Inheritance of Orange Color in Stalks and Midribs of Sorgo

Otto H. Coleman and Jack L. Dean

Sorghum vulgare Pers. has a wide range of plant characters useful for genetic studies and marker genes. Many of these characters are simple mutations. One such mutation is an orange stalk and midrib in the sorgo syrup variety Iceberg. The orange color of stalks and midribs occurs in lignified cell walls and shows up most prominently in vascular bundles and the sclerenchymatous tissues immediately under the epidermis of the stalk. This paper reports the results from crosses between the orange mutant of Iceberg and the variety Sart at Meridian, Mississippi.

LITERATURE REVIEW

Leaf anthracnose resistance (LL) was reported as a simple dominant to susceptibility (ll) by LeBeau and Coleman (6) and stalk red rot resistance was shown by Coleman and Stokes (1) to be controlled by the dominant factor (LsLs). The latter also reported that the factor pairs controlling resistance to leaf anthracnose (Ll) and stalk red rot (Lsls) are linked with about 9.57% crossing over in the coupling phase. Both of these diseases are caused by Colletotrichum graminicola (Ces.) W. Wils. (7).

Erect stalks in sorgo were reported by Coleman and Stakes (2) to be inherited as a simple dominant (EE) over weak stalk (ee). This factor pair was shown to be inherited independently of the factor pairs governing anthracnose resistance (Ll) and stalk red rot resistance (LsLs).

EXPERIMENTAL METHODS

Reciprocal crosses were made between the orange mutant of Iceberg and Sart. The orange mutant of Iceberg has orange stalks and midribs, has weak stalks, and is susceptible to leaf anthracnose and red rot. Sart has strong stalks of normal green color and is resistant to leaf anthracnose and red rot. The F1 plants from these crosses were started in the greenhouse and transplanted into the field about 2 feet apart. The F2 generation was planted at the rate of 3 seeds in hills 22 inches apart. The seedlings were thinned to one plant per hill. The F2 families and parental checks were planted in a randomized-block design. All the F2 and F3 plants were bagged to insure self-fertilization. The F3 generation was planted in 1/100 acre, single-row plots in a check-plot design of 2 replications with parental checks every 30 plots. The seeds were drilled and the seedlings thinned to approximately 1 plant every 8 inches.

The genotype of each F2 plant was determined by the phenotypic expression of stalk red rot and stalk strength. In some cases it was impossible to distinguish the homozygous resistant (LsLs) and the homozygous susceptible (lsls). Except in susceptible lines, all inoculated stalks were split and rated for red rot resistance at least one month after inoculation.

The extremely dry weather during this investigation affected the expression of stalk red rot and stalk strength. In some cases it was impossible to distinguish the homozygous resistant (LsLs) from the heterozygous (Lsls) lines, and the weak stalk (ee) from the heterozygous (Ee). In each case the indistinct classes were grouped together for genetic analysis.

The Fisher (5) maximum likelihood method was used in determining crossover values.

RESULTS

The characteristics of the 2 parents and their F1 progeny given in Table 1 indicate that the orange character of Iceberg was not visible in the F1 generation.

Segregating populations both in the F2 and F3 generations indicated a low incidence of the orange character, with all the families studied having similar distributions as measured by chi-square values for grouping interactions. To determine whether both male and female gametes were involved in the off ratio, the following reasoning was applied. Let s equal the probability of the effectiveness of the dominant gamete (Or) and 1 - s the recessive (or).

Then, the distribution of genotypes in the F2 generation would be as follows if only one gamete (male or female) was low in effectiveness:

\[ \text{OR} = s/2; \text{Or} = (s + 1 - s)/2 = 1/2; \]
\[ \text{or} = (1 - s)/2 \]

Let a, b, and c be the respective number of progeny in the three classes (OrOr), (Or), and (or).

Class (Oror) would not be affected by this off-gametic ratio. Multiplying the logarithm of probabilities by the number of progeny in the first and last class and adding, we have

\[ \log (s/2) + c \log \left(\frac{1 - s}{2}\right) \]

After differentiating with respect to s and maximizing, this expression becomes

\[ a/s - c/(1 - s) = 0 \]

which resolves to

\[ s = a/(a + b) \]

The standard error of s can be estimated from the relationship \( S.E. = \sqrt{1/information when information per F2 progeny = ds [(a/s - c/(1 - s)] which resolves to N/(s(1 - s) for N progeny. Thus

\[ S.E. of s = \sqrt{s(1 - s)}/N \]

If the off ratio for orange:normal (or:Or) is low both for the (or) pollen and the (or) ovules, the following probabilities obtain:

\[ \text{OrOr} = s^2; \text{Or} = 2s(1 - s); \text{or} = (1 - s)^2 \]

In this case the heterozygote does contribute information about the gametic ratio. Following the procedure in the foregoing, we have

\[ a \log s^2 \times b \log 2s (1 - s) + c \log (1 - s)^2 \]

which, after being differentiated with respect to s and maximized, becomes

\[ [(2a + b)/s] - [(b + 2c)/(1 - s)] = 0 \]

which resolves to s = (2a + b)/(2(a + b + c)).

Table 1—Sart, Orange Iceberg, and F1 descriptions.

<table>
<thead>
<tr>
<th>Parent or ( F_1 ) progeny</th>
<th>Leaf anthracnose resistance</th>
<th>Stalk red rot resistance</th>
<th>Weak stalk</th>
<th>Stalk</th>
<th>Orange Midrib</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sart</td>
<td>Resistant (Ll)</td>
<td>Resistant (LsLs)</td>
<td>Weak (ee)</td>
<td>Erect (Ee)</td>
<td>Orange (oror)</td>
</tr>
<tr>
<td>Orange Iceberg</td>
<td>Susceptible (ll)</td>
<td>Susceptible (lsls)</td>
<td>Strong (Or)</td>
<td>Erect (Or)</td>
<td>Non-orange (OrOr)</td>
</tr>
<tr>
<td>( F_1 )</td>
<td>Resistant (Ll)</td>
<td>Resistant (LsLs)</td>
<td>Weak (ee)</td>
<td>Erect (Ee)</td>
<td>Orange (oror)</td>
</tr>
</tbody>
</table>

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