Short Communication

Variability among advanced gamma-irradiation induced large-seeded mutant breeding lines in the ‘Georgia Browne’ peanut cultivar

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Abstract

The objective of this study was to compare the variability among advanced large-seeded ‘Georgia Browne’ mutant breeding lines induced by γ-irradiation. Seeds of the small-seeded, high-yielding, disease-resistant peanut cultivar ‘Georgia Browne’ were exposed to a 200 Gy dose of γ-radiation. Several advanced (M6, γ-M6, γ) ‘Georgia Browne’ mutant breeding lines were developed and evaluated at the University of Georgia, Coastal Plain Experiment Station over three consecutive years 1997–99 for disease incidence, pod yield, total sound mature kernels (TSMK) grade, pod weight, seed weight and seed size distribution. Field performance tests showed significant differences among the advanced large-seeded mutant breeding lines compared with ‘Georgia Browne’ for each of these variables. The results obtained demonstrate the beneficial use of mutation breeding for inducing and developing variable and desirable advanced mutant breeding lines within peanut cultivars.

Key words: Arachis hypogaea L. — disease resistance — genetic variability — pod yield — seed size distribution — yield components

Early peanut mutation breeding in the USA began around 1950 with Gregory (1955) using X-rays. Subsequently, mutation breeding on peanut was conducted in Africa by Tuchlen-ski (1958) using γ-rays, in Israel by Ashri and Goldin (1965), Ashri (1970) using diethyl sulphate, and in India and China by Patil (1968) and Lin (1960), respectively, using X-rays.

Since then, little additional mutation breeding research has been conducted in the USA. Most of the more recent efforts has been in India and China (Murthy and Reddy 1993). However, induced mutations are needed in the cultivated peanut to improve genetic variability as stated by Knauf and Ozias-Akins (1995).

In 1993, the small-seeded peanut cultivar ‘Georgia Browne’ was released by the University of Georgia, Coastal Plain Experiment Station (Branch 1994). For several years, ‘Georgia Browne’ has been compared with other similar small-size Spanish-US market type cultivars in Georgia, and it has consistently yielded > 1100 kg/ha more than the next best cultivar (Day et al. 2000). It has a high percentage of total sound mature seed with excellent taste and flavor. ‘Georgia Browne’, it was selected as the peanut cultivar to use for this study. The objective was to compare the variability induced by γ-irradiation among advanced large-seeded mutant breeding lines in the ‘Georgia Browne’ peanut cultivar.

Plant materials: One-hundred sound mature dry seed of the ‘Georgia Browne’ cultivar of peanut, Arachis hypogaea L., were exposed to a 200 Gy (20 kRad) dose of γ-irradiation from a cobalt-60 source. Pedigree selection was practiced within the M2, M3, M4 and M5 populations for various plant, pod, and seed characteristics at the University of Georgia, Coastal Plain Experiment Station, Tifton, GA, USA. Several advanced ‘Georgia Browne’ mutant breeding lines were developed for subsequent agronomic evaluations.

Field performance testing: In three consecutive years (1997–99), four of the most promising M6 advanced large-seeded ‘Georgia Browne’ mutant breeding lines of peanut, Arachis hypogaea L., were compared with ‘Georgia Browne’ in the M7, M8, and M9 generations, respectively. Comparisons were made for disease incidence, pod yield, total sound mature kernel (TSMK) grade, which includes sound mature kernels plus sound splits, pod weight, seed weight, and seed size distribution.

A randomized complete block design was used with six replications for each field test. Soil type was a Tifton loamy sand (fine loamy, siliceous, thermic Plinthic Kandiudult) at the agronomy research farm near Tifton, GA, USA. Standard cultural practices were followed each year with irrigation. Plots consisted of two rows 6.10 m long by 1.83 m wide, and seeds were spaced at recommended rates, approximately 0.06 m apart within each row.

Planting dates for the field performance tests were 2 May 1997, 5 May 1998, and 4 May 1999, and harvest dates were 16 September 1997, 24 September 1998, and 16 Sept. 1999, except for ‘Georgia Browne’ being about 1 week later. Individual breeding line or cultivar entries were dug at optimum maturity according to visual above-ground plant characteristics in conjunction with the hull-scape maturity method (Williams and Drexler 1981) assessed from adjoining border plots.

Total disease percentages were determined just before each peanut plot was dug and inverted (Branch and Fletcher 2001). A disease class consisted of one or more infected plants in a 30-cm section of row (Branch and Brenneman 1993, Culbreath et al. 1994). The predominant disease was tomato spotted wilt virus (TSWV), however, some soilborne diseases were also present, but at a low level of incidence. After picking with a small-plot thresher, pods were dried with forced warm air to 6% moisture and then were hand-cleaned over a screen table before weighing for yield.

Pod and seed size: Weights of 100 sound mature pods and seeds were determined on each replication. Seed size distribution was made from...
1000 g of pod samples per replicate pre-sized and shelled according to Federal State Inspection Service procedures (Anonymous 1998). Extra large kernels were sound mature seeds riding a screen 8.53 mm in width. Medium size were sound mature seeds retained by a 7.14 mm screen but falling through an 8.53 mm screen. Number 1 size were sound mature seeds retained by a 6.35 mm but falling through a 7.14 mm screen. All screens had 19.05 mm long slotted holes.

### Statistical analyses
Data from each test were statistically analysed by analysis of variance. Waller-Duncan’s T-test (k-ratio = 100) was used for means separation. Highly significant genotype-year interactions (P ≤ 0.01) were found from the combined 3-year statistical analyses. Thus, individual years are presented separately for each of the variables in this study.

Significant differences (P ≤ 0.05) were found between the cultivar ‘Georgia Browne’ and the advanced (M6:7 , M6:8 and M6:9 ) γ-irradiation induced large-seeded mutant breeding lines for total disease, pod yield, TSMK grade, pod weight, seed weight and seed size distribution (Table 1). During 1997, 1998 and 1999, all four mutant breeding lines were found to be comparable to ‘Georgia Browne’ in pod yield, and GA 962569 had significantly higher pod yield than ‘Georgia Browne’ in all three years.

‘Georgia Browne’ was found to have the highest TSMK grade each year, with approximately 75% (Table 1). Total disease percentage was significantly lower with GA 962569 than the multidisease-resistant cultivar ‘Georgia Browne’ in 1998 and equal in 1997 and 1999. Conversely, GA 962567 and GA 962570 had significantly greater total disease than ‘Georgia Browne’ for 1997 and 1999. The predominant disease was TSWV.

All four advanced ‘Georgia Browne’ mutant breeding lines were selected for larger pod and seed sizes. As expected, each was found to have significantly (P ≤ 0.05) larger pod and seed weight than ‘Georgia Browne’ (Table 1). These four mutant lines also had a larger percentage of extra large kernels (ELK), but fewer medium and No. 1 seed compared with ‘Georgia Browne’.

Seed size distribution shows the effect of selecting for larger pod and seed size. GA 962569 and GA 962570 consistently had the highest percentage of ELK, however, both resulted in the lowest percentage of medium and No. 1 seeds in all three years (Table 1). Similarly, ‘Georgia Browne’ had the highest percentage of medium and No. 1 seed, but at the expense of fewer ELK.

Significant genetic variability was obtained within the cultivar ‘Georgia Browne’ by γ-irradiation. Numerous deleterious mutant phenotypes were readily observed in the early segregating generations, similar to those previously reported by Gregory et al. (1968). Most of these point mutations involved recessively inherited genes controlling plant traits such as dwarf, flop, lupinus, rusty and cup leaves, as previously described (Gregory et al. 1968).

However, several large-seeded advanced ‘Georgia Browne’ mutant breeding lines were also induced by γ-irradiation. The results for GA 962569 were particularly encouraging for developing a high-yielding, disease-resistant advanced mutant breeding line with large pod and seed size. It has disease resistance comparable to or better than ‘Georgia Browne’, with significantly higher pod yield and much larger pod and seed size.

GA 962567, GA 962568, and GA 962570 were also found to be similar to ‘Georgia Browne’ in pod yield. However, each of these three advanced mutant breeding lines was more susceptible, with higher total disease percentages than ‘Georgia Browne’. These results agree with a recent report (Branch and Fletcher 2001) which demonstrates the benefit of evaluating for total disease assessment versus any singular pathogen among advanced peanut breeding lines. Seldom does a cultivar or breeding line encounter only one pest: a complex interaction of diseases and insects in a given environment is more common. In two out of three years, Branch and Fletcher (2001) found that ‘Georgia Browne’ had significantly higher

### Table 1: Three-year evaluation of ‘Georgia Browne’ cultivar and four advanced large-seeded ‘Georgia Browne’ mutant breeding lines, 1997–99

<table>
<thead>
<tr>
<th>Cultivar and breeding line</th>
<th>Total Disease (%)</th>
<th>Pod Yield (kg/ha)</th>
<th>TSMK Grade (%)</th>
<th>Pod wt. (g/100)</th>
<th>Seed wt. (g/100)</th>
<th>Seed size distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 generation, 1997</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>GA 962569</td>
<td>12.9 d</td>
<td>6504 a</td>
<td>71.7 c</td>
<td>206.9 a</td>
<td>81.6 a</td>
<td>43.1 a 13.3 e 1.5 d</td>
</tr>
<tr>
<td>‘Georgia Browne’</td>
<td>17.9 ed</td>
<td>5101 b</td>
<td>75.4 a</td>
<td>106.6 e</td>
<td>45.6 e</td>
<td>3.1 d 52.7 a 10.0 a</td>
</tr>
<tr>
<td>GA 962568</td>
<td>24.6 bc</td>
<td>4760 b</td>
<td>71.2 c</td>
<td>129.4 d</td>
<td>55.0 d</td>
<td>11.8 c 46.3 b 7.8 b</td>
</tr>
<tr>
<td>GA 962570</td>
<td>55.4 a</td>
<td>4677 b</td>
<td>74.5 ab</td>
<td>184.5 b</td>
<td>75.3 b</td>
<td>43.2 a 21.0 d 1.8 d</td>
</tr>
<tr>
<td>M2 generation, 1998</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GA 962567</td>
<td>7.9 b</td>
<td>5821 a</td>
<td>71.2 c</td>
<td>175.7 a</td>
<td>79.3 a</td>
<td>38.2 a 15.8 e 1.3 d</td>
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<tr>
<td>‘Georgia Browne’</td>
<td>14.9 a</td>
<td>5331 ab</td>
<td>73.1 ab</td>
<td>143.9 b</td>
<td>62.0 c</td>
<td>21.5 b 39.7 c 4.1 c</td>
</tr>
<tr>
<td>GA 962570</td>
<td>20.0 a</td>
<td>5107 b</td>
<td>72.5 bc</td>
<td>173.3 a</td>
<td>75.8 b</td>
<td>40.1 a 20.8 d 1.8 d</td>
</tr>
<tr>
<td>GA 962568</td>
<td>20.0 a</td>
<td>4848 b</td>
<td>71.4 c</td>
<td>126.8 c</td>
<td>56.4 d</td>
<td>10.3 c 46.7 b 6.8 b</td>
</tr>
<tr>
<td>‘Georgia Browne’</td>
<td>15.4 a</td>
<td>4818 b</td>
<td>74.7 a</td>
<td>97.8 d</td>
<td>42.8 e</td>
<td>2.2 d 50.9 a 13.8 a</td>
</tr>
<tr>
<td>M3 generation, 1999</td>
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</tr>
<tr>
<td>GA 962569</td>
<td>23.3 b</td>
<td>5150 a</td>
<td>71.9 abc</td>
<td>200.2 a</td>
<td>82.4 a</td>
<td>39.6 a 16.3 e 1.8 d</td>
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<tr>
<td>‘Georgia Browne’</td>
<td>35.0 b</td>
<td>4204 b</td>
<td>74.0 a</td>
<td>105.2 d</td>
<td>46.2 e</td>
<td>4.3 d 49.0 a 9.9 a</td>
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<tr>
<td>GA 962567</td>
<td>55.0 a</td>
<td>3768 b</td>
<td>70.9 bc</td>
<td>141.7 c</td>
<td>62.7 e</td>
<td>18.1 b 37.2 c 4.7 c</td>
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<td>55.4 a</td>
<td>3624 b</td>
<td>69.7 c</td>
<td>133.7 c</td>
<td>59.0 d</td>
<td>10.6 c 41.6 b 6.2 b</td>
</tr>
<tr>
<td>GA 962570</td>
<td>62.1 a</td>
<td>3599 b</td>
<td>72.6 ab</td>
<td>175.8 b</td>
<td>75.9 b</td>
<td>37.9 a 19.3 d 2.4 d</td>
</tr>
</tbody>
</table>

1 Measured within the same column and year followed by the same letter are not significantly different at P = 0.05.
2 TSMK, total sound mature kernels.
3 ELK, extra large kernels.
yield than all the other runner cultivars when grown without any pesticides.

Pod and seed weight of GA 962567, GA 962568, and GA 962570 were intermediate between the larger GA 962569 and the smaller ‘Georgia Browne’. Seed size distribution reflected this difference, with increases in percentage of medium, a lesser increase percentage of No. 1 seed, and fewer ELK as pod and seed weights decrease. Conversely, as pod and seed weights increase, there is a general increase in the percentage of ELK but a decrease in the percentage of medium and No. 1 seed size distributions.

Gamma-irradiation was thus successful in creating variability within the ‘Georgia Browne’ cultivar within this study. These results demonstrate the beneficial use of mutation breeding for inducing and developing variable and desirable advanced mutant breeding lines within peanut cultivars.

References