evaluation of Exotic and Local Cultivars of Sorghum (Sorghum bicolor L) for Yield, Maturity and Nonsenescence Associated Characters under Rainfed Conditions.

Abdul Shakoor
National Agricultural Research Centre, Park Road, Islamabad, Pakistan

Abstract
The average performance of the exotic and local cultivars of sorghum over two locations for various characters alongside their analysis of variance revealed that the exotic line from ICRISAT ICSV 107 was the best among the exotic lines for being highest in yield, number of seeds per head, head length and threshing percentage, while ICSV 219 was the best line having the highest number of leaves, more leaf area of the upper six leaves per plant and sugar content. Among the local pure lines, 13-9 was superior in plant height, 1050-gram weight, threshing percentage and earliest in maturity. The overall results show that the nonsenescing (ICRISAT) types generally took 10-12 days longer to reach 50 percent flowering and averaged 8-56 cm shorter in height than the senescing types. The nonsenescing lines had significantly more number of leaves, GSL, percent GLA 50DAF and sugar percentage from flowering through harvest.

Introduction
Sorghum (Sorghum bicolor L) Moench is an important food, feed, and fodder crop worldwide and is grown throughout the tropical and temperate regions. It remains the staple crop for millions of people in the semi-arid regions of the world (Jhon, 1992). With rapid increase in population (2.2%) of Pakistan, sorghum as a food grain crop can support wheat, rice and other food grain crops. A recent law demand dimension has been opened up by its use in poultry feed production. The present national yield of sorghum is 593 kg ha⁻¹ (Agril. Statistics 1997-98 level which is far below the potential (2500 to 3000 kg ha⁻¹).

The gap can only be reduced by developing varieties with desirable characters for each ecological zone of the country. Maturity is an important and complex consideration in sorghum breeding. To avoid yield reduction due to earliness and yet fit a time frame, we need to develop genotypes which utilize the time period most efficiently without sacrificing yield potentials. In earlier work, Hopper (1925) found a range of 57 to 89 days from planting to flowering in 16 varieties of different maturity groups. These differences were due to environmental conditions, date of sowing and varietal inheritance. Varieties with shorter period develop smaller areas of assimilating leaves and consequently should be less productive (Shaw and Thom, 1951a). Saeed and Francis (1983) have suggested to consider seed weight and seed number when breeding for yield stability.

Local sorghum cultivars, lack of stay-green character is one of the factors affecting its acceptance by the farmers because they use sorghum as green fodder to feed their livestock particularly at the end of the crop season when there is general scarcity of green fodder. A small degree of stay-green character in maize has been reported by Bhatti (1964) who has emphasized the importance of this character in maize breeding. Duncan et al. (1976) studied the characteristics and inheritance of nonsenescence in crosses of US and ICRISAT type sorghums. He reported that this characteristic is under the control of only one major factor or chromosome segment. In another study (Duncan 1981) and Duncan (1984) have reported higher stalk sugar content in stay-green sorghum genotypes compared with the nonstay-green genotypes, especially during postanthesis growth. Duncan et al. (1976) have reported that several characteristics were associated with nonsenescence in sorghum. The nonsenescing type generally took about two days longer to reach 50 percent anthesis and averaged 3 to 4 cm shorter in height than the senescing type. The nonsenescing type had a significantly larger stem diameter and maintained a higher sugar concentration in the stem from anthesis through harvest. The nonsenescing type produced and maintained more green leaves and fewer senesced leaves per plant throughout the reproductive phase of growth, and as a result, this type expectedly produced a greater leaf area index (LAI) and the LAI was maintained for a longer period of time as was reflected by the leaf area duration (LAD).

Goldsworthy (1970) when compared a tall variety with a short variety of sorghum for leaf area duration and grain yield, found that the tall variety produced more dry weight after heading and had a larger leaf area duration than did the short variety, but its grain yield was not significant. Jaychandran et al. (1993), indicated that genotypes varied for time of onset rate of progress and final amount of leaf senescence. The best nonsenescent parents retained approximately 70 percent of the area of their upper six leaves green at 50 days after flowering (approximate harvest maturity), compared to 5-15 percent for the most senescent parents.

In view of the importance of early maturity and stay-green characters in sorghum breeding of dual-purpose (grain-cum-fodder) varieties should be considered a priority area in the breeding programme. Hence for incorporation of early maturity and stay-green associated characters in high yielding cultivar, the performance of the exotic and local adapted varieties for early maturity and stay-green characters is a pre-requisite for selection of the parents.

Materials and Methods
This research was a part of a study on inheritance of early maturity and nonsenescence in sorghum to investigate the performance of parental lines for early maturity and nonsenescence characters in cultivars introduced from...
Abdul Shakoor: Evaluation of Exotic and Local Cultivars of Sorghum.

abroad and collected from within the country. The material consisted of three pure lines namely ICSV 107, ICSV 112 and ICSV 219 from ICRISAT and four local types lines namely Red Janpur, Bagdar, DS 75 and Pothwar 3-9. All these lines were planted at NARC Islamabad on July 06 and MMRI, Younaswala on July 10, 1990 in a randomized complete block design with three replication at each location. At both the location normal cultural practices were followed throughout the season. Fertilizer was applied at the 60-30 NP kg ha⁻¹ form of nitrophos and urea. Each plot consisted of four rows 5m long 75 cm apart with 25 cm spacing between the hills. Planting was made at the rate of two seeds per hill and when the seedlings reached six leaf stage, these were thinned to a stand of one plant per hill. At both the locations, the crop had a mild attack of shootfly. Furadan 3 G granules were applied at the rate of 16 kg ha⁻¹ for control of the shootfly. Data on following plant characters were recorded accordingly.

1. Days to 50 percent flowering
2. Plant height
3. Head length
4. Number of seeds per head
5. 1000-grain weight
6. Yield per plant
7. Threshing percentage
8. Maturity Index
9. Number of leaves per plant
10. Leaf area of upper six leaves (LAUSL)
11. Percent green leaf area 50 days after flowering (%GLA 50DAF)
12. Sugar percentage in stem

Statistical analysis for all the characters were run both on the data for individual location as well as for the data combined over two locations. The statistical analysis of average performance over two locations of the lines for various characters analysed according to Fisher (1950) and the comparison of treatment means, made by Duncan’s multiple range test, are presented in Tables 1 to 4.

Results and Discussion

As is apparent from the data presented in Tables 1 and 2, the pure lines included in the present study exhibited a considerable range of differences for yield, maturity and stay-green associated characters. In all cases, the differences among the lines were found to be highly significant. Line ICSV 107 produced the highest grain yield of 33.37 gm per plant and was 50.66 percent higher than Pot. 3-9 the line at the lowest extremes, yielding only 18.04 gm per plant. The second high yielding line was ICSV 219 followed by ICSV 112, yielding 31.56 gm and 28.92 gm per plant, respectively.

Bagdar with a weight of 37.72 gm per 1000-grain weight, produced the heaviest seeds among the male parents followed by Pot. 3-9, giving a mean weight of 34.51 gm per 1000 grain weight. Among the exotic pure lines, ICSV 107 yielded 29.84 gm per 1000 grain weight. Rest of the lines were intermediate and the differences were not significant among them.

A fairly wide range of difference was exhibited by the female and male parents with regard to the number of seeds per head. The line ICSV 107 with a mean of 1221.50 seeds per head was the highest in number of seeds per head, followed by ICSV 219 with an average of 1197.13 seeds per head. Among the local pure lines, DS-75 produced 895.25 seeds per head followed by Bagdar (711.63 seeds per head).

ICSV 107 with 30.84 cm head length was better in head length compared with rest of the local and exotic lines but the difference among the female parents was not significant. Among the local lines, the head length of DS-75 was 22.53 cm. The other local lines did not differ significantly from each other.

A perusal of the data in Table 1 indicates that a narrow range of difference existed for threshing percentage of all the lines studied. Pot. 3-9 with a mean value of 79.47 had the highest threshing percentage and was followed by ICSV 107 with threshing percentage of 76.52.

A considerable range was observed in maturity index of different lines. ICSV 107 among the exotic lines was earlier with regard to maturity having maturity index of 123.50, while among the local lines Pot. 3-9 a local adapted pure line, was the earliest one with maturity index of 154.38. Red Janpur was the next early maturing line. ICSV 112 and ICSV 219 with respective values of 115.25 and 117.25, did not differ significantly from each other.

In case of plant height the local line Pot. 3-9 produced the tallest plants with an average value of 275.41 cm and was 61.28 percent taller than DS-75, which is at the lowest extreme with a mean of 156.81 cm. The exotic lines ICSV 107, ICSV 219 and ICSV 112 were not significantly different from each other. Pot. 3-9 and Bagdar also did not differ significantly from each other.

As regards number of leaves per plant (Table 3) the ICRISAT type lines were having more number of leaves than the local lines, except Bagdar which was at par with the ICRISAT types sorghum lines.

The same trend was observed in leaf area of upper six leaves (LAUSL). ICSV 219 was having the highest leaf area of 3353.13 cm² and that of Pot. 3-9 with lowest leaf area of 2469.25 cm² per plant. Percent GLA 50 DAF was highest case of ICRISAT type line ICSV 219 with a mean value of 82.14 percent. The local lines were lacking this character and none of the lines exceeded 50.39 percent. High sugar of 14.73 percent was recorded in ICSV 219 followed by ICSV 107 with sugar percent of 12.94. The sugar percent in the local lines was recorded very low, which ranged from 4.55 to 5.24 percent. The sugar percent Pot. 3-9 was recorded 5.15. There was no significant difference in sugar content of local lines.

The average performance over two locations of the lines for various characters along with their analysis of variance presented in Tables 1 to 4 reveal that the ICRISAT lines ICSV 107 was the best among the exotic lines for highest in yield, number of seeds per head, head length, threshing percentage, while ICSV 219 was the best having more number of leaves, more leaf area of the six leaves per plant and sugar content. ICSV 112 also showed significant performance with regard to yield and nonsenescent traits in comparison with the local lines. Among the local pure lines, Pot.3-9 was superior.
Table 1: Means of the pure lines for yield, yield components and stay-green character over two locations-1990-91.

<table>
<thead>
<tr>
<th>Pure Lines</th>
<th>Yield per plant (g)</th>
<th>Length of head (cm)</th>
<th>Seeds per head</th>
<th>1000-grain Weight (g)</th>
<th>Threshing %</th>
<th>Maturity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>SV 107</td>
<td>33.37a</td>
<td>30.84a</td>
<td>1221.50a</td>
<td>29.84b</td>
<td>76.52ab</td>
<td>123.50d</td>
</tr>
<tr>
<td>SV 112</td>
<td>28.92b</td>
<td>28.08a</td>
<td>1097.13b</td>
<td>25.90b</td>
<td>71.13b</td>
<td>115.25e</td>
</tr>
<tr>
<td>SV 219</td>
<td>31.56a</td>
<td>28.43a</td>
<td>1197.13a</td>
<td>26.93b</td>
<td>71.90b</td>
<td>117.25e</td>
</tr>
<tr>
<td>S 9.3</td>
<td>18.04d</td>
<td>19.76b</td>
<td>633.75d</td>
<td>34.51a</td>
<td>79.47a</td>
<td>154.38e</td>
</tr>
<tr>
<td>Jand Janpur</td>
<td>20.17c</td>
<td>18.09b</td>
<td>655.00b</td>
<td>29.53b</td>
<td>75.32ab</td>
<td>144.88b</td>
</tr>
<tr>
<td>Naddar</td>
<td>23.78c</td>
<td>16.56b</td>
<td>711.63d</td>
<td>37.72a</td>
<td>70.92b</td>
<td>136.50c</td>
</tr>
<tr>
<td>S 7.5</td>
<td>23.81c</td>
<td>22.53b</td>
<td>895.25c</td>
<td>25.71b</td>
<td>71.38b</td>
<td>134.13c</td>
</tr>
</tbody>
</table>

Means with the same letters are not significantly different according to Waller-Duncan multiple range test (K ratio = 100).

Table 2: Means of the pure lines for yield, yield components and stay-green character over two locations-1990-91.

<table>
<thead>
<tr>
<th>Pure Lines</th>
<th>Plant Height (cm)</th>
<th>Leaves per Plant</th>
<th>LAUSL (cm²)</th>
<th>%GLA 50DAF</th>
<th>Sugar %</th>
</tr>
</thead>
<tbody>
<tr>
<td>SV 107</td>
<td>173.74c</td>
<td>14.71a</td>
<td>3322.75b</td>
<td>75.73b</td>
<td>12.94b</td>
</tr>
<tr>
<td>SV 112</td>
<td>162.29c</td>
<td>14.19a</td>
<td>3259.50b</td>
<td>73.92b</td>
<td>12.15b</td>
</tr>
<tr>
<td>SV 219</td>
<td>178.16c</td>
<td>15.40a</td>
<td>3363.13a</td>
<td>82.14a</td>
<td>14.73a</td>
</tr>
<tr>
<td>S 9.3</td>
<td>275.41a</td>
<td>10.86b</td>
<td>2469.25c</td>
<td>37.66a</td>
<td>5.15c</td>
</tr>
<tr>
<td>Jand Janpur</td>
<td>226.94b</td>
<td>11.16b</td>
<td>2558.50c</td>
<td>42.68b</td>
<td>5.24c</td>
</tr>
<tr>
<td>Naddar</td>
<td>258.91a</td>
<td>13.80a</td>
<td>3003.38b</td>
<td>50.39c</td>
<td>5.04c</td>
</tr>
<tr>
<td>S 7.5</td>
<td>156.81d</td>
<td>12.95b</td>
<td>3002.13b</td>
<td>47.46c</td>
<td>4.55c</td>
</tr>
</tbody>
</table>

Means with the same letters are not significantly different according to Waller-Duncan multiple range test (K ratio = 100).

Table 3: Analysis of variance of pure lines over two locations-1990-91.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Df</th>
<th>Yield per plant (g)</th>
<th>Length of head (cm)</th>
<th>Seeds per head</th>
<th>1000-grain Weight (g)</th>
<th>Threshing %</th>
<th>Maturity Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivations</td>
<td>1</td>
<td>123.76*</td>
<td>111.16</td>
<td>1921.14</td>
<td>69.15*</td>
<td>130.19*</td>
<td>129.26*</td>
</tr>
<tr>
<td>(Loc)</td>
<td>4</td>
<td>25.77</td>
<td>5.97</td>
<td>20187.12</td>
<td>7.67</td>
<td>2.09</td>
<td>5.78</td>
</tr>
<tr>
<td>or</td>
<td>3</td>
<td>4.45</td>
<td>11.88</td>
<td>12294.38</td>
<td>5.37</td>
<td>3.85</td>
<td>17.16</td>
</tr>
<tr>
<td>ges</td>
<td>6</td>
<td>266.75**</td>
<td>254.92**</td>
<td>5215.82**</td>
<td>172.07**</td>
<td>66.46**</td>
<td>1681.39**</td>
</tr>
<tr>
<td>or</td>
<td>36</td>
<td>4.82</td>
<td>5.57</td>
<td>8865.19</td>
<td>5.30</td>
<td>5.57</td>
<td>7.08</td>
</tr>
<tr>
<td>C X Lines</td>
<td>6</td>
<td>35.04**</td>
<td>3.47</td>
<td>13418.82</td>
<td>4.39</td>
<td>24.41**</td>
<td>8.45</td>
</tr>
<tr>
<td>or</td>
<td>36</td>
<td>4.82</td>
<td>5.57</td>
<td>8865.19</td>
<td>5.30</td>
<td>5.57</td>
<td>7.08</td>
</tr>
</tbody>
</table>

Significant at 5% level. ** Significant at 1% level.

Table 4: Analysis of variance of pure lines over two locations-1990-91.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Df</th>
<th>Plant Height (cm)</th>
<th>Leaves per Plant</th>
<th>LAUSL (cm²)</th>
<th>%GLA 50DAF</th>
<th>Sugar %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivations</td>
<td>1</td>
<td>2767.85**</td>
<td>2.84</td>
<td>500283.02*</td>
<td>55.84*</td>
<td>0.39</td>
</tr>
<tr>
<td>(Loc)</td>
<td>4</td>
<td>119.75</td>
<td>1.84</td>
<td>16699.30</td>
<td>2.43</td>
<td>0.96</td>
</tr>
<tr>
<td>or</td>
<td>3</td>
<td>53.30</td>
<td>2.38</td>
<td>50533.83</td>
<td>3.71</td>
<td>0.28</td>
</tr>
<tr>
<td>ges</td>
<td>6</td>
<td>1891.69**</td>
<td>24.10**</td>
<td>1030264.23**</td>
<td>2620.78**</td>
<td>161.61**</td>
</tr>
<tr>
<td>or</td>
<td>36</td>
<td>42.97</td>
<td>0.89</td>
<td>12606.38</td>
<td>4.82</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Significant at 5% level. ** Significant at 1% level.

In general height, 1000-grain weight, threshing percentage and maturity in maturity, Bagdar which was an intermediate grain yield line, though ranked first in 1000-grain weight and second in plant height, was very low in threshing percentage.

Referring to the analysis of variance of the lines over two locations (Tables 3,4), locations were significantly different for yield per plant, 1000-grain weight, threshing percentage, maturity index, plant height, leaves per plant, LAUSL and percent GLA 50DAF. There were highly significant differences in the lines for all the traits studied.

The lines x location interaction was also significant for yield per plant, threshing percentage, plant height, LAUSL and percent GLA 50DAF. The overall results show that the nonsenescent (ICRISAT) types generally took 10-12 days longer to reach 50 percent flowering and averaged 45-56 cm shorter in height than the senescing types. The nonsenescent lines had significantly more number of leaves, LAUSL, percent GLA 50DAF and sugar percentage from flowering through harvest.

As the nonsenescent lines maintained more green leaves and more green leaf area and fewer senesced leaves per plant throughout the reproductive phase of growth, this type expectedly produced a greater leaf area index which was maintained for a longer period of time and was reflected by the leaf area duration. Similar observations...
have been reported by Jagannath et al. (1975). They were of the opinion that yield in sorghum was more directly correlated with leaf area duration and grain leaf ratio, while Goldsworthy (1970) when compared a tall variety with a short variety of sorghum for leaf area duration and grain yield, found that the tall variety produced more dry weight after heading and had a larger leaf area duration than did the short variety, but its grain yield was not significant. The non-senescing type maintained a higher chlorophyll content right from six leaf stage till harvesting. The senescence type showed decrease in chlorophyll content during its growth period. Duncan et al. (1976) have also reported similar results from their study on characteristics of senescence and non-senesence types of sorghum which are in agreement with the results reported here-in.

References
Characteristics of non-senesence in Sorghum bicolor (L)
A. and M. Univ. USA.
Duncan, R.R., 1981. Characteristics and Inheritance of
non-senesence in Sorghum Bicolor (L). Agron. J., 73:
849-853.
Duncan, R.R., 1984. The association of plant senescence
with root and stalk diseases in sorghum. Review of
Proceed. of Consultative Group Discussion on Disease
of Sorghum. ICRISAT India.
Goldsworthy, P. R., 1970. The sources of assimilate for
grain development in tall and short sorghum. J. Agric.
Hopper, T. H., 1925. Composition and maturation of corn
Jayachandran, R.E.J., Van Oosteron and F.R. Biding,
1993. Description and inheritance of non-senesence
Jagannath, M.K., K. Krishnamurthy, B.G. Rajashekar,
G.Raghunatha, A. Bommegowda and N. Venugopal
1975. Path analysis for some growth parameters in
2. 54 Nebraska Centre, Univ. of Nebraska, Page ix.
Shaw, R.W. and H.C.S. Thom, 1951a. Phenology of feed