Yield and Yield Component Responses of Some Cowpea Varieties to Population Density Structures under Rainfed Conditions in Lowland Tropics of Southeast Nigeria

G.E. Nwofia, M.C. Nwanebu and E.U. Mbah

Department of Agronomy, Michael Okpara University of Agriculture, Umudike, Nigeria

Abstract: A study was initiated to generate information on genetic and varying population density effect on growth and yield characters of 12 cowpea varieties maintained under rain-fed conditions, in the humid tropics in 2010 and 2011 cropping seasons. The experiment was conducted using a split plot in randomized complete block design (RCBD) with three replications at National Cereals Research Institute, Amakanma sub-station, Abia State, Nigeria (05° 29’ N, 07° 32’ E, 122 masl). Cowpea population density (40,000; 53,333 and 80,000 plants ha\(^{-1}\)) constituted the main plots while genetically diverse varieties viz., IT960-610, IT90-277-2, Danillo, IT891KD-374-57, IT98K-506-1, IT88D-876-11, Borno local, IT891KD-288, IT860D-719, IT891KD-391, 1AR48 and IT81D-985 were assigned into the subplots of 2 x 3 m. Results indicated that population density and the cowpea varieties studied were found significant (P<0.05) and cowpea population density with 40,000 plants ha\(^{-1}\) showing significant superiority relative to the other population densities, irrespective of the cowpea variety. In both cropping seasons, the characters of cowpea varieties assessed were observed to be genotypically diverse with significant differences between them. Cowpea varieties (IT-960-610, IT89KD-374-57 and IT90K-227-2) were identified to have high yielding potentials, especially at 40,000 plants ha\(^{-1}\) compared to other varieties studied, hence, their planting can be encouraged by farmers within the agro-ecological zone of the study area. Number of branches plant\(^{-1}\), number of leaves plant\(^{-1}\), number of seeds pod\(^{-1}\) and pod length were adjudged to be important selection traits for genetic improvement of the crop.

Key words: Cowpea - Population structure - Characters - Growth - Yield-potential

INTRODUCTION

Grain legumes are important source of protein as calories in many parts of the world. Their high protein and lysine content make them a natural supplement to simple diets cereals, tubers and fruits [1]. Cowpea (Vigna unguilata Walp) is one of the most important food and forage legumes in the tropics. It is a valuable and dependable commodity in dry savannah agro-ecological zones of West Africa [2]. According to [3] as well as [4], cowpea, which is a dietary staple food in Sub-sahara Africa, can be eaten in the form of dry seeds, green pods, green seeds and tender green leaves and it mixes well with other food recipes [5]. Also, it could be used as feed (grazed) or harvested and fed to livestock as fodder. Cowpea seed is an excellent food containing about 24.8% digestible protein, which is rich in amino acids, lysine and tryptophan compared to cereal grains; 63.6% carbohydrate, 1.92% fat, 6.3% fibre, 0.00075% thiamine and 0.00042% riboflavin [6] in human diet. The crop plays a vital agronomic role in various farming systems owing to its ability to fix atmospheric nitrogen in the soil, hence, can serve as a good soil amendment crop [7]; [8]. Advances in cowpea breeding research have prompted the release of a number of high yielding varieties that are less susceptible to pests and diseases attack [9], can effectively serve as cover crop [10] and with high adaptability to humid tropical agro-ecosystems [11]; [12]. Studies have shown low yields of cowpea associated with inappropriate population densities as well as varieties. More so, the high demand for the crop is making it popular among local farmers in the humid tropics. However, there is dearth information on the effect of population densities on cowpea varieties to guarantee reliable yields in the humid tropics where prospects for its commercial cultivation, is high. Studies by [13] on cowpea genotype by row spacing by environment interaction in a semi-arid zone in Senegal revealed that cultivars with

Corresponding Author: G.E. Nwofia, Department of Agronomy, Michael Okpara University of Agriculture, Umudike, Nigeria.
different plant morphology require different plant densities to express their full potentials. Hence, the concept of the study was to determine the optimum population densities and appropriate cowpea variety(s) suitable in a humid environment as well as to assess the genetic variability among the varieties studied.

**MATERIALS AND METHODS**

In 2010 and 2011 cropping seasons, a total of twelve varieties of *Vigna unguiculata* L. Walp were assessed under rain-fed conditions at National Cereals Research Institute, Amakanma sub-station, Abia State, Nigeria (05° 29´ N, 07° 32´ E, 122 masl altitude). In both cropping seasons, soil samples were randomly collected at 0-20 cm depth from representative plots in the experimental sites. The samples were bulked together, mixed thoroughly and a sub-sample collected, which was air-dried, ground and sieved through a 2 mm mesh for physico-chemical analysis in the laboratory using standard procedures. The soil type is a sandy loam. Details of the soil characteristics of the experimental sites in the two years are shown in Table 1.

The location is characterized by a bimodal pattern of rainfall distribution, which peaks in July and September, with a short dry spell in August between the peak periods. In the cropping seasons, annual mean rainfall, rainfall days and relative humidity (0900 hours) were 159.68 mm, 11.4 days and 82.4%, respectively and 176.19 mm, 10.75 days and 81.09%, respectively (2010), while minimum and maximum temperatures as well as sunshine hours were 31.5 °C, 22.7 °C and 3.98 hours, respectively, (2011) as shown in Table 2.

The experimental site was ploughed, harrowed, thinned and leveled. Seeds of 12 diverse cowpea genotypes obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria (IT960-610, IT90-277-2, Danillo, IT891KD-374-57, IT98K-506-1, IT88D-876-11, Borno local, IT891KD-288, IT860D-719, IT891KD-391, 1AR48 and IT81D-985) were sown at three seeds per stand. Plants were thinned to the required densities after emergence (between unfolding of the first leaf pair and unfolding of two trifoliate leaves). Three cowpea population densities (40,000 (50 x 50 cm); 53,333 (75 x 25 cm) and 80,000 (50 x 25 cm) plants/ha) were fitted into the experimental main plots while the twelve cowpea varieties were fitted into the sub-plots of 2 x 3 m (6 m²). The field experiment was laid out a split plot in a randomized complete block design (RCBD) with three replications.

Agronomic maintenance of the experimental plots such as weeding with hoe was done at 4 and 8 WAP while insect pests were controlled by spraying Cypermethrin EC at the rate of 2.5 ml/L of water using a knap sack sprayer at 2 weeks intervals starting from 3 WAP until pod initiation.

<table>
<thead>
<tr>
<th>Soil physical properties</th>
<th>Soil chemical properties</th>
<th>Exchangeable bases (cmol Kg-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>Sand (%)</td>
<td>Silt (%)</td>
</tr>
<tr>
<td>2010</td>
<td>75.20</td>
<td>11.40</td>
</tr>
<tr>
<td>2011</td>
<td>75.80</td>
<td>5.10</td>
</tr>
</tbody>
</table>

Source: Soil Science Laboratory, National Root Crops Research Institute, Umudike, Abia State.

<table>
<thead>
<tr>
<th>Rainfall (mm)</th>
<th>Temperature (°C)</th>
<th>Relative humidity (%)</th>
<th>Sunshine (Hrs.)</th>
<th>Rainfall (mm)</th>
<th>Temperature (°C)</th>
<th>Relative humidity (%)</th>
<th>Sunshine (Hrs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month</td>
<td>Amount</td>
<td>Day</td>
<td>Max.</td>
<td>Min.</td>
<td>0900hrs.</td>
<td>1500hrs.</td>
<td>Amount</td>
</tr>
<tr>
<td>January</td>
<td>0.0</td>
<td>0</td>
<td>35</td>
<td>23</td>
<td>72</td>
<td>45</td>
<td>0.0</td>
</tr>
<tr>
<td>February</td>
<td>78.2</td>
<td>4</td>
<td>35</td>
<td>24</td>
<td>77</td>
<td>53</td>
<td>6.3</td>
</tr>
<tr>
<td>March</td>
<td>34.1</td>
<td>3</td>
<td>34</td>
<td>24</td>
<td>77</td>
<td>53</td>
<td>3.9</td>
</tr>
<tr>
<td>April</td>
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<td>11</td>
<td>34</td>
<td>24</td>
<td>76</td>
<td>59</td>
<td>6.1</td>
</tr>
<tr>
<td>May</td>
<td>138.5</td>
<td>14</td>
<td>32</td>
<td>24</td>
<td>84</td>
<td>77</td>
<td>3.5</td>
</tr>
<tr>
<td>June</td>
<td>427</td>
<td>22</td>
<td>30</td>
<td>24</td>
<td>87</td>
<td>75</td>
<td>3.4</td>
</tr>
<tr>
<td>July</td>
<td>310.2</td>
<td>17</td>
<td>30</td>
<td>23</td>
<td>86</td>
<td>75</td>
<td>3.4</td>
</tr>
<tr>
<td>August</td>
<td>376.3</td>
<td>19</td>
<td>29</td>
<td>23</td>
<td>88</td>
<td>78</td>
<td>2.2</td>
</tr>
<tr>
<td>September</td>
<td>303.3</td>
<td>19</td>
<td>29</td>
<td>23</td>
<td>88</td>
<td>75</td>
<td>2.9</td>
</tr>
<tr>
<td>October</td>
<td>349.9</td>
<td>21</td>
<td>30</td>
<td>23</td>
<td>86</td>
<td>78</td>
<td>2.9</td>
</tr>
<tr>
<td>November</td>
<td>77.8</td>
<td>6</td>
<td>31</td>
<td>23</td>
<td>97</td>
<td>70</td>
<td>4.1</td>
</tr>
<tr>
<td>December</td>
<td>0.4</td>
<td>1</td>
<td>33</td>
<td>22</td>
<td>75</td>
<td>49</td>
<td>4.9</td>
</tr>
<tr>
<td>Total</td>
<td>1,916</td>
<td>137.0</td>
<td>31.8</td>
<td>23.3</td>
<td>82.4</td>
<td>4.3</td>
<td>2,114</td>
</tr>
<tr>
<td>Mean</td>
<td>159</td>
<td>11.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>176</td>
</tr>
</tbody>
</table>
The number of branches plant⁻¹ was obtained by counting all the branches arising from the main stem of the sampled plants, while number of leaves plant⁻¹ was obtained by counting all the fully expanded leaves on the plants. The growth parameters were determined at 8 WAP. Yield parameters such as number of pods plant⁻¹ and number of seeds pod⁻¹ were determined by counting and the mean obtained. Pod length was measured with the aid of a meter rule and expressed in centimeter. Dry matter yield plant⁻¹ (g) and seed yield (kg ha⁻¹) were determined using a weighing balance. Dry matter included oven-dried leaves, stem and roots of sampled plants at 70 °C until constant plant weight was achieved.

Principal component analysis (PCA), which, allows for good visualization of the differences among the individuals and identify possible groups [14] was estimated and used to evaluate the traits contributing to the genotypic variation among the cowpea varieties.

Data on number of branches plant⁻¹, number of leaves per plant, number of pods plant⁻¹, number of seeds pod⁻¹, pod length, dry matter yield plant⁻¹ and seed yield (t ha⁻¹) were subjected to analysis of variance (ANOVA) using the Genstat Discovery Edition 4.23 software [15] while PCA was performed using [16] statistical analysis system (SAS) for Microsoft windows, release 6.12 (1997) in line with PRINCOMP procedure. Least significant differences (LSD) at 5% level of probability were used to detect differences between treatment means following the procedure outlined by [17].

Table 3: Effect of cowpea varieties on some growth yield attributes in 2010 cropping season.

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Number of branches Plant⁻¹</th>
<th>Number of leaves plant⁻¹</th>
<th>Number of branches Plant⁻¹</th>
<th>Number of leaves plant⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT960-610</td>
<td>3.22</td>
<td>34.78</td>
<td>3.33</td>
<td>34.67</td>
</tr>
<tr>
<td>IT90K-277-2</td>
<td>3.33</td>
<td>36.78</td>
<td>3.22</td>
<td>36.67</td>
</tr>
<tr>
<td>Danillo</td>
<td>3.78</td>
<td>29.11</td>
<td>2.89</td>
<td>35.89</td>
</tr>
<tr>
<td>IT89K-374-57</td>
<td>3.89</td>
<td>31.22</td>
<td>3.11</td>
<td>32.67</td>
</tr>
<tr>
<td>IT88K-506-1</td>
<td>3.44</td>
<td>27.67</td>
<td>3.00</td>
<td>28.44</td>
</tr>
<tr>
<td>IT88D-867-11</td>
<td>4.00</td>
<td>30.33</td>
<td>2.44</td>
<td>25.44</td>
</tr>
<tr>
<td>Borno local</td>
<td>4.56</td>
<td>42.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>IT89KD-288</td>
<td>4.11</td>
<td>38.22</td>
<td>4.11</td>
<td>23.11</td>
</tr>
<tr>
<td>IT86D-719</td>
<td>3.78</td>
<td>31.22</td>
<td>3.00</td>
<td>28.00</td>
</tr>
<tr>
<td>IT89KD-391</td>
<td>4.22</td>
<td>37.11</td>
<td>3.33</td>
<td>30.22</td>
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<tr>
<td>IAR 48</td>
<td>3.22</td>
<td>27.33</td>
<td>3.00</td>
<td>27.78</td>
</tr>
<tr>
<td>IT81D-95</td>
<td>4.33</td>
<td>41.78</td>
<td>3.00</td>
<td>23.44</td>
</tr>
<tr>
<td>LSD0.05</td>
<td>0.72</td>
<td>5.107</td>
<td>0.569</td>
<td>4.91</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

In both cropping seasons number of branches plant⁻¹ and number of leaves plant⁻¹ exhibited significant (P<0.05) differences among the cowpea varieties (Table 3). Number of branches plant⁻¹ and number of leaves plant⁻¹ ranged from 3.22 to 4.56 and 27.33 to 42.00 (2010), respectively and from 2.44 to 4.11 and 23.11 to 36.67 (2011), respectively. In 2010, cropping season, IT960-610 and IAR 48 cowpea varieties significantly (P>0.05) had the lowest number of branches plant⁻¹ while IAR 48 had the lowest number of leaves per plant. The trend, however, was not consistent in 2011 cropping season. The differences in the growth parameters assessed were perhaps due to inherit genetic properties of the cowpea varieties studied. Similarly, [18-25] and [26] in their different works on quantitative characters of soybean, mashbean, pea and cowpea varieties reported increased genotypic variability among some growth parameters such as number of leaves plant⁻¹ and number of branches plant⁻¹ and concluded that crop improvement to an extend depends on the magnitude of such variations.

In both cropping seasons, all the yield attributes assessed (number of pods plant⁻¹, number of seeds pod⁻¹, pod length and dry matter yield plant⁻¹) were highly significant (P<0.001) among the cowpea varieties (Table 4) except number of pods plant⁻¹ and dry matter yield plant⁻¹ in 2010. The cowpea variety (IT89KD-391) gave significantly the highest number of seeds per pod
Table 4: Effect of cowpea varieties on some yield attributes of cowpea in 2010 and 2011 cropping seasons

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Number of pods Plant⁻¹</th>
<th>Number of seeds Pod⁻¹</th>
<th>Pod length (cm)</th>
<th>Dry matter yield plant⁻¹ (g)</th>
<th>Number of pods plant⁻¹</th>
<th>Number of seeds pod⁻¹</th>
<th>Pod length (cm)</th>
<th>Dry matter yield plant⁻¹ (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT960-610</td>
<td>16.44</td>
<td>9.00</td>
<td>11.89</td>
<td>29.6</td>
<td>10.78</td>
<td>9.33</td>
<td>10.92</td>
<td>7.82</td>
</tr>
<tr>
<td>IT89K-374-57</td>
<td>19.00</td>
<td>10.11</td>
<td>11.71</td>
<td>29.3</td>
<td>9.33</td>
<td>7.56</td>
<td>9.26</td>
<td>12.41</td>
</tr>
<tr>
<td>IT98K-506-1</td>
<td>15.00</td>
<td>10.44</td>
<td>12.30</td>
<td>25.6</td>
<td>7.56</td>
<td>7.89</td>
<td>10.24</td>
<td>6.48</td>
</tr>
<tr>
<td>IT88D-867-11</td>
<td>11.78</td>
<td>10.44</td>
<td>12.76</td>
<td>27.5</td>
<td>7.44</td>
<td>10.33</td>
<td>10.94</td>
<td>5.20</td>
</tr>
<tr>
<td>Borno local</td>
<td>13.89</td>
<td>8.89</td>
<td>12.63</td>
<td>23.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>IT89KD-288</td>
<td>12.67</td>
<td>9.67</td>
<td>11.71</td>
<td>33.4</td>
<td>6.56</td>
<td>7.11</td>
<td>9.32</td>
<td>4.84</td>
</tr>
<tr>
<td>IT86D-719</td>
<td>14.00</td>
<td>11.22</td>
<td>12.99</td>
<td>43.1</td>
<td>4.78</td>
<td>7.44</td>
<td>9.13</td>
<td>5.80</td>
</tr>
<tr>
<td>IT89KD-391</td>
<td>17.33</td>
<td>12.33</td>
<td>14.32</td>
<td>43.1</td>
<td>5.22</td>
<td>7.56</td>
<td>11.97</td>
<td>11.34</td>
</tr>
<tr>
<td>IAR 48</td>
<td>16</td>
<td>327</td>
<td>81.70</td>
<td>81.70</td>
<td>7.22</td>
<td>7.89</td>
<td>10.60</td>
<td>10.36</td>
</tr>
<tr>
<td>IT81D-95</td>
<td>15.00</td>
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<td>35.4</td>
<td>35.4</td>
<td>4.78</td>
<td>10.12</td>
<td>9.54</td>
<td>12.30</td>
</tr>
<tr>
<td>LSD0.05</td>
<td>ns</td>
<td>1.182</td>
<td>ns</td>
<td>ns</td>
<td>2.73</td>
<td>1.24</td>
<td>1.14</td>
<td>5.19</td>
</tr>
</tbody>
</table>

Table 5: Effect of plant populations on some growth and yield attributes of cowpea in 2010 and 2011 cropping seasons.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Dry matter yield plant⁻¹</th>
<th>Number of leaves plant⁻¹</th>
<th>Number of pods plant⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>40,000</td>
<td>25.30</td>
<td>8.34</td>
<td>32.86</td>
</tr>
<tr>
<td>53,333</td>
<td>41.20</td>
<td>10.12</td>
<td>34.00</td>
</tr>
<tr>
<td>80,000</td>
<td>26.70</td>
<td>9.18</td>
<td>34.28</td>
</tr>
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<td>LSD0.05</td>
<td>6.92</td>
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<td>1.32</td>
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</table>

(12.33) and longest pod length (14.32 cm) relative to the other varieties except IT86D-719 and IAR 48 as it relates to number of seeds per plant as well as IAR 48 as it relates to pod length in 2010. Contrary to our findings in 2010 cropping season, in 2011, number of pods plant⁻¹ and dry matter yield plant⁻¹ showed significant difference with IT960-610 and IT95K-271-2 giving the highest number of pods plant⁻¹ and dry matter yield plant⁻¹, respectively. However, number of seeds pod⁻¹ produced by IT86D-719 and IAR48 cowpea varieties did not differ significantly (P>0.05) from that of IT89KD-391. Also, pod length of IAR48 and IT81D-95 was not different from that of the variety with the longest pod (IT89 KD-39). These variations may be attributed to the inherit transferable parental trait differences in the varieties as well as environmental influence. This observation supports earlier reports of [27-29] as well as [30] in their various studies on genetic variability, heritability and advances in grin yield of cowpea in which they surmised that plants respond differently to environmental factors depending on their genetic make-up and degree of adaptation.

Except dry matter yield plant⁻¹ that was significant in 2010, the other attributes such as number of leaves plant⁻¹ and number of pods plant⁻¹ indicated significance only in 2011 cropping season (Table 5). However, the trend was not the same in both years for all the parameters assessed. Population density of cowpea at 53,333 plants ha⁻¹ significantly (P<0.05) gave the highest dry matter yield plant⁻¹ (41.20 g) compared to the other population densities of 40,000 plants ha⁻¹ (25.30 g) and 80,000 plants ha⁻¹ (26.70 g) in 2010. The trend was the same in 2011, though the values were not significant (P>0.05). In 2011, contrary to the findings of [31] and [32], who reported that number of leaves decreased linearly as plant population increased, our studies revealed that the highest population density (80,000 plants ha⁻¹) gave the highest number of leaves plant⁻¹ but significantly (P<0.05) produced the lowest number of pods plant⁻¹, which was lower by 14 and 12%, compared to cowpea population densities at 40,000 and 53,333 plants ha⁻¹, respectively. Similar observations were reported by [32] and [33].
Table 6: Interaction effects of plant population density and cowpea variety on seed yield (kg ha\(^{-1}\)) in 2010 and 2011 cropping seasons.

<table>
<thead>
<tr>
<th>Varieties</th>
<th>40,000</th>
<th>53,333</th>
<th>80,000</th>
<th>Mean</th>
<th>40,000</th>
<th>53,333</th>
<th>80,000</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT960-610</td>
<td>633</td>
<td>439</td>
<td>632</td>
<td>568</td>
<td>633.30</td>
<td>244.40</td>
<td>600.60</td>
<td>492.80</td>
</tr>
<tr>
<td>IT90K-277-2</td>
<td>750</td>
<td>439</td>
<td>192</td>
<td>460</td>
<td>276.00</td>
<td>238.90</td>
<td>93.80</td>
<td>202.90</td>
</tr>
<tr>
<td>Danillo</td>
<td>750</td>
<td>328</td>
<td>417</td>
<td>498</td>
<td>94.90</td>
<td>49.20</td>
<td>101.20</td>
<td>81.80</td>
</tr>
<tr>
<td>IT89K-374-57</td>
<td>750</td>
<td>324</td>
<td>347</td>
<td>474</td>
<td>855.20</td>
<td>432.60</td>
<td>486.50</td>
<td>591.40</td>
</tr>
<tr>
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<td>750</td>
<td>262</td>
<td>450</td>
<td>487</td>
<td>148.60</td>
<td>87.60</td>
<td>169.50</td>
<td>135.30</td>
</tr>
<tr>
<td>IT88D-867-11</td>
<td>351</td>
<td>189</td>
<td>361</td>
<td>300</td>
<td>91.80</td>
<td>38.80</td>
<td>64.10</td>
<td>64.30</td>
</tr>
<tr>
<td>Borno local</td>
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<td>35</td>
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<td>63</td>
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<td>IT89KD-288</td>
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<td>198</td>
<td>377</td>
<td>314</td>
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<td>74.80</td>
<td>48.30</td>
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<td>431</td>
<td>817</td>
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<td>255</td>
<td>89.20</td>
<td>46.60</td>
<td>76.00</td>
<td>70.60</td>
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<tr>
<td>IT89KD-391</td>
<td>562</td>
<td>236</td>
<td>498</td>
<td>432</td>
<td>67.30</td>
<td>72.20</td>
<td>122.20</td>
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<td>528</td>
<td>221</td>
<td>233</td>
<td>327</td>
<td>147.40</td>
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<td>103</td>
<td>219</td>
<td>172</td>
<td>38.30</td>
<td>19.70</td>
<td>29.90</td>
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<td>Mean</td>
<td>508</td>
<td>238</td>
<td>342</td>
<td>228.60</td>
<td>126.10</td>
<td>171.10</td>
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</table>

LSD0.05

Plant population density = 114.90, ** 31.94, **
Genotype = 110.60, ** 85.20, **
Interaction = ns 142.46, **

The interaction of plant population density and cowpea varieties showed high significant (P<0.05) and consistent increase in seed yield of the cowpea varieties in both cropping seasons (Table 6). Irrespective of population density, cowpea variety IT 960-610 gave the highest seed yield (568 kg ha\(^{-1}\)) followed by Daullo (498 kg ha\(^{-1}\)) in 2010 while in 2011 IT 89KD-374-57 had the highest seed yield (591.40 kg ha\(^{-1}\)) followed by IT 960-610 (492.8 kg ha\(^{-1}\)). Furthermore, irrespective of cowpea variety planted, population density of 40,000 plants ha\(^{-1}\) significantly (P<0.05) gave higher seed yields in 2010 (508 kg ha\(^{-1}\)) and 2011 (228.60 kg ha\(^{-1}\)), by 47 and 45% compared to the mean lowest seed yield obtained under 53,333 plants hectare\(^{-1}\) in 2010 and 2011 cropping seasons.
seasons, respectively. The wide differences in seed yield obtained from the studies could be due to the genetic constituents of the cowpea varieties as well as variations in their population densities. The findings corroborate similar studies by [22] and [34] as well as [26] on bush cowpea.

Furthermore, [35] in their studies on 25 tropical soybean genotypes reported the influence of gene characters on grain yield of the crop, which correlated with the observations we made in our studies on cowpea varieties. The values obtained from the principal component analysis (PCA) of the traits of the cowpea varieties as influenced by population density in 2010 and 2011 cropping seasons (Table 7) revealed that percentage variations among the principle components ranged from 10.54% (PC4) to 26.68% (PC1) and 13.03 % (PC3) to 21.35% (PC1), respectively. In PC1, dry matter yield plant\(^{-1}\) and number of branches plant\(^{-1}\) did not contribute to cowpea grain yield in both years. Under PC2, dry matter yield plant\(^{-1}\), number of seeds plant\(^{-1}\) and pod length were the principal components that contributed to yield in 2010 while in 2011, apart from dry matter yield plant\(^{-1}\), number of leaves plant\(^{-1}\) and seed weight pod\(^{-1}\); all the other characters contributed to grain yield. In PC3, plant characters such as number of branches per plant\(^{-1}\), number of leaves per plant\(^{-1}\), number of pods per plant\(^{-1}\) and plant height with percentage variations of 11.85% contributed to grain yield in 2010 cropping season. However, the trend was not the same in 2012 cropping season. In PC4, with the exception of number of branches plant\(^{-1}\), number of pods plant\(^{-1}\), plant weight and pod length (2010) as well as dry matter yield plant\(^{-1}\) and number of leaves plant\(^{-1}\) (2011), the other principal components did not influence grain yield of cowpea. The results of [14] in their earlier studies on cowpea and [36] in their findings on hybrid maize corroborated these findings, which indicated that principal components such as dry matter yield plant\(^{-1}\), number of seeds plant\(^{-1}\), pod length and number of pods plant\(^{-1}\) could serve as useful materials during breeding, selection and crop improvement in legumes and cereals.

**CONCLUSIONS**

Three cowpea varieties (IT960-610, IT90K-277-2 and IT89 KD-374-57) differed significantly in their growth and yield performance compared to the other varieties. The principal components that determined yield were number of pods plant\(^{-1}\), dry matter yield plant\(^{-1}\), number of seeds plant\(^{-1}\) and pod length, hence, the traits demand special attention during breeding and selection of cowpea. The cowpea varieties IT960-610, IT90K-277-2 and IT89 KD-374-57 produced higher grain yields relative to the other varieties at 40,000 plants ha\(^{-1}\), hence, farmers in the agro-ecological zone of the study area can be encouraged to plant them at the same population density.

**REFERENCES**


