

Influence of Weed Removal Techniques on the Outcome of Early Interference of Itchgrass *Rottboellia cochinchinensis* (Lour.) W. D. Clayton) on Cowpea (*Vigna unguiculata* (L.) Walp) Growth

Iyagba A. G.

Department of Agricultural Science,
Ignatius Ajuru University of Education, Port Harcourt, Nigeria.
Email: apegragba@yahoo.com

Ayeni, A. O.

Rutgers University, Rutgers Agricultural and Extension Centre,
Bridgeton, New Jersey, 08302-5919, U.S.A.

Abstract – The influence of weed removal techniques on early itchgrass (*Rottboellia cochinchinensis* (Lour.) Walp) growth characteristics were determined in a pot experiment at the Teaching and Research Farm of the University of Ibadan, Ibadan, Nigeria in two planting seasons. The weed removal techniques employed were hand pulling, slashing and the herbicide, haloxyfop-ethoxyethyl applied at the rate of 0.25kg ha⁻¹ while the weed free interference durations considered were weed free, 15, 20, 25, 30 and 60 days after sowing (DAS). The result revealed that weed removal technique and interference durations significantly affected the early interference of itchgrass on cowpea growth characteristics. Maximum cowpea growth was observed when itchgrass was hand pulled at 15 DAS which was significantly higher than the weed free pots.

Keywords – Cowpea, Haloxyfop-Ethoxyethyl, *Rottboellia cochinchinensis*, Weed Interference.

I. INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) which originated in Nigeria (Faris, 1963) is widely grown in tropical Africa for the consumption of its leaves, green pods and seeds. It is the most important legume diet of the rural and urban dwellers in Nigeria because it provides an important source of both proteins, caloric energy and other nutrients with a minimum amount of cooking preparation. Moreover, the levels of toxic substances and antimetabolites like trypsin inhibitor, haemoglutinins and flatul factors are minimal in the seed (Liener, 1969). In Nigeria, cowpea is consumed in three basic forms. Most frequently they are cooked together with vegetables, spices and other ingredients. The other two forms are prepared from decorticated cowpea flour and fried cakes (akara balls) and also steamed bean cake (moin-moin) to which onions and seasonings are added.

In Nigeria, the yield of cowpea has been very low in farmers' plots. Statistics from the Food and Agriculture Organization (FAO) cited by the International Institute of Tropical Agriculture (IITA) revealed about 7.56 million tons (IITA, 2013a). About 70% of the total world production was said to have been accounted by Sub-Saharan Africa (IITA, 2013a). Nigeria which produces about 2 million tonnes per annum is the second world largest cowpea producer is followed by Niger (650,000 tons) and Mali producing 110,000 tons (IITA, 2013b). The average world cowpea grain yield is less than 0.3 tons ha⁻¹

which is quite low while within Africa, the average cowpea yields range from 0.05 to 0.55 ton ha⁻¹ (Cisse *et al.*, 1995).

Among other factors like pests and diseases, weeds are one of the major limiting factors to successful cowpea production. Labrada and Parker (1999) indicated that the presence of weeds in crop area reduces the efficiency of inputs such as fertilizer and irrigation water, enhances the density of other pest organisms, and finally severely reduces crop yield and quality. The effects may be direct or indirect and the degree of competition encountered by an individual cowpea plant depends on the density, distribution, duration and species of the weed associates as well as chemical and adaphic factors (Bleasdale, 1960).

Several definitions for the word 'competition' have been given by various authors. Bleasdale (1960) stated that two plants are in competition with each other when the growth of either one or both of them is reduced or their form modified as compared with their growth or from in isolation while according to Mather (1961) competition implies the presence of one individual as an effective part of the other's environment and a similarity of needs or activities so their impact on each other is prospectively detrimental. Competition is open to criticism and is often used to describe ecological and agronomic phenomena in a rather loose manner with little scientific foundations, which may lead to a misunderstanding of the actual processes involved. These definitions do not embrace all the mutual influences of plants growing together. In these context the term 'plant interference' was proposed. Hall (1974) defined interference as the response of an individual plant or plant species to its total environment as this is modified by the presence and/or growth of the other individuals or species. Competition itself is only one facet of interference between plants although at times it may be a dominating one. Hall (1974) distinguished two types of interference in a grass/legume association namely competitive and non-competitive interference. In competitive interference one specie directly affects the growth of the other by competing for a resource or resources available equally to both and is non-competitive interference when symbiologically fixed N which in the early stages of growth available to the legumes may or not be available to the grass. One of the most studied aspects of interference is that of the length of weedy and weed free periods. Zimdahl (1980) reported that growers often

assume erroneously that removing weed competition anytime during the growing season solves the problem of yield reduction caused by weed interference.

Substantial evidence indicates that the time of removal of weeds is as important as removal itself. Ecologists have defined a 'critical period' of weed competition. This is the time when the weed reduces crop yield (Frick and Johnson, 2013) while Bleadale (1960) defined critical period as the maximum period weeds can be tolerated without affecting final crop yields or the point after which weed growth does not affect final yield. Kasasian and Seeyave (1969) indicated that crops require a weed free respite for one fourth to one third of their growing period while Doll (1994) stated that for several annual crops, the critical period of competition is approximately equal to the first one-third to one-half of the life cycle of the crop. For example, he stated that in rice and maize which often take 100 to 120 days to mature, keeping the crop free of weeds for 30 to 40 days usually assures near maximum productivity. The critical period of weed competition for cowpea is the first 3 – 4 weeks of crop growth (Akinyemiju and Echendu, 1987).

Ayeni (1982) noted that in South-West Nigeria, one major weed which seriously infects cowpea field is itchgrass (*Rottboellia cochinchinensis* (Lour) W.D Clayton (*syn.R. exaltata*). This weed has been identified to cut across many crops and ecological zones in Nigeria and West Africa (Chikoye *et al.*, 2000; Akobundu, 1982a). It is an erect, strongly tufted C⁴ self pollinated annual grass, characterized as a vigorous competitor and for being able to reach a height of 4 metres (Holm *et al.*, 1977). Its common name in English and other languages relate to the siliceous, fragile, irritating hairs covering the leaf sheaths that break off on contact with the skin (Valverde, 2013). It is found in the tropics and sub-tropics world wide and is particularly widespread in the Caribbean region (Millhollon and Burner, 1993). Akobundu (1982b) indicated that a 68 - 85% yield reduction occurred in cowpea growing with uncontrolled itch grass while Holm *et al.* (1977) noted that itchgrass infestations can result in up to 80% crop loss, or even abandonment of agricultural lands. Yield reductions were greater in the dry season (17 - 85%) than in the wet season (17-65%) due to moisture differences between the two periods and involvement in weed, weed/crop interaction (Zimdahl, 1980).

Smith (1983) observed that reductions occurred in cowpea fields when itchgrass was not removed after the first four weeks of crop growth but yields were significantly higher under weed association for 20 days after planting (DAS) than for the control, and later stages. This positive response of cowpea at that period he also stated was independent of the planting season. However, cowpea is one of the legumes noted to suppress the growth of itchgrass in the Guanacaste region in Costa Rica (Dela Cruz *et al.*, 1994).

This study was therefore conducted to determine whether the higher yield due to early interference of itchgrass depends on weed removal techniques.

II. MATERIALS AND METHODS

A pot of experiment was set up in the green house of the Teaching and Research Farm of the University of Ibadan, Ibadan, Nigeria to determine the influence of weed removal techniques on the outcome of early interference of itchgrass on cowpea growth characteristics in 2005 wet and dry planting seasons. Black polythene bags (pots) with a surface diameter of 25 cm and 42 cm deep were filled with topsoil.

Soil sample was collected before planting, oven dried, ground and sieved through 2mm sieve and the sand, silt and clay contents were determined by the Bouyoucos method (1951). The soil pH was determined using the pH-metre in a 1:2.5 soil/water ratio, total Nitrogen content was by micro-kjedahl method (Jackson, 1962) and total Phosphorus was by Bray 1 method (Bray and Kurtz, 1945). Calcium (Ca) and Magnesium (Mg) were determined by the Atomic Absorption Spectrophotometer (AAS) and Potassium (K) and Sodium (Na) by flame emission photometry. The organic carbon was according to Walkey and Black (1934) and the present organic matter was estimated by multiplying the percent organic carbon with a factor of 1.724. The soil has the following characteristics; pH (in H₂O) 5.7, organic carbon 1.45%, total N 0.34%; extractable P 5.16g kg⁻¹, extractable K 0.17, Ca 1.96 and Mg 0.63 in cmol kg⁻¹. Soil particle distribution was sand 57%, clay 21% and silts 22%.

The treatments applied consisted of two factors, weed removal techniques as factor A and weed interference duration as factor B. The weed removal techniques used were hand pulling, slashing and chemical control. Slashing was done with a pair of scissors by clipping the weeds to the ground level while in the case of chemical control haloxyfop-ethoxyethyl (Ethyl 2-[4-[[3-chloro-5]trifluoromethyl]-2-pyridinyl]phenoxy]propanoate) was used at the rate of 0.25kg ha⁻¹. The chemical was applied with a knapsack sprayer calibrated to deliver 250 Lha⁻¹ of spray volume. Weed interference durations used were weed free, 15, 20, 25, 30 and 60 days after sowing (DAS). The experiment was a 3 x 6 factorial in a randomized block design replicated four times. A semi – prostrate broad leaf indeterminate cultivar of cowpea (VITA-5) released by the IITA was used. The weed seeds were also obtained from IITA. Five and twenty seeds of the cowpea and weed respectively were sown at a depth of 2.5cm in each pot. They were later thinned to 1 cowpea to 15 itchgrass stands per pot. The pots were watered as necessary to prevent moisture stress and water logging throughout the duration of the experiment. Insect pests were controlled by spraying with cypermethrin to check the incident of pests that attack the leaves of cowpea plant. The experiment lasted for 60 days. The growth parameters determined were plant height, number of leaves/plant, leaf area/plant, number of branches/plant, leaf and vine dry weights, days to 50% flowering, weed density, weed dry weight and weed control efficiency. Days to 50% flowering was estimated by counting the number of days from sowing to the time taken when half of the plants start to produce flowers. Weed density was determined by counting the number of

weeds in a pot. Weed control efficiency was calculated based on the method suggested by Bhattacharya and Mandal (1988) as follows:

$$\frac{\text{Dry weed weight (DWT) of unweeded control} - \text{DWT of treatment}}{\text{DWT of unweeded control}} \times 100$$

The result presented are means of the two planting seasons. The data collected were subjected to analysis of variance (ANOVA) and means compared using the Duncan's Multiple Range Test (DMRT) at a probability of level of 5% according to Gomez and Gomez (1984).

III. RESULTS AND DISCUSSION

Influence of weed removal technique on cowpea vegetative growth parameters

Plant height was significantly influenced ($P < 0.05$) by the different weed removal techniques (Table 1). Among the treatments, slashing of itchgrass produced the tallest plants while the shortest plants were observed when the weeds were hand pulled. Plant height when the weeds interfered with the crop at different interference duration were significantly different. The tallest plants (98.75cm) were recorded among the weed free plots while plants that associated with the weeds for 60 DAS were the shortest (68.55cm). However, the weed free plants and those that associated with the weeds for 15 and 20 DAS were not significantly different.

Leaves produced when the weed were hand pulled were significantly greater than the other treatments. Number of leaves produced when the weeds associated with the crops at various durations were also significantly different. Leaves produced when the weeds associated with the crop for 15 DAS were more compared with the weed free plots. Leaf area showed significant difference ($P < 0.05$) among the different weed removal treatments. Pots where the weeds were slashed produced the highest leaf area which differed significantly from the other weed removal techniques. Plants associated with the weeds for 15 DAS had higher (1603.17cm²) leaf area than those from the weed free pots (1511.79cm²).

There was significant difference in the number of cowpea branches produced with the different weed removal techniques. Plants from where the weeds were slashed produced more branches than the others. Weed interference duration also caused significant difference in the number of branches produced. The weed free pots produced the highest number of branches while the least number of branches were produced from those that interfered with the weeds for 60 DAS.

There was significance difference in the leaf and vine dry weights among the various weed removal techniques. In both cases, weeds removed by hand pulling led to the highest leaf and vine dry weight while the lowest leaf and vine dry weights were from among the pots that were chemically treated. Weed interference duration similarly caused significant difference in leaf and vine dry weights were observed, crops associating with the weeds for 15 DAS producing the highest leaf and vine dry weights compared with the weed free treatments. The lowest leaf

and vine dry weights were produced when the weeds were left till 60 DAS.

There were no significance difference ($P > 0.05$) among the plants when the weeds were removed by slashing and chemically treated in terms of number of days to 50% flowering but they differed significantly from the hand pulling of the weeds. Weed free pots and plants associated with the weeds for 15 and 20 DAS produced flowers significantly earlier than the rest of the weed interference duration. The unweeded pots took the highest time to reach 50% flowering which were comparable to pots weeded at 25 and 30 DAS. Plants associated with the weeds for 15 DAS had the shortest number of days to 50% flowering but not statistically different from the weed free pots.

Weed growth and control

Weed dry weight, weed density and weed control efficiency were significantly influenced by the weed removal techniques (Table 2). Slashing the weeds caused better weed control (74.9%) though not statistically different when the weeds were hand pulled (69.8%). The different weed interference duration significantly influenced the weed dry weight, weed density and weed control efficiency as well. However, there was no statistical difference in weed control efficiency between the weed free pots and keeping the weeds in association with the crops for 15 and 20 DAS.

Interactive effects between the weed removal techniques and weed interference duration were significant (Tables 3 and 4).

IV. DISCUSSION

The findings indicate that cowpea plants benefited for a certain period of weed interference for maximum production of leaves. The period of positive increase varies with the weed removal techniques.

Generally, slashing itch grass led to a better vegetable growth and the accumulation of a biomass while application of the chemical had a reduced vegetative growth. This indicates that on the field, tillage method in cowpea cultivation will affect growth parameters differently. Adeyemi *et al.* (2008) noted that tillage practices had significant effect in the number and yield of okra pods during the early and late seasons. The enhanced vegetative growth in cowpea by slashing the weeds over the other treatments could have been due to reduced weed density and weed control effectiveness of this treatment.

Tillage practices including weed removal techniques influence weed diversity, species richness, growth and distribution (Wiese, 1985; Smith and Akinade, 2000 and Adeyemi, 2005). Taiwo and Ekeleme (2008) had noted significant difference in speargrass shoot density, shoots and rhizome biomass between tillage systems and weed control methods in soybean cultivation. The result also showed that the herbicide, haloxyfop-ethoxyethyl had adverse effect on cowpea growth and was not very effective in controlling itchgrass. Heap (2002) recorded that this weed has however, evolved resistance, in one instance to fluzifop-p-butyl having the same phenoxy

propanoate moiety with haloxyfop-ethoxyethyl in soybeans in Louisiana, United States. It is therefore necessary to screen other postemergence herbicides to control itchgrass in cowpea cultivation. However, Sunday and Udensi (2013) have recommended cordal^(R) gold (250g prometryne + 162.5 kg metolachlor per litre) at the rate of 3.0kg a. i. ha⁻¹ in a forest-Savannah transition zone. The high temperature and moisture and high population of micro-organisms are conducive to faster degradation of pre-emergence herbicides in this part of the country (Akinyemiju *et al*, 1986; Iyagba and Ayeni, 1997). Based on this, their recommendation of using pre-emergence herbicides may not give the desired result of controlling weeds in this part of the country.

Cowpea vegetative characters performed better when cowpea associated with the weeds at 15 DAS though not statistically different from the cowpea weed free pots. Ayeni (1982) had reported different types of responses of cowpea to early weed interference. There is a type A response – a zero (no effect) response to weeds within the first 15 or more DAS followed by a negative response. The type B response is a positive response to weed within the first 15 or more DAS and is followed by a negative response and the type C, a negative response to weeds within the first 15 or more DAS followed by a positive response. Most of the growth parameters determined followed the type B response.

V. CONCLUSION

The work has shown that itchgrass removal technique and the period of weed interference duration significantly influenced the early outcome of cowpea growth. Better cowpea growth seems to be enhanced when itcgrass was hand pulled at 15 DAS.

REFERENCES

- [1] Adeyemi, O. R. (2005). Effect of time of weed removal and tillage methods on the growth and yield of okra (*Abelmoschus esculentus* (L.) Moench) *Ph.D Thesis. Federal University of Technology, Akure, Nigeria* 177pp.
- [2] Adeyemi, O.R., Smith, M.A.K. and Ojeniyi, S. O. (2008). Effect of land preparation techniques on weed control effectiveness in okra (*Abelmoschus esculentus* L.) Moench). *Nigerian Journal of Weed Science* 21: 72-83.
- [3] Akinyemiju, O. A. and Echendu, T.N.C. (1987). Influence of tillage method and pre-emergence herbicide on weed control in cowpea (*Vigna unguiculata* (L.) Walp). *Crop Prot.* 6: 289 – 294.
- [4] Akinyemiji, O.A., Ogunyemi, S.O. and Ojo, I. O. (1986). Persistence of atrazine in a humid tropical soil. *Nig. J. of Agronomy.* 1:14- 21.
- [5] Akobundu, I. O. (1982a). Itch grass interference and control in maize. *IITA Annual Report* (1981) pp 33-39.
- [6] Akobundu, I.O. (1982b). Weed control in cowpea (*Vigna unguiculata*) in the humid tropics. *Weed Science* 30: 331-334.
- [7] Ayeni, A.O. (1982). Response of maize (*Zea mays* L.), cowpea (*Vigna unguiculata* (L.) Walp and maize/cowpea intercrop to weed interference in a sub humid tropical environment. *Ph.D. Thesis, Cornell University, U.S.A.*
- [8] Bhattacharya, P.S. and Mandal, P.K. (1990). Efficacy of pendimethalin in controlling weeds in transplanted rice. *Oryza.* 25: 385-391.
- [9] Bleasdale, F.T. (1960). In: Zimdahl, R.L. (ed.) Crop weed competition: A review (1980) – *International Plant Protection Centre.* Oregon State University, pp. 151.
- [10] Bouyocos, G. J. (1951). A recalibration of hydrometer method for mechanical analysis of soil. *Agronomy Journal* 43: 434-438.
- [11] Bray, R. H. and Kurtz, L.T. (1945). Determination of total organic carbon and available phosphorus in soil. *Soil Science* 59: 39-45.
- [12] Chikoye, D., Manyong, V. M. and Ekeleme, F. (2000). Characteristics of speargrass (*Imperata cylindrica*) dominated fields in West Africa: crops, soil properties, farmer perceptions and management strategies. *Crop Protection.* 19:481-487.
- [13] Cisse, N.; Ndiaye, M.; Thiaw, S. and Hall, A.E. (1995). Registration of Mouride cowpea. *Crop Sci.* 35: 1215-1216.
- [14] De la Cruz, R. Rojas, C. E. and Merayo, A. (1994). Uso de leguminosas de cobertura para el manejo de la caminadora (*Rottboellia cochinchinensis*) durante el ciclo de cultivo del maiz y el periodo de barbecho en el tropic seco en Costa Rica. *Manejo Integrado de plagas* 31:29-35.
- [15] Doll, J. D. (1944). Dynamics and complexity of weed competition. Weed Management for developing countries. (Ed.) In: Labrada, J. C. Caseley, C. and Parker, *Plant Production and protection paper. No. 120, FAO, Rome* , pp. 29 -34.
- [16] Faris, D.G. (1963). Evidence for the West African origin of *Vigna sinensis* (L.)Savi. *Ph.D. Dissertation, University of California*, 84 – 87.
- [17] Frick, B. and Johnson, E. (2012). Weeds – when are they problem? (2012). Organic Agriculture Centre of Canada (OACC). Dorhouse University Available: <http://www.organiccentre.ca/.../text-p.....> searched last August 12th, 2013.
- [18] Gomez, A. K. and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research. 2nd Edition, *John Wiley and Sons, Inc. New York* pp 96-107, 119-205.
- [19] Hall, R. L. (1974). Analysis of the nature of interference between plants of different species I. Concepts and extension of the De wit. Analysis to examine effects. *Australian J. Agric. Res.* 25: 739 – 749.
- [20] Heap, I. (2002). The International Survey of Herbicide Resistant Weeds. Available at www.weedscience.com.
- [21] Holm, L. G., Plucknett, D.L., Pancho, J.V. and Herberger, J.P. (1977). The World's Worst Weeds, Distribution and Biology. *University Press of Hawaii, Honolulu*, pp 139-145.
- [22] International Institute of Tropical Agriculture (IITA) (2013a). Cowpea. IITA annual report. 2009; 29th July, 2013. Available: http://www.IITA.org/cons/details/cowpea_projectdetails.aspx?Zonied63xcriticed269.
- [23] International Institute of Tropical Agriculture (2013b). Crop and farming systems 2001. Assessed 29th July, 2013. Available: <http://www.IITA.org/cowpea.intml>.
- [24] Iyagba, A.G. and Ayeni, I.O. (1997). Control of Siam weed (*Chromolaena odorata* (L.) R.M. King and Robinson) and Guinea grass (*Panicum maximum* Jacq.) in a maize (*Zea mays* L.) and cassava (*Manihot esculentus* Crantz) mixture with postemergence herbicides. *Nig. Journal Crops soil and For.* 31: 196 -205.
- [25] Jackson, M.I. (1962). Soil Chemical Analysis. *Practice Hall, Inc. Eaglewood chaff*, New York.
- [26] Liener, E. (1969). Toxic constituents of plant food stuffs In: C.L.A. Leakey and Willis (eds.). Food Crops of the lowland tropics. *Oxford University Press* pp 41-59.
- [27] Mather, H.J. (1961). Definition of plant competition In: Zimdahl, R.L. (ed.) Weed Crop competition: A review. *International Plant Protection Centre, Oregon State University* p 12.
- [28] Millholon, P.W. and Burner, D.M.C. (1993). Itchgrass (*Rottboellia cochinchinensis*) biotypes in world populations. *Weed Science* 4: 379 – 387.
- [29] Parker, C. (1999). Plant Production and protection paper (50) In: Valverde, B.E. (2013) Progress on *Rottboellia cochinchinensis* Management. Available : <http://www.fao.org/doorep/006.../y503le07.ht.....> Assessed August 20, 2013.
- [30] Smith, M.A.K. and Akinade, R.A. (2000). Comparative weed succession in uncropped and cropped lands in a Tropical rainforest zone. *African Journal of Environmental studies* Vol.1. No. 1 & 2:104 – 114.
- [31] Sunday, O. and Udensi, E.A. (2013). Evaluation of pre-emergence herbicides for weed control in cowpea (*Vigna*

- unguiculata* (L.) Walp.) in a forest – Savanna Transition Zone. *American Journal of Experimental Agriculture* 3(4): 767 -779.
- [32] Taiwo, S.O. and Ekeleme, F. (2003). Effect of tillage, weeding regimes and mulching on speargrass (*imperata cylindrical* (L.) *Raeuschel*) suppression and soybean (*Glycine max* (L.) *Merril*) yield. *Nigerian Journal of Weed Science* 21:84-94.
- [33] Walkey, A. and Black, C.A. (1934). An estimation of Detrigareff method for determining soil organic matter and proposed modification of the chromic titration method. *Soil Science* 37: 29-31.
- [34] Wiese, F.A. (1985). Weed control in Limited tillage system. *Weed Science Society of America*. Monog. No. 2: 297 pp.
- [35] Valverde, B. E (2013). FAO paper Progress on *Rottboellia cochinchinesis*. Weed Management for developing countries. Agriculture and Consumer Protection. Available: <http://www.fao.org/docrep/006/.../y5031e07.ht...> assessed August 20, 2013.
- [36] Zimdahl, R.L. (1980). Weed-crop competition: A review. *International Plant Protection Centre*. Oregon State University, U.S.A. 195pp

Table 1: Effects of weed removal techniques and interference duration on cowpea growth Parameters

Treatments	Plant height (cm)	No. of leaves/plant	Leaf area /plant (cm ²)	No .of branches/plant	Leaf dry wt.(g/plant)	Vine dry wt.(g/plant)	Day to 50% flowering
Weed removal techniques							
Hand pulling	109.25b ²	30.17a	1414.61c	5.90a	16.03a	21.44a	42a
Slashing	114.36a	29.43a	1668.12a	5.98a	14.19a	19.33a	43b
Chemical	112.40a	24.19b	1525.30b	5.64b	11.69b	16.91b	43b
Mean	112.0	27.93	1536.01	5.84	13.97	19.23	43b
SE(±)	2.79	3.26	127.09	0.18	2.18	2.22	0.58
Weed interference duration							
Weed free	98.75a	31.83a	1511.79a	5.89a	18.07a	24.29c	42a
15 DAS ¹	97.44a	32.14a	1603.17a	5.80a	19.24a	26.52c	42a
20 DAS	93.22a	27.70a	984.34b	5.36a	15.36a	18.08b	44a
25 DAS	80.76b	24.14b	868.78b	5.11a	12.65b	15.64b	46b
30 DAS	84.00b	20.36b	888.36b	4.91b	11.23b	14.91b	48b
60 DAS	68.55c	17.24c	592.19bc	4.24b	7.10bc	8.14c	52bc
Mean	87.14	25.57	1074.11	5.21	13.94	17.93	46
SE (±)	11.58	6.09	397.48	0.60	4.54	6.70	4.0

¹Days after sowing ²Values followed by the same letter(s) in a column are not significantly different at 5% level using DMRT.

Table 2: Effects of weed removal techniques and weed interference duration on weed dry weight, weed density and weed control efficiency in cowpea

Treatments	weed dry weight (g/plant)	weed density (no./m ²)	weed control efficiency (%)
Weed removal techniques			
Hand pulling	14.94a ²	9.3a	69.8a
Slashing	12.39b	7.4b	74.9a
Chemical	12.65b	7.6b	62.4b
Mean	13.33	8.1	69.0
SE(±)	1.40	1.0	6.3
Weed interference duration			
Weed free	0a	0a	100a
15 DAS ¹	11.98b	6.9b	67.6a
20 DAS	11.29b	7.8b	69.5a
25 DAS	13.27b	9.4b	64.1b
30 DAS	14.38b	11.5b	61.1b
60 DAS	36.98a	17.6a	0c
Mean	14.65	8.9	60.4
SE (±)	12.12	5.8	32.7

¹Days after sowing ²Values followed by the same letter(s) in a column are not significantly different at 5% level using DMRT.

Table 3: Interaction between weed removal techniques and weed interference duration on cowpea growth parameters.

Treatments	Plant height (cm)	No. of leaves/plant	Leaf area /plant (cm ²)	No .of branches/plant	Leaf dry wt.(g/plant)	Vine dry wt.(g/plant)	Day to 50% flowering
Weed removal techniques							
Hand pulling	68.43c ²	29.34a	1398.34a	5.67a	15.07a	20.62a	42a
Slashing	76.14a	28.76a	1406.29a	5.64a	13.68a	19.01a	43b
Chemical	72.06b	26.39b	1394.63a	4.56b	10.89b	15.67b	43b
Mean	72.21	28.16	1399.75	5.29	13.21	18.43	43
SE(±)	3.86	1.65	53.21	0.63	2.13	2.52	0.58
Weed interference duration							
Weed free	92.77a	29.68a	28.36a	6.44a	17.11a	23.42a	42a
15 DAS ¹	88.15a	28.47a	27.84a	5.67b	18.76a	25.89a	42a
20 DAS	84.21	23.65a	22.56ab	5.20b	15.21a	17.24ab	43a
25 DAS	70.63	21.28b	20.34b	4.95c	11.89b	15.21b	46ab
30 DAS	62.11	16.83b	16.11b	4.91c	10.16b	14.14c	47b
60 DAS	42.94	16.30c	15.84b	4.21c	6.63bc	7.26d	52c
Mean	73.47	22.70	21.84	5.23	13.29	17.19	45
SE (±)	18.83	5.66	5.48	0.76	4.57	6.73	4.0

¹ Days after sowing ²Values followed by the same letter(s) in a column are not significantly different at 5% level using DMRT.

Table 4: Interaction between weed removal techniques and weed interference duration on weed dry weight, weed density and weed control efficiency

Treatments	weed dry weight (g/plant)	weed density (no./m ²)	weed control efficiency (%)
Weed removal techniques			
Hand pulling	13.62a ²	8.8a	67.4a
Slashing	11.94b	7.4b	72.8a
Chemical	12.13b	6.9c	61.9b
Mean	12.56	7.7	67.4
SE(±)	0.92	1.0	5.5
Weed interference duration			
Weed free	0c	0c	100a
15 DAS ¹	11.20b	5.4b	67.9a
20 DAS	10.86b	6.7b	68.8b
25 DAS	13.18b	7.2b	60.4b
30 DAS	14.07b	9.5b	59.6b
60 DAS	34.85a	16.3a	0c
Mean	14.13	7.5	59.5
SE (±)	11.39	5.3	32.6

¹Days after sowing ²Values followed by the same letter(s) in a column are not significantly different at 5% level using DMRT.