

# Evaluation of pre-emergence herbicides for weed control in cowpea (*Vigna unguiculata* (L.) Walp.) in a forest - savanna transition zone

Omoybude, Sunday<sup>1</sup> and Udensi, Ekeke Udensi<sup>1\*</sup>

<sup>1</sup>Department of Crop and Soil Science, University of Port Harcourt, East-West Road, Choba P.M.B 5323 Port Harcourt, Nigeria

## Authors' contributions

This work was carried out in collaboration between the authors. OS designed the study, performed the statistical analysis, wrote the protocol, and the first draft of the manuscript. UEU assisted in the organization of the data, reviewed the manuscript and literature, designed the economic analyses of the study and prepared the manuscript for publication. Authors read and approved the final manuscript.

## ABSTRACT

**Aims:** To evaluate the efficacy and economic benefits of selected pre-emergence herbicides for weed control in cowpea

**Study design:** Randomized complete block design with four replications was used.

**Place and Duration of Study:** Research and Teaching Farm of Ambrose Alli University in Ekpoma (Lat. 6° 45'N, Long. 6° 8'E), in a forest-savanna transition zone of Nigeria, between August 2005 and August 2006

**Methodology:** Five weed control treatments evaluated against unweeded control were; Codal gold<sup>(R)</sup> (250g prometryne + 162.5 g metolachlor per litre) at a rate of 1.65 kg a.i ha<sup>-1</sup>, Galex<sup>(R)</sup> (Metolachlor 250g + metobromuron 250g per litre) at the rate of 3.0 kg a.i ha<sup>-1</sup>; Pendilin<sup>(R)</sup> (Pendimethalin 500g per litre) at a rate of 2.0 kg a.i ha<sup>-1</sup>, one hoe – weeding at 3 weeks after planting (WAP) and two hoe weeding at 3 and 7 WAP.

**Results:** Herbicides treatments and hoe weeded twice gave an acceptable (≥70%) weed control in both years. Cowpea yield was best under Codal gold at 1.65 kg a.i ha<sup>-1</sup> (with an average yield of ≥ 1600kg ha<sup>-1</sup>) while the unweeded control had the poorest yield (between 800 and 900 kg ha<sup>-1</sup>) in both years. The highest profit was obtained under Codal gold at 1.65 kg a.i ha<sup>-1</sup> and the lowest in plot hoe weeded twice. The highest cost benefit ratio (CBR) of 24.61 in 2005 and 28.21 in 2006 were recorded with Codal gold<sup>(R)</sup> treated plot while the lowest of 1.25 and 1.22 were obtained in 2005 and 2006 respectively under plot hoe weeded twice.

**Conclusion:** Codal gold<sup>(R)</sup> at 1.65 kg a.i ha<sup>-1</sup> was better than the other herbicides tried, in reducing weed infestation in cowpea as evidenced on the performance, yield of cowpea and higher economic returns. With the range of herbicides tried in this study, Codal gold<sup>(R)</sup> at 1.65 kg a.i ha<sup>-1</sup> appears to be the best herbicide for weed control in cowpea under the present study.

\* Tel.: +234 0703502542. E-mail address: [ueudensi@yahoo.co.uk](mailto:ueudensi@yahoo.co.uk) or [udensi.udensi@uniport.edu.ng](mailto:udensi.udensi@uniport.edu.ng)

**Keywords:** Cowpea, herbicides, weed smothering efficiency, CBR.

## ABBREVIATIONS

CBR: Cost Benefit Ratio; LSD: least significant difference; ANOVA: Analysis of variance; CBN: Central Bank of Nigeria.

## 1. INTRODUCTION

Cowpea (*Vigna unguiculata* (L) Walp.) is an annual legume that is widely cultivated in Nigeria mainly for its edible seeds. A more recent and reliable statistics, by Food and Agricultural Organization (FAO) reported that about 7.56 million tons of cowpea were produced annually on about 12.76 million hectares of land (IITA, 2007). Sub – Saharan Africa was reported to account for about 70% total World Production (IITA, 2007). Nigeria is still said to be the world largest cowpea producer where about 2 million tones are produced per annum. This is followed by Niger (650,000 tons) and Mali with 110, 000 tones (IITA, 2001).

Average world yield of cowpea grain is quite low at less than 0.3 ton/ha. Within Africa, average cowpea yields range from 0.05 to 0.55 ton/ha (Cisse *et al*, 1995). Alghali (1992) reported 200-300 kg ha<sup>-1</sup> in Nigeria and more than 2000kg ha<sup>-1</sup> under research environment (Rusoke and Rubaibage, 1994). Among other factors limiting cowpea production, inadequate weed control had been identified as a major contributory factor for yield gap. Uncontrolled weed growth and/or inadequate weed control in the crop have been reported to account for 40-80% reduction, in grain yield (Olofintoye and Adesiyun, 1989, Tijani – Eniola, 2001). Crop losses by weeds could be aggravated by delay in weeding or inability to weed through the entire crop growth period. However, studies of the threshold levels of weeds have shown that complete weed eliminations is not essential for high yields (Sangakkara, 1999), probably because the crop can also compete strongly with weeds, after the critical period of weed interference.

The critical period of weed competition for cowpea is the first 3 – 4 weeks of crop growth (Akinyemiju and Echendu, 1987). Weed competition has the capability of lowering vegetative growth, flowering, fruiting and seed production, which will determine yield. Whenever possible, several weed control methods which include, cultural, biological or chemical could be used separately or in combination to give the desired result (Gibson *et al* 2007).

Weed reduced crop yield by interfering with crop growth. Hand weeding limits agricultural productivity because there is a limit to the amount of land area that can be weeded even when the labor is free (Akobundu, 1987). Hand weeding required over 50% of the farmers' time leaving him and his family with little or no time for other activities (Akobundu, 1987). Use of herbicides may therefore provide a timely and adequate alternative to hand weeding as this will not only remove the drudgery associated with it but also lower the cost of weeding and provide protection for crop against early weed competition when pre-emergence herbicides are used (Akobundu, 1987).

Presently, existing herbicides for pre-emergence weed control in cowpea are no longer consistent in their spectrum of effective weed control. This may be as a result of some weeds becoming resistant to these herbicides. Codal gold<sup>(R)</sup> which is one of the recently introduced new herbicides in the early twenty (20<sup>th</sup>) century in Nigeria had not been widely experimented upon by farmers. Hence, the objective of this study was to assess the effectiveness of selected pre-emergent herbicides [Galex<sup>(R)</sup> and Pendilin<sup>(R)</sup>(old herbicides) and Codal gold<sup>(R)</sup> (new herbicide) ] for weed control and their economic returns in cowpea.

## 2. MATERIAL AND METHODS

### 2.1 Experimental site

The experiment was conducted between August and December, 2005 and repeated in the same season of 2006 at the Teaching and Research Farm of Ambrose Alli University (Latitude 6° 45', 6° 8' E and an altitude of 313 metres above sea level) in the forest – savanna transitions zone of Nigeria. The experimental site was under short fallow for about two (2) years, previously cropped to maize. Pre-cropping vegetation in the experimental site was dominated by *siam weed* (*Chromolaena odorata* (L) R.M. King & Robinson), goat weed (*Ageratum conyzoides* Linn), broom weed (*Sida acuta* Burm F), guinea grass (*Panicum maximum* Jacq) and *Cyperus* spp. Soil samples were randomly collected from 10 spots (0-15cm depth) over the entire field using an auger before the commencement of the experiment. The soil samples were bulked and mixed thoroughly for analysis. The soil analysis results are presented in Table 1.

**Table 1: Physico- chemical properties of the top soil (0-15cm) of the experimental site before cropping in 2005 and 2006**

| Soil Properties                        | Values |        | Methods                                                                  |
|----------------------------------------|--------|--------|--------------------------------------------------------------------------|
|                                        | 2005   | 2006   |                                                                          |
| Sand (g/kg)                            | 950.00 | 951.00 | Hydrometer method ( Gee and Bauder, 1986)                                |
| Silt (g/kg)                            | 45.00  | 46.00  | Hydrometer method( Gee and Bauder, 1986)                                 |
| Clay (g/kg)                            | 5.00   | 3.00   | Hydrometer method( Gee and Bauder, 1986)                                 |
| p <sup>H</sup> (H <sub>2</sub> O, 1.1) | 6.20   | 6.50   | Glass electrode in soil: water ratio (Mclean, 1982)                      |
| Organic carbon (g/kg)                  | 14.00  | 12.00  | Wet Oxidation (Walkey and Black, 1934)                                   |
| Total N (g/kg)                         | 0.90   | 0.70   | Macro-Kjedahl (Jackson, 1958)                                            |
| Available P (mg/kg)                    | 15.40  | 16.78  | Bray II Method (Bray and Kurtz, 1945)                                    |
| Exchangeable cations (cmol/kg)         |        |        |                                                                          |
| Ca                                     | 3.90   | 3.70   | Ammonium Acetate Method(Tel and Rao 1982)                                |
| Mg                                     | 2.10   | 1.90   | Ammonium Acetate Method(Tel and Rao 1982)                                |
| K                                      | 0.29   | 0.26   | Ammonium Acetate Method(Tel and Rao 1982)                                |
| Na                                     | 0.30   | 0.24   | Ammonium Acetate Method(Tel and Rao 1982)                                |
| TE A (cmol/kg)                         | 0.60   | 0.40   | Summation method H <sup>+</sup> and Al <sup>3+</sup> (Tel and Rao, 1982) |
| ECEC (cmol/kg)                         | 7.19   | 6.50   | Summation of TEB and TEA (IITA , 1979)                                   |

TE A = Total Exchangeable Acidity  
ECEC = Effective Cation Exchange Capacity  
TEB = Total Exchangeable Bases

The soil in both years was neutral sandy, moderate organic carbon, low nitrogen and acidic. Phosphorus (P) and Potassium (K) values were adequate. Number of rainy days and total rain fall during the trials are presented in Table 2.

**Table 2 Monthly and Rainfall during 2005 and 2006 trial.**

| Months    | 2005       |                    | 2006       |                    |
|-----------|------------|--------------------|------------|--------------------|
|           | Rainy Days | Rainfall Days (mm) | Rainy Days | Rainfall Days (mm) |
| January   | 1          | 60.2               | 2          | 5.3                |
| February  | 3          | 107.0              | 2          | 9.2                |
| March     | 3          | 45.2               | 6          | 96.9               |
| April     | 6          | 108.0              | 5          | 112.0              |
| May       | 10         | 180.9              | 13         | 234.1              |
| June      | 17         | 376.8              | 15         | 292.7              |
| July      | 21         | 439.6              | 19         | 449.9              |
| August    | 7          | 38.3               | 15         | 348.1              |
| September | 20         | 351.6              | 28         | 554.2              |
| October   | 12         | 320.2              | 19         | 41.2               |
| November  | 2          | 145.7              | 1          | 2.2                |
| December  | 2          | 3.2                | 0          | 0.0                |
| Total     | 104        | 2176.7             | 125        | 2145.8             |
| Mean      | 8.69       | 187.4              | 10.42      | 178.8              |

**Source:** Edo State Agricultural Development Project (EADP), Irrua, Edo State, 2005 and 2006

The total rainfall was 2176.7mm distributed over 104 days in 2005 and 2145.8mm distributed in 2006 over 125 days in 2006 (Table 2).

## 2.2 Field Procedures

The land was manually slashed, stumped before leveling the soil surface with spades. Plot size was 3m x 4m with an alley way of 1m among plots and between replicates. There was thus, a total of 28 plots occupying an experimental area of 23m× 19m (437m<sup>2</sup>) corresponding to approximately 0.04ha. There were six (6) treatments involved in the experiment and which included no weeding(control), weeding once at 3 weeks after planting (WAP), weeding twice at 3 and 7 WAP, Galex<sup>(R)</sup> at 3.0kg a.i./ha, Codal gold<sup>(R)</sup> at 1.65 kg a.i /ha and pendilin<sup>(R)</sup> at 2.0kgai/ha. The chemical names of the herbicides are shown in Table 3.

124 **Table 3: Chemical names of Herbicides used in the Study**

| Trade name   | Chemical name                                                                                                                                                                                                          |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pendilin®    | [N-(1-ethylpropyl) – 3,4 – dimethyl 1-2, 6 dinitro benzenamine]                                                                                                                                                        |
| Galex ®      | Metobromuron,( 2-chloro – N-(2-ethyl – 6- methyl phenyl) – N- (2- methoxy - 1-methyl ethyl acetamide + Metolachlor (N <sup>1</sup> – 4 (4- bromophenyl) – N- methoxy – N- methyl urea]                                 |
| Codal gold ® | Prometryne, [N, N <sup>1</sup> – bis (1-methyl ethyl) – 6- ( methylthio) – 1, 3, 5-triazine – 2, 4-diamine + Metolachlor (2 chloro – N- (2-ethyl – 6- methyl phenyl) – N- ) (2- methoxyl – 1- methyl ethyl) acetamide] |

125

126

127 The cowpea cultivar Ife brown (IT84S-2246-4) used for the experiment was obtained from  
 128 International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Cowpea seeds were planted on  
 129 30<sup>th</sup> of August in 2005 and 31<sup>st</sup> of August 2006 at a spacing of 60cm×25cm. Two seeds were  
 130 planted per hole and the seedlings thinned to one per stand at 2WAP, giving a desired population of  
 131 66667 plants/ha. No fertilizer was applied to the crop. The herbicides were applied at the specific  
 132 rate of each herbicides using CP3 knapsack sprayer calibrated to deliver approximately 250L/ha at  
 133 210kpa using a red poliject nozzle (Chikoye *et al.*, 2005). The first hand weeding was done by  
 134 hoeing at 3WAP and the second weeding at 7 WAP in both years.

135

### 136 **2.3 Data collection and Analysis**

137 Weed density was recorded at final harvest. Weed samples were collected from 1m x 1m  
 138 quadrat per plot, bulked and oven dried at 80<sup>0</sup>C for 48 hours. Weed smothering efficiency (WSE) of  
 139 the different weed control methods was calculated according to Subramanian *et al.* (1991).

140

$$141 \quad WSE\% = \frac{WDWC - WDWT}{WDWC} \times \frac{100}{1}$$

142 Where:

143 WSE = Weed smothering Efficiency

144 WDWC = Weed dry weight of unweeded control

145 WDWT = Weed dry weight in treated plots

146 The crop parameters determined were:

147 **Number of leaves/ Plant:** The numbes of leaves were obtained by physical count of six (6) tagged  
 148 plants randomly selected from the net plots (3m<sup>2</sup>). The average of the 6 plants was taken as number  
 149 of leaves per plant.

150 **Plant height:** This was done by randomly selecting 6 plants from the net plot size of 3m<sup>2</sup> and  
151 measured their vine length from the soil level to the tip of the apical bud with a measuring tape. The  
152 mean of the plant heights was recorded per plant.

153 **Leaf area:** This was done by randomly selecting 6 plants and tagged. The leaf area was determined  
154 by graph tracing method. The total leaf area per plant was calculated as leaf area multiplied by the  
155 number of leaves using Remison (1997) procedures.

156 **Days to 50% flowering:** This was estimated by counting the number of days from sowing to the  
157 time when half of the plants start to produce flowers.

158 **Number of seeds/plant:** This was estimated as:

159 
$$\frac{\text{number of seeds per net plot}}{\text{number of plants per net plot}}$$

160 **Number of pods/plant:** This was estimated as:

161 
$$\frac{\text{number of harvested pods per net plot}}{\text{number of plants per net plot}}$$

162

163

164 **2.4 Cowpea grain yield:** Harvesting was assessed from net plot of 3m<sup>2</sup>. The pods were  
165 handpicked and four pickings were done at weekly intervals starting from 56 days after planting  
166 (DAP). The pods were sun dried for one week and then shelled. The grain yield in each net plot was  
167 weighed with weighing balance and the weight recorded. The yield per net plot was extrapolated to  
168 kilograms per hectare (kg/ha).

169

170 The statistical model of the trial was based on randomized complete block design. All agronomic  
171 data were subjected to ANOVA and, where appropriated means were separated using Fisher's  
172 protected LSD at 5% level of probability.

173

174

175 **2.5 Economic Assessment:** Economic evaluation of the weed control treatment was done  
176 using partial farm budgeting (Okoruwa et al., 2005) at prevailing labor and market costs of materials  
177 to estimate revenue. Sale revenue was obtained by multiplying the final grain yield (kg ha<sup>-1</sup>) by the  
178 market price (₦ kg<sup>-1</sup>). This is represented below in the following formula:

179 (i) Revenue = Yc x Pc (where, Yc = cowpea yield in kilogram/ ha; Pc = Price of cowpea grain.  
180 The profit was calculated by subtracting the costs of production from the sale revenue  
181 represented as follows:

182 (ii) Profit (net revenue) = Revenue – Total cost of Production

183 (iii) Simple proportion of total cost of weed control (cost of production) and net revenue (profit)  
184 were used to determine the cost/ benefits ratio (CBR) of each of the weed control  
185 treatment as follows:

186 Cost Benefit Ratio (CBR) = Profit (net revenue)/ Total cost of production.

187

### 3. RESULTS

#### 3.1 Weed growth and Control

Weed density and weed dry weight were significantly influenced by weed control treatments at final harvest in 2005 and 2006 cropping seasons (Table 4).

**Table 4: Effect of the weed control treatments on weed density, biomass, and weed smothering efficiency at harvest in 2005 and 2006 cropping season**

| Treatment                 | Rate<br>(kg<br>a.i./ha) | Weed density (no/m <sup>2</sup> ) |        | Weed dry weight<br>(g/m <sup>2</sup> ) |        | Weed smothering<br>efficiency (WSE) (%) |       |
|---------------------------|-------------------------|-----------------------------------|--------|----------------------------------------|--------|-----------------------------------------|-------|
|                           |                         | 2005                              | 2006   | 2005                                   | 2006   | 2005                                    | 2006  |
| No weeding                | -                       | 197.00                            | 222.25 | 118.85                                 | 202.00 | -                                       | -     |
| Codal gold <sup>(R)</sup> | 1.65                    | 61.25                             | 67.00  | 15.58                                  | 19.50  | 87.08                                   | 90.35 |
| Galex <sup>(R)</sup>      | 3.0                     | 90.00                             | 116.00 | 19.93                                  | 29.75  | 82.72                                   | 85.27 |
| Pendilin <sup>(R)</sup>   | 2.0                     | 90.25                             | 117.00 | 20.78                                  | 28.00  | 83.06                                   | 86.07 |
| Weeded x 1 (3WAP)         | -                       | 125.00                            | 151.25 | 85.00                                  | 84.25  | 29.19                                   | 58.67 |
| Weeded x 2 (3 + 7WAP)     | -                       | 90.25                             | 115.75 | 23.50                                  | 31.00  | 80.18                                   | 84.56 |
| LSD(P = 0.05)             |                         | 4.667                             | 9.548  | 7.139                                  | 2.510  | 1.134                                   | 3.286 |

All the herbicides reduced weed density considerably over the weedy checks. Codal gold<sup>(R)</sup> at 1.65 kg a.i /ha was most effective in suppressing weeds compared to the rest of the treatments. The differences observed on weed density for plots treated with Galex<sup>(R)</sup> at 3.0 kg a.i /ha, Pendilin<sup>(R)</sup> at 2.0 kg a.i /ha and plots hoe – weeded twice were not significant, but they differ significantly from plots hoe weeded once. Weed dry weight was significantly reduced by herbicide application in both years.

In 2005 the lowest weed dry weight was recorded in Codal gold<sup>(R)</sup> treated plots at 1.65 kg a.i /ha but it was similar with Galex<sup>(R)</sup> at 3.0 kg a.i /ha and Pendilin<sup>(R)</sup> plots at 2.0 kg a.i /ha but differs significantly from plots hoe-weeded twice. Though plot hoe weeded twice had high weed dry weight, it was comparable with that of Galex<sup>(R)</sup> at 3.0 kg a.i /ha and Pendilin<sup>(R)</sup> treated plots at 2.0 kg a.i /ha. In 2006, plots hoe- weeded twice differ significantly (P < 0.05) in dry weight from Pendilin<sup>(R)</sup> treated plots at 2.0 kg a.i /ha, but it had a comparable value with that of Galex<sup>(R)</sup> treated plot at 3.0 kg a.i /ha. Weed smothering efficiency in both years was distinctly higher in Codal gold<sup>(R)</sup> plots at 1.65 kg a.i /ha than Pendilin<sup>(R)</sup> treated plots at 2.0 kg a.i /ha, Galex<sup>(R)</sup> treated plot at 3.0 kg a.i /ha, plot hoe weeded twice (3 and 7 WAP) and plot hoe weeded once (3 WAP) in that order.

### 217 3.2 Vegetative Growth Characteristics

218 Leaves produced in unweeded plots was significantly lower than the treatment plots. Plots treated  
 219 with Codal gold<sup>(R)</sup> at 1.65 kg a.i /ha had the highest number of leaves. There were no significant  
 220 differences ( $P>0.05$ ) among Galex<sup>(R)</sup> at 3.0 kg a.i /ha, Pendilin<sup>(R)</sup> at 2.0 kg a.i /ha and plots hoe  
 221 weeded twice in leaf production but they differ significantly from plots hoe – weeded once (Table5).

222 Plant height was significantly influenced by different herbicides treatments (Table5). Among  
 223 the treatments Codal gold<sup>(R)</sup> at 1.65 kg a.i /ha produced the tallest plants while the shortest plant  
 224 was observed in weedy check. There were no significant different among Galex<sup>(R)</sup> at 3.0 kg a.i /ha,  
 225 Pendilin<sup>(R)</sup> at 2.0 kg a.i /ha and plot- hoe weeded twice since uniform plant height were observed in  
 226 them, but they differ from plot hoe weeded once, which had medium plant height.

227 Leaf area showed significant difference ( $P<0.05$ ) among the treatments. Codal gold<sup>(R)</sup> plot at  
 228 1.65 kg a.i /ha recorded the highest leaf area which differs significantly from other treatments. There  
 229 were no significant difference in cowpea leaf area in Galex<sup>(R)</sup> at 3.0 kg a.i /ha, Pendilin<sup>(R)</sup> 2.0 kg a.i  
 230 /ha and plots hoe weeded twice but they differ from plots hoe- weeded once.

231

232 **Table 5: Effect of weed control treatments on cowpea height and leaf area**

| Treatment                 | Rate<br>(kg a.i./ha) | Plant height<br>(cm) |        | Leaves /plant<br>(no) |       | Leaf Area /plant<br>(cm <sup>2</sup> ) |        |
|---------------------------|----------------------|----------------------|--------|-----------------------|-------|----------------------------------------|--------|
|                           |                      | 2005                 | 2006   | 2005                  | 2006  | 2005                                   | 2006   |
| No weeding                | -                    | 64.75                | 72.78  | 16.50                 | 17.25 | 511.2                                  | 614.0  |
| Codal Gold <sup>(R)</sup> | 1.65                 | 107.48               | 115.25 | 31.75                 | 35.25 | 1591.6                                 | 1735.0 |
| Galex <sup>(R)</sup>      | 3.0                  | 97.10                | 102.50 | 25.50                 | 27.25 | 1178.9                                 | 1271.3 |
| Pendilin <sup>(R)</sup>   | 2.0                  | 97.03                | 103.00 | 25.75                 | 27.75 | 1191.7                                 | 1272.3 |
| Weeded x 1 (3WAP)         | -                    | 89.88                | 91.75  | 20.00                 | 22.00 | 817.0                                  | 910.8  |
| Weeded x 2 (3+7WAP)       | -                    | 96.03                | 102.00 | 25.50                 | 27.00 | 1173.0                                 | 1268.3 |
| LSD(P = 0.05)             |                      | 2.503                | 2.021  | 1.150                 | 1.499 | 55.22                                  | 65.35  |

233

### 3.3 Effects of weed control treatment on yield and yield components of cowpea.

In 2005, there were no significant difference ( $P>0.05$ ) among the herbicides treated plot and plot that were hoe weeded twice in terms of number of days to 50% flowering but they differ significantly from plot hoe weeded once and unweeded plots (Table 6). The unweeded plot took the highest time to reach 50% flowering which was comparable to plots hoe weeded once. In 2006, unweeded plots differ significantly from other treatments by the time it took to reach 50% flowering. Codal gold<sup>(R)</sup> at 1.65 kg a.i /ha had the shortest number of days to 50% flowering but it was not significantly difference from Galex<sup>(R)</sup> at 3.0 kg a.i /ha, Pendilin<sup>(R)</sup> at 2.0 kg a.i /ha and plot hoe weeded twice which differ significantly from plot hoe weeded once (Table 6).

In 2006, Codal gold<sup>(R)</sup> treated plot at 1.65 kg a.i /ha had significantly the highest number of pods than other treatments. The second highest number of pods was produced in plots treated with Pendilin<sup>(R)</sup> at 2.0 kg a.i /ha but it was not different from Galex<sup>(R)</sup> treated plot at 3.0 kg a.i /ha and plot hoe weeded twice. Plot hoe weeded once differ significantly from the rest of the treatments including the weedy check which had the lowest number of pods (Table 6).

In 2005, there was no significant difference ( $P>0.05$ ) among the treatments although Codal gold<sup>(R)</sup> at 1.65 kg a.i /ha had a slight number of seeds/pod. In 2006, the number of seeds/ pod differs significantly. Weedy plots recorded the lowest number of seeds/pod but it was not different from plots hoe weeded once. Codal gold<sup>(R)</sup> treated plots at 1.65 kg a.i /ha recorded highest number of seeds/pod but the value was comparable with that of Pendilin plots at 2.0 kg a.i /ha. No significance difference was observed among Galex<sup>(R)</sup> at 3.0 kg a.i /ha, Pendilin<sup>(R)</sup> at 2.0 kg a.i /ha and plots that were hoe weeded twice. The grain yield of cowpea was significantly ( $P<0.05$ ) affected by the weed control treatments in the two years of study (Table 6). Cowpea grain yield followed the trend Codal gold<sup>(R)</sup> at 1.65 kg a.i /ha > Pendilin<sup>(R)</sup> at 2.0 kg a.i /ha > Galex<sup>(R)</sup> at 3.0 kg a.i /ha > Two hoe weedings > one hoe weeding > weedy plots.

**Table 6: Effect of weed control treatment on yield and yield components of cowpea**

| Treatment                 | Rate<br>(kg a.i /ha) | Days to 50<br>flowering |      | Pods/plant (no) |      | Seed \pod (no) |      | Grain yield (kg/ha) |         |
|---------------------------|----------------------|-------------------------|------|-----------------|------|----------------|------|---------------------|---------|
|                           |                      | 2005                    | 2006 | 2005            | 2006 | 2005           | 2006 | 2005                | 2006    |
| No weeding                | -                    | 52                      | 52   | 9               | 11   | 10             | 9    | 814.00              | 905.25  |
| Codal Gold <sup>(R)</sup> | 1.65                 | 46                      | 46   | 13              | 14   | 11             | 13   | 1652.50             | 1841.25 |
| Galex <sup>(R)</sup>      | 3.0                  | 46                      | 46   | 11              | 13   | 10             | 12   | 1180.00             | 1236.50 |
| Pendilin <sup>(R)</sup>   | 2.0                  | 46                      | 46   | 11              | 13   | 10             | 12   | 1185.83             | 1240.75 |
| Weeded x 1 (3WAP)         | -                    | 50                      | 50   | 10              | 12   | 10             | 10   | 999.93              | 1085.50 |
| Weeded x 2 (3+7WAP)       | -                    | 46                      | 46   | 11              | 13   | 10             | 12   | 1171.67             | 1230.50 |
| LSD(P = 0.05)             |                      | 3                       | 21   | 2               | 0.6  | NS             | 1    | 81.528              | 36.085  |

### 267    **3.4      Economic Evaluation**

268            The value of the output per hectare (total revenue) from the use of pre-emergence herbicides  
269 varied from ₦119, 991.6 to ₦ 198, 300 in 2005. (Table 7) The highest revenue (₦ 198, 300) was  
270 recorded under Codal gold<sup>(R)</sup> plot at 1.65 kg a.i /ha followed by Pendilin<sup>(R)</sup> treated plot at 2.0 kg a.i  
271 /ha while the lowest was recorded under plot hoe weeded once (₦119, 991.6) compared to the rest  
272 of the treatments. Similar trend was observed in 2006 with Codal gold<sup>(R)</sup> at 1.65 kg a.i /ha recording  
273 the highest revenue (₦293, 362.5) followed by Pendilin<sup>(R)</sup> treated plot at 2.0 kg a.i /ha while the  
274 lowest was recorded under plot hoe weeded once (₦141, 115) compared to the rest of the  
275 treatment.(Table 8) The above results were due to differences in yield/ha recorded by the different  
276 treatments with Codal gold<sup>(R)</sup> at 1.65 kg a.i /ha resulting in the highest yields.

277

278

279

280 **Table 7: Economics evaluation of the use of pre emergence herbicides in cowpea production in 2005 cropping season**

| Treatment                 | Rate (kg<br>a.i./ha) | Rate (L/ha) | Herbicides<br>cost N/ha | Time of<br>treatment<br>application<br>(man – hr/ha) | Cost of<br>treatment<br>application<br>(N/ha) | Total cost<br>N/ha | Grain yield (kg/ha) | Revenue<br>(N/ha) | Net Revenue<br>(profit) N/ha | CBR   |
|---------------------------|----------------------|-------------|-------------------------|------------------------------------------------------|-----------------------------------------------|--------------------|---------------------|-------------------|------------------------------|-------|
| Codal gold <sup>(R)</sup> | 1.65                 | 4           | 7000                    | 5                                                    | 850                                           | 7,850              | 1,652.50            | 198,300.00        | 190,450.00                   | 24.26 |
| Gale <sup>(R)</sup>       | 3.0                  | 5           | 6000                    | 5                                                    | 850                                           | 6,850              | 1,180.00            | 141,600.00        | 134,750.00                   | 19.67 |
| Pendilin <sup>(R)</sup>   | 2.0                  | 5           | 6500                    | 5                                                    | 850                                           | 7,350              | 1,185.83            | 142,299.60        | 134,949.60                   | 18.36 |
| Weeded x1                 | 3 WAP                | -           | 0.00                    | 120                                                  | 31,200                                        | 31,200             | 999.93              | 119,991.60        | 88,791.60                    | 2.85  |
| Weeded x 2                | 3 + 7 WAP            | -           | 0.00                    | 240                                                  | 62,400                                        | 62,400             | 1,171.67            | 140,600.40        | 78,200.40                    | 1.25  |
| Unweeded                  | -                    | -           | 0.00                    |                                                      |                                               |                    |                     |                   |                              |       |

281 **N128.65 = \$1(Exchange rate of naira to US dollar Central Bank of Nigeria (CBN, 2005)**

282

283 CBR = Cost of benefit Ratio = Net Revenue / Total Cost

284 1kg of cowpea = N120.00

285 1litre of Codal gold<sup>®</sup> = N1, 750.00286 1litre of Galex<sup>®</sup> = N1, 200.00

287 1litre of Pendilin = N1, 300.00

288 Cost of application of herbicides = 150/hr. knapsack (hired) = N100 / treatment

289 Cost of hand weeding = N260/hr (N600- N700 = (N1300 average) between 7.00am – 12noon = 5 hours approximately

290

291

292

293

294

295

296

297 **Table 8: Economics evaluation of the use of pre-emergence herbicides in cowpea production in 2006 cropping season**

| Treatment                 | Rate (kg<br>a.i./ha) | Rate (L/ha) | Herbicides<br>cost N/ha | Time of<br>treatment<br>application<br>(man – hr/ha) | Cost of<br>treatment<br>application<br>(N/ha) | Total cost<br>N/ha | Grain yield (kg/ha) | Revenue<br>(N/ha) | Net Revenue<br>(profit) N/ha | CBR   |
|---------------------------|----------------------|-------------|-------------------------|------------------------------------------------------|-----------------------------------------------|--------------------|---------------------|-------------------|------------------------------|-------|
| Codal gold <sup>(R)</sup> | 1.65                 | 4           | 7200                    | 5                                                    | 1,020                                         | 8,220              | 1,841.25            | 239,362.50        | 231,142.50                   | 28.12 |
| Galex <sup>(R)</sup>      | 3.00                 | 5           | 6250                    | 5                                                    | 1,020                                         | 7,270              | 1,236.50            | 160,745.00        | 153,475.00                   | 21.11 |
| Pendilin <sup>(R)</sup>   | 2.00                 | 5           | 6750                    | 5                                                    | 1,020                                         | 7,770              | 1,240.75            | 161,297.50        | 153,527.50                   | 19.76 |
| Weeded x1                 | 3 WAP                | -           | 0.00                    | 120                                                  | 36,000                                        | 36,000             | 1,085.50            | 141,115.00        | 105,115.00                   | 2.92  |
| Weeded x 2                | 3 + 7 WAP            | -           | 0.00                    | 240                                                  | 72,000                                        | 72,000             | 1,230.50            | 159,965.00        | 87,965.00                    | 1.22  |
| Unweeded                  | -                    | -           | 0.00                    |                                                      |                                               |                    |                     |                   |                              |       |

298 **N125.83 = \$1 (Exchange rate of naira to US dollar CBN, 2006)**

299 CBR = Cost of benefit Ratio = Net Revenue/Total Cost

300 1kg of cowpea = N130.00

301 1litre of Codal gold<sup>(R)</sup> = N1, 800.00302 1litre of Galex<sup>(R)</sup> = N1, 250.00303 1litre of Pendilin<sup>(R)</sup> = N1, 350.00

304 Cost of application of herbicides = 180/hr. knapsack (hired) = N120 / treatment

305 Cost of hand weeding = N300/hr (N700- N800) = (N1500 average) between 7.00am – 12noon = 5 hours approximately

306 Plots hoe weeded twice at 3 and 7WAP recorded the highest cost of production (N62, 400)  
307 followed by plots hoe weeded once (N31, 200) compared to other treatments while the  
308 lowest was recorded under Galex<sup>(R)</sup>, treated plots at 3.0 kg a.i /ha (N6, 850) in 2005. In  
309 2006, the same trend was observed with the highest cost of production incurred by weeding  
310 at 3 and 7WAP compared to all other treatments while Galex<sup>®</sup> treated plots at 3.0 kg a.i /ha  
311 resulted in the lowest cost of production.

312 In 2005, the highest net revenue (profit) (N190, 450) was obtained under Codal  
313 gold<sup>(R)</sup> plots at 1.65 kg a.i /ha and the lowest under plots hoe-weeded twice (N78, 200.4).  
314 Similar trend was observed in 2006 with Codal gold<sup>(R)</sup> at 1.65 kg a.i /ha having the highest  
315 profit of (N231, 142.5) and the lowest in plot hoe weeded twice (N87,965). The highest cost  
316 benefit ratio (CBR) (24.26) was recorded in Codal gold<sup>(R)</sup> plot at 1.65 kg a.i /ha and the  
317 lowest in plot weeded twice (1.25). In 2006, the same trend was observed, Codal gold plot at  
318 1.65 kg a.i /ha had the highest CBR (28.12) and the lowest in plot hoe weeded twice (1.22).

319

#### 320 4.0 DISCUSSION

321 The high weed density recorded in the weedy plots in both years which invariably  
322 result to high weed dry weight could be attributed to low ground cover by cowpea vines.  
323 Also, the low weed density observed in the herbicides treated plots could be attributed to  
324 effective weed control of the herbicides and their ability to control weed beyond the critical  
325 period of cowpea growth. The adequate weed cover by cowpea vine led to smothering effect  
326 of the weeds judging from low weed population and low weed dry weight which invariably led  
327 to increase in weed smothering efficiency (WSE).

328 Hoe – weeding once at 3WAP was obviously not adequate for effective weed control  
329 in cowpea since it was not comparable to twice hoe weedings. The low weed density and  
330 low dry weight in plot hoe weeded twice results to high WSE. The cowpea vines were able to  
331 smother weeds in plots hoe weeded twice compared to plot hoe weeded once which had  
332 moderate increase in weed dry weight. The moderate increase in weed dry weight could be  
333 attributed to frequent re-occurrence and persistent characteristics of weeds.

334 Hand weeding and herbicide application significantly encouraged vigorous growth in  
335 cowpea. Weed competition delayed the number of days to 50% flowering and considerably  
336 reduced the yield and yield components of cowpea in the unweeded. Remison (1978)  
337 reported that low yield obtained from weedy plots may be due to competition from natural  
338 flora. The higher grain yields obtained from the herbicide – treated plots compared to hand-  
339 weeding could be due to minimal weed competition with cowpea and herbicides treated  
340 plots. Weedy plots gave the lowest grain yield as a result of intense weed competition. The  
341 percentage yield reduction in the current study was 30.53% in 2005 and 26.43% in 2006.

342 This study has confirmed earlier reports (Akobundu, 1979; Sangakkara, 1999) of a possible  
343 yield loss due to weed infestation in cowpea.

344 The yield difference per hectare recorded by the different treatments account for the  
345 variation observed in value of output/ha (total revenue) in both years. Codal gold<sup>(R)</sup> at 1.65  
346 kg a.i /ha was the most profitable method of weed control in both years. It had the highest  
347 grain yield coupled with low weed control cost. Although grain yield was high in plots hoe  
348 weeded twice, the cost of weeding was also high consequent upon scarcity of labor at time  
349 of weeding, thereby reducing the profit. This confirms the report of Adigun and Lagoke  
350 (2003) that hoe weeding is expensive. It also shows the advantage of herbicide application  
351 over hoe weeding in reduction of cost of production in cowpea. This agrees with the findings  
352 of Nazear *et al.* (2004) that a very lucrative cost – effective was recorded due to application  
353 of bactril-M on wheat and the gain in yield from hand weeded plot was nullified with  
354 additional cost of weeding. The results obtained from economic evaluation is also in  
355 conformity with that of Chikoye *et al.* (2005) who noted that chemical control is a better  
356 alternative to manual weeding because it is cheaper, faster and gives better weed control.

357

358

359

## 5. CONCLUSION

The applied herbicides enhanced cowpea productivity, through enhanced growth and yield of cowpea by reducing weed infestation. Consequent on the condition of the present study and spectrum of herbicide use or tried, Codal gold<sup>(R)</sup> at 1.65 kg a.i /ha seem to be the best or most effective herbicide for reducing weed infestation in cowpea in the forest transition zone of Edo State Nigeria.

## ACKNOWLEDGEMENTS

The authors wish to thank Edo State Agricultural Development Programme (ADP) Irrua, Edo State, Nigeria for assisting with the rainfall data of the study site. This study was not sponsored by any funding agency.

## COMPETING INTERESTS

: Authors have declared that no competing interests exist.

## REFERENCES

- Adigun, I.A and Lagoke. S.T. O (2003). Weed control in transplant rain fed and irrigated tomatoes in the Nigerian savanna. *Nigerian Journal of Weed Science* 16:23-29
- Akinyemiju, O.A and Echendu, T.N.C (1987). Influence of tillage method and pre-emergence herbicide on weeds control in cowpea (*Vigna unguiculata* (L.) Walp). *Crop Protection* 6 289 – 294
- Akobundu, I.O (1979). Weed control strategies for multiple cropping systems of the humid and sub-humid tropics. In Akobundu, I.O. (Ed), weeds and their control in the humid and sub-humid tropics. IITA Proceedings series 3:80 -100.
- Akobundu, I.O (1987). *Weed Science in the Tropics. Principles and Practices*. 2<sup>nd</sup> Edition, John Wiley and Sons Inc. Chichester 522p.
- Alghali, A.M (1992). Insecticide application and schedules to reduce grain yield losses caused by insect pests of cowpea in Nigeria. *Insect Science Applied* 13:725-730.
- Bray, R.H. and Kurtz, L.T. (1945) Determination of Total Organic and Available Phosphorus in soils, *Soil Science* 59; 39-45.
- CBN.(2011). Real Exchange Rate Misalignment: An Application of Behavioral Equilibrium Exchange Rate (BEER) to Nigeria. CBN Occasional Papar No.41 pp .15-16
- Chikoye, D. Udensi, U.E and Lum, A.E (2005). Evaluation of new formulation of atrazine and metolachlor mixture for weed control in maize *Crop Protection* 24:1016-1020.

409 Cisse N. Ndiaye, M. Thiaw, S. Hall. A.E (1995). Registration of Mouride cowpea *Crop*  
410 *Science* 35:1215-1216.

411

412 Gee, G.W. and J.W. Bauder, 1986. Particles size analysis. In : Methods of Soil analysis Part  
413 1. Klute (ed) *American Society of Agronomy*. Madision 101 USA : 38 - 41

414

415

416 Gibson, D.J, Miller, K.; Delong, M.; Commelly, J.; Kiwan L.; Wood A.J.; and Breyan G.  
417 (2007). The weed community effects on yield and quality of soybean (*Glycine Max (L)*  
418 *Merk*). *Journal of the Science of Food and Agriculture* 88 (3) 371 – 381.

419

420 International Institute of Tropical Agriculture (IITA) 1979. Selected Methods for Soil and  
421 Plant Analysis. Manual series No. 1 International Institution of Tropical Agriculture,  
422 Ibadan, Nigeria.

423

424 International Institute of Tropical Agriculture (IITA) (2001) Crop and farming systems.  
425 <http://www.IITA.org/cowpea.int.ml>.

426

427 International Institute of Tropical Agriculture (IITA) (2007). Cowpea. IITA annual report.  
428 [http://www.IITA.org/cons/details/cowpea project details.aspx? Zonied 63 & articelcid](http://www.IITA.org/cons/details/cowpea%20project%20details.aspx?Zonied%2063&artid=63)  
429 269.

430

431 Jackson, M.L. (1958): *Aggregate Stability*. In: method for Soil Analysis (ed). C.D. Black  
432 Agron; No.9, American Society Agron, Madison Wis.USA

433

434 Mclean, D.W (1982). *Soil pH and lime requirements* in: pp a...ed. Methods of soil analysis,  
435 part 2 chemical and microbiological properties (2<sup>nd</sup> ed.). Agronomy series No.SSA.  
436 Maidison, Wis. USA.PP.199-234.

437

438 Nazeer, H.S.; Gal, H.; Sad, U.R.; Nazir, A. and Eazles, S. (2004). Weed management in  
439 wheat on farmer field DASP command area. *Weed Science Society of Parkistan* 10 (1-  
440 2):25-35.

441

442 Okoruwa, V.O.; Obadaki, F.O and Ibrahim ,G. (2005). Profitability of beef cattle farming  
443 fattening in the cosmopolitan city of Ibadan, Oyo State. *Moore Journal of Agricultural*  
444 *Research* 6 (1): 45-51

445

446 Olofintoye, J.A and Adesiyun, A (1989). Weed control in cowpea (*Vigna unguiculata (L)*  
447 *Walp*) with sethoxym and galex *Nigerian Journal of weed Science* 2:29-34

448

449 Remison, S.U (1978). The performance of cowpea (*Vigna unguiculata (L) Walp*) as  
450 Influenced by Weed Competition *Journal of Agricultural Science* Cambridge 90:523-  
451 530

452

453 Remison S.U (1997). *Basic principles of crop physiology*. Sadoh Press, Benin City, Nigeria,  
454 320p.

455

456 Rusoke, D.D, Rubaihayo. P.(1994). The Influence of some crop Protection Management  
457 Practices on Yield Stability of Cowpea. *Africa crop science journal* 2:143-146.

458

459 Sangakkara, U.R (1999). Effect of weeds on yield and seed quality of two tropical grain  
460 legumes. *Tropical Science* 39:227-232.

461

462  
463  
464  
465  
466  
467  
468  
469  
470  
471  
472  
473  
474  
475  
476  
477  
478

Subramaniam, S. Alli, A.M and Kumar R.J. (1991) All about weed control. Kalyani Publisher, New Delhi – 110002, India, 315p.

Tel, D. and F. Rao, 1982. Automated and semi-automated methods for soil and plant analysis, IITA manual series No. 17:15-25.

Tijani – Eniola, H. (2001). Influence of intra –row spacing and weeding regime on the performance of cowpea (*Vigna unguiculata* (L) Walp). *Nigerian Journal of weed science* 14:11-15

Walkey, A. and Black, C.A. (1934). An examination of the Degtjareff methods for determining soil organic matter and proposed modification of the chromic acid digester method. *Soil Science* 37:29-38