*Original Research Article*

# Response of cowpea (*Vigna unguiculata*, L., Walp) to inter-row spacing and weed competition

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## Abstract

Weed infestation is one of the major factors attributed for the poor yield of cowpea in Nigeria and other parts of sub-Sahara Africa (SSA). Field trials were therefore conducted to evaluate the effect of row spacing and different weeding levels on weed control, growth and yield of cowpea during the early and late wet seasons of 2009. In both seasons, the use of 60 cm row spacing resulted in significant ($P < 0.05$) reduction in weed density by 18–39% and weed biomass by 17–27% with subsequent increase in cowpea growth and grain yield than 75 and 90 cm row spacing. Cowpea grain yield increased by 67–109% in the early season and 24–56% in the late season at 60 compared to 75 and 90 cm row spacing. Hoe weeding reduced weed growth significantly in both seasons with the lowest weed density and biomass recorded in plots weeded thrice. However, this was not significantly different from weed density and biomass recorded with two weedings in both seasons. Hoe weeding twice resulted in optimum growth and grain yield of cowpea. An additional weeding, however, did not improve cowpea growth and yield in both seasons. The results of this study showed that narrow (60 cm) inter-row spacing and two hoe weedings at 3 and 6 weeks after sowing (WAS) will improve weed control and productivity of cowpea. Additional weeding is considered superfluous.

**Keywords:** Weed interference; weed control; row spacing; hand weeding; cowpea.

## INTRODUCTION

Cowpea (*Vigna unguiculata*, L., Walp) is an important economic legume crop of the world. It is the most economically important indigenous legume crop cultivated by farmers in Africa (Timko et al., 2007). Cowpea is of vital importance to the livelihood of several millions of people in sub Saharan Africa (SSA) as a cheap source of protein (23–38%) for human diet and fodder for livestock production (Andargie et al., 2011; Abudulai et al., 2017). It also has ability to improve soil fertility by fixing atmospheric nitrogen in the range of 88–150 kg N/ha, adapt to different types of soils and suitable for inter cropping (Yusuf et al., 2006).

Nigeria is the largest producer and consumer of cowpea in the world with an estimated 45% share of the global cowpea production and over 55% of the production in Africa (Alene et al., 2015). Out of an area of about 12 million ha under cowpea production in SSA, Nigeria accounts for 5 million ha producing over 2.4 million t (Kamara et al., 2014). However, cowpea grain yields in farmers' field are generally low averaging < 500 kg/ha (Abudulai et al., 2017). This is mainly due to high weed infestation, severe attacks of pest, diseases, low soil fertility and inappropriate cultural practices (Ajeigbe et al., 2010; Kamara et al., 2014). Of all these factors, weed infestation is the most deleterious. According to estimates, yield losses caused by weeds alone in cowpea production ranges between 25–76% depending on the level of weed infestation and infesting weed species (Osipitan et al., 2016).

Smallholder farmers control weeds in cowpea using hand hoe, but face high cost as a result of labour shortages. Herbicide use on the other hand does not provide season-long weed control and are often not available to smallholder farmers at the time of need, and when available, farmers lack the requisite knowledge and skill to use herbicides correctly (Ekeleme et al., 2009). Although herbicides use reduce drudgery and alleviate the problem of labour for weeding, incorrect use may bring other environmental problems (Labrada, 2003). A change in outlook from weed control to weed management is thus needed to adequately address the problem posed by weeds in cowpea production. Weed management

**Table 1.** Summary of weather data during the cropping seasons

| Season | | Total rainfall | Average Temperature (°C) | | Relative Humidity (%) |
|---|---|---|---|---|---|
| | | | Max | Min | |
| Early | April | 101.0 | 26.4 | 26.2 | 53.0 |
| | May | 124.0 | 26.6 | 26.1 | 73.0 |
| | June | 140.0 | 26.5 | 26.0 | 72.0 |
| | July | 160.0 | 27.0 | 26.4 | 77.0 |
| Late | August | 162.1 | 26.7 | 26.2 | 80.7 |
| | September | 151.6 | 35.0 | 24.0 | 77.0 |
| | October | 180.1 | 26.9 | 26.4 | 74.7 |
| | November | 64.6 | 26.6 | 26.1 | 68 |

Sourced from Department of Agrometeorological Station, Ogun Osun River Basin Development Authority

involves the integration of knowledge and techniques that minimizes weed emergence and interference with crop (Osipitan et al., 2013). Combining cultural management technique with reduced frequency of hoe weeding will reduce weed interference and reliance on labour. The application of cultural approaches to weed management is gaining worldwide attention in order to improve crop competitiveness against weeds, thus becoming an important component of integrated weed management system (Bhagirath et al., 2013). One of such approaches is the reduction of row spacing to improve crop competitiveness against weeds. Narrow row spacing reduces weed germination and growth, and gives the crop a competitive advantage over weeds due primarily to rapid canopy closure (Chauhan and Johnson, 2011).

According to Knezevic et al. (2003), all crops have a stage during their life cycle when they are particularly sensitive to weed competition. Cowpea usually develops full canopy cover at about 6 weeks after emergence and it can then compete with weeds till maturity (Osipitan et al., 2016). Although the effects of weed competition on crop yield are documented (Osipitan et al., 2016; Adigun et al., 2017), the influence of crop row spacing and/or number of weedings required to achieve minimum weed competition and optimum yield in cowpea is still poorly understood. Since manual weed control is a major aspect of crop production in Nigeria, the future expansion of area under cowpea cultivation is contingent upon appropriate cultural practices such as row spacing that would reduce weed competition and consequently the labour input required for weeding. We hypothesised that efficient weed management and optimum yield of cowpea can be achieved through the integration of narrow row spacing and reduced number of hoe weeding. The objective of this study was therefore to determine the effect of inter-row spacing and different weeding levels on growth and yield of cowpea.

## MATERIALS AND METHODS

### Site description

Field trials were conducted at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Nigeria (07 15′N; 03 25′E) in the Forest Savanna transition zone of South West Nigeria during the early (April–July) and late (August–October) wet season of 2009. The location is characterised by bimodal pattern of rainfall with mean annual rainfall of 1000 mm. The site received a total rainfall of 525 and 423 mm throughout the period of crop growth in the early and late seasons, respectively (Table 1). The soils of the fields had a sandy loam texture, pH of 7.7 and 7.5; organic matter of 2.5 and 2.3% and nitrogen of 0.25 and 0.24% in the early and late seasons, respectively.

### Treatment details

The experiments in both seasons had three row spacings (60, 75 and 90 cm) all at intra row spacing of 30 cm as the main plots treatments, and three weeding levels (one weeding at 3 weeks after sowing; WAS), two weedings at 3 and 6 WAS, three weedings at 3, 6 and 9 WAS) and un-weeded plot (zero-weeding) as the sub plots treatments. All the treatments were arranged in a split-plot design with three replications. The gross and net plot sizes in both seasons were 4.5 m×3.0 m and 3.0 m×3.0 m, respectively. The cowpea variety (var. Ife brown) used in this study is an early maturing and high yielding variety recommended for the Forest Savanna transition zone of South West Nigeria.

### Weed observations

Weed density and species composition were accessed at cowpea maturity from three 1 m×1 m quadrats placed in each plot in each season. Weed dry weight (weed biomass) was measured at cowpea maturity from three 1 m×1 m quadrats placed in each plot in each season.

**Table 2.** Weed flora at the experimental site and their level of occurrence in the early and late season

| Weed species | Plant family | Level of infestation | |
|---|---|---|---|
| | | Early season | Late season |
| **Broad leaf weeds** | | | |
| *Tridax procumbens* (L) | Asteraceae | + + + | + + |
| *Euphorbia heterophylla* (L) | Euphorbiaceae | + + + | + + |
| *Commelina benghalensis* (Burn.) | Commelinaceae | + + + | + + |
| *Gomphrena celosioides* (Mart.) | Amaranthaceae | + + | + |
| *Spigelia anthemia* (L) | Loganiaceae | + | + + |
| *Boerhavia diffusa* (L) | Nyctaginaceae | + | + + |
| *Talinum triangulare* (Jacq.) Willd. | Portulacaceae | + | + + |
| *Laportea aestuens* (L) dhew | Urticaceae | + | - |
| *Ipomea triloba* (L) | Convolvulaceae | + | + + |
| *Chromoleana odorata* (L) R.M. King and Robinson | Asteraceae | + | - |
| *Amaranthus spinosus* (L) | Amaranthaceae | + | + + |
| **Grasses** | | | |
| *Digitaria horizontalis* (Willd.) | Poaceae | + + + | + |
| *Paspalum scrobiculatum* (L) | Poaceae | + + | + + |
| *Panicum maximum* (Jacq) | Poaceae | + + | + |
| *Axonopus compressus* (Sw.) P. Beauv | Poaceae | + + | + + |
| *Eleusine indica* (Gaertn) | Poaceae | + | + |
| *Rottboellia conchinchinensis* (Lour.) Clayton | Poaceae | + | - |
| *Cynodon dactylon* (L) Gaertn | Poaceae | + | + + |
| **Sedge** | | | |
| *Cyperus rotundus* Linn. | Cyperaceae | + + | + |
| *Cyperus esculentus* Linn. | Cyperaceae | + | - |

+ + + - High infestation (60–90%); + + - Moderate infestation (30–59%); + - Low infestation. (1–29%); – not notice

Weeds within each quadrat were clipped to ground level, bulked to form a sample, oven dried at 70 °C to constant weight.

### Cowpea growth and yield observations and measurement

Cowpea canopy height (cm/plant), canopy diameter (cm/plant), number of leaves per plant and leaf area ($cm^2$/plant) at 12 WAS and pod and grain yield (kg/ha) at harvest were the growth and yield parameters used to evaluate the performance of the treatments.

### Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) using GENSTAT discovery package to determine the level of significance of the treatments. Treatment means were separated using the least significant difference (LSD at $P \leq 0.05$).

## RESULTS

### Effect of inter-row spacing and weeding level on weed density and biomass

Twenty (20) weed species were recorded in the early wet season and eighteen (18) in the late wet season (Table 2). There were differences in species composition between the two seasons. Some of the weed species such as *Euphorbia heterophylla*, *Commelina benghalensis*, *Gomphrena celosioides*, *Digitaria horizontalis* and *Panicum maximum* with moderate infestation in the late season were found with high infestation in the early season. Weed density and biomass were significantly affected by row spacing and weeding level in both early and late seasons (Table 3). However, inter-row spacing ×weeding level was not significant for weed density and biomass in the early and late wet seasons (Table 4). There was a significant reduction in weed density and biomass with reduction in row spacing from 90 to 75 and 60 cm in both early and late wet seasons. Weeds in cowpea growing in 75 and 90 cm rows had 1839% greater density and 17–27% greater biomass (data averaged for both early and late seasons) than weeds in cowpea growing in 60 cm row spacing. Similarly, 75 cm row spacing reduced weed density by 20% and biomass by 7% compared to 90 cm row spacing in both early and late wet seasons (data averaged for both early and late seasons).

Weeding levels had significant effect on weed density and biomass in both years. Weed density was similar between plots weeded once and those kept weedy in the early season. However, one hoe weeding

**Table 3.** Effect of row spacing and weeding level on weed density and biomass in cowpea

| | Weed density (no/m²) | | Weed biomass (t/ha) | |
|---|---|---|---|---|
| | Early season | Late season | Early season | Late season |
| **Inter-row spacing (cm)** | | | | |
| **60** | 49.25 | 74.00 | 4.94 | 7.04 |
| **75** | 61.88 | 81.88 | 6.49 | 7.31 |
| **90** | 73.38 | 97.25 | 7.93 | 7.49 |
| **LSD (*P* ≤ 0.05)** | 4.00 | 4.51 | 0.46 | 0.12 |
| **Weeding level** | | | | |
| **Zero weeding** | 70.33 | 124.67 | 11.37 | 14.90 |
| **One weeding** | 69.33 | 87.33 | 5.23 | 6.89 |
| **Two weedings** | 59.00 | 76.33 | 4.64 | 4.10 |
| **Three weedings** | 55.23 | 73.30 | 4.50 | 4.00 |
| **LSD (*P* ≤ 0.05)** | 6.71 | 14.00 | 0.72 | 2.51 |
| **Row spacing × Weeding level** | 12.4 NS | 21.8 NS | 2.4 NS | 4.9 NS |

Interaction: row spacing × weeding level was not significant

**Table 4.** Inter-row spacing × weeding level effect on weed density and weed biomass in cowpea

| | Weeding level | Weed density (no/m²) | | | Weed biomass (t/ha) | | |
|---|---|---|---|---|---|---|---|
| | | Inter-row spacing (cm) | | | | | |
| | | 60 | 75 | 90 | 60 | 75 | 90 |
| **Early season** | Zero weeding | 62.5 | 70.5 | 74.4 | 8.5 | 12.6 | 13.3 |
| | One weeding | 54.7 | 70.4 | 79.9 | 3.6 | 5.6 | 6.8 |
| | Two weedings | 50.0 | 56.9 | 68.7 | 4.5 | 4.3 | 5.0 |
| | Three weedings | 36.0 | 53.9 | 75.3 | 3.5 | 4.6 | 5.4 |
| **LSD (*P* ≤ 0.05)** | | | 12.4ns | | | 2.4ns | |
| **Late season** | Zero weeding | 97.3 | 111.5 | 135.5 | 12.6 | 15.8 | 14.8 |
| | One weeding | 74.4 | 75.1 | 95.3 | 6.7 | 6.9 | 6.8 |
| | Two weedings | 63.5 | 76.4 | 85.2 | 4.7 | 3.0 | 4.4 |
| | Three weedings | 64.5 | 73.6 | 77.6 | 3.6 | 4.5 | 4.0 |
| **LSD (*P* ≤ 0.05)** | | | 21.8NS | | | 4.9NS | |

reduced weed density significantly compared to the weedy plot in the late season. Two hoe weedings reduced weed density significantly compared to one hoe weeding in the early season; however, one and two hoe weeding treatments recorded similar weed density in the late season. Weed density and biomass was similar between plots weeded twice and those weed thrice in the early and late wet seasons. Plots weeded thrice had lower weed density and biomass than those weeded once or kept weedy (Table 3). During the early season, average weed density was reduced by 16% at two weedings and 21% at three weedings compared to the Zero-weeding control. During the late season, average weed density was reduced by 39% at two weedings and 41% at three weedings compared to the Zero-weeding control. Similarly, weed biomass was reduced by 58%at two weedings in the early season and 70.7% in the late season. The corresponding reduction at three weedings was 59% in the early season and 71.4% in the late season compared to zero weeding treatment.

## Effect of inter-row spacing and weeding level on growth and yield of cowpea

Row spacing and weeding levels significantly affected growth and yield of cowpea in both early and late seasons (Table 5). However, inter-row spacing × weeding level interaction was not significant for all the growth and yield attributes in both early and late wet seasons (Tables 6 and 7). The use of 60 cm row spacing resulted in significant increase in canopy height, canopy diameter and number of leaves than 75 and 90 cm row spacing. Similarly, the use of 75 cm row spacing resulted in significant increase in canopy diameter in the early season, and number of leaves in the early and late seasons than 90 cm row spacing. However, difference in

**Table 5.** Effect of row spacing and weeding level on growth and yield of cowpea in the early and late seasons

| | Canopy height (cm) | | Canopy diameter (cm) | | Number of leaves | | Leaf area (cm²) | | Pod yield (kg/ha) | | Grain yield (kg/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Early | Late | Early | Late | Early | Late | Early | Late | Early | Late | Early | Late |
| **Inter-row spacing (cm)** | | | | | | | | | | | | |
| **60** | 58.32 | 59.19 | 35.03 | 37.97 | 92.37 | 93.83 | 94.88 | 100.71 | 672.11 | 791.25 | 483.40 | 527.49 |
| **75** | 56.29 | 57.15 | 34.94 | 38.78 | 90.92 | 92.29 | 95.02 | 100.46 | 546.57 | 620.47 | 386.19 | 418.39 |
| **90** | 55.20 | 56.07 | 32.46 | 37.25 | 88.52 | 89.38 | 92.00 | 100.30 | 342.30 | 422.38 | 231.05 | 336.33 |
| **LSD ($P \leq 0.05$)** | 1.78 | 2.32 | 0.66 | 1.86 | 1.64 | 1.63 | 3.7ns | 4.0ns | 45.88 | 47.47 | 24.04 | 24.03 |
| **Weeding level** | | | | | | | | | | | | |
| **Zero weeding** | 61.27 | 62.58 | 28.18 | 30.24 | 57.68 | 58.67 | 81.76 | 88.87 | 237.98 | 347.5 | 202.77 | 229.11 |
| **One weeding** | 53.28 | 53.94 | 29.77 | 33.19 | 103.56 | 82.67 | 86.64 | 91.18 | 334.73 | 439.00 | 295.78 | 265.44 |
| **Two weedings** | 56.53 | 54.57 | 34.52 | 39.94 | 111.00 | 113.90 | 103.38 | 110.30 | 665.09 | 743.78 | 474.88 | 575.69 |
| **Three weedings** | 53.90 | 57.20 | 38.23 | 43.68 | 104.00 | 106.33 | 92.06 | 118.77 | 695.46 | 795.33 | 495.58 | 595.22 |
| **LSD ($P \leq 0.05$)** | 3.84 | 4.58 | 4.12 | 5.32 | 8.4 | 9.96 | 11.25 | 8.61 | 72.66 | 125.69 | 51.68 | 113.21 |
| **Row spacing × Weeding level** | 8.5ns | 10.9ns | 9.6ns | 11.9ns | 15.3ns | 17.8ns | 34.7ns | 47.5ns | 246.7ns | 343.5ns | 298.8ns | 313.5ns |

Interaction: row spacing × weeding level was not significant

**Table 6.** Inter-row spacing × weeding level effect on canopy height, canopy diameter and number of leaves of cowpea

| | Weeding level | Canopy height (cm) | | | Canopy diameter (cm) | | | Number of leaves | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Inter-row spacing (cm) | | | | | | | | |
| | | 60 | 75 | 90 | 60 | 75 | 90 | 60 | 75 | 90 |
| **Early season** | Zero weeding | 59.32 | 60.33 | 63.40 | 30.20 | 27.15 | 28.71 | 58.82 | 54.40 | 50.81 |
| | One weeding | 54.30 | 54.33 | 51.11 | 30.41 | 30.33 | 29.10 | 105.71 | 103.81 | 91.40 |
| | Two weedings | 59.40 | 54.90 | 54.31 | 36.81 | 35.20 | 30.52 | 102.42 | 110.00 | 116.00 |
| | Three weedings | 56.40 | 53.41 | 53.40 | 40.90 | 36.81 | 38.60 | 104.73 | 103.60 | 100.31 |
| **LSD ($P \leq 0.05$)** | | | 8.5ns | | | 9.6ns | | | 15.3ns | |
| **Late season** | Zero weeding | 65.40 | 59.80 | 62.31 | 30.51 | 31.60 | 30.21 | 59.83 | 61.940 | 54.32 |
| | One weeding | 53.41 | 56.71 | 52.20 | 33.40 | 34.31 | 32.30 | 85.71 | 84.31 | 80.60 |
| | Two weedings | 54.40 | 54.42 | 55.40 | 40.41 | 42.61 | 38.51 | 115.70 | 112.50 | 115.81 |
| | Three weedings | 59.52 | 56.90 | 55.22 | 45.61 | 41.72 | 43.60 | 108.70 | 107.90 | 103.40 |
| **LSD ($P \leq 0.05$)** | | | 10.9ns | | | 11.9ns | | | 17.8ns | |

**Table 7.** Inter-row spacing × weeding level effect on leaf area, pod yield and grain yield of cowpea

| | Weeding level | Leaf area (cm²) | | | Pod yield (kg/ha) | | | Grain yield (kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Inter-row spacing (cm) | | | | | | | | |
| | | 60 | 75 | 90 | 60 | 75 | 90 | 60 | 75 | 90 |
| **Early season** | Zero weeding | 82.30 | 84.60 | 81.44 | 238.60 | 237.90 | 238.93 | 200.50 | 201.52 | 202.60 |
| | One weeding | 89.54 | 87.70 | 84.40 | 332.70 | 336.81 | 336.90 | 301.51 | 284.61 | 300.70 |
| | Two weedings | 106.80 | 107.81 | 99.31 | 996.81 | 664.81 | 505.41 | 476.52 | 475.50 | 470.92 |
| | Three weedings | 95.61 | 94.23 | 99.42 | 1122.90 | 950.90 | 298.90 | 954.80 | 585.91 | 200.90 |
| **LSD ($P \leq 0.05$)** | | | 34.7ns | | | 246.7ns | | | 298.8ns | |
| **Late season** | Zero weeding | 89.92 | 87.80 | 88.00 | 349.50 | 358.60 | 335.84 | 232.91 | 230.82 | 223.62 |
| | One weeding | 90.43 | 92.30 | 90.33 | 443.61 | 435.55 | 437.65 | 270.50 | 260.70 | 262.90 |
| | Two weedings | 113.32 | 109.60 | 104.80 | 749.50 | 743.54 | 736.12 | 588.90 | 578.71 | 567.91 |
| | Three weedings | 111.90 | 113.81 | 119.90 | 1620.41 | 942.60 | 300.91 | 999.61 | 600.90 | 287.90 |
| **LSD ($P \leq 0.05$)** | | | 47.5ns | | | 343.5ns | | | 313.5ns | |

canopy diameter in the late season, and canopy height in the early and late seasons was not significant between 75 and 90 cm row spacing. The highest pod (672 kg/ha) and grain (483 kg/ha) yields in the early season were obtained from crops planted at 60 cm row spacing. Similarly, highest pod (791 kg/ha) and grain (527 kg/ha) yields in the late season were obtained from crops planted at 60 cm row spacing, indicating a 17.7% and 9% increase in pod and grain yields, respectively, in the late compared to the early season. During both seasons, cowpea pod and grain yields increased significantly with reduction in row spacing from 90 to 75 and 60 cm. Cowpea pod yield increased by 60–96% in the early season and 47–87% in the late season at 60 compared to 75 and 90 cm row spacing. Similarly, cowpea grain yield increased by 67–109% in the early season and 24–56% in the late season at 60 compared to 75 and 90 cm row spacing. The use of 75 cm row spacing increased pod and grain yields by 46–60% and 24–67%, respectively, more than 90 cm row spacing in both seasons.

Difference in canopy height was not significant among crops weeded once, twice and thrice in both early and late wet seasons. Crops in the weedy plots significantly grew taller than those subjected to one, two and three weeding levels in both early and late seasons. However, canopy diameter, leaf area, pod and grain yields were significantly improved by two weedings compared to one weeding and zero-weeding treatments in both early and late seasons. An additional weeding, however, had no significant effect on cowpea growth and yield in both seasons. Number of leaves was improved significantly by two and three hoe weedings compared to one weeding only in the late season. These treatments recorded similar number of leaves in the early season.

## DISCUSSION

### Effect of row spacing and weeding level on weed density and biomass

Higher weed growth in early compared to late wet season in this study was probably due to higher total rainfall recorded in the former than in the latter. It has been reported that rainfall affects weed species distribution and their competitiveness within a weed community (Adigun et al., 2017). However, the result of this study showed that weed density and biomass were reduced significantly with reduction in cowpea inter-row spacing from 90–75 and 60 cm in both seasons. This was probably due to increased crop competitiveness and rapid canopy closure which could have limited light penetration to the weeds emerging below cowpea canopy at narrow compared to wide inter-row spacing (Dalley et al., 2004). That idea was supported by our observation that cowpea planted at 60 cm inter-row spacing achieved complete shading of the ground 15–25 days earlier than those planted at 75 and 90 cm inter-row spacing in both early and late wet seasons (data not shown). This result is consistent with the reports of Adigun et al. (2017) in groundnut and Daramola et al. (2019) in soybean.

Similar weed density and biomass recorded in plots weeded thrice and those weeded twice in both early and late wet seasons indicates that weed control in cowpea can be achieved by two weedings done between 3 and 6 WAS. Additional weeding is, however, considered superfluous. This result showed that if weeds were controlled within the first 6 WAS, the canopy of cowpea can suppress late emerging weeds. Daramola et al. (2019) reported a similar result in which weed removal until 6 WAS only was sufficient for effective weed control in narrow row soybean.

### Effect of row spacing and weeding level on growth and yield of cowpea

Lower pod and grain yields in the early compared to the late wet season may be attributed to higher weed infestation occasioned by higher total rainfall in the former than in the latter. Significantly higher cowpea growth and yield observed with reduction in row spacing in this study was probably due to reduced weed competition for growth resources at narrow compared to wide row spacing. Previous findings of Acciaresi and Zuluaga (2006) have shown that there is a better use of resources (moisture, light and nutrient) for crop growth and yield at narrow compared to wide row spacing as a result of reduced weed competition. Furthermore, the rapid canopy development at narrow row spacing might have resulted in more light interception per unit leaf area index, thereby increasing photosynthetic rates of the leaves and hence, better growth and development (Zhao et al., 2013). There were two obvious advantages in narrow row spacing; first, there was rapid and better canopy formation for effective weed suppression, coupled with higher plant population for enhanced productivity.

Increase in canopy height in the weedy plots compared to hoe weeded plots in this study was probably due to increased competition among crops and weeds mostly for light. Mutual shading in weedy plots could have contributed to stem elongation and ultimately canopy height increase (Pederson and Lauer, 2003). Furthermore, competition and requirement for light interception might have prompted the crops to grow significantly taller than crops kept weed-free.

In this study, hoe weeding thrice did not increase cowpea growth and yield significantly compared to hoe weeding twice. This was probably because two and three hoe weedings resulted in similar weed control effect in both early and late wet seasons. This result showed that hoe weeding twice was adequate for optimum yield of cowpea and could be cost effective in cowpea production compared to three weedings with the advent of increase cost of labour for hoe weeding.

## CONCLUSION

The results of this study demonstrated the benefits of narrow (60 cm) over intermediate (75 cm) and wide (90 cm) row spacings for early vigour, weed competitiveness and consequently higher cowpea yield. Our study also showed that hoe weeding twice at 3 and 6 WAS is sufficient for effective weed control and optimum growth and yield of cowpea. The use of narrow (60 cm) row spacing with hoe weeding twice at 3 and 6 WAS is therefore recommended to farmers for efficient weed control and optimum cowpea yield.

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