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Research Article

Effect of different potassium levels on the yield and sugar recovery of sugarcane varieties under the agro-climatic condition Tandojam Sindh-Pakistan

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Abstract

Potassium (K) is an essential for a multitude of biological processes in plants. It plays a crucial role in various functions such as photosynthesis, translocation of photosynthesis, protein synthesis, regulation of ionic balance, control of plant stomata and water use and activation of plant enzymes. However, the mechanism and different level of potassium in response to sugarcane has not been elucidated yet. This study aims to investigate different potassium levels in response to sugarcane against the two local varieties Thatta-10 and LRK-2001. Here in this study the results showed potash at the rate of 210 kg ha^{-1} produced higher percent germination, cane length, cane girth, tillers stool^{-1}, cane yield, brix and sugar recovery. Similarly, the crop at the rate of 180 kg ha^{-1} potash resulted in significant percent germination, cane length, cane girth, tillers stool-1, cane yield, brix and sugar recovery. Alternatively, the potash at the rate of 150 and 120 kg ha^{-1} produced lower values for all the traits studied and control remained the least. Furthermore, sugarcane varieties, LRK-2001 produced better performance than Thatta-10 with percent germination, cane length, cane girth, tillers stool^{-1}, tons ha^{-1} cane yield, brix and sugar recovery. Whereas, sugarcane variety Thatta-10 produced lower percent germination, cane length, cane girth, tillers stool^{-1}, tons ha^{-1} cane yield, brix and sugar recovery. It was concluded that highest potash level of 210 and 180 kg ha^{-1} overall significant performance beneficial for sugarcane regardless the varieties and differences compare to 150 and 120 kg ha^{-1}. Variety LRK-2001 showed overall better performance under the 180 kg ha^{-1}potash level and proving more responsive to potash fertilizer quantity for future potash growing areas for farmers.

Keywords: Cane yield; Growth performance; Potassium; Sugarcane; Sugar recovery

Introduction

Sugarcane (*Sachharum officinarum* L.) belongs to the family Gramineae [1] and source of livelihood for millions of people in Pakistan [2]. Pakistan has the 5th largest sugarcane growing area in the world and is the 15th biggest global producer of sugar. For the farming community of Pakistan, it is an important source of employment and income. Sugarcane is grown on around a million hectares and provides the raw material for Pakistan's 84 sugar mills. The sugar industry is the country's second largest agro-industry after textiles. Sugarcane crop is the major sugar producing crop in our country. Sugarcane was cultivated on area of 943, 988, 1058, 129 and 1173 thousand hectares during 2009-10, 2010-11, 2011-12, 2012-13 and 2013-14, respectively and the area during 2013-14 was 3.9 percent higher than the preceding year 2012-13. The sugarcane production during 2009-10, 2010-11, 2011-12, 2012-13 and 2013-14 was 49,373, 55,309, 58,397, 63,750 and 66,669 thousand tons, respectively, showing 4.3 percent increase in production during 2013-14 over the year 2012-13. The yield per hectare during 2009-10, 2010-11, 2011-12, 2012-13 and 2013-14 was 52,357, 55,981, 55,196, 56,466 and 56,666 kg per hectare, respectively, showing 0.4 percent increase in yield per hectare during 2013-14 over the year 2012-13 **[3]**.

Brazil is the leading sugarcane producer, where sugarcane was cultivated on 7.94 million hectares, producing 719.157 million tons of cane with average yield of 90.574 tons ha^{-1}. Pakistan ranks 4th in sugarcane area (1.040 million ha) and production (60.474 million tons) after Brazil, India (4.785 million ha) and China (1.66 million ha), while other major sugarcane growing countries are Thailand (0.991 thousand ha), Mexico (0.680 million ha), Indonesia (0.414 million ha), Australia (0.397 million ha), Cuba (0.381 million ha), South Africa (0.367 million ha), USA (0.354 million ha) and Argentina (0.333 million ha). However, in cane yield ha^{-1} Pakistan (58.148 t ha^{-1}) is far behind Brazil (90.574 t ha^{-1}), Australia (84.363 t ha^{-1}), Argentina (79.180 t ha^{-1}), Mexico (75.879 t ha^{-1}), U.S.A. (75.562 t ha^{-1}), China (70.031 t ha^{-1}), India (68.877 t ha^{-1}) and Thailand (68.848 t ha^{-1}) **[4]**.

The average yield of sugarcane in Pakistan is much lower (54 t ha^{-1}) than that of world average (65 t ha^{-1}). The reasons for low yield include conventional planting methods, seed preparation, costly inputs, heavy weed infestation, improper land preparation, imbalanced fertilizer application, illiteracy, less support price, lack of coordination between growers and mill owners, natural calamities, shortage of irrigation water, delayed harvesting, attack of insect, pests and diseases, poor management of ratoon crop and salinity **[5]**.

The essential elements for a healthy sugarcane crop include carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, boron, chlorine, copper, iron, manganese, molybdenum, sulfur and zinc. Silicon, although not strictly needed for the sugarcane plant to complete its life cycle, may enhance sugarcane production significantly. An over-abundance of one element may cause a deficiency or toxicity of another **[1]**.

Potassium (K) plays a vital role in photosynthesis, translocation of photosynthesis, protein synthesis, control of ionic balance, regulation of plant stomata and water use, activation of plant enzymes and many other processes **[6]**. Potassium is one of sixteen essential nutrients required for plant growth and reproduction. It is classified as a macronutrient. Potash is defined as K2O and is used to express the content of various fertilizer materials containing potassium, such as muriate of potash (KCl), sulfate of potash (K_2SO_4), double sulfate of potash and magnesium (K_2SO_4 $_2MgSO_4$), and nitrate of potash (KNO_3). K is one of the most abundant nutrient elements in soil and one that is required in large amounts by plants. The huge amount of K in many soils only a function is available for immediate uptake by plants in the large term, and in the absence of any added K, the vulnerability of crop production to K availability is mainly related to the amount and rate of release of K from soil minerals. The extent to which soil K can be exploited will depend on soil type and mineralogy cropping system and time scale. The different soil types and cropping systems require a site specific approach to K management **[7]**.

In Pakistan, use of K is very low which is around 0.73 kg ha^{-1} as against 85 kg of nitrogen and 21 kg of P_2O_5 which seems to be inadequate and imbalanced to explore the production potential of the crop **[8]**. Pakistan soils have developed from micaceous alluvium and the irrigation water has high K contents, the crop is well supplied with the element. So it is generally presumed that crops will not positively respond to K and only N and P are applied. However, with the introduction of high yielding varieties and intensive agronomic practices sugarcane crop is becoming more responsive to higher K levels than recommended rates. A little research work has been done regarding K application time as it is often applied at sowing and that too in small quantity **[8, 9]**. Responses of sugarcane to K fertilization reflect to a large extent the available K status of soil, significant responses being obtained only in soils low in available K. Evaluating the response of sugarcane to K fertilization must also take into account the semi-perennial nature of sugarcane plant. In this context as sugarcane is able to mine the soil of its K reserves, responses to K fertilizers are frequently not observed in plant cane and often even in first and second ratoons. The importance of a balanced nutrition particularly between nitrogen (N) and K in the attainment of the maximum yield should also not be overlooked. In general sugarcane responds to K fertilizers by an increase in cane yield without any change in sucrose concentration in the cane. As an excessive uptake of K by the sugarcane depresses the recovery of sucrose during milling, K fertilization of sugarcane must be kept just adequate to produce an optimum yield and to help regulate maturity so that maximum sugar is recovered from the millable canes **[10]**. Therefore, the present study was is aim to investigate the effect of different K levels on the cane yield and recovery of sugarcane varieties.

Materials and Methods

The experiment was conducted during autumn 2013-14 to investigate the effect of different potassium levels on the sugarcane yield and recovery of sugarcane varieties. The experiment was laid out at the experimental fields of Sugarcane Section, Agriculture Research Institute, Tandojam in a three replicated Randomized Complete Block Design with factorial arrangements having plot size of 8m x 3m (24m^2). Ridges were prepared to place the seed setts by end-to-end method.

Results

Two sugarcane varieties (Thatta-10 and LRK-2001) were evaluated against five potash levels (0, 120, 150, 180 and 210 kg ha^{-1} K_2O). The experiment was conducted at the experimental fields of Sugarcane Section, Agriculture Research Institute, Tandojam in a three replicated randomized complete block design with factorial arrangements. The treatment effect was recorded on germination percentage, cane length, cane girth, tillers stool^{-1}, cane yield ha^{-1}, brix content in juice and sugar recovery percentage. The data on these characters are shown in (Tables 1 to 7). These tables were also statistically Analysed and analysis of variance is presented as Appendix-I to VII.

Germination (%)

The effect of different potash levels on the germination percentage of two sugarcane varieties was investigated and the results are presented in (Table 1). The analysis of variance suggested that germination was significantly ($P<0.05$) influenced by potash levels; while similarity in germination percentage was recorded between varieties and interaction between potash levels and varieties (P>0.05). The sugarcane crop supplied with potash at the rate of 210 kg and 180 kg ha^{-1} resulted in higher germination of 74.0 and 73.9 percent, respectively; while germination slightly decreased to 72.7 and 72.9 when the plots were given potash at the rate of 150 and 120 kg ha^{-1}, respectively. However, the lowest germination of 66.3 percent was recorded in control plots, where potash application was not practiced. Among varieties, LRK-2001 showed relatively higher germination (72.3%) than Thatta-10 (71.6%). The treatment interaction of 210 kg ha^{-1} K × LRK-2001 resulted in maximum germination (74.4%) and lowest germination (66.0%) was observed in the interaction of Control K × Thatta-10. There was remarkable effect of potash application on the germination of sugarcane regardless the varieties. Seed viability for germination was found to be higher in variety LRK-2001 than Thatta-10. However, the LSD test indicated that the differences in germination were non-significant (P>0.05) between potash levels of 120, 150, 180 and 210 kg ha^{-1}; while significant (P<0.05) when compared with control.

Cane length (cm)

The cane length of sugarcane varieties Thatta-10 and LRK-2001 as influenced by different levels of potash fertilizer was examined and the data are given in (Table 2). The analysis of variance demonstrated that cane length was significantly (P<0.05) influenced by potash levels and varieties; interaction between varieties and potash levels was non-significant (P>0.05). The sugarcane crop fertilized with potash at the rate of 210 kg and 180 kg ha^{-1} caused significantly greater cane length of 239.20 cm and 238.96 cm, respectively; while cane length considerably reduced to 230.11 cm and 225.61 cm when the plots were given potash at the rate of 150 and 120 kg ha^{-1}, respectively. However, the lowest cane length of 205.41 cm was noted in control plots, where potash was not applied. In varieties, LRK-2001 produced longer canes (229.21 cm) than Thatta-10 (226.50 cm). The treatment interaction of 210 kg ha^{-1} K × LRK-2001 produced canes of maximum length (240.63 cm) and lowest cane length (204.18 cm) was noted in interaction of Control K × Thatta-10. The results clearly indicated the essentiality of soil applied K, and there was a considerable decrease in cane length when soil application of K was controlled even recommended doses of N and P were already applied. The response of variety LRK-2001 to soil applied K was more than the variety Thatta-10. The LSD test described that the differences in cane length between 180 kg and 210 kg K ha^{-1} were non-significant (P>0.05); and significant (P<0.05) when compared with rest of the K levels and control. This suggested that application of 180 K ha^{-1} was an optimum level for producing economically maximum cane length regardless the varieties and there was no economical impact of 210 kg K application on this trait.

Cane girth (cm)

Cane thickness (cane girth) of two sugarcane varieties as affected by different levels of potash fertilizer was assessed and the data are presented in (Table 3). The analysis of variance (Appendix-III) illustrated that cane girth was significantly (P<0.05) affected by potash levels, varieties as well as by K levels × varieties interaction. The application of potash fertilizer at higher rates of 210 kg and 180 kg ha^{-1} produced significantly thicker canes with average cane girth of 3.09 cm and 3.08 cm, respectively; while cane girth was considerably lower i.e. 2.96 cm and 2.82 cm when potash was applied at the rate of 150 and 120 kg ha^{-1}, respectively. However, the minimum cane girth of 2.56 cm was observed in control plots. In case of sugarcane varieties, LRK-2001 produced thicker canes (2.99 cm) as compared to variety Thatta-10

(2.85 cm). The treatment interaction of 210 kg ha^{-1} K × LRK-2001 produced canes of maximum girth (3.29 cm) and minimum cane girth (2.55 cm) was observed in interaction of Control K × variety Thatta-10. It was observed that in absence of potash application the cane thickness was severely affected and that justified the potash as an indispensable element for cane development. Variety LRK-2001 was found to be more responsive to potash when cane thickness is concerned as compared to variety Thatta-10. The LSD test indicated that the differences in cane girth between 180 kg and 210 kg K ha^{-1} were insignificant (P>0.05); and significant (P<0.05) when compared with rest of K levels and control. This indicated that 180 ha^{-1} was an optimum potash level for producing canes with economically maximum thickness; while 210 kg ha^{-1} K did not prove to be an economical potash level for sugarcane crop.

Tillers stool^{-1}

Tillers stool^{-1} in sugarcane is a yield component that influences the cane yield substantially. The response of sugarcane varieties to different potash levels for tillering capacity was determined and subsequent results are shown in (Table 4). The analysis of variance (Appendix-IV) indicated that tillers stool^{-1} were significantly (P<0.05) influenced by potash levels, varieties as well as by Potash × variety interaction. The application of potash fertilizer at higher rates of 210 kg and 180 kg ha^{-1} produced significantly more tillers stool^{-1} of 6.50 and 6.48, respectively; while tillers stool^{-1} decreased to 6.21 and 5.94 when potash was applied at the rate of 150 and 120 kg ha^{-1}, respectively. However, the minimum tillers stool^{-1} of 5.08 was noted in control. LRK-2001 produced more tillers stool^{-1} (6.24) than variety Thatta-10 (5.84). The treatment interaction of 210 kg ha^{-1} K × LRK-2001 resulted in maximum tillers stool^{-1} (6.75) and minimum tillers stool^{-1} (4.75) were noted in interaction of Control K × variety Thatta-10. In absence of potash from fertilizer program, the tillers stool^{-1} were markedly decreased justifying the essentiality of potash for development of tillering capacity in sugarcane varieties. In varieties, LRK-2001 possessed higher tillering capacity than Thatta-10. The LSD test indicated that the differences in tillers stool^{-1} between 180 kg and 210 kg K ha^{-1} were insignificant (P>0.05); and significant (P<0.05) when compared with rest of K levels and control. This suggested that 180 kg ha^{-1} would be enough to fulfill the sugarcane crop K requirement and further increase in K level did not show an economical impact on tillering capacity.

Cane yield (kg ha^{-1})

The response of sugarcane varieties Thatta-10 and LRK-2001 to different potash levels for cane yield ha^{-1} was assessed and the results are presented in (Table 5). The analysis of variance (Appendix-V) demonstrated that cane yield ha^{-1} was significantly (P<0.05) affected by potash levels, varieties as well as by Potash levels × varieties interaction. It is evident from the results (Table 5) that the application of potash fertilizer at higher rates of 210 kg and 180 kg ha^{-1} produced higher cane yield of 98.08 and 97.95 tons ha^{-1}, respectively; while cane yield decreased to 93.03 and 88.83 tons ha^{-1} when potash was applied at the rates of 150 and 120 kg ha^{-1}, respectively. However, the lowest cane yield of 77.95 tons ha^{-1} was observed in control. In case of varieties, LRK-2001 produced higher cane yield (94.17 tons ha^{-1}) than variety Thatta-10 (88.25 tons ha^{-1}). The treatment interaction of 210 kg ha^{-1} K × variety LRK-2001 resulted in highest cane yield (102.54 tons ha^{-1}) and lowest cane yield ha^{-1} (74.55 tons ha^{-1}) was observed in interaction of Control K × variety Thatta-10. It was observed that with increase in potash levels, the cane yield ha^{-1} was simultaneously increased; while LRK-2001 showed more positive response to potash application as compared to Thatta-10. The LSD test showed that the differences in cane yield ha^{-1} between 180 kg and 210 kg K ha^{-1} were insignificant (P>0.05); and significant (P<0.05) when compared with lower potash levels as well as control. Hence, for achieving economically maximum cane yield, 180 kg ha^{-1} potash would be an optimum level for sugarcane varieties.

Brix content (%)

The results in regards to brix content in cane juice of different varieties are shown in (Table 6). The analysis of variance (Appendix-VI) indicated that brix content was significantly (P<0.05) influenced by potash levels and varieties while interactive effect of Potash levels × varieties on this brix was insignificant (P>0.05). The brix content was higher i.e. 22.17, 22.13 and 22.04 percent in sugarcane crop given potash fertilizer at rates of 210 kg, 180 kg and 150 kg ha^{-1}, respectively. The brix content decreased to 21.64% when potash was applied at the lower rate of 120 kg ha^{-1}, while the lowest brix content of 20.63% was determined in crop given no potash fertilizer (control). In case of varieties, the cane juice of variety LRK-2001 contained higher brix content (22.04 %) than variety Thatta-10 (21.42 %). The treatment interaction of 210 kg ha^{-1} K × variety LRK-2001 resulted in highest brix content (22.50%) and lowest brix content (20.33%) was determined in interaction of Control K × variety Thatta-10. It was noted that increasing potash levels upto 150 kg ha^{-1} improved the brix content in cane juice considerably; while further increase in potash level did not affect the brix content significantly (P>0.05); and LRK-2001 showed its superiority in brix content over Thatta-10. The LSD test showed that the differences in brix content between 150 kg, 180 kg and 210 kg K ha^{-1} were insignificant (P>0.05); and significant (P<0.05) when compared with lower potash level of 120 kg ha^{-1} and control.

Sugar recovery (%)

The data pertaining to sugar recovery in cane juice of different sugarcane varieties are presented in (Table 7). The analysis of variance (Appendix-VII) demonstrated that sugar recovery was significantly (P<0.05) influenced by potash levels and varieties while interactive effect of Potash levels × varieties on sugar recovery was insignificant (P>0.05). It was observed that the sugar recovery was higher i.e. 11.08, 11.07 and 11.02 percent in sugarcane crop given potash fertilizer at the rates of 210 kg, 180 kg and 150 kg ha^{-1}, respectively. The sugar recovery decreased to 10.82% when potash was applied at the lower rate of 120 kg ha^{-1}, while the lowest sugar recovery of 10.32% was determined in crop given no potash fertilizer (control). In case of varieties, the cane juice of variety LRK-2001 contained higher sugar recovery (11.02%) than variety Thatta-10 (10.70%). The treatment interaction of 210 kg ha^{-1} K × variety LRK-2001 resulted in highest sugar recovery (11.25%) and lowest sugar recovery (10.16%) was determined in interaction of Control K × variety Thatta-10. The increasing potash levels upto 150 kg ha^{-1} caused an increase in the sugar recovery of cane juice considerably; while further increase in potash level did not influence the sugar recovery significantly (P>0.05). On the other hand, LRK-2001 showed its superiority in sugar recovery over Thatta-10. The LSD test indicated that the differences in sugar recovery between 150 kg, 180 kg and 210 kg K ha^{-1} were insignificant (P>0.05); and significant (P<0.05) when compared with lower potash level of 120 kg ha^{-1} as well as control.

Table 1. Germination (%) of sugarcane varieties as influenced by different levels of potassium

Potassium levels	Varieties		Mean
	Thatta-10	LRK-2001	
0 kg ha^{-1} (control	66.0	66.7	66.3 b
120 kg ha^{-1}	72.5	73.2	72.8 a
150 kg ha^{-1}	72.3	73.0	72.7 a
180 kg ha^{-1}	73.5	74.3	73.9 a
210 kg ha^{-1}	73.6	74.3	74.0 a
Mean	**71.6**	**72.3**	-

	Potassium levels (K)	Varieties (V)	K x V
S.E.	0.9298	0.5881	1.3150
LSD 0.05	1.9535	-	-

Table 2. Cane length (cm) of sugarcane varieties as influenced by different levels of potassium

Potassium levels	Varieties		Mean
	Thatta-10	LRK-2001	
0 kg ha^{-1} (Control)	204.1	206.6	205.4 d
120 kg ha^{-1}	224.3	227.0	225.6 c
150 kg ha^{-1}	228.8	231.4	230.1 b
180 kg ha^{-1}	237.5	240.4	239.0 a
210 kg ha^{-1}	237.8	240.6	239.2 a
Mean	**226.5 b**	**229.2 a**	-

	Potassium levels (K)	Varieties (V)	K x V
S.E.	1.5955	1.0091	2.2563
LSD 0.05	3.3520	2.1200	-

Table 3. Cane girth (cm) of sugarcane varieties as influenced by different levels of potassium

Potassium levels	Varieties		Mean
	Thatta-10	LRK-2001	
0 kg ha^{-1} (Control)	2.5	2.6	2.6 d
120 kg ha^{-1}	2.8	3.0	3.0 c
150 kg ha^{-1}	2.9	3.0	3.0 b
180 kg ha^{-1}	3.0	3.3	3.1 a
210 kg ha^{-1}	3.0	3.3	3.1 a
Mean	**2.85 b**	**2.99 a**	-

	Potassium levels (K)	Varieties (V)	K x V
S.E.	0.0251	0.0159	0.0355
LSD 0.05	0.0527	0.0333	0.0746

Table 4. Tillers stool^{-1} of sugarcane varieties as influenced by different levels of potassium

Potassium levels	Varieties		Mean
	Thatta-10	LRK-2001	
0 kg ha^{-1} (Control)	4.7	5.4	5.1 d
120 kg ha^{-1}	5.9	6.0	5.9 c
150 kg ha^{-1}	6.1	6.3	6.2 b
180 kg ha^{-1}	6.2	6.7	6.5 a
210 kg ha^{-1}	6.2	6.7	6,5 a
Mean	**5.8 b**	**6.2 a**	

	Potassium levels (K)	Varieties (V)	K x V
S.E.	0.0745	0.0471	0.1054
LSD 0.05	0.1566	0.0990	0.2214

Table 5. Cane yield (t ha^{-1}) of sugarcane varieties as influenced by different levels of potassium

Potassium levels	Varieties		Mean
	Thatta-10	LRK-2001	
0 kg ha^{-1} (Control)	74.5	81.3	77.9 d
120 kg ha^{-1}	88.5	89.6	88.8 c
150 kg ha^{-1}	91.0	95.0	93.0 b
180 kg ha^{-1}	93.5	102.4	97.9 a
210 kg ha^{-1}	93.6	102.5	98.1 a
Mean	**88.2 b**	**94.2 a**	-

	Potassium levels (K)	Varieties (V)	K x V
S.E.	0.6746	0.4267	0.9541
LSD 0.05	1.4173	0.8964	2.0044

Table 6. Brix content (%) of sugarcane varieties as influenced by different levels of potassium

Potassium levels	Varieties		Mean
	Thatta-10	LRK-2001	
0 kg ha^{-1} (Control)	20.3	20.9	20.6 c
120 kg ha^{-1}	21.3	22.0	21.6 b
150 kg ha^{-1}	21.7	22.3	22.0 a
180 kg ha^{-1}	21.8	22.5	22.1 a
210 kg ha^{-1}	21.9	22.5	22.2 a
Mean	**21.4 b**	**22.0 a**	-

	Potassium levels (K)	Varieties (V)	K x V
S.E.	0.0904	0.0572	0.1287
LSD 0.05	0.1898	0.1201	-

Table 7. Sugar recovery (%) of sugarcane varieties as influenced by different levels of potassium

Potassium levels	Varieties		Mean
	Thatta-10	LRK-2001	
0 kg ha^{-1} (Control)	10.2	10.5	10.3 c
120 kg ha^{-1}	10.7	11.0	10.8 b
150 kg ha^{-1}	10.9	11.2	11.0 a
180 kg ha^{-1}	10.9	11.2	11.1 a
210 kg ha^{-1}	10.9	11.2	11.1 a
Mean	**10.7 b**	**11.0 a**	-

	Potassium levels (K)	Varieties (V)	K x V
S.E.	0.0455	0.0288	0.0644
LSD 0.05	0.0956	0.0605	-

Discussion

In Pakistan, use of K is very low which is around 0.73 kg ha-1 as against 85 kg of nitrogen and 21 kg of P_2O5 which seems to be inadequate and imbalanced to explore the production potential in sugarcane [11]. With the introduction of high yielding varieties and intensive agronomic practices sugarcane crop is becoming more responsive to higher K levels than recommended rates. A little research work has been done regarding K application time as it is often applied at sowing and that too in small quantity [11, 12]. Due to drought stress caused by water shortage, foliar application of essentially required elements has proved to be effective in maintaining the crop growth and found substantial increase in the crop yields. The present study was conducted to evaluate sugarcane varieties Thatta-10 and LRK-2001 against of different potash levels (0, 120, 150, 180 and 210 kg ha-1 K_2O). The findings are discussed as under:

The study showed that the effect of different potash levels and varieties was significant (P<0.05) on germination percentage, cane length, cane girth, tillers stool-1, cane yield ha-1, brix content in juice and sugar recovery percentage with the exception of germination percentage that was significantly affected by potash levels and variation was insignificant (P>0.05) between varieties. Interactive effect of potash levels and varieties on cane girth, tillers stool-1 and cane yield was significant; but insignificant (P>0.05) for germination percentage, cane length, brix and sugar recovery. The sugarcane crop given potash at the rate of 210 kg ha-1 produced 73.98 percent germination, 239.20 cm cane length, 3.09 cm cane girth, 6.50 tillers stool-1, 98.08 tons' ha-1 cane yield, 22.17 % brix and 11.08% sugar recovery. Similarly, the crop receiving potash at the rate of 180 kg ha-1 resulted in 73.91 percent germination, 238.96 cm cane length, 3.08 cm cane girth, 6.48 tillers stool-1, 97.95 tons' ha-1 cane yield, 22.13 % brix and 11.07% sugar recovery. The potash at the rate of 150 and 120 kg ha-1 produced simultaneously lower values for all the traits studied and control remained the least. The highest potash level of 210 kg ha-1 did not prove beneficial for sugarcane regardless the varieties and differences in overall crop performance under K levels of 180 kg ha-1 and 210 kg ha-1 were non-significant; hence 180 kg ha-1 potash would be an optimum level for sugarcane. Variety LRK-2001 showed better overall performance than Thatta-10 proving more responsive to potash fertilizer than its companion Thatta-10. These results are fully supported by those of Ashraf *et al.* [13], who found that application of potassium through soil at the rate of 150 kg K_2O ha-1 and foliar application of @ 2.50% concentration proved to be effective in achieving economical sugarcane yield, optimum nutrient uptake under drought conditions. Moreover, foliar fertilizers are being used in field crops that contain various macro and micronutrients. Foliar feeding is the practice of applying liquid fertilizers to plant which play essential role in regulating the crop growth. Foliar fertilizers immediately deliver nutrients to the tissues and organs of the crop. Similarly, reported that the cane yield increased from 50 t ha–1 without K fertilization to 74.5 t ha–1 with only 60 kg K ha–1 reported that the Indian soils are well comparable with the agricultural soils of Pakistan; where K application in 2 equal splits (50% at sowing and 50% at end of monsoon) gave maximum cane yield and number of millable canes, juice quality was unaffected. Akhtar *et al.* **[11]** conducted experiments to see the effect of various potassium levels on the growth, cane yield and juice quality in sugarcane and the results revealed that the maximum sugar yield was ascribed to higher stripped cane yield and CCS percent; and the cane yield recorded higher with increased rate of K_2O; while the CCS was also improved markedly with increasing rate of K_2O fertilizers. Ashraf *et al.* **[13]** concluded that the application of potassium at the rate of 150 kg K_2O ha-1 is effective in achieving economical sugarcane yield and optimum nutrient uptake under saline conditions. The influential role of K in the water economy of the sugarcane plant is also worth pointing out and application of K at time of planting under water stress conditions significantly increased the stomatal diffusive resistance, thereby decreasing transpiration rate and increasing the leaf water potential, cane length, sucrose content in juice and cane yield. Cheema *et al.* **[14]** reported that the application of 168 kg K_2O ha-1 in two splits; 84 kg K_2O at sowing + 84 kg K_2O ha-1 at 90 DAS produced maximum stripped cane yield of 116 & 107 t ha-1 during 2006 and 2007, respectively. Maximum cane length and number of mill able canes were also recorded at the same treatment. A positive and strong relationship was observed between stripped cane yield and leaf area index, number of shoots, cane length, cane girth and number of mill able canes. Ghaffar *et al.* **[15]** found that K_2O @ 168 kg in two splits; half at sowing + half at 90 DAS produced maximum cane length (305 and 290 cm), number of millable canes (13.0 and 12.7/m2) and stripped cane yield (116 and 107 tons ha-1) during the year 2006 and 2007, respectively. A positive and strong relationship was observed between stripped cane yield and number of shoots, cane length, cane girth and number of millable canes. In recent studies concluded that the sugarcane variety GT-11 showed markedly high performance when the crop was supplied with K_2O at 75% RR (soil applied) + 2 foliar sprays at 3% K_2O concentration (30g SOP L-1 water). This treatment interaction resulted in significantly highest cane yield and sugar recovery; while replacing 50% K_2O (soil applied) by foliar spray could not compensate well and negative effect on crop performance was noticed.

Conclusion

It was concluded that highest potash level of 210 kg ha^{-1} did not prove beneficial for sugarcane regardless the varieties and differences in overall crop performance under K levels of 180 kg ha^{-1} and 210 kg ha^{-1} were non-significant; hence 180 kg ha^{-1} potash would be an optimum level for sugarcane. Variety LRK-2001 showed better overall performance than Thatta-10 proving more responsive to potash fertilizer than its companion Thatta-10. The farmers are suggested cultivation of LRK-2001 variety with 180 kg potash application as basal dose along with recommended dose of N and P fertilizers.

Authors' contributions

Conceived and designed the experiments: A Buksh & S Ahmed, Performed the experiments: A Buksh & S Ahmed, Analyzed the data: A Raziq, Contributed materials/ analysis/ tools: A Raziq, Wrote the paper: A Buksh & S Ahmed

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