Research Findings

Ready to harvest sugar beet field at Layyah in Pakistan. Photo by A. Wakeel.

Sugar Beet Response to Potassium Fertilizer under Water Sufficient and Water Deficient Conditions*

Mubarak, M.U.[(1)], M. Zahir[(1)], M. Gul[(2)], M. Farooq[(3)], and A. Wakeel[(1)]**

Introduction

Sugar beet (*Beta vulgaris* L.) is an industrial crop, grown as a sugar crop contributing ~25% of total sugar production worldwide. In Pakistan, however, sugar is mostly extracted from sugarcane. Sugar beet has high sucrose content, even more than that in sugarcane; and sugar beet yield can be sustained, or even can be further increased by potassium (K) fertilization. In Pakistani soils K concentration is higher, because these soils are developed from mica minerals. However, its high concentration in soil K does not represent plant available K for sustainable plant growth. Due to strong binding within clay minerals, K is not released at required rate for the optimum plant growth. K increases root growth and improves drought resistance and plays a critical role in enzyme activation, osmoregulation, and charge

*Paper published in the Proceedings of the International Conference on "Soil Sustainability for Food Security", 15-17 November 2015, Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan
(1)Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad-38040, Pakistan.
(2)Department of Soil Science, Bahauddin Zakariya University, Multan, Pakistan
(3)Department of Agronomy, University of Agriculture Faisalabad-38040, Pakistan
**Corresponding author: umairmubarakuaf@gmail.com

balance in plants (Cakmak, 2005). This study was conducted to investigate the effect of K on the sugar beet yield.

Materials and Methods

A pot experiment was conducted in the wire house at Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad. Treatments were K_0 (No K), K_1 (148 kg ha^{-1}) and K_2 (296 kg ha^{-1}). Levels of irrigation used were water sufficient at 60% water holding capacity and water deficient at 40% water holding capacity. The growth, yield and beet quality data were analyzed statistically using LSD with factorial design. The crop was irrigated with distilled water and plants were harvested 200 days after transplanting, beet size including length and diameter was measured with the help of measuring scale and vernier caliper. Fresh weight of shoot and beet were recorded and then shoot and beets were oven dried at 80°C in an oven after isolating the fresh beet sample for sugar analyses. Oven-dried shoot and beet samples were digested by dry ashing method (Chapman and Pratt, 1961) and Boron (B) in filtrate was measured by colorimetric method using Azomethine-H (Bingham, 1982) as an indicator. Sodium (Na) and potassium (K) in shoot and beet were determined in plant samples by wet digestion procedure using a mixture of nitric and perchloric acids with ratio 2:1. K and Na were determined by flame photometer according to the method described by Chapman and Pratt (1961). Chlorophyll contents were measured with a chlorophyll meter (SPAD 502 P).

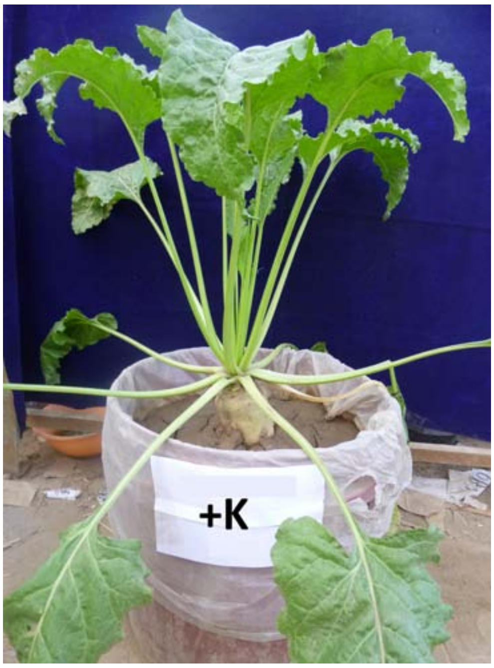
Results and Discussion

Sugar beet growth and yield responded well to K fertilization and the plant height, beet diameter and length of sugar beet were improved over the control. The K application at the rate of 296 kg ha^{-1} (K_2) with water sufficient showed further increase, and maximum plant height (23 cm), beet diameter (6.88 cm) and length (21 cm) of sugar beet was achieved in K_2 (Table 1). It was observed that increase in K fertilization up to 296 kg ha^{-1} can increase the sugar yields significantly at both water levels. Sugar yield per hectare was increased from 3.45 to 5.5 ton ha^{-1} at water sufficient level, whereas the increase was 2.1 to 3.4 ton ha^{-1} at water deficient level (Table 1). All physiological parameters aresignificantly influenced by increasing the levels of K fertilizers in different crops (Celik *et al.*, 2010). Potassium fertilization significantly ($p<0.05$) increased K^+ concentration in shoot and beet of sugar beet at both water levels. Application of K fertilizer significantly decreased the Na^+ concentration in shoot as well as in beet under water sufficient and water deficient conditions (Table 2). Interestingly application of K fertilizers improved the concentration of Boron (B) in shoot as well as in beet showing a synergistic effect, at both fertilizer levels (Table 2). Significant effect of K fertilization on the chlorophyll contents as compared to control at water sufficient and water deficient levels was observed (Table 2).

Table 1. Effect of potassium on the plant growth and yield of sugar beet under water sufficient and water deficient conditions.

Irrigation level	K fertilizer treatments	Plant height	Beet diameter	Beet length	Sugar yield*
		-cm-			*t ha^{-1}*
Water sufficient	K_0 (No K fertilizer)	15.75 c	4.57 bc	13.5 c	3.45 cd
	K_1(148 kg K_2O ha^{-1})	20.37 b	6.35 ab	16.5 b	4.8 b
	K_2 (296 kg K_2O ha^{-1})	23 a	6.86 a	21 a	5.5 a
Water deficient	K_0 (No K fertilizer)	12 e	3.95 d	11 d	2.1 e
	K_1(148 kg K_2O ha^{-1})	13.5 de	5.22 d	14.5 c	2.9 d
	K_2 (296 kg K_2O ha^{-1})	13.5 de	5.38 cd	16.5 bc	3.4 c

**This is extended yield calculated from pot experiment.*



Comparison of sugar beet grown in pots having 45 kg soil with and without potassium fertilization.
Photos by U. Mubarak.

Table 2. Effect of potassium on the concentration of K, Na, B and chlorophyll contents in shoot and beet.

Irrigation level	K fertilizer treatments	Shoot			Beet			
		K	Na	B	K	Na	B	Chl. content
		-------------------*mg/kg*-------------------			-------------------*mg/kg*-------------------			*μgg⁻¹*
Water sufficient	K_0 (No K fertilizer)	1108.2 cd	119.6 a	48.0 cd	190.7 e	19.4 a	48.0 cd	26 c
	K_1 (148 kg K_2O ha^{-1})	1286.7 ab	90.5 c	54.0 ab	388.7 c	13.5 c	54.5 ab	35.7 ab
	K_2 (296 kg K_2O ha^{-1})	1409.0 a	71.5 e	57.25 a	503.2 a	9.1 e	58.2 a	40.3 a
Water deficient	K_0 (No K fertilizer)	845.6 d	99.7 b	44.0 d	129.0 f	18.3 b	44.2 d	22.2 d
	K_1 (148 kg K_2O ha^{-1})	962.8 bc	80.7 d	51.5 bc	239.2 d	12.1 d	52.0bc	27 c
	K_2 (296 kg K_2O ha^{-1})	1183.3 ab	63.0 f	53.5 ab	452.2 b	6.8 f	54.3ab	34.2 b

Conclusion

Application of K fertilizers showed significant increase in quality and yield of sugar beet under water sufficient as well as in deficient conditions.

Sugar beet with and without potassium fertilizer grown in wire house in large plastic pots. Photo by A. Wakeel.

References

Bingham, F.T. 1982. Boron in Methods of Soil Analysis. Page, A.L. *et al.* (eds.). Agronomy 9, Am. Soc. Agron. Soil Sci. Soc. Am. Inc. Madison, Wis. 431-442.

Cakmak, I. 2005. The Role of Potassium in Alleviating Detrimental Effects of Abiotic Stresses in Plants. J. Plant Nutr. Soil Sci. 168:521-530.

Celik, H., B.A. Bulent, G. Serhat, and V.A. Katkat. 2010. Effect of Potassium and Iron on Macro Element Uptake of Maize. Zemdirbyste Agric. 97:11-22.

Chapman, H.D., and P.F. Pratt. 1961. Methods of Analysis for Soil Plant and Waters. Barkeley, CA, USA: University of California, Division of Agriculture Science.

The paper "Sugar Beet Response to Potassium Fertilizer under Water Sufficient and Water Deficient Conditions" also appears on the IPI website at:

Regional activities/WANA