Effect of Various Potassium Sulfate Rates on Growth, Yield and Quality of Potato Grown under Sandy Soil and Arid Conditions

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ABSTRACT

Potatoes require high amounts of potassium (K) fertilizer for optimum growth, production and tuber quality. Farmers and farming industries in the arid conditions and sandy soils of Saudi Arabia are applying K fertilizer to potatoes without attention to plant requirements. The objective of this study was to evaluate the effect of different potassium sulfate rates on vegetative and reproductive performance, tuber quality and total yield of potatoes grown on a sandy soil in the arid environment of Central Saudi Arabia. This field experiment was carried out during 2001-2002 Autumn season at the Experimental Farm of King Saud University in Al-Qassim region (latitude 26-27 N, longitude 44-45 E). The experimental layout was a randomized complete block design with 5 levels of Potassium Sulfate (KS) (ranging from 0 up to 600kg KS/ha) and 3 replicates. Increasing potassium sulfate rates resulted in a significant increase (p=0.05) in plant height, leaf area, chlorophyll concentration, specific gravity, K concentration and carbohydrate content. Marketable tuber yield was also significantly improved with increasing potassium sulfate rates. Under conditions of this experiment, it is concluded that K is needed by potatoes for economic yield. The recommended rate for Qassim and similar regions is 450 kg potassium sulfate per hectare.
Key words: Potato, Solanum tuberosum, potassium sulfate, fertilization, K element vegetative growth, yield quality, potato production.

1. Introduction

The potato (Solanum tuberosum L.) is the fourth most important world crop, after rice, wheat, and maize (Spooner and Bamberg, 1994). It is a major source of inexpensive energy. It contains high levels of carbohydrate and significant amounts of vitamins B and C and minerals. Moreover, potato is used in many industries, such as French fries, chips, starch and alcohol production (Abdel-Aal, et al., 1977).

In Saudi Arabia, potato is one of the most important crops, and Qassim region alone accounts for about half of the annual potato production in the country (Zaag, 1991). It is mainly produced on coarse textured calcareous soils in arid lands, and under center pivot irrigation systems. Average yields vary between 20 and 40 t/ha (Abdelgadir et al., 2003).

The crop is judiciously fertilized with N, P and K and other elements based mainly on practical experience as there is a lack of recommendations based on correlation/calibration research. Potato plants require much more potassium than many other vegetable crops. Although most soils in Saudi Arabia are rich in K. Potassium fertilizer should be applied to sustain high yields (Zaag, 1991). An adequate supply of potassium strengthens stems to prevent lodging, increases yield and improves tuber quality (Beringer 1987; Ibrahim, et al., 1987 and Omran, et al., 1991). It also allows the crops to adapt to environmental stress. It promotes plant tolerance to insect infection and resistance to fungal disease.

From early studies, Terman (1950) pointed out that there was a consistent decrease in the starch content of potato tubers with increase in the rate of K_2O application. In a similar study Hart and Smith (1966) reported that dry matter of potatoes decreased with increasing K level. Excess K fertilizer was reported to reduce dry matter or specific gravity (Schippers, 1968; McDole, 1978 and Westermann et al., 1994a,b).

There is a general belief among farming communities in Saudi Arabia that a higher and a better quality yield of potato crop is always obtained when K is added in quantities. Although the potato crop requires a heavy input of K for high yields (Errebhi et al., 1998), adequate levels should be established for economic yields and sustainable productivity. It is well documented that K affects potato quality and yield. Insufficient K results in reduced potato yield and smaller-sized tubers (McDole, 1978; Satyanarayana and Arora, 1985). Other workers found that a significant tuber yield responses to K fertilization (Westermann et al., 1994a and Panique et al., 1997).

Under the arid conditions of Wadi Ad Dawassir (latitude 20-21 N, longitude 45-46 E), Saudi Arabia, Abdelgadir et al. (2003) found that application of 215 kg K_2O ha^{-1} was sufficient to produce economic yield and high quality potatoes. On the other hand farming industries (Nadec, 2003) are applying rates higher than those reported by Abdelgader et al. (2003).

Therefore, the objective of this study was to evaluate the effect of different rates of potassium sulfate, K_2SO_4, (50% K_2O) on plant vegetative performance, tuber quality and total yield of potatoes grown in a sandy soil under arid environmental conditions.

2. Materials and methods

Plant material and experimental design : This study was conducted during the autumn season of 2001-2002 at the Experimental farm of the College of Agriculture and Veterinary Medicine, King Saud University, Al-Qassim region (latitude 26-27 N, longitude 44-45 E), Kingdom of Saudi Arabia. Soil samples were collected prior to planting at 0-20 cm depth and their properties were given in Table 1. Experimental area was divided in to 15 plots separated by 1 m as border. Plot size was 4 x 3 m. Plots were arranged in a randomized complete block design, with 3 replications.

All plots received basic application of 250 kg N and 250 kg P_2O_5 ha^{-1}. Five treatments (0, 150, 300, 450, and 600 kg K_2SO_4 ha^{-1}) were therefore studied. Granular fertilizers were hand spread before planting. Phosphorus source was di-ammonium phosphate, applied at once before planting. Nitrogen source was urea 46-0-0, split 10 times to minimize leaching and volatilization in the sandy calcareous soil and delivered through the drip irrigation system. Pre-sprouted tubers of cultivar Ajax were planted in rows (75 cm apart) at 30 cm spacing between plants. Planting date was 18 September 2001. Irrigation water samples were also collected and analyzed for EC and pH (Table 1).

Table 1. Physicochemical characteristics of soil and water used in the study

Analysis	Soil	Water
Sand (%)	96.3	-
Silt (%)	1.8	-
Clay (%)	1.9	-
Texture	sandy	-
PH_e[1]	8.4	7.1
EC (mS/cm)	-	1.5
Nutrient (µg/g)[2]		
Total N	15	-
P	16.5	-
K	36	-

1 pH in saturated paste extract.
2 P by Olsen method.
3 K by NH_4OAc at pH 7.

During the growing season, plant height, leaf area, chlorophyll and carbohydrate content were determined. Harvesting was carried out on 10 January 2002. Potato tubers were then graded visually into marketable (>3.5 cm in diameter) and cull (<3.5 cm, bruised, green or sprouted tubers). Marketable and total tuber yield were determined by weight, and only marketable tuber data is reported in this manuscript. Potato tuber samples were then collected from all treatments for dry matter, specific gravity, percent carbohydrates and K content determinations. Specific gravity was determined by the hydrometer method on a 5.0-kg subsample of the marketable potatoes (Edgar, 1951).

Statistical analysis was performed on all data using analysis of variance and for treatments comparison, least significant difference at 0.05 probability was used.

3. Results and discussion

3.1. Plant growth parameters:

Plant height was significantly affected by K rate. The highest reading was reached when 450 kg K_2SO_4 ha^{-1} were applied (Table 2). Leaf area ranged from 1127.66 cm^2 per plant at no potassium applied to 2603.33 cm^2 per plant with application of 600 kg K_2SO_4. Highest significant area was obtained with 600 kg K_2SO_4 ha^{-1}. The number of stems per plant, however, was not affected by K rate.

Table (2). Effect of different levels of potassium sulfate on vegetative performance of potato plant

Treatment (kg $K_2SO_4 ha^{-1}$)	Plant height (cm)	Leaf area ($cm^2 plant^{-1}$)	Number of stems (per plant)	Chlorophyll (%)
0	28.00	1127.66	4.0	25.00
150	28.66	1502.66	4.3	27.66
300	39.33	1797.00	3.7	31.00
450	46.33	2504.00	4.7	40.33
600	47.33	2603.33	4.3	43.00
LSD (0.005)	5.48	159.43	NS	4.46

3.2. Tuber yield and quality parameters

Tuber potassium content increased significantly with K rates to reach a statistical maximum of 2.09 % at K rate of 450 kg K_2SO_4 ha^{-1}. Carbohydrate percent was increased significantly with K rates. The highest level was reached with application of 450 kg K_2SO_4 ha^{-1}. Specific gravity was also affected by K rates. These findings are not in accordance with reports by McDole (1978) and Westerman et al. (1994a) who found that the specific gravity of potato tubers decreased with increasing rates of K fertilizers. In addition, our results did not agree with those of Davenport and Bentley (2001) and Abdelgadir et al (2003) who found that specific gravity did not respond to K application.

Table (3). Effect of different levels of potassium sulfate on tuber specific gravity, carbohydrates, potassium concentration and marketable yield.

Treatment (kg $K_2SO_4 ha^{-1}$)	Specific gravity	Carbohydrates (%)	K (%)	K Yield (Ton ha^{-1})
0	1.067	36.66	1.08	17.91
150	1.069	39.66	1.17	21.53
300	1.069	42.66	1.71	28.66
450	1.084	50.66	2.09	31.90
600	1.086	51.33	2.12	31.96
LSD (0.05)	0.003	1.65	0.21	2.43

Marketable tuber yield increased significantly ($p < 0.05$) with increasing K rates until 450 kg K_2SO_4 ha^{-1}. Higher K rates did not improve yield. These results agree with earlier reports by James et al. (1968), McDole (1978), Lal and Singh (1983), Rhue et al. (1986) and Chapman et. al. (1992). Marketable tuber yield for K fertilized plots ranged from 21.53 to 31.96 tons ha^{-1}. These yield ranges are within the 20 to 40 kg ha^{-1} yields for Saudi Arabia; they are also comparable to yield data reported by Abdelgadir et al. (2003) for Wadi Ad Dawassir (latitude 20-21 N, longitude 45-46 E), Saudi Arabia.

4. Conclusion and recommendation

Plant growth indicators, plant nutritional status, and tuber quality parameters responded positively to K application rates. Marketable tuber yield was significantly affected by K fertilizer levels. Highest yield and other quality parameters were achieved when a rate of 450 kg K_2SO_4 ha^{-1} was used. We recommend that, for Qassim and similar regions in Saudi Arabia, farmers apply potassium sulfate at the rate of 450 kg K_2SO_4 ha^{-1} for optimum yield.

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