MORPHOLOGICAL DIVERSITY AND AGRONOMIC EVALUATION OF PROMISCUOUS VARIETIES OF SOYABEAN

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ABSTRACT

Promiscuous varieties have the potential to increase soybean (Glycine max (L.) Merrill) production of resource poor farmers who cannot afford artificial inoculum. Some varieties grown by smallholders are known to be promiscuous but their yields are reported to have declined overtime, yet researchers questions their purity. It is suspected that these varieties are made up of mixtures of genotypes with varying nodulation capacities. A study was carried out to quantify diversity in two promiscuous varieties, Local, and A&M using morphological markers to initiate mass selection to reconstitute the original varieties. Eight Phenotypic Groups (PGs) were identified in the variety Local mainly based on days to flowering, growth habit and flower colour, whereas in the variety A&M, days to flowering, number of primary branches, and response to rust infection revealed seven PGs. A second study evaluated the agronomic performance of the PGs in comparison with a specifically nodulating commercial variety Storm. Five of the PGs identified in A&M had significantly (P<0.01) higher grain yield than the commercial standard. All eight PGs identified in Local yielded the same as the commercial standard.

Key Words: Genotype, Glycine max, nitrogen fixation, nodulation

RéSUMÉ

Les espèces à reproduction aisé possèdent le potentiel d'augmenter la production de grain de soja [Glycine max (L.) Merrill] au sein d'agriculteurs à ressources médiocres qui ne peuvent pas se permettre les couts de l'inoculation artificielle. Certaines espèces cultivées par de petits planteurs sont connues pour leurs facilité de reproduction mais il a été noté que leur rendement se détériore avec le temps alors que les chercheurs mettent question leur pureté. Des suspicions existent selon lesquelles ces variétés seraient composées de mélanges de génotypes à capacité de nodulation variable. Une étude a été entreprise en vue de pouvoir quantifier la diversité au sein de 2 variétés à reproduction facile, Locale et A&M en utilisant les marqueurs morphologiques pour initier la sélection de masse dans le but de reconstituer les variétés originales. 8 groupes phénotypiques (PGs) étaient identifiés dans l'variété Locale en se basant principalement sur les jours à la floraison, habitude de croissance et couleur de la fleur tandis que dans la variété A&M, les jours à la floraison, nombre de branches et réaction à l'infection de rouille révélaient 7 PGs. Une 2ème étude a évalué la performance agronomique des PGs en comparaison avec une variété commerciale à nodulation spécifique : Storm. 5PGs identifiés au sein de A&M avaient un rendement de grain significativement (P<0.01) élevé par rapport au standard commercial. Tous les 8 PGs au sein de Locale ont produit un rendement similaire à celui du standard commercial.

Mots Clés: Génotype, Glycine max, fixation d'azote, nodulation
INTRODUCTION

Soyabean (Glycine max [L.] Merril) production in Zimbabwe is mainly confined to the large-scale commercial farming sector which has easy access to commercial Rhizobium inoculum required for nodulation. Naturally nodulating (promiscuous) varieties can nodulate without artificial inoculum. These can potentially increase soyabean production of resource poor farmers. According to Jhaveri (1994), access by smallholders to artificial inoculum is limited by lack of: (i) facilities to produce quality inoculum and distribute in many developing countries; (ii) appropriate facilities to store inoculum; (iii) education in the correct use of inoculum; and (iv) finance to carry out research in fields like selection to correct rhizobium species for various environments. Therefore, promiscuous varieties provide an alternative option in soyabean production to overcome these problems.

The yield of promiscuous varieties grown by smallholders in Zimbabwe has declined and researchers suspect existing varieties not to be pure due to observed variable agronomic performance. Available data suggests that there has been little improvement in soyabean productivity amongst smallholders, in spite of intensive efforts to improve agronomic practices. Mabika and Mariga (1996) reported that the average yield of promiscuous varieties was 600 kg ha\(^{-1}\) in 1985/86 in the Zimbabwean smallholder sector and showed no improvement at 593 kg ha\(^{-1}\) in 1993/94. The agronomic characterisation of these promiscuous soyabean varieties is, therefore, considered an important activity that would facilitate their purification and promotion in the smallholder farming sector. Availability of uniform materials of the promiscuous varieties would facilitate better response in research plots and a field level.

Morphological diversity studies can indicate the possibility of selecting from within varieties to reconstitute an original variety or to develop new ones. This can be done using the mass selection method of plant breeding as outlined by Allard (1960), Singh (1983) and Poehlman and Smeal (1987). Mass selection has been used successfully in developing varieties in different crops around the world. Sharama (1992) gave an account of the varieties developed by mass selection in India and these include maize varieties Jaunpur local; Tinpakh; Bass, T13; T19 and T41. In pearl millet varieties like Bajra 207; Bajri-28-15; LM-38-59 and CO1 were developed (Sharma, 1992) and there are examples in sorghum, mustard, cotton and peanut that can also be cited.

MATERIALS AND METHODS

Two studies, one on morphological diversity and another on field evaluation of phenotypic groups (PhG) were conducted during the period 2002 to 2004. Field experiments were carried out at Thornpark Farm (31° East, 17°31’ South) in the 2002/2003 and 2003/2004 rainy seasons. Fields are 1480 metres above sea level and soils are classified as 5E.2 on the Zimbabwean system of Chromic Luvisol on the FAO system. Average rainfall experienced is 815 mm with reliable distribution over 19.2 rainy pentads. In both experiments, basal fertiliser was drill-applied at 150 kg ha\(^{-1}\) at planting as Cottonfert [N (5%); P\(_2\)O\(_5\) (17%); K\(_2\)O (10%); B (0.25%)].

Seed was planted at a depth of about 3 cm in fine seedbed prepared by ploughing with a tractor-drawn mould board plough followed by discing to fine tilth. Inter-row spacing was 0.45 m and 0.03 m within the row. Seed was not prior to planting. Planting irrigation of about 20 mm was applied to ensure maximum germination in each of the two experiments.

Morphological diversity studies in Local and A&11. Two promiscuous varieties, Local and A711, and a commercial control, Soma were planted at Thornpark Farm, each in a plot measuring 135 m\(^2\) at a density of 74 plants m\(^2\). Mass selection (Allard, 1960; Singh, 1983; and Poehlman and Smeal, 1987) was used to conduct the morphological diversity study. The method was modified to group identified plants into PGs; retain seed of the PGs for further testing and document information on the PGs. Tags with information on plant height, number of primary branches per plant, flower colour, growth habit, response to disease, leaf shape and pod colour were tied to individual plants within Local and A711. From these traits, a final set was selected for use in grouping the plants into PGs. Response
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Results and Discussion

Results of the morphological diversity study showed that eight and seven PGs could be established from the promiscuous varieties Local and A711 (Table 1). The results are consistent with the phenotypic heterogeneity reported by researchers who have worked on promiscuous varieties in Zimbabwe. The variability was attributed to seed mixtures. Mixture could have arisen as a result of mutations as pointed out by Poehlman and Sleper (1987). Natural hybridisation could not possibly have caused variations such as the presence of determinate and indeterminate plant types in Local.

Days from emergence to onset of flowering varied from 61 to 82 in Local and 58 to 61 in A711 (Table 1). This was the most important differentiating trait in both varieties' PGs. The trait is also used to differentiate between soyabean varieties. Joshi and Jahaveri (1986) described the flowering times of the promiscuous varieties Magoye and Hernon 147, as 56 and 50 days, respectively. Thus heterogeneity in flowering times within a variety can be said to be an indication of mixtures of genotypes. In Local, growth habit was also an important trait. Tattersfield (1986) reported that most soyabean varieties were either indeterminate or determinate and the main difference between soyabean varieties Storm and Solitaire was that the former is determinate and the later indeterminate (Seed Co, 2000). Local was described as indeterminate and the presence of determinate plants is an indication of contamination. There was good agreement between phenotypic groupings on the basis of growth habit and dates to onset of flowering with later flowering plants being indeterminate and early ones determinate in Local (Table 1). This could be a result of gene linkage or pleiotropy although no work has been reported to that effect.

On evaluating the PGs, significant differences (P < 0.05) were observed on the number of primary branches, plant height, and pod clearance in Local PGs (Table 2) and on days to first flowering, days to 95% physiological maturity and pod clearance.
TABLE 1. The PGs identified in the promiscuous varieties Local and A711

<table>
<thead>
<tr>
<th>Code</th>
<th>Phenotypic group</th>
<th>Hilum colour</th>
<th>Description of group</th>
</tr>
</thead>
</table>

**Phenotypic groups identified in the variety Local**

1. LP61D  Cream  Selected from local, had purple flowers, were in the 61 days
2. LP63D  Cream  Selected from Local, had purple flowers, were in the 63 days to flowering group and had a determinate growth habit.
3. LP65D  Cream  Selected from Local, had purple flowers, were in the 65 days to flowering group and had a determinate growth habit.
4. LP681  Brown  Selected from Local, had purple flowers, were in the 68 days to flowering group and had an indeterminate growth habit.
5. LP711  Brown  Selected from Local, had purple flowers, were in the 71 days to flowering group and had an indeterminate growth habit.
6. LP751  Brown  Selected from Local, had purple flowers, were in the 75 days to flowering group and had an indeterminate growth habit.
7. LP791  Brown  Selected from Local, had purple flowers, were in the 79 days to flowering group and had an indeterminate growth habit.
8. LP821  Brown  Selected from Local, had purple flowers, were in the 82 days to flowering group and had an indeterminate growth habit.

**Phenotypic Groups Identified in the variety A711**

1. AP582  Grey  Selected from A711, had Purple flowers, were in the 58 days to flowering group and had 2 primary branches.
2. AP583  Grey  Selected from A711, had purple flowers, were in the 58 days to flowering group and had 3 primary branches.
3. AP584  Grey  Selected from A711, had purple flowers, were in the 58 days to flowering group and had 4 primary branches.
4. AP614  Grey  Selected from A711, had purple flowers, were in the 61 days to flowering group and had 4 primary branches.
5. AP54V  Dark Brown  Selected from A711, had purple flowers, were in the 54 days to flowering group and had variable numbers of primary branches.
6. AP56V  Black  Selected from A711, had purple flowers, were in the 56 days to flowering group and had variable numbers of primary branches.
7. AP61RT  Brown  Selected from A711, had purple flowers, were in the 61 days to flowering, had variable numbers of primary branches and had some Rust Tolerance.
in A & 11 PGs (Table 3). There was no significant yield difference between the control and the Local PGs. This was due to high variability in the data as indicated by CV of 35%. As shown in Table 2, five of the PGs achieved yields approximating 2 t ha\(^{-1}\) indicating the potential of developing some good lines from Local. There were significant differences in grain yield (P<0.01) between Storm and the A711 PGs (Table 3). Three of the PGs AP61RT, AP582 and AP584 yielded between 2.5 and 3.3 t ha\(^{-1}\) and all were superior to Storm without nodulation. This yield level is in excess of the national average obtained for soybean production in Zimbabwe. The results obtained in the trials are consistent with those obtained by Khonje (1994) in Malawi, who reported specifically nodulating variety Geduld producing the same yield with the promiscuous variety Magoye under the same environmental conditions. The differences observed among the phenotypic groups and control variety, Storm, may be explained by differences in promiscuity levels as explained by Mwakalombe (1988), who worked with varieties Heron 147 and Magoye. Since the site on which the trial was established was previously grown to maize, the Rhizobium levels might have been low as reported by Sanginga \textit{et al.} (1996), who worked with the varieties TGX 1456-2E and TGX 1669 - 19F in Northern and Southern Guinea and detected low indigenous rhizobia levels on soils previously cropped with maize or other cereals but higher levels on soils with a history of soyabean.

Further evaluation of the PGs can lead to reconstitution of the originally released promiscuous varieties and the contaminating germplasm can be uses in crop improvement programmes. There is also need to confirm genetic differences among the PGs with promising yield performance as shown in Tables 2 and 3. Yields achieved are far in excess of the average of about 600 kg ha\(^{-1}\) achieved by smallholders in Zimbabwe (Mabika and Mariga, 1996). These low yields could have resulted from some of the materials failing to behave promiscuously and fix nitrogen possibly as a result of mixture with specific
TABLE 3. Field performance of PGs identified in the variety A711 in comparison with a Seed Commercial variety Storm

<table>
<thead>
<tr>
<th>PG</th>
<th>DTF</th>
<th>DPM</th>
<th>NPB</th>
<th>Ht</th>
<th>PC</th>
<th>Gain yield (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP582</td>
<td>62.0</td>
<td>116.0</td>
<td>6.0</td>
<td>75.0</td>
<td>18.0</td>
<td>2800</td>
</tr>
<tr>
<td>AP583</td>
<td>69.0</td>
<td>111.0</td>
<td>6.0</td>
<td>73.0</td>
<td>27.0</td>
<td>2151</td>
</tr>
<tr>
<td>AP584</td>
<td>55.0</td>
<td>123.0</td>
<td>6.0</td>
<td>78.0</td>
<td>20.0</td>
<td>3325</td>
</tr>
<tr>
<td>AP614</td>
<td>69.0</td>
<td>113.0</td>
<td>6.0</td>
<td>68.0</td>
<td>14.0</td>
<td>1680</td>
</tr>
<tr>
<td>AP61RT</td>
<td>68.0</td>
<td>120.0</td>
<td>5.0</td>
<td>76.0</td>
<td>23.0</td>
<td>2480</td>
</tr>
<tr>
<td>Storm</td>
<td>68.0</td>
<td>112.0</td>
<td>5.0</td>
<td>76.0</td>
<td>13.0</td>
<td>1195</td>
</tr>
<tr>
<td>Mean</td>
<td>65.2</td>
<td>115.8</td>
<td>5.7</td>
<td>74.3</td>
<td>19.2</td>
<td>2272</td>
</tr>
<tr>
<td>LSD</td>
<td>12.4</td>
<td>5.6</td>
<td>ns</td>
<td>ns</td>
<td>6.0</td>
<td>889</td>
</tr>
<tr>
<td>CV(%)</td>
<td>5.9</td>
<td>2.0</td>
<td>22.7</td>
<td>6.4</td>
<td>12.8</td>
<td>16.9</td>
</tr>
</tbody>
</table>

Key
PG - Phenotypic Group
NPB - Number of primary branches
Ht - Plant height at physiological maturity
PC - Pod clearance
DFT - Days to first flowering
DPM - Days to 95% physiological maturity
ns - not significant

varieties. This assertion is supported by a high requirements for inorganic fertiliser in soybean production on smallholder farms in Zimbabwe noted by Tsikisayi (1996) contrary to conventional wisdom that only low level of start-up fertiliser are required. If properly targeted in environments with indigenous *Rhizobia*, promiscuous varieties would require lower levels of inorganic fertilisers and their use would not only result in savings in fertiliser, but the lines identified in this study would also increase yield achieved by promiscuous varieties.

ACKNOWLEDGEMENT

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