EFFECT OF K₂O LEVELS AND ITS APPLICATION TIME ON GROWTH AND YIELD OF SUGARCANE*

Abdul Ghaffar, M. Farrukh Saleem**, Asghar Ali*** and Atta Muhammad Ranjha****

ABSTRACT

In a study conducted at Sugarcane Research Institute, AARI, Faisalabad, Pakistan during the year 2006 and 2007, four K₂O levels (0, 112, 168 and 224 kg/ha) were applied to sugarcane crop at three different times i.e. at sowing, 90 days after sowing (DAS) and half at sowing + half at 90 DAS. Layout system was RCBD with three replications having a net plot size of 6 x 8 meter. The results revealed significant differences among all treatment means except germination percentage and number of shoots. K₂O @ 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), 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.

KEYWORDS: Saccharum officinarum; potash fertilizers; agronomic characters; time; Pakistan.

INTRODUCTION

Sugarcane (Saccharum officinarum L.) is one of the important cash crops of Pakistan. It is grown on an area of 1.241 million hectares with a total annual stripped cane production of 63.92 million tons with an average stripped cane yield of 51.51 tons per hectare. Important factors responsible for low yield of sugarcane in Pakistan include scarcity of irrigation water, low plant population per unit area and untimely, imbalanced as well as inadequate use of fertilizers especially K₂O. Sugarcane is a long duration and exhaustive crop that requires high quantity of nutrients heavily. Sugarcane production of 100 tons per hectare removes 207 kg N, 30 kg P₂O₅ and 233 kg K₂O from the soil (11). Therefore, these elements must be present in adequate quantities in the

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*A part of Ph. D. Thesis, **Assistant Research Officers, Sugarcane Research Institute, AARI, Faisalabad, ***Department of Agronomy, University of Agriculture, Faisalabad, ****Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan.

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root zone of crop for attaining higher yield. A big gap exists between attainable cane yield potential (300 t/ha) and average national harvested yield (49 t/ha) of existing cane varieties (17). The growth and yield of sugarcane primarily depends on fertility status of the soil, climate, genetic potential of cultivars and proper management of the crop including application of fertilizer at appropriate rate and time. In Pakistan, use of K is very low which is around 0.73 kg per hectare as against 85 kg of nitrogen and 21 kg of P$_2$O$_5$ (4) which seems to be inadequate and imbalanced to explore the production potential of the crop. Pakistan soils have developed from micaceous alluvium and the irrigation water has high K contents, the crop is well supplied with the element (1). 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.

The present study was conducted to investigate effect of K$_2$O levels and its time of application on growth and yield of sugarcane crop.

**MATERIALS AND METHODS**

This study was carried out at Sugarcane Research Institute, AARI, Faisalabad, Pakistan during 2006-07 in a randomized complete block design with three replications. Net plot size was 6 x 8 meter. The physico-chemical properties of experimental soil are given in Table 1. Sugarcane crop (cv. HSF-240) was sown in 1st week of March during both years. The seed rate used was 75000 DBS (double budded setts) per hectare and was placed end to end in two parallel rows, 1.2 meter apart trenches. N and P$_2$O$_5$ fertilizer levels were kept constant at 168 and 112 kg per hectare, respectively and were applied in trenches in the form of urea and SSP. Whole of P and one third of N was applied at the time of sowing and remaining two third N was applied in two equal splits i.e. at completion of germination (45 DAS) and at the time of earthing up (90 DAS) while K was applied in the form of SOP as per treatment i.e. no K$_2$O (T$_1$), 112 kg at sowing (T$_2$), 112 kg at 90 DAS (T$_3$), 56 kg at sowing + 56 kg at 90 DAS (T$_4$), 168 kg at sowing (T$_5$), 168 kg at 90 DAS (T$_6$), 84 kg at sowing + 84 kg at 90 DAS (T$_7$), 224 kg at sowing (T$_8$), 224 kg at 90 DAS (T$_9$) and 112 kg at sowing + 112 kg per hectare at 90 DAS (T$_{10}$). All other agronomic practices were kept normal and uniform for all the treatments. The crop was harvested manually at its physiological maturity on 16$^{th}$ and 18$^{th}$ of December, 2006 and 2007, respectively. Meteorological data for growing periods of crop were collected from the Observatory of Ayub Agricultural Research Institute, Faisalabad (Fig.1). Data were recorded on
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germination percentage at 45 DAS while number of shoots per square meter was counted at 90 DAS. Ten canes were selected randomly from each plot at harvest to collect data on cane height and cane girth. Number of millable canes at harvest was counted from 28.8 m² and was converted into millable canes per square meter. All stripped canes of each plot (28.8 m²) at harvest were weighed (kg) and then converted to tons per hectare. Sugar yield was determined by multiplying stripped cane yield (t/ha) with commercial cane sugar (%) divided by 100. The data were analyzed statistically using Duncan’s new multiple range (DNMR) test at 5 percent probability to compare treatments’ means (23).

Table 1 Physico-chemical properties of the experimental site (0-15 cm), during the year 2006 and 2007.

<table>
<thead>
<tr>
<th>Properties</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture</td>
<td>Loam</td>
<td>Loam</td>
</tr>
<tr>
<td>PH</td>
<td>7.9</td>
<td>7.9</td>
</tr>
<tr>
<td>EC (dS/m)</td>
<td>0.37</td>
<td>1.40</td>
</tr>
<tr>
<td>OM %</td>
<td>0.87</td>
<td>0.87</td>
</tr>
<tr>
<td>Available N (%)</td>
<td>0.044</td>
<td>0.044</td>
</tr>
<tr>
<td>Available P (ppm)</td>
<td>7.5</td>
<td>7.5</td>
</tr>
<tr>
<td>Available K (ppm)</td>
<td>116.00</td>
<td>108.00</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

Germination

Fig. 1 Meteorological data recorded at AARI, Faisalabad, Pakistan, during crop growth period (2006 & 2007).
The results showed that K$_2$O levels and its time of application did not significantly affect the germination percentage of spring planted sugarcane during both years (Table 2). Germination percentage ranged between 48.0-50.4 and 40.6-43.5 during 2006 and 2007, respectively. Non-significant effect of K$_2$O levels and its time of application on germination percentage might be due to almost uniform climatic conditions such as temperature, moisture, etc. during germination period and enough food reserve in all the seed setts of sugarcane. These results are supported by earlier scientists (6, 9, 12, 18) who recorded non-significant effect at varied levels of potassium on germination percentage. The year effect on germination was also non-significant.

**Number of tillers**

The data on number of tillers also showed non-significant effect of K$_2$O levels and its time of application (Table 2). However, maximum number of tillers (19.7 and 20.1/m$^2$ during year 2006 and 2007) were recorded in T$_7$ (84 kg K$_2$O/ha at sowing + 84 kg K$_2$O/ha at 90 DAS) against minimum (16.5/m$^2$ during 2006 and 16.6/m$^2$ during 2007) in T$_1$. The year effect on number of tillers was also non-significant. Significantly maximum number of tillers per square meter was observed by Rathore et al. (21) at higher dose of 100 kg K$_2$O applied in two splits. Similarly Bokhtiar et al. (8) and Jeyaraman and Alagudurai (12) recorded significant effect of different K$_2$O rates and noted maximum number of tillers upto 160 and 132.5 kg K$_2$O per hectare, respectively. In present study similar number of tillers was produced during both years. These results are in accordance with those of previous workers (6, 9, 18) who also found non-significant effect of different K$_2$O levels on number of tillers. The correlation analysis showed a strong and positive association between number of shoots and stripped cane yield during both years. It was also supported by regression model (Fig. 2) which indicated the dependence of stripped cane yield on number of tillers.

**Cane length**

Significant effect of K$_2$O levels and its application time on cane length was noted during both years (Table-2). Maximum cane length of 305 cm during 2006 and 290 cm during 2007 was recorded in T$_7$ (84 kg K$_2$O/ha at sowing + 84 kg K$_2$O/ha at 90 DAS). It was statistically at par with T$_{18}$ (112 kg K$_2$O at...
Table 2. Effect of K₂O levels and its application time on growth and yield parameters of sugarcane during the year 2006 and 2007.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Germination (%)</th>
<th>Number of tillers/m²</th>
<th>Cane length (cm)</th>
<th>Cane girth (cm)</th>
<th>Number of millable canes/m²</th>
<th>Stripped cane yield (t/ha)</th>
<th>Sugar yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁</td>
<td>50.4</td>
<td>40.6</td>
<td>16.5</td>
<td>16.8</td>
<td>185d</td>
<td>170c</td>
<td>6.46d</td>
</tr>
<tr>
<td>T₂</td>
<td>48.4</td>
<td>42.7</td>
<td>18.5</td>
<td>18.4</td>
<td>255bc</td>
<td>250ab</td>
<td>6.92c</td>
</tr>
<tr>
<td>T₃</td>
<td>50.0</td>
<td>41.3</td>
<td>18.3</td>
<td>18.2</td>
<td>250c</td>
<td>246b</td>
<td>6.83c</td>
</tr>
<tr>
<td>T₄</td>
<td>48.0</td>
<td>43.4</td>
<td>18.5</td>
<td>18.5</td>
<td>254bc</td>
<td>252ab</td>
<td>6.81c</td>
</tr>
<tr>
<td>T₅</td>
<td>49.7</td>
<td>42.5</td>
<td>19.2</td>
<td>19.4</td>
<td>295abc</td>
<td>285ab</td>
<td>7.58b</td>
</tr>
<tr>
<td>T₆</td>
<td>49.5</td>
<td>42.1</td>
<td>19.1</td>
<td>19.2</td>
<td>290abc</td>
<td>280ab</td>
<td>7.61b</td>
</tr>
<tr>
<td>T₇</td>
<td>49.3</td>
<td>43.5</td>
<td>19.7</td>
<td>20.1</td>
<td>305a</td>
<td>290a</td>
<td>7.95a</td>
</tr>
<tr>
<td>T₈</td>
<td>48.7</td>
<td>42.9</td>
<td>19.1</td>
<td>18.9</td>
<td>285abc</td>
<td>283ab</td>
<td>7.74ab</td>
</tr>
<tr>
<td>T₉</td>
<td>49.8</td>
<td>43.0</td>
<td>18.7</td>
<td>18.6</td>
<td>286abc</td>
<td>278ab</td>
<td>7.67ab</td>
</tr>
<tr>
<td>T₁₀</td>
<td>48.4</td>
<td>43.3</td>
<td>19.3</td>
<td>19.4</td>
<td>300ab</td>
<td>285ab</td>
<td>7.89ab</td>
</tr>
<tr>
<td>SE</td>
<td>4.07</td>
<td>3.52</td>
<td>1.28</td>
<td>1.23</td>
<td>13.8</td>
<td>12.94</td>
<td>0.096</td>
</tr>
<tr>
<td>Year mean</td>
<td>49.2</td>
<td>42.4</td>
<td>18.7</td>
<td>18.7</td>
<td>271a</td>
<td>262b</td>
<td>7.35</td>
</tr>
<tr>
<td>SE</td>
<td>1.75</td>
<td>0.29</td>
<td>1.6</td>
<td>0.381</td>
<td>0.32</td>
<td>2.3</td>
<td>0.30</td>
</tr>
</tbody>
</table>

T₁: No potash, T₂: 112 kg K₂O/ha at sowing, T₃: 112 kg K₂O/ha at 90 DAS, T₄: 56 kg K₂O/ha at sowing + 56 kg K₂O at 90 DAS, T₅: 168 kg K₂O/ha at sowing, T₆: 168 kg K₂O/ha at 90 DAS, T₇: 84 kg K₂O/ha at sowing + 84 kg K₂O at 90 DAS, T₈: 224 kg K₂O/ha at sowing, T₉: 224 kg K₂O/ha at 90 DAS, T₁₀: 112 kg K₂O/ha at sowing + 112 kg K₂O/ha at 90 DAS

Means in a column not sharing the same letters differ significantly from each other at P = 0.05.

SE = Standard error
sowing + 112 kg K₂O/ha at 90 DAS), T₅ (168 kg K₂O/ha at sowing), T₆ (224 kg K₂O/ha at sowing), T₆ (168 kg K₂O/ha at 90 DAS) and T₉ (224 kg K₂O/ha at 90 DAS) during the year 2006. However there was no difference among treatments during 2007 except control. Year effect on cane length was significant which clearly indicate the seasonality effects. Significantly higher cane length at various doses of K₂O over control was observed upto 168 kg K₂O per hectare beyond which non-significant effect was recorded. Khosa (13), Kumar et al. (15) and Gawander et al. (9) recorded significant increase in cane length with increasing level of K₂O, while contrary to that Rathore et al. (21) and Kumar (14) did not observe any significant increase in cane length. Increase in cane length upto a certain K₂O level might be attributed to availability of balanced nutrients, which might have accelerated crop growth rate. Significantly more cane length during the year 2006 was due to more rainfall during crop growth period (June to September). Correlation analysis revealed strong and positive relationship between cane length and stripped cane yield during both years. It was further supported by regression model, which indicated the dependence of stripped cane yield on cane length (Fig.3).

Cane girth

Year effect on cane girth was found non-significant. Data exhibited significant difference at varied K₂O levels and time of its application on cane girth, during both years (Table 2). Maximum cane girth (7.95 cm) was recorded in T₇ (84 kg K₂O at sowing + 84 kg K₂O/ha at 90 DAS) which was statistically at par with T₁₀ (112 kg K₂O at sowing + 112 kg K₂O/ha at 90 DAS), T₈ (224 kg K₂O/ha at sowing) and T₉ (224 kg K₂O/ha at 90 DAS) during the year 2006 while minimum cane girth (6.46 cm) was recorded in control treatment. During 2nd year (2007) cane girth of 7.35 cm was recorded in T₅ (168 kg K₂O/ha at sowing) and T₁₀ (112 kg K₂O at sowing + 112 kg K₂O/ha at 90 DAS). These results are at par with T₅ to T₈. Cane girth increased upto 168 kg K₂O level when applied in two splits. These results corroborates the findings of Akhtar et al. (3) who found significant enhancement in cane diameter upto a certain limit of K₂O. However, Rathore et al. (21) did not agree with present investigations who recorded non-significant effect of different K₂O levels and application time on cane girth. There was a positive and linear correlation between cane girth and stripped cane yield during both years, which has further been supported by regression model showing dependence of stripped cane yield on cane girth (Fig.4).
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Fig. 2 Relationship between number of shoots and stripped cane yield of sugarcane (a) 2006 and (b) 2007.

Fig. 3 Relationship between cane length and stripped cane yield of sugarcane (a) 2006 and (b) 2007.

Fig. 4 Relationship between cane girth and stripped cane yield of sugarcane (a) 2006 and (b) 2007.
Number of millable canes

Effect of K$_2$O levels and its application time on number of millable canes was significant over control treatment (T$_1$) while all other treatments showed non-significant difference with each other during both years. Maximum number of millable canes (13.0/m$^2$ during 2006 and 12.7/m$^2$ during 2007) was recorded in T$_7$ (84 kg K$_2$O at sowing + 84 kg K$_2$O/ha at 90 DAS) against minimum in T$_1$ (10.1/m$^2$ during 2006 and 9.7/m$^2$ during 2007). These results agree to those of many workers (6, 7, 8, 9, 12, 21) while Hussain et al. (10), Ahmad et al. (2) and Singha (22) do not endorse the present findings who observed non-significant effect of K$_2$O on number of millable canes. A positive and linear correlation between number of millable canes and stripped cane yield was observed during the year 2006 and 2007 (Fig. 5) which was further supported by regression model and showed dependence of stripped cane yield on number of millable canes.

Stripped cane yield

This parameter also exhibited significant effect of K$_2$O levels and its application time during both years. Maximum stripped cane yield (116 t/ha during 2006 and 107 t/ha during 2007) was recorded in T$_7$ which was statistically at par with all other treatments except control during the year 2006. Similar findings were recorded during 2007. Maximum stripped cane yield in T$_7$, might be attributed to higher values of yield contributing parameters like cane length, cane girth and number of millable canes (Table 2). Significant increase in stripped cane yield upto an optimal K$_2$O level has

Fig. 5 Relationship between number of millable canes and stripped cane yield of sugarcane (a) 2006 and (b) 2007.
already been reported earlier (8, 12, 13, 15, 16, 19). Contrary to that Ramesh and Varghese (20) and Patel et al. (18) reported non-significant difference in cane yield with different doses of K₂O. Gawander et al. (9) registered statistically same stripped cane yield at varied levels of potassium on sites having high K status and significant effect on soils with low exchangeable K.

Sugar yield

Sugar yield was also significantly affected by K₂O levels and its application time during both years of experimentation. During 2006, maximum sugar yield (14.7 t/ha) was recorded in T₇ (84 kg K₂O at sowing + 84 kg K₂O/ha at 90 DAS), which was statistically at par with all other treatments except control (T1) (7.7 t). During 2007, T₁₀ (112 kg K₂O/ha at sowing + 112 kg K₂O/ha at 90 DAS) excelled in sugar yield (14.1 t/ha) against minimum (7.4 t/ha) in control treatment. Maximum sugar yield could be ascribed to higher stripped cane yield and CCS percent. Rathore et al. (21), Akhtar et al. (3) and Gawander et al. (9) also recorded higher sugar yield with increased rate of K₂O.

CONCLUSION

The study concludes that maximum stripped cane yield was recorded with the application of 168 kg K₂O in two splits (64 kg/ha at sowing + 64 kg/ha at 90 DAS). Therefore, sugarcane growers are advised to apply potassium fertilizer for higher yield.

REFERENCES

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