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Effect of Time of Weed Removal and Population Density on Weed Control and Crop Performance in Okra/Amaranthus Intercrop

ABSTRACT

Intercropping is an agricultural system that provides enabling environment for weed control in field crop production. A field trial was conducted during the late wet seasons of 2011 and 2012 at the Research Farm of the Federal University of Agriculture, Alabata, Abeokuta ($7^0$15'N, $3^0$25'E) in the forest savanna- transition zone of Ogun State, South Western Nigeria. The objective was to evaluate the effect of time of weed removal and population density on weed control and crop performance in Okra/Amaranthus intercrop. The experiment was laid out in a Randomized Complete Block Design (RCBD) in a Split- plot arrangement. The treatments consisted of three main plots and five sub plots replicated three times. The main plot treatments were hoe- weeding at 3 weeks after planting (WAP), weeding at 3 and 6WAP and weedy check, while the sub plots consisted of okra intercropped with amaranthus at 0.5g/m^2 or 1.0g/m^2, okra sole and amaranthus sole at 0.5g/m^2 or 1.0g/m^2. Results from the study showed that intercropping of okra with amaranthus reduced weed infestation significantly ($p<0.05$) compared to sole okra. Weed control treatments significantly ($p<0.05$) reduced weed infestation in the intercrop while cropping pattern did not have any significant effect ($p<0.05$) on the weed biomass, plant height, pod length, number of pods and pod fresh weight. Uncontrolled weed infestation led to 50.7% yield loss in okra. It is therefore concluded that intercropping of okra with amaranthus is an effective means of reducing weed pressure in okra production as well as increasing land productivity.

Key words: Intercropping, weed removal, cropping pattern, amaranthus, okra

INTRODUCTION

Okra (*Abelmoschus esculentus L. Moench*) which is also known as Lady's finger is one of the most important vegetable crop of the tropical and sub-tropical regions of the world (Schippers, 2000). Okra is a popular health food due to its high fibre, vitamin C and folate content. (Siemonsma & Kouame 2004). It is also known to be high in antioxidants, calcium and potassium. (Duvauchelle, 2011).

Okra, because of its growth habit and importance in the diets of most Africans, is often grown as an annual in mixture with staple food crops such as Yam, Cassava, Maize, green amaranth in most agricultural zones of sub-saharan Africa (Ikeorgu *et al.,*1989; Muoneke and Asiegbu, 1996).

Weeds are the major constraints to efficient okra production. Losses in crop yield due to weed may be greater than those due to other plant pests and diseases (Orkwor *et al.,* (1994). Okra farmers use hand hoe for most farm operations, including weed control. Timing of weed removal has been shown to be more critical than the frequency of weeding in

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yam/maize/okra/sweet potato intercrop. According to Orkwor et al 1994 the critical period of weed interference in the intercrop was between 3 and 16 weeks after planting, Weed interference in the mixture reduced yam tuber yield by 35%, maize by 60%, okra 79% and sweet potato roots by 80%. They observed that there was no added advantage in keeping the intercrop weed-free throughout the growing season.

The need to reduce the number of weedings in okra production has become imperative owing to the increasingly scarcity and high cost of labour.

Crop production per unit area must be increased because of remaining fixed or diminishing suitable land for food production. Intercropping through more efficient use of water, nutrient and solar energy can significantly enhance crop productivity compared to the growth of sole crops (Midmore, 1995).

Intercropping is the most popular cropping system in subsistence agriculture (Obadoni, 2010). It provides more profit through enhanced utilization of soil nutrients and space and reduces risk of crop failures due to weed, diseases and pest infestation. Intercropping also ensures efficient utilization of light and other resource, reduces soil erosion, suppresses weed growth and thereby helps to maintain greater stability in crop yield (Susan and Mini, 2005). A number of studies have shown that increased crop density would decrease the magnitude of effect of weed competition with crops (Andrade *et al.,* 2002; Teasday and Frank, 1983; Adigun, 1992; Adigun, 2001; Ismail and Hall 2001; Adigun 2002). Increase crop density has the advantage of shading weeds and better competitive advantage in crop production.

Green amaranth (*Amaranthus hybridus*) is one of the vital nutritious vegetable crop commonly intercropped with okra. The crop is mainly planted by broadcasting within the row or on the seed bed. Broadcasting green amaranth within the rows of okra is a procedure whereby the space which otherwise would have been occupied by weeds is replaced by the amaranth. The implication of this is that instead of the farmer wasting his time and resources to control weeds within the rows he would only need to remove the amaranthus and sell to enhance his income.

Till date there is paucity of information on the time of weed removal and population density and their effect on weed suppression and crop productivity in okra/amaranthus intercrop.

The objective of this study therefore was to investigate the effect of effect of time of weed removal and plant population density on weed control and crop performance in okra/amaranthus intercrop

MATERIALS AND METHODS

Two field experiments were carried out at the Research Farm of the Federal University of Agriculture, Abeokuta ($7^0$15'N, $3^0$25'E) in the Forest Savanna Transition agro-ecological zone of South Western Nigeria. The location has a bimodal rainfall distribution pattern which peaks in July and October. (Figure 1) The land had been left fallow for two years after which it was used to cultivate Chochorus and green amaranth. The soil used was a sandy loam with the physical and chemical properties shown in Table 1.

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Table 1: Soil Physico-chemical analysis of the Experimental Plot before Planting

Soil property	2011	2012
pH (H2O)	7	6.8
pH (KCl)	6.6	6.3
Organic carbon (%)	1.55	1.24
Total Nitrogen %	0.089	0.094
Organic matter	2.67	2.14
Available P (mg/kg)	21.63	16.44
TEA (cmolKg-1)	0.3	0.3
Ca (cmolKg-1)	8	5.6
Mg (cmolKg-1)	5.2	5.3
K+ (cmolKg-1)	0.46	0.36
Na (cmolKg-1)	0.64	0.22
ECEC	14.6	11.78
BS	97.95	98.75
Sand (g/kg)	694	730
Silt (g/kg)	130	124
Clay (g/kg)	176	146
Texture	Sandy loam	Sandy loam

The following weed species were present during the pre-cropping stage at the experimental site; *Talinum triangulare , Ageratum conyzoides, Spigelia anthelmia, Mitracarpus villosus, Phyllantus amarus, Euphorbia heterophylla, Tridax procumbens, Chromolaena odarata, Mucuna pruriens, Euphorbia herterophyll, Panicum maximum, Imperata cylindrical, Cynodon dactylon, Axonopus compressus. and Cyperus rotundus.*

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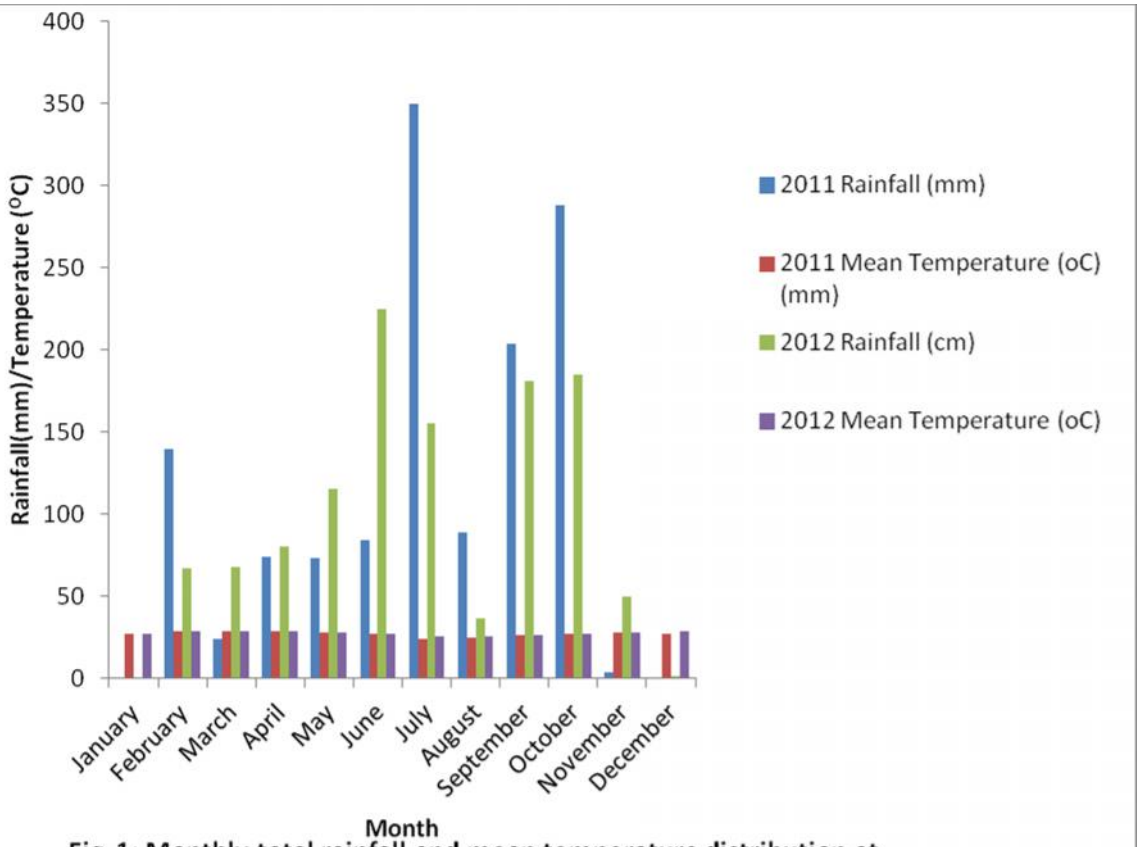

Fig. 1: Monthly total rainfall and mean temperature distribution at Alabata in 2011 and 2012.

Experimental Design, Treatment and Plot size

The experiment was laid out in a Randomized Complete Block Design (RCBD) in a Split- plot arrangement which consisted of fifteen treatment combinations replicated three times. The main plot consisted three period of weed removal (WR) namely: hoe weeding at 3weeks after planting (WAP), weeding at 3 and 6WAP, weedy check while the sub plots which consisted of five cropping pattern (CP) okra intercropped with amaranthus at 0.5g/m^2 (P1), or 1.0g/m^2 (P 2), sole okra, sole amaranthus at 0.5g/m^2 (population1), or 1.0g/m^2 (population 2). The gross and net plot sizes were 4m X 4m and 3m X 3m respectively.

Cultural operation

The field was prepared manually using cutlass to remove the established vegetation. Marking out of the field and plot layout was also done while the seed bed was prepared using African hoe. An improved variety of okra (NHAE-47) and a local variety of green amaranth were obtained from NIHORT (National Horticultural Research Institute, Ibadan, Nigeria). Three seeds of okra were planted at a spacing of 90 cm X 30 cm and later thinned to two plants, two

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weeks after planting. Weeding operations were carried out as specified above in the treatments. Leaf eating beetles were controlled with cypermethrin at 10ml/10litres of water.

Data collection

Data collected from the experiment included the following:

Weed Data

Weed samples were collected at 3, 6 and 9 weeks after planting from three random $0.5m^2$ quadrat along a diagonal transect in each plot for identification by species, plant taxa and growth form. All plants within the quadrat were cut at the soil surface and weighed. Weed dry weights were later determined after oven-drying the samples at 70° C for 48 hours.

Okra growth and Developmental parameters

Okra Height: At 3, 6 and 9 WAP, the maximum height of the canopy was measured on five tagged plants in the central row with a meter rule. The average of the five measurements in each plot was recorded.

Days to 50% flowering and days to 100% podding. Number of days from planting to 50% flowering was recorded, when half of the plants flowered as well as the number of days when all the plants in each plot podded (100% podding).

Yield and yield components of Okra.

Five plants were tagged on each plot and yield components such as number of pods, pod length, pod girth, and fruit yield were determined. The number of pods was determined by cumulating the number of harvested pods for each plant. Pod length was measured with measuring tape from the base of the pod to the tip while the pod girth was taken with a venier caliper. The

fruit yield was determined by harvesting the fruits every 3 days.

***Amaranthus growth and Yield parameters*:**

Amaranthus height: This was done by measuring from the base to the tip of five tagged plants at 3 and 6 WAP.

Fresh weight at harvest: At harvest, fresh weight of amaranthus in the net plot was taken.

The Land Equivalent Ratio (LER)

The Land Equivalent Ratio (LER) was calculated using the formular:

$$\frac{\text{Yield of Intercropped X}}{\text{Yield of Sole X}} + \frac{\text{Yield of Intercropped Y}}{\text{Yield of Sole Y}}$$

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Where X = Okra and Y = Amaranthus. The LER was calculated to determine the relative advantage of intercropping over sole cropping

The data collected were subjected to analysis of variance (ANOVA) and treatment means were compared using Fisher's Protected Least Significant Difference (LSD) at $P < 0.05$.

RESULTS

Effect of time of weed removal and plant population density on weed specie composition and weed dry weight in Okra/Amaranthus intercrop.

In 2011, the most dominant weed species were *Ageratum conyzoides, Tridax procumbens, Euphorbia heterophylla* and *Panicum maximum* while in 2012*, Ageratum conyzoides, Tridax procumbens, Talinum triangulare, Axonopus compressus* had the highest weed intensity (Table 2).The weed control treatments had significant effect ($p < 0.05$) on weed dry weight at 3, 6 and 9 WAP (Table 3). There was increasing weed biomass as the season progresses in plots where weeds were left uncontrolled. Weed removal at 3 WAP and weeding at 3 and 6WAP plots maintained a relatively constant weed biomass throughout the period of observation. The study also showed that there was no significant difference among the weed biomass in the pure stands of okra and amaranthus as well as their mixtures (Table 3). Interaction between the time of weed removal and plant population on weed dry weight was not significant.

Effect of time of weed removal and plant population density of amaranthus on the growth and yield of okra in Okra/Amaranthus intercrop

Weed control treatments had no significant effect on plant height of okra at 3 WAP and 6 WAP (Table 4) and also had no significant effect on days to 50% flowering, days to 100% podding and dry matter production (Table 5). There was no significant difference among cropping systems and weed control methods on the days to 50% flowering and days to 100% podding of Okra. Interaction between the time of weed removal and plant population density of amaranthus on the growth of Okra was also not significant.

Effect of weed removal and plant population density on the yield and yield components of okra in Okra/Amaranthus intercrop

Results from this study showed that pod length and fruit yield were significantly ($p < 0.005$) affected by the time of weed removal (Table 6). Weed removal at 3 WAP compared favourably well with maximum values obtained from weeding at 3 and 6WAP period. The weeding at 3 and 6WAP plots and plot weeded 3 WAP gave 5.16 and 4.77 t/ha fruit yield respectively in 2011 while in 2012, weeding at 3 and 6WAP plots and plot weeded 3 WAP gave 2.92 and 2.80 t/ha fruit yield respectively. It was also observed that cropping system had no significant ($p > 0.05$) effect on the fruit length, pod girth and fruit yield irrespective of the year of planting (Table 6).

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Effect of time weed removal and plant population density on the growth and yield of amaranthus in Okra/Amaranthus.

The effect of time of weed removal and plant population density of amaranthus on plant height, fresh and dry weight of amaranthus is presented on Table 7. The result indicated that time of weed removal and cropping pattern (intercropping) had no significant ($p< 0.05$) effect on plant height and fresh weight of amaranthus. Furthermore, the interactions between the time of weed removal and plant population density on plant height and yield of amaranthus were not significant either.

Intercrop Productivity:

The study showed that intercropping had advantage over sole crop. The Land equivalent (LER) of the okra/amarnthus intercrop population 1 and population 2 were 1.93 and 1.50 respectively.

Discussion

In this study, comparable maximum fruit yield was obtained in weeding at 3 and 6WAP and plots weeded 3 WAP. Uncontrolled weed infestation led to 50.7 % yield loss in okra fruit yield while weed removal at 3 WAP only resulted in 5.2% yield reduction. In these treatments there were corresponding decreases in weed biomass (Table 2). Okra and amaranthus were observed to have higher canopy than the weeds. Obasi (1989) and Orkwor *et.al*., (1991) observed that the most important feature of plants that determine their competitive ability for light is height. They reported that a successful competitor for light is the component that has its foliage at a higher canopy layer. Palaniappan (1985) also reported that in an intercropping situation, the taller component crop intercepted the major share of light such that the growth rates of the two crops would be proportional to the quantity of the photosynthetic active radiation they intercepted.

Fruit yield obtained in 2011 was generally higher than 2012. This could be attributed to ceasation of rain at the reproductive stage of the crops in 2012. This reduction in yield also reflected in the values obtained from the height of the crop (okra).The height of okra plants in 2011 almost doubled that of 2012 (Table 4). It was also observed that the yield of each component crop was higher at higher amaranth plant population ($1.0g/m^2$). Amaranth through competition would have provided an environment of reduced weed biomass for okra. Several authors (Midmore *et al.,* 1995, Susan and Mini 2005, Olasantan and Bello (2004) have reported that weed suppression was stronger in intercrop than in monocultural components and at higher plant population.

This study showed that weed biomass increased with time in the weed infested plot while the rate of increase was constant in plots weeded 3WAP and weeding at 3 and 6WAP. Weeding at 3 WAP and weeding at 3 and 6WAP control methods significantly reduced weeds which resulted in increased yield and yield components of okra. From the values obtained from the Land Equivalent ratios (LER), there was yield advantage of intercropping okra with amarnthus. In this situation intercropping okra with amaranthus at 0.5g/m2 and 1.0 g/m2 would have required 93 % and 50 % more land if planted in sole stands of okra and amaranthus respectively. This result agrees with the findings of Susan and Mini (2005) who worked on the

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biological efficiency of intercropping okra with amaranthus. Their finding showed that the LER was greater than unity for wider and closer spacing (1.77 and 1.91) respectively.

CONCLUSION

This study showed that intercropping of okra and amaranthus could be a veritable way of reducing weed pressure in okra/amaranth intercrop as well as increasing land productivity. At high population density of amaranthus ($1.0g/m^2$), and single- timed weed removal at 3 WAP, growth and optimum fruit yield of okra and amaranthus will still be sustained.

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Table 2: Pre-cropping Weed specie composition of the experimental site in 2011 and 2012

Weed specie	Family	Growth form	2011	2012
Ageratum conyzoides	Asteraceae	ABL	+++	+++
Mucuna pruriens	Leguminoseae	PBL	+	-
Tridax procumbens	Asteraceae	ABL	+++	+++
Spigelia anthelmia	Loganiaceae	ABL	++	++
Mitracarpus villosus	Rabiaceae	ABL	++	-
Phyllantus amarus	Euphorbiaceae	ABL	+	-
Euphorbia heterophylla	Euphorbiaceae	ABL	+++	++
Chromoleana odorata	Asteraceae	ABL	++	++
Talinum triangulare	Portulacaceae	ABL	++	+++
Panicum maximum	Poaceae	PG	+++	++
Axonopus compressus	Poaceae	AG	++	+++
Imperata cylindrical	Poaceae	PG	++	+
Cyperus rotundus	Cyperaceae	PS	++	+

+= Low intensity, ++= moderate intensity,+++=high intensity, ABL= Annual Broadleaf, PG=Perennial Grass, PS=Perennial Sedges

Table 3: Effect of time of time of weed removal and plant population on weed biomass in okra/amaranthus intercrop in 2012

Treatment	**Weed dry weight (g/m^2)**			
	3WAP	6WAP	9WAP	Mean Weed Dry Weight (g/m^2)
Time of weed Removal (W)				
Weedy check	73.2b	137.6c	197.9b	136.3b
Weeding at 3 and 6 WAP	15.9a	16.7a	16.0a	16.87a
Weeding 3WAP	61.1b	62.6b	61.9b	61.9ab
SED	6.61*	12.7*	16.7**	29.2*
LSD (0.05)	18.4	35.2	46.3	81.3
Cropping Pattern (C)				
Okra Sole	48.1	78.5	101.7	76.10
Sole amaranthus P1	52.8	73.9	92.4	73.03

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Sole amaranthus P2	52.0	73.0	90.3	71.77
Okra+Amaranthus P1	49.2	72.3	89.5	70.33
Okra +Amaranthus P2	48.3	63.6	85.6	65.83
SED	4.4ns	7.0ns	7.3ns	3.02ns
LSD (0.05)	9.0	16.7	20.1	6.96
Interaction (WXC)				
SED	9.5ns	14.2ns	15.1ns	
LSD (0.05)	20.3	36.8	46.2	

WAP= Weeks after planting, ns=not significant, *=significant at 0.05, **=significant at 0.001, P1= amaranthus at 0.5g/m^2, P2= amaranthus at 1.0g/m^2

Figures followed by the same alphabets in a column are not significantly different by LSD test at 5% probability.

Table 4: Effect of time of weed removal and Plant population on Plant Height of okra in okra/amaranthus intercrop in 2011 and 2012 wet seasons

Treatment	**Plant Height (cm)**			
	3WAP		6WAP	
	2011	2012	2011	2012
Time of weed Removal (W)				
Weedy check	34.09	9.80,	32.42	15.70
Weeding at 3 and 6WAP	34.26	9.80	32.65	18.10
Weeding 3WAP	36.80	8.70	35.73	13.60
SED	2.30ns	0.75ns	2.38ns	2.61ns
Cropping Pattern (C)				
Okra Sole	35.73	9.18	34.17	17.50
Okra+Amaranthus P1	35.28	10.10	33.48	14.60
Okra +Amaranthus P2	31.14	9.71	33.15	15.3
SED	2.30 ns	0.75ns	2.38ns	2.61ns
Interaction (WXC)				
SED	3.99ns	2.00ns	4.12ns	4.51ns

WAP= Weeks after planting, ns=not significant, P1= amaranthus at 0.5g/m^2, P2= amaranthus at 1.0g/m^2

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Table 5: Effect of time of weed removal and plant population on plant height, days to 50% flowering and days to 100% podding of okra in okra/amaranthus intercrop in 2012

Treatment	Plant Height (cm)		Days to 50% flowering	Days to 100% podding
	3WAP	6WAP		
Weedy removal (W)				
Weedy check	34.09	32.42	24.00	46.90
Weeding at 3 and 6WAP	34.26	32.65	28.60	52.70
Weeding at 3WAP	36.80	35.73	27.10	52.10
SE±	2.30 ns	2.38ns	2.84ns	5.51ns
Cropping pattern (C)				
Sole okra	35.73	34.17	28.00	52.60
Okra+ Amaranthus P1	35.28	33.48	27.60	47.00
Okra+ Amaranthus P2	31.14	33.15	24.10	52.10
SE±	2.30	2.38	2.84	5.51
Interaction SE± (WxC)	3.99ns	4.12ns	9.33ns	9.55ns

WAP= Weeks after planting, ns=not significant, P1= amaranthus at 0.5g/m^2, P2= amaranthus at 1.0g/m^2

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Table 6: Effect of time of weed removal and plant population on pod length, number of pods and fruit weight of okra/amaranthus intercrop in 2011 and 2012 wet seasons

Treatment	Pod Length (cm)		Pod Girth (cm)		Number of Pods/plant		Fruit weight (t/ha)	
	2011	2012	2011	2012	2011	2012	2011	2012
Time of weed Removal (W)								
Weedy check	4.50	2.45a	4.11	1.91	9.89	4.44	2.48a	1.50a
Weeding at 3 and 6WAP	4.61	3.04b	4.41	2.36	11.02	7.33	5.16 b	2.92b
Weeding 3WAP	4.55	3.19b	4.16	2.36	10.67	6.33	4.77 b	2.80b
SED	0.38ns	0.18*	0.31ns	0.18ns	0.85ns	0.29**	0.85*	0.44*
Cropping Pattern (C)								
Okra Sole	4.69	2.93	4.36	2.18	11.00	5.67	4.27	2.46
Okra+Amaranthus P1	4.33	3.04	4.07	2.23	10.11	6.33	4.17	2.35
Okra +Amaranthus P2	4.55	2.81	4.26	2.28	10.67	6.11	3.98	2.44
SED	0.38	0.18ns	0.38	0.05ns	0.85	0.38ns	0.36ns	0.07ns
Interaction (WXC)								
SED	0.66ns	0.31ns	0.54ns	0.19ns	1.48ns	0.61ns	0.62ns	0.456ns

WAP= Weeks after planting, ns=not significant, *=significant at 0.05, **=significant at 0.001,, P1= amaranthus at 0.5g/m^2, P2= amaranthus at 1.0g/m^2

Figures followed by the same alphabets in a column are not significantly different by LSD test at 5% probability.

Table 7: Effect of time of weed removal and plant population on growth and yield characteristics of amaranthus in okra/amaranthus intercrop in 2012

Treatment	Plant Height (cm)			Fresh Weight at Harvest (t/ha	Dry matter(t/ha)
	3WAP	6 WAP	9 WAP		
Time of weed Removal					

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(W)					
Weedy check	16.72	28.3	41.3	2.49	1.24
Weeding at 3 and 6WAP	19.18	34.8	56.4	5.62	2.43
Weeding 3WAP	16.12	38.6	50.9	3.17	1.63
SED	2.32ns	3.83ns	5.83	0.98ns	0.73ns
Cropping Pattern (C)					
Sole amaranthus (P1)	16.57	34.00	42.4	3.65	1.88
Sole amaranthus (P2)	19.00	34.80	52.3	5.18	2.15
Okra+Amaranthus P1	16.59	31.7	50.1	3.56	1.21
Okra +Amaranthus P2	17.36	35.1	47.2	2.64	1.80
SED	1.95ns	4.23ns	5.97ns	1.23ns	0.55ns
Interaction (WXC)					
SED	3.69ns	7.41ns	10.68ns	2.09ns	1.10ns

WAP= Weeks after planting, ns=not significant, P1= amaranthus at $0.5g/m^2$, P2= amaranthus at $1.0g/m^2$