Influence of Bradyrhizobium Strains on Peanut Advanced Breeding Lines (Arachis hypogaea L.) Yield in North Cameroon

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Keywords: Bradyrhizobium- Environment- Nitrogen fixation- Peanut- Rhizobium- Cameroon

Summary

Peanut yields may be reduced due to early season nitrogen deficiency. A study was conducted in 1994 and 1995 at two locations (Guiring and Guetale), the peanut belt of Cameroon, to investigate the use of Bradyrhizobium strains to improve the nitrogen use by selected peanut advanced breeding lines. Thirty treatments were arranged in a 5 x 6 factorial and grown in a randomized complete block with four replications in 1994 and three in 1995. The treatments were a factorial set of five peanuts lines tested with four introduced inoculants, one local strain and the nitrogen treatment. Results over locations and years showed significant differences among strains for plant stand and seed weight, and among peanut lines for all traits except days to flowering. Genotypes CGS-269 (1.225 t/ha) and CGS-1272 (1.032 t/ha) had the highest pod yield (1.483 t/ha). Although the strain x host interaction was significant for plant stand, pod length and pod yield. The environment x strain x host interaction was also significant for haulm yield. Strain NC92 (-) (45.2 plants/7 m²) produced higher plant stands than nitrogen treatment (40.3 plants/7 m²) or indigenous strain (41 plants/7 m²), but was not significantly superior to other strains. Strain NC92 (+) performed poorly for seed weight. The combination of peanut line CGS-1272/NC-120 and CGS-383/NC92(+) produced the highest means for pod length (58.2 cm). Genotype CGS-269 with strain NC-120 produced the highest pod yield (1.483 t/ha). Although the strain x host interaction was not significant for haulm yield, there was a good performance of line CGS-1272 with 3G4B20 and NC92 (+) which outyielded the indigenous/CGS-1272 combination by 20.3% and 17.8%, respectively.

Résumé

Influence des souches de Bradyrhizobium sur le rendement des lignées avancées d’arachide (Arachis hypogaea L.) au Nord Cameroun

Les rendements de l’arachide (Arachis hypogaea L.) peuvent être réduits à cause des déficiences précoces en azote au début de la saison culturelle. Une étude a été menée en 1994 et 1995 sur deux sites, notamment Guiring et Guétalé. Trente traitements arrangés en factoriel 5 x 6 et disposés en blocs complètement randomisés avec quatre répétitions en 1994 et trois en 1995 ont été mises en culture. Les traitements étaient constitués de cinq lignées d’arachide, quatre souches exotiques de rhizobium, une souche locale et l’azote appliqué sous forme minérale. Les résultats au travers les sites et les campagnes ont montré d’une part, des différences significatives entre les souches pour la densité et le poids en grains, d’autre part entre les lignées d’arachide pour toutes les variétés sauf le nombre de jours semis-floraison. Les génotypes CGS-269 (1,225 t/ha) et CGS-1272 (1,032 t/ha) ont eu les meilleurs rendements à travers les sites. L’interaction entre les souches et les lignées a été significative pour le nombre de plants, la longueur des gousses et le rendement en gousses. La triple interaction, environnement x souche x plante hôte a été aussi significative pour le rendement en fanes. La souche NC92(-) a donné une meilleure densité de plants que l’azote et la souche indigène (45,2 et 40,3 plants/7 m², respectivement), mais n’a pas été significativement supérieure à d’autres souches. La souche NC92(+) a eu une mauvaise performance pour le poids de grains. Les combinaisons entre la lignée CGS-1272 et la souche NC-120 d’une part, et entre la lignée CGS-383 et la souche NC92(+) d’autre part, ont eu la moyenne la plus élevée pour la longueur des gousses (58,2 cm). Par ailleurs, le génotype CGS-269 et la souche NC-120 ont eu le meilleur rendement en gousses (1,483 t/ha). Malgré la non-signification statistique de l’interaction souche x hôte pour le rendement en fanes, on a constaté une bonne performance de la combinaison entre la lignée CGS-1272 et les souches 3G4B20 et NC92(+) qui a dépassé la souche indigène/CGS-1272 d’environ 20,3% et 17,8%, respectivement.

Introduction

Observations made in North Cameroon peanut (Arachis hypogaea L.) fields showed nitrogen deficiency symptoms in the preflowering growth stage (6). Such deficiencies could contribute to the low yields encountered in the region. Peanuts grown in the region are generally nodulated by an indigenous but inefficient Bradyrhizobium strain population. In addition, nitrogen fertilizers are becoming more and more expensive to buy, making them less readily available to poor farmers. To circumvent this problem, a rhizobium x peanut lines trial was conducted during two growing seasons (1994, 1995) at two locations (Guiring and Guetale).

Biological nitrogen fixation is tightly controlled by the combination of two genetic systems of both the host and the Rhizobium strain. In addition, these systems are affected by the environment and the interaction between these factors. It was reported effective combinations of peanut genotypes and Rhizobium strains under field and laboratory conditions (2, 9). It was also reported a significant increase in pod yield of one cultivar (Robut-33-1) when inoculated with strain NC92 but none when inoculated with other effective strains (3). A similar result was observed in North Cameroon, where in years 1994 and 1995, the most popular cultivar grown in the country, yielded a significant yield increase when inoculated with strain NC92 (6, 7). Unlike the genetic systems of the host and of the Rhizobium strain which could be controlled by artificial manipulations...
The following observations were done on the two inner rows of each plot: plant stand at harvest (7 m²), number of days from planting to flowering (days), number of days from planting to maturity (days), pod and seed dry weight (about 8% moisture) (kg), 20-pod length (cm), 100-seed weight (g), plant height in cm (Guiring 1994 only), haulm weight (kg), and meat content or shelling percentage (%). All data were calculated from pod and seed weights [(seed weight / pod weight) x 100]. Pod, seed and haulm (biomass) weights were obtained using a laboratory scale (Universal) with precision to 0.1 g, and converted onto t/ha; haulm weight was obtained in the field using a field scale ("Peson") with precision to 0.5 kg, and converted onto t/ha. After shelling, 100 seeds were sampled and weighted using an electronic scale with precision to 0.1 g (Mettler PC 4400).

Analysis of variance by environment was first performed using PROC GLM procedure of SAS (5). Mean separation was carried out, where appropriate, using the Least Significant Difference (LSD) method (8). Since the number of replications varies among years and given that the interactions of genotypes with locations and years must be taken into account, the analysis of variance combined over years and locations was performed from genotypes-environments means (1). The environments (combination of locations-years) were considered as random effects in the linear model while genotypes were considered fixed effects.

Results and discussion

Guiring

The combined analysis over years showed a significant difference at the 5% level of probability only for seed weight. The strain x host interaction was significant for plant stand while the strain x year interaction was significant for number of days from planting to flowering and pod length, indicating that plant stand for a given peanut line varies depending on the strain, and that strain performance varies from year to year. Strain NC-120 yielded the highest seed weight and was significantly different from NC92 (+) and from the indigenous strain (Table 2). Strain 3G4B20 significantly yielded higher plant height than NC-120, nitrogen treatment and the indigenous microflora. Significant strain x host interaction was observed for plant height (one year data) (Table 2).

Significant differences were found among genotypes for pod length, seed weight, meat content and haulm yield. Genotype CGS-1272 significantly outyielded the others for haulm yield (Table 2).

Guetale

No significant difference was found among strains for any traits. The effect of years was significant for plant stand, days to flowering, days to maturity, pod length, haulm yield and meat content. The strain x year interaction was significant for plant stand and number of days from planting to flowering. The strain x year x host interaction was highly significant for haulm yield. Variation among genotypes was highly significant for pod length, seed weight, pod and seed yields. Genotypes CGS-269 and CGS-1272 had the highest means even though no significant difference existed for certain traits (Table 3). The combination of CGS-1272 / NC92 (+) and CGS-1272 / 3G4B20 strains produced the highest and significant haulm yield as compared to CGS-1272 / NC92 (-) and CGS-1272 / NC-120 strains, nitrogen and the indigenous microflora.

Combined analysis over environments

As stated earlier, a combination of location-year gave a total of four environments. The effect of the environment...
was highly significant for all traits but seed and pod yields, meat content and harvest index. Variation among strains was significant for plant stand and seed weight (p<0.10). The effect of lines was highly significant for all traits except days to flowering. The strain x host interaction was significant for plant stand, pod length and pod yield (p<0.10). The environment x strain was significant only for days to flowering, indicating that flowering differs among strains depending on the specific environment. The environment x strain x host interaction was significant for haulm yield. Strain NC92 (-) had the highest plant stand compared to mineral nitrogen treatment and indigenous strain but was not significantly superior to NC92 (+) and 3G4B20. Strain NC-120, had the highest seed weight, but not different from NC92 (-) and 3G4B20. Strain NC92 (+) performed poorly for seed weight (Table 4). As far as haulm yield, pod yield and seed yield are concerned, no significant differences were observed among the strains and the uninoculated treatment performed as well as the inoculated ones.

The combination of genotype CGS-269 with strains NC92 (+) and NC92 (-) produced the highest plant stand, significantly superior to indigenous / CGS-269 combination (LSD= 7.2, p<0.05). The combinations of NC-120 / CGS-1272 and NC92 (+) / CGS-383 produced the highest and significant means for pod length (58.2 cm, LSD= 1.6 cm, p< 0.05) as compared to that of the indigenous strain (Table 5). In addition, CGS-269 with NC-120 produced the highest and significant pod yield (1.483 t/ha, LSD=0.168 t/ha, p< 0.10). Although the strain x host interaction was not significant for haulm yield, there was good performance of CGS-1272 with 3G4B20 and NC92 (+) (3.470 t/ha and 3.581 t/ha, respectively) which

**Table 2**
Rhizobium x host study: strains and host means at Guiring, for selected plant growth and yield parameters over two cropping seasons (1994 & 1995)

<table>
<thead>
<tr>
<th>Strains</th>
<th>Stand (7 m²)</th>
<th>Flowering (days)</th>
<th>Maturity (days)</th>
<th>Pod length (cm)</th>
<th>Seed weight (g)</th>
<th>Pod yield (t/ha)</th>
<th>Seed yield (t/ha)</th>
<th>Meat content (%)</th>
<th>Plant height (cm)</th>
<th>Haulm yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC92(+)</td>
<td>49.6</td>
<td>28.6</td>
<td>108.8</td>
<td>52.3</td>
<td>35.7</td>
<td>0.850</td>
<td>0.490</td>
<td>57.9</td>
<td>32.0</td>
<td>1.875</td>
</tr>
<tr>
<td>NC92(-)</td>
<td>51.7</td>
<td>28.7</td>
<td>108.7</td>
<td>52.6</td>
<td>36.7</td>
<td>0.871</td>
<td>0.500</td>
<td>57.9</td>
<td>31.6</td>
<td>2.200</td>
</tr>
<tr>
<td>NC-120</td>
<td>45.1</td>
<td>29.2</td>
<td>108.9</td>
<td>53.3</td>
<td>37.7</td>
<td>0.522</td>
<td>0.472</td>
<td>57.0</td>
<td>30.5</td>
<td>1.909</td>
</tr>
<tr>
<td>3G4B20</td>
<td>49.1</td>
<td>29.1</td>
<td>109.3</td>
<td>52.6</td>
<td>37.1</td>
<td>1.008</td>
<td>0.612</td>
<td>60.1</td>
<td>34.4</td>
<td>2.012</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>45.1</td>
<td>29.8</td>
<td>109.3</td>
<td>51.9</td>
<td>36.7</td>
<td>0.724</td>
<td>0.440</td>
<td>57.9</td>
<td>30.2</td>
<td>1.751</td>
</tr>
<tr>
<td>Indigenous</td>
<td>47.0</td>
<td>28.3</td>
<td>109.3</td>
<td>53.0</td>
<td>36.3</td>
<td>0.798</td>
<td>0.464</td>
<td>57.7</td>
<td>29.9</td>
<td>1.796</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>1.0</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**Table 3**
Rhizobium x host study: strains and host means at Guétalé, for selected plant growth and yield parameters over two cropping seasons (1994 & 1995)

<table>
<thead>
<tr>
<th>Strains</th>
<th>Stand (7 m²)</th>
<th>Flowering (days)</th>
<th>Maturity (days)</th>
<th>Pod length (cm)</th>
<th>Seed weight (g)</th>
<th>Pod yield (t/ha)</th>
<th>Seed yield (t/ha)</th>
<th>Meat content (%)</th>
<th>Plant height (cm)</th>
<th>Haulm yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC92(+)</td>
<td>39.1</td>
<td>29.4</td>
<td>111.1</td>
<td>50.8</td>
<td>35.8</td>
<td>0.688</td>
<td>0.404</td>
<td>58.4</td>
<td>2.239</td>
<td></td>
</tr>
<tr>
<td>NC92(-)</td>
<td>38.7</td>
<td>30.9</td>
<td>111.4</td>
<td>51.0</td>
<td>36.0</td>
<td>0.696</td>
<td>0.381</td>
<td>55.0</td>
<td>2.097</td>
<td></td>
</tr>
<tr>
<td>NC-120</td>
<td>37.8</td>
<td>31.1</td>
<td>110.6</td>
<td>50.6</td>
<td>36.1</td>
<td>0.786</td>
<td>0.425</td>
<td>55.0</td>
<td>2.245</td>
<td></td>
</tr>
<tr>
<td>3G4B20</td>
<td>37.8</td>
<td>29.6</td>
<td>111.7</td>
<td>50.8</td>
<td>36.4</td>
<td>0.710</td>
<td>0.408</td>
<td>65.7</td>
<td>2.178</td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>35.6</td>
<td>30.4</td>
<td>111.4</td>
<td>50.6</td>
<td>34.9</td>
<td>0.649</td>
<td>0.372</td>
<td>56.0</td>
<td>1.899</td>
<td></td>
</tr>
<tr>
<td>Indigenous</td>
<td>35.1</td>
<td>31.3</td>
<td>111.2</td>
<td>49.9</td>
<td>35.6</td>
<td>0.704</td>
<td>0.418</td>
<td>58.3</td>
<td>2.176</td>
<td></td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

**Genotypes**
CGS-269 55.0 29.1 108.2 57.5 43.5 1.208 0.735 60.7 34.8 1.996
CGS-1272 54.8 29.8 106.9 58.1 39.2 1.031 0.553 53.3 34.2 2.30
CGS-384 44.0 29.2 110.2 51.0 33.9 0.572 0.317 56.2 27.9 1.896
CGS-383 45.5 29.0 109.0 51.2 36.1 0.750 0.469 61.8 28.8 1.775
K3237-80 41.2 28.5 108.2 45.2 30.9 0.666 0.407 60.3 31.4 1.622
Means 47.9 29.1 109.0 52.6 36.7 0.854 0.496 58.4 31.4 1.924
LSD (0.05) ns ns ns ns ns ns ns ns ns

**Genotypes**
CGS-269 47.7 29.5 109.5 55.7 42.4 1.243 0.744 67.5 2.412
CGS-1272 44.0 29.7 113.4 56.4 41.0 1.032 0.547 53.4 3.340
CGS-384 32.2 30.9 113.1 49.3 34.2 0.441 0.250 56.7 1.733
CGS-383 32.4 30.6 112.3 48.5 34.2 0.484 0.285 58.6 1.628
K3237-80 30.4 31.5 108.3 43.0 37.0 0.329 0.182 55.1 1.582
Means 37.3 30.4 111.3 50.6 35.8 0.706 0.401 58.1 2.139
LSD (0.05) ns ns ns ns ns ns ns ns ns

superior to indigenous / CGS-269 combination (LSD= 7.2, p< 0.05). The combinations of NC-120 / CGS-1272 and NC92 (+) / CGS-383 produced the highest and significant means for pod length (58.2 cm, LSD= 1.6 cm, p< 0.05) as compared to that of the indigenous strain (Table 5). In addition, CGS-269 with NC-120 produced the highest and significant pod yield (1.483 t/ha, LSD=0.168 t/ha, p< 0.10). Although the strain x host interaction was not significant for haulm yield, there was good performance of CGS-1272 with 3G4B20 and NC92 (+) (3.470 t/ha and 3.581 t/ha, respectively) which

Figure 1: Interaction between line CGS-1272 with some selected rhizobia strains for haulm yield (t/ha).
The most striking result is the interesting haulm yield increase, resulting from the combination of CGS-1272 with strains NC92 (+) and 3G4B20 (Figure 1). Biomass from peanut is extensively used for animal feeding in the region.

It also appears that Bradyrhizobium strains differed in their effectiveness and were affected by the host and the environment. Nitrogen fixation might have been reduced in 1995 experiments since the rainfall (1016 mm) was much higher than the previous growing season, which recorded only 710.6 mm (Table 1); the influence of soil moisture on Nitrogen fixation was reported previously (4).

### Conclusion

The results obtained from this study indicate that the inoculation of peanuts with Bradyrhizobium strains in Northern Cameroon can result in yield increases and improvement of agronomic characteristics of promising lines as reported in previous studies (6, 7). The most striking result is the interesting haulm yield increase, resulting from the combination of CGS-1272 with strains NC92 (+) and 3G4B20 (Figure 1). Biomass from peanut is extensively used for animal feeding in the region.

It also appears that Bradyrhizobium strains differed in their effectiveness and were affected by the host and the environment. Nitrogen fixation might have been reduced in 1995 experiments since the rainfall (1016 mm) was much higher than the previous growing season, which recorded only 710.6 mm (Table 1); the influence of soil moisture on Nitrogen fixation was reported previously (4).
Acknowledgement

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Literature


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