Analysis of Pod and Seed Development in Cowpea [Vigna unguiculata (L.) Walp]

D.V. Deshmukh, S.N. Mate, R.W. Bharud and P.N. Harer

Department of Agricultural Botany, Mahatma Phule Krishi Vidyapeeth,
Rahuri-413 722, Dist.: Ahmednagar (M.S.), India

Abstract: Five cowpea genotypes were evaluated in RBD with four replications during Kharif 2009 and 2010 to analyze characters of pod and seed growth. Five hundreds flowers were tagged at 50% flowering for sampling the pods. Ten pods were sampled at three days interval from days after flowering (DAF) from every plot and recorded the observations on pod and seed growth characters. The characters of pod and seed growth were increased progressively with the advancing age of crop up to 12 to 15 DAF, thereafter, it declined towards maturity due to drying of pods. The genotypes, C 152, Phule Pandhari and Konkan Safed had higher values for pod length, pod girth, pod diameter, polar and equatorial diameter of seed at various stages of growth. The genotypes, GC 3 and VCM 8 had higher growth rates for characters of pod and seed growth between 3 and 6 DAF, whereas, it was higher in C 152 and Phule Pandhari between 6 and 9 DAF. The genotype, Konkan Safed and C 152 recorded higher values for the growth rates of pod and seed growth characters. The genotypes, C 152 was promising for characters of pod and seed growth and growth rate of pod and seed growth characters between 6 and 12 DAF along with high seed yield ha⁻¹.

Key words: Growth rates • Characters of pod and seed development

INTRODUCTION

Reproductive phase commence with the appearance of buds, opening of flowers, setting of pods, development of pods in terms of length, breadth, girth and volume [1-3]. The pod of the legume provides a protective envelope to the developing seeds; it acts as catchments, transport link and temporary reservoir for solutes mobilized from vegetative parts to seeds; and if green and illuminated, it functions significantly in photosynthetic fixation of CO₂ [4]. Thus, the pod shell is initially developed and then at the same stage the setting of grain occurs which is followed by filling of the seeds[5-6]. The seed develops by length, breadth, girth and volume and ultimate product is formed by deposition of photosynthates in the reproductive sink. In cowpea, the overall yield depends upon number of pods and size of seed. It is well known that the size and number of pods are the genetically determined characters [7-8]. The rates of development of pod, pod wall and the seed inside the pods have direct bearing on overall crop performance [9-10].

MATERIALS AND METHODS

Five cowpea genotypes were evaluated in RBD with four replications during Kharif 2009 and 2010 to study the characters of seed and pod growth and it’s growth rates. The gross and net plot sizes were 4.00 x 3.60 and 3.60 x 3.00 m². The plant to plant and row to row spacing was 30 x 10 cm. At the time of 50% flowering, 500 flowers were tagged. Ten pods from each plot were sampled at every 3 days interval between flowering and full maturity. The observations were recorded on length, girth, polar and equatorial diameter of pod, polar and equatorial diameter of seed and seed volume. The growth rate of pod and seed growth characters was calculated by the formula given by Briggs et al. [11] on per day basis.

RESULTS AND DISCUSSION

Pod length, girth, diameter and volume were increased progressively with the advancing age of crop up to 12 to 15 DAF, thereafter, it declined towards maturity due to drying of pods (Table 1). The loss of moisture in maturing seed is an inherent phase of seed development [12-13]. Mayer [14] stated that, accumulation of dry matter with loss of moisture as the characteristic feature during seed development and maturation. Natarajan and Srimathi [15] observed decrease in moisture content of pod with advancement in maturation correlated with higher dehydration rate of pod at maturity [16].
The periodical changes for pod growth characters are presented in Table 1. It revealed that, the genotype Konkan Safed (5.75 cm) and C 152 (5.19 cm) at 3 DAF, GC 3 (10.67 cm) and Konkan Safed (9.27 cm) at 6 DAF and C 152 at 9 (15.38 cm), 12 (16.06 cm), 15 (16.15 cm), 18 (15.11 cm), 21 (15.00 cm) and 24 DAF (15.00 cm) recorded higher pod length (Fig. 1A). The genotype, Konkan Safed (6.52 mm) at 3 DAF, GC 3 (12.84 mm) at 6 DAF, Phule Pandhari (18.62 mm) at 9 DAF and C 152 at 12 (20.99 mm), 15 (21.19 mm), 21 (20.55 mm) and 24 DAF (20.54 mm) recorded higher pod girth(Fig. 1B). The genotype, Konkan Safed (2.07 mm) 3 DAF, at GC 3 (4.09 mm) 6 DAF, Phule Pandhari (5.92 mm) at 9 DAF and C 152 at 12 (6.68 mm), 15 (6.74 mm), 18 (6.60 mm), 21 (6.54 mm) and 24 DAF (6.53 mm) recorded highest pod diameter (Fig. 1C). The rate of increase of pod volume was rapid in VCM 8 which completes its full growth within 12 DAF. However, remaining genotypes required 15 DAF for full growth of green pods. The genotypes, Konkan Safed at 3 (0.182 ml), 18 (4.068 ml), 21 (3.253 ml) and 24 DAF (3.253 ml); GC 3 at 6 DAF (0.659 ml) and C 152 at 9 (2.698 ml), 12 (4.646 ml) and 15 DAF (4.251) recorded the highest pod volume (Fig. 1D).
Ogunbodede and Fatula [17] reported a higher estimate of narrow sense heritability for pod length and seed size. Li Wang and Grusak [18] given a developmental characterization of M. truncatula at the four time points (3, 6, 13 and 20 DPP) in which growing pod walls (3 and 6 DPP), developing ovules and the early emergence of reflect pods (13 DPP) and have reached a plateau in fresh weight mass and seeds (20 DPP).

Data on pod growth rates influenced by cowpea genotypes at various stages of growth are presented in Table 2. It evidenced that, the rate of increase for pod length was higher in GC 3 (1.96 cm/day) and VCM 8 (1.60 cm/day) between 3 and 6 DAF, however it was higher in C 152 (2.46 cm/day) and Phule Pandhari (1.26 cm/day) at 6-9 DAF. Konkan Safed (0.66 cm/day) and Phule Pandhari (0.50 cm/day) had higher rate for increasing pod length at 9-12 DAF. The rate of increase for pod girth was higher in GC 3 (2.75 mm/day) and VCM 8 (1.50 mm/day) between 3 and 6 DAF, however, it was higher in C 152 (2.87 mm/day) and Phule Pandhari (2.80 mm/day) at 6 to 9 DAF. Konkan Safed maintained higher rate for increasing pod girth at 9 to 12 (0.99 mm/day) and 12 to 15 DAF (0.38 mm/day). The rate of increase for pod girth was higher in GC 3 (0.87 mm/day) and VCM 8 (0.48 mm/day) between 3 and 6 DAF, however, it was higher in C 152 (0.91 mm/day) and Phule Pandhari (0.89 mm/day) at 6-9 DAF. Konkan Safed maintained higher rate for increasing pod diameter at 9-12 (0.31 mm/day) and 12-15 DAF (0.12 mm/day). The rate of increase for pod volume was higher in Phule Pandhari at 3 to 6 DAF (0.13 ml/day), while it was higher in C 152 (0.76 ml/day) at 6 to 9 DAF. At 9-12 DAF, C 152 (0.65 ml/day) and Konkan Safed (0.52 ml/day) maintained higher rate of increase in pod volume. At 12-15 DAF, Phule Pandhari (0.88 ml/day) had higher rate for increasing pod volume.

Data on polar and equatorial diameter of seed and seed volume are presented in Table 3. It evident that the polar and equatorial diameter of seed increased progressively upto 12 DAF in VCM 8, whereas, it was increased progressively up to 15 DAF in other genotypes, thereafter it declined towards maturity due to loss of moisture from seeds. The genotype, Phule Pandhari recorded maximum polar diameter of seed at 3 (0.69 mm),
Table 2: Periodical pod growth rates influenced by cowpea genotypes

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>Days after flowering</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3-6</td>
</tr>
<tr>
<td>Pod length (cm/day)</td>
<td></td>
</tr>
<tr>
<td>VCM 8</td>
<td>1.60</td>
</tr>
<tr>
<td>Konkan Safed</td>
<td>1.17</td>
</tr>
<tr>
<td>Phule Pandhari</td>
<td>1.52</td>
</tr>
<tr>
<td>C 152</td>
<td>0.94</td>
</tr>
<tr>
<td>GC 3</td>
<td>1.96</td>
</tr>
<tr>
<td>Pod girth (mm/day)</td>
<td></td>
</tr>
<tr>
<td>VCM 8</td>
<td>1.50</td>
</tr>
<tr>
<td>Konkan Safed</td>
<td>1.17</td>
</tr>
<tr>
<td>Phule Pandhari</td>
<td>1.48</td>
</tr>
<tr>
<td>C 152</td>
<td>1.31</td>
</tr>
<tr>
<td>GC 3</td>
<td>2.75</td>
</tr>
<tr>
<td>Pod diameter (mm/day)</td>
<td></td>
</tr>
<tr>
<td>VCM 8</td>
<td>0.48</td>
</tr>
<tr>
<td>Konkan Safed</td>
<td>0.37</td>
</tr>
<tr>
<td>Phule Pandhari</td>
<td>0.47</td>
</tr>
<tr>
<td>C 152</td>
<td>0.42</td>
</tr>
<tr>
<td>GC 3</td>
<td>0.88</td>
</tr>
<tr>
<td>Pod volume (ml/day)</td>
<td></td>
</tr>
<tr>
<td>VCM 8</td>
<td>0.07</td>
</tr>
<tr>
<td>Konkan Safed</td>
<td>0.09</td>
</tr>
<tr>
<td>Phule Pandhari</td>
<td>0.13</td>
</tr>
<tr>
<td>C 152</td>
<td>0.09</td>
</tr>
<tr>
<td>GC 3</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Table 3: Periodical changes for seed growth characters

<table>
<thead>
<tr>
<th>Genotype</th>
<th>DAF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polar diameter of seed (mm)</td>
<td></td>
</tr>
<tr>
<td>VCM 8</td>
<td>0.66</td>
</tr>
<tr>
<td>Konkan Safed</td>
<td>0.68</td>
</tr>
<tr>
<td>Phule Pandhari</td>
<td>0.69</td>
</tr>
<tr>
<td>C 152</td>
<td>0.62</td>
</tr>
<tr>
<td>GC 3</td>
<td>0.68</td>
</tr>
<tr>
<td>Mean</td>
<td>0.67</td>
</tr>
<tr>
<td>SE±</td>
<td>0.02</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>0.06</td>
</tr>
<tr>
<td>Equatorial diameter of seed (mm)</td>
<td></td>
</tr>
<tr>
<td>VCM 8</td>
<td>0.24</td>
</tr>
<tr>
<td>Konkan Safed</td>
<td>0.26</td>
</tr>
<tr>
<td>Phule Pandhari</td>
<td>0.27</td>
</tr>
<tr>
<td>C 152</td>
<td>0.24</td>
</tr>
<tr>
<td>GC 3</td>
<td>0.27</td>
</tr>
<tr>
<td>Mean</td>
<td>0.26</td>
</tr>
<tr>
<td>SE±</td>
<td>0.01</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>0.04</td>
</tr>
<tr>
<td>Seed volume (ml)</td>
<td></td>
</tr>
<tr>
<td>VCM 8</td>
<td>0.003</td>
</tr>
<tr>
<td>Konkan Safed</td>
<td>0.009</td>
</tr>
<tr>
<td>Phule Pandhari</td>
<td>0.006</td>
</tr>
<tr>
<td>C 152</td>
<td>0.005</td>
</tr>
<tr>
<td>GC 3</td>
<td>0.005</td>
</tr>
<tr>
<td>Mean</td>
<td>0.006</td>
</tr>
<tr>
<td>SE±</td>
<td>0.000</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>0.001</td>
</tr>
</tbody>
</table>
### Table 4: Periodical seed growth rates influenced by cowpea genotypes

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>Days after flowering</th>
<th>Polar diameter of seed (mm)</th>
<th>Equatorial diameter of seed (mm)</th>
<th>Seed volume (ml/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3-6</td>
<td>6-9</td>
<td>9-12</td>
<td>12-15</td>
</tr>
<tr>
<td>VCM 8</td>
<td>0.74</td>
<td>1.08</td>
<td>0.70</td>
<td>-0.09</td>
</tr>
<tr>
<td>Konkan Safed</td>
<td>0.75</td>
<td>1.11</td>
<td>0.17</td>
<td>0.58</td>
</tr>
<tr>
<td>Phule Pandhari</td>
<td>0.77</td>
<td>1.13</td>
<td>0.49</td>
<td>0.17</td>
</tr>
<tr>
<td>C 152</td>
<td>0.70</td>
<td>1.02</td>
<td>0.70</td>
<td>0.31</td>
</tr>
<tr>
<td>GC 3</td>
<td>0.76</td>
<td>1.11</td>
<td>0.53</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VCM 8</td>
<td>0.34</td>
<td>0.61</td>
<td>0.39</td>
<td>-0.07</td>
</tr>
<tr>
<td>Konkan Safed</td>
<td>0.37</td>
<td>0.65</td>
<td>0.17</td>
<td>0.28</td>
</tr>
<tr>
<td>Phule Pandhari</td>
<td>0.38</td>
<td>0.67</td>
<td>0.41</td>
<td>0.03</td>
</tr>
<tr>
<td>C 152</td>
<td>0.35</td>
<td>0.61</td>
<td>0.57</td>
<td>-0.01</td>
</tr>
<tr>
<td>GC 3</td>
<td>0.39</td>
<td>0.69</td>
<td>0.24</td>
<td>0.06</td>
</tr>
<tr>
<td>Seed volume (ml/day)</td>
<td>0.008</td>
<td>0.028</td>
<td>0.024</td>
<td>-0.013</td>
</tr>
<tr>
<td>Konkan Safed</td>
<td>0.008</td>
<td>0.018</td>
<td>0.040</td>
<td>-0.002</td>
</tr>
<tr>
<td>Phule Pandhari</td>
<td>0.008</td>
<td>0.018</td>
<td>0.031</td>
<td>0.003</td>
</tr>
<tr>
<td>C 152</td>
<td>0.009</td>
<td>0.019</td>
<td>0.039</td>
<td>-0.003</td>
</tr>
<tr>
<td>GC 3</td>
<td>0.011</td>
<td>0.027</td>
<td>0.018</td>
<td>0.005</td>
</tr>
</tbody>
</table>

### Table 5: Yield and yield contributing characters as influenced by cowpea genotypes

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Days to initiation of flower</th>
<th>Days to last pod maturity</th>
<th>Pods/plant</th>
<th>100 seeds weight (g)</th>
<th>Seed yield (kg/ha)</th>
<th>Harvest index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCM 8</td>
<td>34.00</td>
<td>69.00</td>
<td>13.35</td>
<td>9.02</td>
<td>918</td>
<td>41.25</td>
</tr>
<tr>
<td>Konkan Safed</td>
<td>44.75</td>
<td>87.00</td>
<td>15.10</td>
<td>10.20</td>
<td>962</td>
<td>32.74</td>
</tr>
<tr>
<td>Phule Pandhari</td>
<td>45.00</td>
<td>78.00</td>
<td>14.05</td>
<td>8.40</td>
<td>1115</td>
<td>36.05</td>
</tr>
<tr>
<td>C 152</td>
<td>49.50</td>
<td>84.00</td>
<td>15.95</td>
<td>8.75</td>
<td>1274</td>
<td>38.36</td>
</tr>
<tr>
<td>GC 3</td>
<td>42.00</td>
<td>74.00</td>
<td>15.40</td>
<td>9.21</td>
<td>958</td>
<td>52.52</td>
</tr>
<tr>
<td>Mean</td>
<td>43.05</td>
<td>78.40</td>
<td>14.77</td>
<td>9.12</td>
<td>1045</td>
<td>40.18</td>
</tr>
<tr>
<td>SE±</td>
<td>0.801</td>
<td>0.606</td>
<td>0.537</td>
<td>0.031</td>
<td>49.5</td>
<td>0.0021</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>2.468</td>
<td>1.866</td>
<td>1.654</td>
<td>0.094</td>
<td>152.7</td>
<td>0.0063</td>
</tr>
</tbody>
</table>

### Discussion

6 (3.01 mm) and 9 DAF (6.40), VCM 8 at 12 DAF (8.21 mm), C 152 at 15 DAF (8.77 mm) and Konkan Safed at 18 (8.44 mm), 21 (7.14 mm) and 24 DAF (7.13 mm) recorded higher polar diameter of seed. The genotype, GC 3 at 3 (0.27 and 0.24 mm), 6 (1.44 and 1.27 mm) and 9 DAF (3.52 and 3.09 mm), C 152 at 12 (4.81 mm) and 15 DAF (4.78 mm), Konkan Safed at 18 DAF (4.66 mm) and Phule Pandhari at 21 (4.01 mm) and 24 DAF (4.01 mm) recorded maximum equatorial diameter of seed. The seed volume increased progressively up to 12 DAF in VCM 8, Konkan Safed and C 152. However, in Phule Pandhari and GC 3 the period was extended 3 more days for increasing seed volume. The genotypes, Konkan Safed at 3 (0.009 ml), 15 (0.197 ml), 18 (0.202 ml), 21 (0.181 ml) and 24 DAF (0.181 ml); GC 3 at 6 (0.038 ml) and 9 DAF (0.118 ml) and C 152 at 12 (0.206 ml) and 15 DAF (0.197) recorded higher seed volume.

Data on rate of increase for polar and equatorial diameter of seed and seed volume are presented in Table 4. The rate of increase for polar diameter of seed was higher in Phule Pandhari at 3 to 6 DAF (0.77 mm/day) and 6 to 9 DAF (1.13 mm/day), C 152 and VCM 8 (0.70 mm/day) at 9 to 12 DAF (0.31 mm/day) and Konkan Safed (0.58 mm/day) and C 152 (0.30 mm/day) at 12-15 DAF maintained higher rate for increasing polar diameter of seed (Fig. 2A). The rate of increase for equatorial diameter of seed was higher in GC 3 at 3 to 6 (0.39 mm/day) and 6 to 9 DAF (0.69 mm/day), Phule Pandhari at 9-12 DAF (0.57 mm/day) and Konkan Safed at 12-15 DAF (0.28 mm/day) had higher rate for increasing equatorial diameter of seed (Fig. 2B). The rate of increase for seed volume was higher in GC 3 at 3 to 6 (0.011 ml/day) and 6 to 9 DAF (0.027 ml/day), Konkan Safed (0.040 ml/day) at 6 to 9 DAF, C 152 at 9 to 12 DAF (0.65 ml/day) and GC 3 at 12 to 15 DAF (0.005 ml/day) showed higher rate of increase in pod volume (Fig. 2C).

The genotypes, C 152 (49.50 and 84.00 days), Konkan safed (45.00 and 78.00 days) and Phule Pandhari (44.75 and 87.00 days) were late for initiation of flowering and maturity (Table 5). C 152 (15.95), GC 3 (15.40) and Konkan Safed (15.10) recorded higher number of pods/plant. Bhaskarain et al. (19) reported that in the high yielding parents of cowpea, pods per plant and 100 seed weight was most important yield contributing characters.
Khan and Stofella (20) concluded that, pod/plant was single component related to seed yield in cowpea. Konkan Safed (10.20 g/100 seed) and GC 3 (9.21 g/100 seed) possessed bold seed size. The genotypes, C 152 (1274 kg/ha), Phule Pandhari (1115 kg/ha) and Konkan Safed (962 kg/ha) were high yielding genotypes. This might be due to better performance for pod and seed growth characteristics, higher growth rates, medium duration and higher number of pods/plant.

**CONCLUSIONS**

The highest yielding genotypes, C 152, Phule Pandhari and Konkan Safed had higher values for pod length, pod girth, pod diameter, pod volume, polar and equatorial diameter of seed and seed volume/pod. Growth rates for pod and seed growth characteristics were higher between 6 and 9 DAF which was declined towards maturity. The genotype, C 152 maintained higher growth rates for pod length, girth, diameter and volume between 6 and 9 DAF, whereas, Phule Pandhari and Konjan Safed had higher growth rates for seed diameter and seed volume. It may be concluded that, the genotypes having higher growth rates for pod and seed growth between 6 and 9 DAF resulted in higher productivity in cowpea.

The present investigation have clearly brought out the importance of reproductive growth approaches in locating the causes for yield differences in cowpea. In this context, the model appeared for seed and pod development based on the periodical data of pod and seed growth generated from five divergent genotypes of cowpea. It can be used as heuristic model for understanding the phenomenon and planning of research programme. Thus, pod and seed growth in terms of length, breadth, width and pod shell growth in terms of fresh and dry weight and growth rates appeared to be highly predictable and the genetic variations can be predictably studied in cowpea.
REFERENCES