., resulted in the vigor plant growth. The obtained results are in good accordance with that recorded by Fatma *et al.*, 2012 on the onion.

Chemical constituents

Summary of the analysis of variance for the K and S contents of the tuber are given in Tables 8, 9 and 10. The effects of the K and S fertilizers were statistically significant ($P < 0.01$) at all chemical constituents. Data presented in Table (8) indicated that the highest percents of K, P, N, Ca and protein contents were 1.52, 0.4, 1.43, 2.58 and 8.94 % accumulated by 300 kg K ha^{-1}, 0 kg K ha^{-1}, 200 kg K ha^{-1}, 300 kg K ha^{-1} and 200 kg K ha^{-1} respectively.

The higher levels of sulfur, lead to the higher values of K and Ca if compared to the application of lower sulfur level. The maximum percents of K, P, N, Ca and protein contents of 1.37, 0.37, 1.37, 1.99 and 8.55 % recorded by 200 kg S ha^{-1}, 200 kg S ha^{-1}, 100 kg S ha^{-1}, 100 kg S ha^{-1} and 100 kg S ha^{-1} respectively (Table 9).

Whereas, the higher levels of sulfur, resulted in the higher values of K and P if compared to the application of lower sulfur level. These results might be attributed to the favorable positive effect of sulphur to increasing plant growth parameters, consequently increasing the uptake of N, P, K, Fe, Mn, Cu and Zn by rooting system, which might have influenced the synthesis and translocation of stored materials These results are in good accordance with Dabhi *et al*., 2004; Jaggi, 2005; Sankaran *et al*., 2005 and Fatma *et al.*, 2012.

Table8. Effect of Potassium fertilization (kg ha^{-1}) on some mineral content and protein in potato tuber

Potassium fertilizer levels (kg ha^{-1})	K content (%)	P content (%)	N content (%)	Ca content (%)	Protein (%)
0	1.14	0.40	1.27	1.27	7.95
100	1.22	0.38	1.22	1.61	7.62
200	1.46	0.33	1.43	2.09	8.94
300	1.52	0.33	1.39	2.58	8.68
LSD	*0.05*	*0.03*	*0.04*	*0.17*	*0.27*

Table9. Effect of Sulfur fertilization (kg ha^{-1}) on some mineral content and protein in potato tuber

Sulfur fertilizer levels (kg ha^{-1})	K content (%)	P content (%)	N content (%)	Ca Content (%)	Protein (%)
0	1.30	0.37	1.28	1.81	8.00
50	1.31	0.35	1.30	1.96	8.14
100	1.36	0.36	1.37	1.99	8.55
150	1.33	0.36	1.33	1.89	8.34
200	1.37	0.37	1.35	1.78	8.46
LSD	*0.06*	*0.03*	*0.04*	*0.17*	*0.28*

Table10. Effect of Potassium and Sulfur fertilization on some mineral content and protein in potato tuber

Levels K + S (kg ha^{-1})	K content (%)	P content (%)	N content (%)	Ca content (%)	Protein (%)
0 K + 0 S	1.16	0.38	1.21	1.18	7.56
0 K + 50 S	1.14	0.36	1.23	1.15	7.69
0 K + 100 S	1.14	0.44	1.35	1.22	8.46
0 K + 150 S	1.12	0.42	1.24	1.30	7.75
0 K + 200 S	1.14	0.43	1.33	1.48	8.31
100 K + 0 S	1.17	0.37	1.23	1.38	7.67
100 K + 50 S	1.19	0.39	1.20	1.71	7.48
100 K + 100 S	1.23	0.36	1.28	1.43	7.98
100 K + 150 S	1.19	0.38	1.18	1.83	7.35
100 K + 200 S	1.30	0.41	1.22	1.69	7.62
200 K + 0 S	1.26	0.38	1.35	2.17	8.46
200 K +50 S	1.39	0.32	1.41	2.61	8.83
200 K + 100 S	1.50	0.34	1.45	2.47	9.04
200 K + 150 S	1.58	0.31	1.47	1.63	9.19
200 K + 200 S	1.57	0.32	1.47	1.56	9.19
300 K + 0 S	1.60	0.34	1.33	2.50	8.31
300 K + 50 S	1.53	0.33	1.37	2.38	8.56
300 K + 100 S	1.58	0.32	1.39	2.84	8.71
300 K + 150 S	1.44	0.31	1.45	2.81	9.06
300 K + 200 S	1.46	0.33	1.40	2.37	8.73
LSD	*0.12*	*0.07*	*0.09*	*0.34*	*0.56*

Concerning the combination of K and S, it observed that highest percents of K, P, N, Ca and protein contents were 1.60, 0.44, 1.47, 2.84 and 9.19 % registered by 300 kg K ha^{-1} x 0 kg S ha^{-1}, 0 kg K ha^{-1} x100 kg S ha^{-1}, 200 kg K ha^{-1} x100 kg S ha^{-1}, 300 kg K ha^{-1} x100 kg S ha^{-1} and 200 kg K ha^{-1} x 200 Kg S ha^{-1} respectively (Table 10). The lowest content of K, P, N, Ca and protein were observed with 0 kg K ha^{-1} x150 kg S ha^{-1}, 200 kg K ha^{-1} x150 kg S ha^{-1}, 100 kg K ha^{-1} x 50 kg S ha^{-1}.

Eppendorfer and Eggum (1994) and Singh *et al*., (2008) says that S application increased in tuber of total – N, P, K, Na, Ca, Mg, Zn Mn, Cu and Fe contents. Singh and Srivastava (1996) supplemented S for potato in a dose of 20 kg ha^{-1}, in the $CaSO_4$ kind and had demonstrated an increase of iron in chloroplasts and higher content iron in tubers. Also, El-Fayoumy and El-Gamal (1998) have studied that sulfur fertilization increased in tubers: carotene, vitamin C, starch, protein, micronutrients and reduced sugar content.

CONCLUSION

The application of K to potato along with S is very essential to improve tuber yield and its quality. Optimal S and K application are required for better nutrient management in agriculture. On the basis of experimental results it can be concluded that application of 300 kg K ha^{-1} and 100 kg S ha^{-1} can be economically recommended for cultivation of potato as it favored crop growth, high yield and enhanced K and S use efficiency. Our results indicated that sulfur did not have a strong effect on growth and yield of potato.

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تأثير الاسمدة المحتوية على البوتاسيوم والكبريت في بعض مؤشرات النمو والمكونات الكيميائية والانتاج البطاطس *Solanum tuberosum* L. من صنف Binella Böhm 52 72 × Sirco

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تم تنفيذ تجربة ميدانية عاملية لدراسة تأثيرإضافة ألاسمدة البوتاسية والكبريتية في بعض معاير النمو و المكونات الكيميائية و حاصل البطاطا، اجريت الدراسة باضافة أربعة مستويات من البوتاسيوم و هي (٠, ١٠٠, ٢٠٠, ٣٠٠ كغم هكتار-١) و خمسة مستويات من كبريت وهي (٠, ٥٠, ١٠٠, ١٥٠ كغم هكتار-١)، تم زراعة البطاطس (*Solanum tuberosum* L.) صنف (Binella Böhm 52 72 × Sirco) عروة خريفية و باستخدام تصميم القطع المنشقة (Split plot design) و بثلاثة مكرارات في محطة البحوث كانيبانكه في المحافظة السليمانية-اقليم الكردستان العراق, تحت ظروف مروية. أظهرت النتائج بان التداخل بين البوتاسيوم والكبريت له تأثيرات معنوية على النمو الخضري (مساحة الورقة ، عدد الساق و المنطقة المغطاة لكل نبات). وقد زاد إنتاج الكلي لدرنات بمعدل (١٧,٥٪و ٣٧,٦٣٪) (عند ٢٠٠ كغم بوتاسيوم هكتار-١ و ٣٠٠ كغم بوتاسيوم هكتار-١) على التوالي، عند مقارنة بعدم استخدام البوتاسيوم. كان لتطبيق الكبريت تأثير كبير على انتاج الكلي لدرنة و انتاج مناسب للتسويق و انتاج غير مناسب للتسويق و انتاج غير مناسب للتسويق إلى انتاج الكلي و عدد الدرنات و وزن الدرنة. فيما يتعلق ببيانات المحتويات الكيميائية ان التداخل بين البوتاسيوم والكبريت له تأثيرات معنوية على نسبة محتوى (K و P و N و Ca والبروتين) في درنات البطاطس، و هي (١,٦٠ و ٠,٤٤ و ١,٤٧ و ٢,٨٤ و ٩,١٩ ٪) مسجلة في معاملة (٣٠٠ كغم بوتاسيوم هكتار-١) مع (٠ كغم كبريت هكتار-١) و (٠ كغم بوتاسيوم هكتار-١) مع (١٠٠ كغم كبريت هكتار-١) و(٢٠٠ كغم بوتاسيوم هكتار-١) مع (١٠٠كغم كبريت هكتار-١) و (٣٠٠ كغم بوتاسيوم هكتار-١) مع (١٠٠ كغم كبريت هكتار-١) و(٢٠٠ كغم بوتاسيوم هكتار-١) مع (٢٠٠ كغم كبريت هكتار-١) على التوالي.