GENOTYPIC EVALUATION OF SUGARCANE GENOTYPES FOR RATOONING ABILITY

SYED MEHAR ALI SHAH*, HIDAYAT-UR-RAHAMAN*, ZAHID IQBAL*, FIDA MUHAMMAD ABBASSI**, DURRISHAHWAR*, AMJAD ALI***, MOHAMMAD YASIR KHAN* and DAWOOD JAN****

* Department of Plant Breeding and Genetics, NWFP Agricultural University, Peshawar – Pakistan
Email: mehrbp@gmail.com
** Institute of Agricultural Biotechnology and Genetic Resources, National Agricultural Research – Pakistan
*** Sugarcane Research Institute, Mardan – Pakistan
**** Department of Agricultural Economics, NWFP Agricultural University, Peshawar – Pakistan

ABSTRACT

Five sugarcane genotypes (Malakand-9, Malakand-10, Malakand-11, Malakand-12 and Malakand-13) along with one check cultivar (CP 77-400) were evaluated for ratooning/stubbling ability. The experiment was planted in randomized complete block design with four replications at the Plant Breeding and Genetics Research Farm, NWFP Agricultural University, Peshawar during 2004-05 crop season. Data were recorded on number of tillers stool\(^{-1}\), growth rate, stalk thickness, response to diseases i.e. ratoon stunting disease (RSD) and mosaic disease, refractive brix, cane yield, sucrose content and sugar yield. Highly significant (p<0.01) differences among the genotypes were observed for RSD, refractive brix, cane yield, sucrose content and sugar yield whereas variation among the genotypes for growth rate were only of significant (p<0.05) nature. Differences among the genotypes were observed non-significant (p>0.05) for stalk thickness, mosaic disease and number of tillers stool\(^{-1}\). Cane yield showed significantly positive correlations with refractive brix, sucrose content and sugar yield while it gave significantly negative correlation with RSD. Malakand-9 exhibited superiority among all genotypes for most of the traits and its genetic potential can be exploited in future breeding programs.

Key Words: Mosaic disease, Ratooning/Stubbling ability, Ratoon stunting disease, Screening, Sugarcane, Yield traits

INTRODUCTION

Sugarcane (Saccharum officinarum L.) is a giant robust tropical grass native to Asia where it has been grown in gardens for over four thousand years (Poehlman and Borthakur, 1972). The crop is mostly valued for the juices extracted from its stem. Its juice, at the proper stage of maturity, contains sucrose or crystalline sugar. It, thus, serves as a basic raw material for sugar production.

Over half of the world’s sugar source is sugarcane crop (Braun, 1994). In ancient times sugarcane was used for chewing and its juice for drinking purpose. In the present times of modern technology, sugar mills extract sugar from sugarcane all over the world. Cane producing countries like Brazil, India, Cuba, Pakistan, USA, Equador, Egypt, Mauritius, Australia, Spain, New Guinea and Philippines (FAOSTAT, 2008) are having sugar producing factories from sugarcane (Sugar Factories of the World, 2008).

In Pakistan sugarcane is an important cash crop and the surplus sugar can be exported to other counties to earn foreign exchange. In Pakistan it is planted on area of 0.91 million hectare with cane production of 44.7 million tonnes (MINFAL, 2007).

Peshawar valley is one of the most important sugarcane growing tracts of Pakistan, which lies, between 32-36°N latitude with altitude ranging from about 300-350 m. The valley has got extreme type of climatic conditions. Average summer temperature range between 100 and 105 °F temperature and sometime goes as high as 115 °F. Frost of high and low intensities is the common feature of winter season.

Good ratooning in sugarcane is beneficial for the farming community as its production costs lower than the plant crop. However, during the last few years ratoon crop of sugarcane has shown a declining tendency in yield. Almost all the locally adapted exotic sugarcane genotypes have shown this trend. Genetic variation among
sugarcane genotypes for ratooning potential has previously been reported by researchers (Bhatnagar et al., 2003; Rafiq et al., 2006). As ratoon crop failure is the major problem of the cane growers in Peshawar valley, therefore, the prime objective of this study was to identify suitable sugarcane genotypes for ratooning/stubbling ability under the agro-climatic conditions of Peshawar valley.

MATERIALS AND METHODS

The present study was conducted at the Plant Breeding and Genetics Research Farm, NWFP Agricultural University Peshawar, during 2004-05 crop season. The experiment was carried out on five sugarcane promising genotypes (Malakand-9, Malakand-10, Malakand-11, Malakand-12, and Malakand-13) evolved at Sugarcane breeding Station, Dargai and one check cultivar, CP 77-400. Malakand-9, Malakand-10, Malakand-11, Malakand-12, and Malakand-13 are the advanced sugarcane clones and were derived from random crossing among the selected clones of indigenous Saccharum officinarum L., S. spontaneum L., and S. barberi Jeswiet whereas, the pedigree of check cultivar is CP66/315*CP71/400. The experiment was laid out in a randomized complete block design with four replications. Seven rows of each genotype per replication with row length of 6 m and row-to-row distance of 90 cm were used. Standard crop production technology as needed for sugarcane crop was used in the experiment. Number of tillers stool$^{-1}$ was counted before earthing up in five stools for each genotype replication$^{-1}$ and then the mean value for this trait was determined. For growth rate, five competitive stools were selected for each genotype and plant height data were recorded from 1$^{st}$ June to 15$^{th}$ August 2005 with fifteen days interval with the help of a meter rod. The plants were measured from soil level to the fresh leaves. During the period from 1$^{st}$ June to 15$^{th}$ August 2005, plants were measured eight times and then mean value was determined for each genotype. Stalk thickness data were taken on five selected stalks for each genotype at the time of harvest.

The effect of ratoon stunting disease on sugarcane genotypes was studied in the form of percentage of the diseased plants. Leaves of each genotype used in the study were visually observed for presence or absence of mosaic disease and then percentage of the diseased plants were estimated. For refractive brix, brix degree readings on ten randomly selected canes were determined with the help of brix refractometer standardized at 20$^\circ$C according to Spencer and Meade (1945) in laboratory of Khazana Sugar Mill, Peshawar. Cane yield was recorded by harvesting the whole plots of all genotypes. The stalks were stripped, topped and weighed with the help of spring balance. The cane yield (kg) of each genotype was converted into tonnes hectare$^{-1}$. For sucrose content, five cane samples of each genotype were taken at the time of harvest and sugar recoveries were worked out at Khazana Sugar Mill, Peshawar. Sugar yield was calculated with the help of commercial cane sugar percentage (CCS%) of cane e.g. sucrose content, and cane yield by the following formula according to Spencer and Meade (1945).

Sugar yield (tonnes ha$^{-1}$) = CCS% × cane yield (tonnes ha$^{-1}$)/100

The data after compiling were statistically analyzed using MSTATC package version 1.2 (Freed, 1990) and least significant difference (LSD) test was applied to test the significance of genotypic difference. Correlation coefficients were also worked out using the same package.

RESULTS AND DISCUSSION

Tillers Stool$^{1}$

Non-significant differences (p>0.05) were observed among the genotypes for number of tillers stool$^{1}$ (Table I). Tillers stool$^{1}$ among the genotypes ranged between 9 and 28. Malakand-12 displayed maximum number of tillers (28) in one stool (Table II). These results are contrary to the findings of Jamro et al. (2000) which may be due to different genetic backgrounds of the genotypes used in the present study. Number of tiller stool$^{1}$ showed significantly positive correlation with stalk thickness (Table III), which is in line with the findings of Anwar et al. (1992) and Munir et al. (1992).

Table I. Mean squares for tiller stool$^{1}$(TS), growth rate (GR), stalk thickness (ST), response to ratoon stunting disease (RRSD), response to mosaic disease (RMD), refractive brix (RB), cane yield (CY), sucrose content (SC) and sugar yield (SY) of six sugarcane genotypes during 2004-05, Peshawar

<table>
<thead>
<tr>
<th>SOV</th>
<th>DF</th>
<th>TS</th>
<th>GR</th>
<th>ST</th>
<th>RRSD</th>
<th>RMD</th>
<th>RB</th>
<th>CY</th>
<th>SC</th>
<th>SY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replications</td>
<td>3</td>
<td>247</td>
<td>49.4</td>
<td>0.03</td>
<td>1</td>
<td>1.4</td>
<td>0.6</td>
<td>11.7</td>
<td>0.19</td>
<td>0.2</td>
</tr>
<tr>
<td>Genotypes</td>
<td>5</td>
<td>199</td>
<td>270</td>
<td>0.05</td>
<td>4.6</td>
<td>4.8</td>
<td>7.6</td>
<td>223</td>
<td>4</td>
<td>7.7</td>
</tr>
<tr>
<td>Error</td>
<td>15</td>
<td>170</td>
<td>77.4</td>
<td>0.02</td>
<td>1</td>
<td>2.7</td>
<td>0.6</td>
<td>7.5</td>
<td>0.5</td>
<td>0.4</td>
</tr>
</tbody>
</table>

* = Significant at 5% level of probability
** = Significant at 1% level of probability
Table II. Mean values for tiller stool\(^1\) (TS), growth rate (GR), stalk thickness (ST), response to ratoon stunting disease (RRSD), response to mosaic disease (RMD), refractive brix (RB), cane yield (CY), sucrose content (SC) and sugar yield (SY) of six sugarcane genotypes during 2004-05, Peshawar

<table>
<thead>
<tr>
<th>Genotype</th>
<th>TS (cm)</th>
<th>GR (cm)</th>
<th>ST (cm)</th>
<th>RRSD (%)</th>
<th>RMD (%)</th>
<th>RB (%)</th>
<th>CY (t ha(^{-1}))</th>
<th>SC (%)</th>
<th>SY (t ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malakand-9</td>
<td>12</td>
<td>114 bc</td>
<td>1.1</td>
<td>5.2 c</td>
<td>5.5</td>
<td>20.8 a</td>
<td>90 a</td>
<td>11 a</td>
<td>9.9 a</td>
</tr>
<tr>
<td>Malakand-10</td>
<td>11</td>
<td>132 a</td>
<td>1.1</td>
<td>5.7 bc</td>
<td>5.0</td>
<td>19.9 a</td>
<td>76 bc</td>
<td>11 a</td>
<td>8.3 bc</td>
</tr>
<tr>
<td>Malakand-11</td>
<td>11</td>
<td>111 c</td>
<td>1.1</td>
<td>6.0 bc</td>
<td>3.5</td>
<td>20.0 a</td>
<td>81 b</td>
<td>11 a</td>
<td>8.7 ab</td>
</tr>
<tr>
<td>Malakand-12</td>
<td>28</td>
<td>114 bc</td>
<td>1.4</td>
<td>6.0 bc</td>
<td>4.0</td>
<td>19.9 a</td>
<td>75 c</td>
<td>9.7 b</td>
<td>7.2 c</td>
</tr>
<tr>
<td>Malkand-13</td>
<td>10</td>
<td>122 bc</td>
<td>1.1</td>
<td>7.2 ab</td>
<td>3.7</td>
<td>19.8 a</td>
<td>77 bc</td>
<td>10.7 b</td>
<td>8.2 bc</td>
</tr>
<tr>
<td>CP-77-400</td>
<td>9</td>
<td>125 ab</td>
<td>1.1</td>
<td>8.0 a</td>
<td>6.2</td>
<td>16.8 b</td>
<td>68 d</td>
<td>8.6 c</td>
<td>5.8 d</td>
</tr>
<tr>
<td>LSD(0.05)</td>
<td>-</td>
<td>-</td>
<td>1.5</td>
<td>2.5</td>
<td>1.2</td>
<td>5.7</td>
<td>1.1</td>
<td>1.3</td>
<td></td>
</tr>
</tbody>
</table>

Table III. Correlation coefficients for tiller stool\(^1\) (TS), growth rate (GR), stalk thickness (ST), response to ratoon stunting disease (RRSD), response to mosaic disease (RMD), refractive brix (RB), cane yield (CY), sucrose content (SC) and sugar yield (SY) of six sugarcane genotypes during 2004-05, Peshawar

<table>
<thead>
<tr>
<th></th>
<th>TS</th>
<th>GR</th>
<th>ST</th>
<th>RRSD</th>
<th>RMD</th>
<th>RB</th>
<th>CY</th>
<th>SC</th>
<th>SY</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS</td>
<td>-0.41</td>
<td>0.98(*)</td>
<td>-0.32</td>
<td>0.34</td>
<td>0.30</td>
<td>-0.02</td>
<td>-0.17</td>
<td>-0.12</td>
<td></td>
</tr>
<tr>
<td>GR</td>
<td>-0.50</td>
<td>0.37</td>
<td>0.42</td>
<td>0.42</td>
<td>-0.53</td>
<td>-0.16</td>
<td>-0.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST</td>
<td>-0.26</td>
<td>0.37</td>
<td>0.22</td>
<td>0.02</td>
<td>-0.06</td>
<td>-0.27</td>
<td>-0.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RRSD</td>
<td></td>
<td>0.23</td>
<td>0.86(\ast)</td>
<td>-0.78(\ast)</td>
<td>-0.73</td>
<td>-0.79(\ast)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMD</td>
<td></td>
<td>0.55</td>
<td>-0.18</td>
<td>0.49</td>
<td>-0.29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RB</td>
<td></td>
<td>0.83(\ast)</td>
<td>0.87(\ast)</td>
<td>0.89(\ast)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CY</td>
<td></td>
<td>0.76(\ast)</td>
<td>0.95(\ast)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC</td>
<td></td>
<td>0.92(\ast)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Growth Rate**

The genotypes displayed significant (p<0.05) differences for growth rate (Table I). Growth rate among the genotypes varied from 111 to 132 cm. Maximum growth rate (132 cm) was recorded for Malakand-10 whereas, Malakand-11 had minimum growth rate (111 cm) (Table II). Ghosh and Singh (1997) also observed significant differences among twelve diverse sugarcane genotypes for this trait. Growth rate demonstrated non-significant correlations with yield components (Table III). These results are not supported by the findings of Sugimoto et al. (2000) which might be due to differences of germplasm of the two studies.

**Stem Thickness**

The statistical analysis revealed non-significant differences (p>0.05) among the genotypes for stalk thickness (Table I). Mean data showed that stalk thickness ranged from 1.1 to 1.4 cm. Malakand-12 had maximum stalk thickness of 1.4 cm (Table II). Stalk thickness manifested negative correlations with cane yield and sucrose content which are compatible with the findings of Bailey and Bechet (1995) and Das et al. (1996).

**Response to Ratoon Stunting Disease (RSD)**

Analysis of variance revealed highly significant (p<0.01) differences among the genotypes in response to ratoon stunting disease (Table I). This differential response of sugarcane genotypes to this disease has also previously been reported by Roach and Jackson (1992). Percent RSD among the genotypes varied from 5.2 to 8%. Malakand-9 appeared more resistant against RSD and displayed minimum value (5.2%) for the trait. The genetic potential of this sugarcane genotype against ratoon stunting disease can be utilized in sugarcane breeding programs with the prime objective to cope with this disease problem. Check cultivar CP77-400 displayed maximum percent RSD value (8%) and thus, had maximum susceptibility to this disease (Table II). Our field surveys during the study year revealed ratoon stunting disease incidence of about 10% on commercially grown sugarcane crop. This data is almost compatible with the incidence of this disease on check cultivar used in the present study. Ratoon stunting disease drastically affects both yield and quality parameters of sugarcane. Significantly negative association of this disease with both cane and sugar yield (Table III) as observed in the present study is in line with the findings of Roach and Jackson (1992), Bailey and Bechet (1995) and Perez et al. (2000).
Response to Mosaic Disease

Non-significant (p>0.05) differences among the genotypes were observed in response to mosaic disease (Table I). Anwar et al. (1992) and Munir et al. (1993) also studied the effect of this disease on yield characteristics of sugarcane genotypes and didn’t observe any significant variation among the genotypes for this trait. Percentage of mosaic plants among the genotypes ranged between 3.5 and 6.2%. Malakand-11, however, displayed resistance to this disease with minimum value of 3.5% for the trait (Table II). Our field studies showed that during the study year mosaic disease appeared on almost 7% of commercially grown sugarcane crop which is in agreement with occurrence of this disease on check cultivar used in the present study. Negative impact of mosaic disease on number of tillers, stalk thickness, cane yield and sugar as observed in the present study (Table III) is in line with the findings of Anwar et al. (1992) and Munir et al. (1992).

Refractive Brix

Mean square revealed highly significant (p<0.01) differences among the genotypes for refractive brix values (Table I) which is in agreement with the findings of More et al. (1994) and Gowda et al. (2000). Refractive brix values among the genotypes varied from 16.8 to 20.8%. Maximum refractive brix value (20.8%) was recorded for Malakand-9 whereas minimum refractive brix value (16.8%) was observed for CP77-400 (Table II). This trait manifested significantly positive correlations with cane yield, sucrose content and sugar yield (Table III).

Cane Yield

Highly significant (p<0.01) differences among the genotypes were observed for cane yield (Table I). Goswami and Singh (1996) and Singh and Singh (2000) also reported significant genetic variation among sugarcane genotypes for this trait in ratoon crop. Mean data revealed that cane yield among the genotypes varied between 68 and 90 t ha\(^{-1}\). Malakand-9 showed maximum cane yield (90 t ha\(^{-1}\)) whereas check cultivar CP77-400 had minimum cane yield (68 t ha\(^{-1}\)) (Table II). It is also worth mentioning that Malakand-9 had also displayed resistance to ratoon stunting disease. Thus the highest cane yield coupled with disease resistance among the sugarcane genotypes included in the study depicts its potential to replace the existing commercial cultivars of sugarcane in this region. Cane yield displayed significantly positive association with refractive brix, sucrose content and sugar yield. The trait also had negative correlations with stalk thickness, ratoon stunting and mosaic diseases (Table III). Anwar et al. (1992) and Munir et al. (1992) also reported significant losses in cane yield on account of ratoon stunting and mosaic diseases of sugarcane.

Sucrose Content

Analysis of variance revealed highly significant (p<0.01) differences among the genotypes for sucrose content (Table I) in line with the findings of More et al. (1994) and Gowda et al. (2001). Sucrose content among the genotypes ranged from 8.6 to 11%. Malakand-9, Malakand-10 and Malakand-11 exhibited maximum sucrose content of 11% whereas CP77-400 had minimum sucrose content of 8.6% (Table II). Sucrose content had significantly positive relationship with refractive brix and sugar yield. This trait also displayed negative correlations with number of tillers, stalk thickness, growth rate, ratoon stunting disease, mosaic disease and cane yield (Table III), which are compatible with the findings of Anwar et al. (1992), Baljit et al. (1994) and Miligan et al. (1996).

Sugar Yield

Statistical analysis manifested highly significant differences (p<0.01) among the genotypes for sugar yield (Table I). Genetic variation among sugarcane genotypes for this trait has previously been reported by Sundra et al. (1992) and Das et al. (1996). Mean data depicted that sugar yield among the genotypes varied between 5.8 and 9.9 t ha\(^{-1}\). Malakand-9 showed maximum sugar yield (9.9 t ha\(^{-1}\)), whereas CP77-400 had minimum sugar yield (5.8 t ha\(^{-1}\)) (Table II). Correlations of sugar yield with refractive brix, cane yield and sucrose content were significantly positive while its correlations with other plant parameters were negative (Table III). Das et al. (1996) and Sukhchain (1997) also reported positive relationships of sugar yield with refractive brix, cane yield and sucrose content. Negative association of sugar yield with mosaic disease as observed in the present study is compatible with the findings of Bailey and Bechet (1995).

CONCLUSION

In the present study five sugarcane genotypes viz. Malakand-9, Malakand-10, Malakand-11, Malakand-12 and Malakand-13 along with one check cultivar CP 77-400 were screened for ratooning/stubbling ability. Data were recorded on various agronomic and commercially important plant characteristics which included number of tillers stool\(^{-1}\), growth rate, stalk thickness, response to diseases i.e. ratoon stunting disease (RSD) and mosaic disease, refractive brix, cane yield, sucrose content and sugar yield. Genotypes revealed highly significant (p<0.01) variation
for RSD, refractive brix, cane yield, sucrose content and sugar yield whereas differences among the genotypes for growth rate were only of significant (p<0.05) nature. Cane yield displayed significantly positive association with refractive brix, sucrose content and sugar yield while it had significantly negative relationship with RSD. The results of the first ever sugarcane hybridization program of North West Frontier Province (N-W.F.P), Pakistan revealed that the locally evolved sugarcane genotypes excelled in performance for ratooning ability than the exotic commercial cultivar CP77-400. Of all the genotypes used in this study, Malakand-9 appeared more resistant against ratoon stunting disease. This genotype also had maximum cane yield, sucrose content and sugar yield. Malakand-9 thus had the potential to replace the existing commercial sugarcane cultivars of Peshawar valley. The genetic potential of this genotype can also be exploited in future sugarcane breeding programs of the country.

REFERENCES