Heritabilities of Seven Sweet Potato Root Traits

Alfred Jones

U. S. Vegetable Laboratory, Agricultural Research Service
U. S. Department of Agriculture, Charleston, S. C. 29407

Additional index words: Ipomoea batatas, vegetable breeding

Abstract Forty-five plants of sweet potato (Ipomoea batatas (L.) Lam.) taken randomly from the second cycle of a mass-selection population, and 25 open-pollinated progeny from each were used to estimate heritabilities (h²) of 7 root traits: root weight, 0.25 ± 0.13; intercellular space (IS), 0.70 ± 0.14; percent of dry matter (DM), 0.65 ± 0.12; sprouting, 0.39 ± 0.14; flesh oxidation, 0.24 ± 0.13; flesh color, 0.53 ± 0.14; and cortex thickness, 0.25 ± 0.13. IS was distributed normally with mean and mode of about 7%. DM had a bimodal distribution with mean 28.8 and modes of 27 and 31%. At least 2 genetic systems were apparently involved in expression of DM; one was associated with orange flesh and the other, with white flesh. This is the first report of the h² for IS, DM, and sprouting.

During the last decade the adaptation of quantitative genetic principles to sweet potato breeding has been investigated in considerable detail (1, 4, 5, 6, 7, 8, 14, 15, 17). Mass selection within open-pollinated populations became possible once the problem of poor flowering was solved (15). However, many theoretical considerations and practical problems remain to be investigated. Genetic information about many traits of direct economic importance is not yet available and most published results are from sweet potatoes of similar genetic background (1, 4, 5, 6, 7, 8, 16). This report presents heritability estimates for 7 root traits (3 for the first time) from a population with a

Literature Cited


Heritabilities of Seven Sweet Potato Root Traits

Alfred Jones

U.S. Vegetable Laboratory, Agricultural Research Service
U.S. Department of Agriculture, Charleston, S. C. 29407

Additional index words: Ipomoea batatas, vegetable breeding

Abstract Forty-five plants of sweet potato (Ipomoea batatas (L.) Lam.) taken randomly from the second cycle of a mass-selection population, and 25 open-pollinated progeny from each were used to estimate heritabilities (h²) of 7 root traits: root weight, 0.25 ± 0.13; intercellular space (IS), 0.70 ± 0.14; percent of dry matter (DM), 0.65 ± 0.12; sprouting, 0.39 ± 0.14; flesh oxidation, 0.24 ± 0.13; flesh color, 0.53 ± 0.14; and cortex thickness, 0.25 ± 0.13. IS was distributed normally with mean and mode of about 7%. DM had a bimodal distribution with mean 28.8 and modes of 27 and 31%. At least 2 genetic systems were apparently involved in expression of DM; one was associated with orange flesh and the other, with white flesh. This is the first report of the h² for IS, DM, and sprouting.

During the last decade the adaptation of quantitative genetic principles to sweet potato breeding has been investigated in...
Results and Discussion

Although h² of root wt, flesh color, and cortex thickness (Table 1) were lower than those previously estimated from 6 environments (8), they were within the range of estimates from the separate environments. The h² estimate for root-flesh oxidation was much lower in this study than in previous studies (8). No previous h² estimates are available for IS, DM, or sprouting. Sakai (17) found larger additive effects and smaller nonadditive effects of DM and starch content than for root sprouting. Sakai (17) found larger additive effects and smaller nonadditive effects of DM and starch content than for root sprouting.

Materials and Methods

Forty-five plants, taken randomly from the second cycle of mass-selection population H, and 25 open-pollinated progeny from each were used in a parent-offspring study. Population H originated with 950 seedlings from 52 sweet potato lines selected for good flowering and seed production characteristics. About 79.5% of H/2 (generation 2) traced genetically to our original open-pollinated population C (4); 13.6%, to Plant Introductions (PI) 280036 (Taiwan), 308196 (Thailand), 308198 (South China), and 308203 (Peru), and the other 6.9%, to F/3, a population with a broad genetic base.

The test was grown in 1970 for 154 days at Tifton, Georgia. There were 5 replications of 5-plant plots. Each parent plot contained 5 clonal cuttings, and each offspring plot contained vine cuttings from 5 different seedlings. The roots of each plant were weighed at harvest, and a 4-root sample from each was cured by standard procedures for later examinations. One root of each sample was cut, and the thickness of the cortex was measured in mm. Flesh color was rated subjectively 1–6 for white, yellow, light orange, orange and dark orange. The reaction of the cut roots to an oxidizing agent was coded 1–9 (no appreciable blackening) to 5 (complete blackening) (6). Intercellular space (IS) and tissue specific gravity (TSG) were estimated in accordance with procedures developed by Kushman et al. (9, 10, 11, 12, 13, 16). TSG was expressed as dry-matter content (DM) for statistical analyses (9). Roots of parents and offspring were field-bedded at Charleston, South Carolina, the following spring and coded 1–9 for degrees of sprouting, from no sprouts to uniformly vigorous sprouts.

Twice the regression of offspring means on parent means provided narrow-sense heritability (h² = 2b) estimates (2). Simple correlations of the 7 traits were obtained from the 45 parent means, and from the means of the offspring of each of the 45 parents and of 161 light-orange, orange or dark-orange rooted H/3 plants from 28 H/2 parents with IS less than 8% and DM greater than 25.6%.

Table 1. Scale of measurement for 7 sweet potato root traits, their h², 45 parent (H/2) means and range, offspring (H/3) means, and 161 selected orange-flesh H/3 means.

<table>
<thead>
<tr>
<th>Traits</th>
<th>Scale</th>
<th>h²</th>
<th>H/2</th>
<th>H/3</th>
<th>Selected H/3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>mean</td>
<td>range</td>
<td>mean</td>
</tr>
<tr>
<td>Root wt</td>
<td>lb</td>
<td>0.25±0.13</td>
<td>2.2</td>
<td>0.6–5.5</td>
<td>1.8</td>
</tr>
<tr>
<td>IS</td>
<td>ml/100 ml</td>
<td>0.70±0.14</td>
<td>7.0</td>
<td>3.0–14.6</td>
<td>6.8</td>
</tr>
<tr>
<td>DM</td>
<td>%</td>
<td>0.65±0.12</td>
<td>28.7</td>
<td>17.9–35.0</td>
<td>28.8</td>
</tr>
<tr>
<td>Sprouting²</td>
<td>1–9</td>
<td>0.39±0.14</td>
<td>5.3</td>
<td>2.0–8.0</td>
<td>4.1</td>
</tr>
<tr>
<td>Flesh oxidation²</td>
<td>1–5</td>
<td>0.24±0.13</td>
<td>3.8</td>
<td>1.2–5.0</td>
<td>3.8</td>
</tr>
<tr>
<td>Flesh color²</td>
<td>1–6</td>
<td>0.53±0.14</td>
<td>3.4</td>
<td>1.0–5.8</td>
<td>3.4</td>
</tr>
<tr>
<td>Cortex thickness</td>
<td>mm</td>
<td>0.25±0.13</td>
<td>2.8</td>
<td>1.3–4.9</td>
<td>2.8</td>
</tr>
<tr>
<td>No. plants observed</td>
<td></td>
<td></td>
<td>45 x 5</td>
<td>916</td>
<td>161</td>
</tr>
</tbody>
</table>

²Increasing degrees of sprouting.
²Increasing degrees of darkening.
²Increasing degrees of orange color.

Results and Discussion

Although h² of root wt, flesh color, and cortex thickness (Table 1) were lower than those previously estimated from 6 environments (8), they were within the range of estimates from the separate environments. The h² estimate for root-flesh oxidation was much lower in this study than in previous studies. (8). No previous h² estimates are available for IS, DM, or sprouting. Sakai (17) found larger additive effects and smaller nonadditive effects of DM and starch content than for root sprouting. Li (14) reported more important nonadditive than additive genetic variance for root yield, which suggests a low h². This study, therefore, tends to confirm earlier observations.

Parental (H/2) correlations (Table 2) generally agreed with those available from other open-pollinated populations (4, 8). The significant association of root wt and sprouting in H/3 was due to poor sprouting in those plants with very small roots, which stored poorly. When data from plants of very low root yield. Li (14) reported more important nonadditive than additive genetic variance for root yield, which suggests a low h². This study, therefore, tends to confirm earlier observations.

Parental (H/2) correlations (Table 2) generally agreed with those available from other open-pollinated populations (4, 8). The significant association of root wt and sprouting in H/3 was due to poor sprouting in those plants with very small roots, which stored poorly. When data from plants of very low root yield were removed, the correlation became nonsignificant. The unfavorable correlations of cortex thickness with IS and flesh color in H/2 apparently are of little concern to practical selection, as they were not present in H/3.

DM content, sprouting, flesh oxidation and flesh color were obviously interrelated (Table 2). A negative association of flesh color and DM has been noted previously (3, 8), as has the association of white- or cream-flesh color and severe oxidation (5, 6). White- and cream-fleshed roots tended to sprout exceptionally well, which may represent a carryover from primitive genetic background slightly different from those previously studied.
types, which depended on good sprouting and rapid vine growth for successful competition. It was not, however, difficult to find orange-flesh types with good sprouting. White- or cream-flesh, good sprouting, excessive oxidation, and high DM appeared associated. Perhaps all represent the more primitive type, with orange-flesh types of more recent evolutionary origin.

Because of the limited information available on IS and DM, frequency distributions for these characters in 916 H/3 plants were studied. The distribution for IS was normal, with a mode of 6.6–7.0 and a range from 0.9–19.2%. The DM distribution appeared bimodal, with modes at 27 and 31% and a range from 13–43%. When DM was studied within 3 flesh-color groups (Fig. 1), it was apparent that the differences of orange and white-flesh distributions accounted for most of the bimodality. Thus, at least 2 genetic systems were apparently involved in the expression of DM, one associated with orange flesh and the other with white flesh.

Both IS and DM had high h² estimates (Table 1). Because improvement in both traits could be considered desirable breeder goals, a simulated practical selection scheme was followed. Those parental types with DM less than 25.6% or IS greater than 8% were removed. Because orange-flesh types were selected in the seedling stage in the U.S., correlations were studied. The distribution for IS was normal, with a mode appears bimodal, with modes at 27 and 31% and a range from 13–43%. When DM was studied within 3 flesh-color groups, the lack of change in the DM mean represented improvement within the orange-flesh segment of the population. There was some increase in root wt, although no association between this trait and IS, DM, or flesh color had been detected earlier.

This study indicates that selection within sweet potato for high root wt, thin cortex, orange flesh, low oxidation, good sprouting, and an IS less than 8 ml/100 ml should be effective. Concurrent selection for high DM may be more difficult but is possible. Selection for high DM in white-fleshed types should not be difficult.

**Literature Cited**