Response of Maize + Egusi melon to Intercropping and Weeding Frequency in a Rainforest Zone of Nigeria

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Abstract
The experiment was conducted in a farmer's field located by the David Ejoor Army Barracks Effurun within Warri metropolis (latitude 5° 31' N and Longitude 5° 45' E), Nigeria in 2012 and 2013 cropping seasons. The factors studied were cropping system and weeding frequency. The levels of the cropping system (CS) were sole maize (CS1), sole egusi-melon (CS2) and maize + egusi melon intercrop (CS3), while weeding regime (WF) consist of four levels, viz; no weeding or control (WF1), weeding at 3WAP (WF2), weeding at 6WAP (WF3) and weeding at 3, 6 and WAP (WF4). The factors were arranged in 4 x 3 factorial with RCBD. The results showed depressed growth and yield of maize and melon when weeding was delayed or non-frequent weeding, while frequent weeding improved crop growth. Maize + melon intercrop reduced weed biomass by 66% (10WAP). Land use efficiency of 63% was achieved in intercrops.

Keywords: weeding frequency, Intercropping, maize, melon; land use efficiency

Introduction

Many smallholder crop farmers in sub-Sahara Africa spend about 35 to 70% of the total agricultural labour on weeding yearly, and this cost of production in most cases exceeds all other farm operations (Chivinge, 1984; Waddington and Karigwindi, 1996). In rainy seasons, weeding is more frequent since farmers have to obtain good crop harvests. In some situations, farmers who are unable to meet up with weeding (commonly practiced manual weeding), usually abandon the crops and make do with whatever that is obtained from such plots. As earlier observed by Mashingaidze and Chivinge (1998), the implication is that, with little or no economic yield of the abandoned crops, farm inputs and resources earlier committed are invariably lost.

Most smallholder farmers place much emphasis on the traditional weed control than weed management; Vandeman (1994) and Cardina *et al..*, (1999) reported that in weed control much attention is on killing of the weeds rather than protecting the crop, and ignores possible positive biological interactions within the farm ecosystem that may check weed populations. Weed management, however places more emphasis on reducing emergence of weeds, limiting production of propagule and reducing competition of weeds with the crop (Zimdahl, 1991; Buhler, 1996).

Sustainable crop management practices that improve the interception of incoming solar radiation with increased growth and yield of the crop, may at the same time reduce the incident solar radiation on the germinating weeds growing below the crop canopy (Mashingaidze, 2004). This practice is a better option for smallholder farmers since it will result in higher crop yield and reduced weed infestation. Intercropping which has been defined as the cultivation of two or more crops species on same field within a cropping season (Ofori and Stern, 1987), has been shown to have several advantages over monocropping or sole cropping. Various reasons have been given why farmers practice intercropping and these include production of higher crop yield per unit land area, insurance against crop failure, weed suppression, reduction in level of insect pest infestation, optimal use of growth resources, among others (Poggio, 2005;Njoku and Muoneke, 2008).

Maize is one of the cereals which is cultivated in every agro-ecological zone in Nigeria, mainly for its role in human food and livestock feed. Weeds constitute one of the biotic factors which contributes to widening the gap between potential and actual yield of maize. Intercropping systems which incorporates smoother crops such as melon may be options for reducing weed infestation and increasing crop yield in maize farms. In mixture crop populations, Liebman and Dyck (1993), reported reduction in weed density and biomass compared to sole plant populations when broadleaf smoother crop species were intercropped with the main crop. From related reports at IITA Ibadan, Akobundu (1993) observed that egusi melon when intercropped with maize suppressed weed growth and reduced weeding frequency from two-three times to once per season. Ofosu-Anim and Lambani (2007) also reported reduced weed infestation in okra-cucumber intercropping.

This study was therefore undertaken to determine the effect of weeding frequency and intercropping on weed suppression and performance of maize-melon intercrop.

Materials and Methods

The experiment was conducted in a farmer's field located by the David Ejoor Army Barracks Effurun within Warri metropolis (latitude 5° 31' N and Longitude 5° 45' E), Nigeria in 2012 and 2013 cropping seasons. The factors studied were cropping system and weeding frequency. The treatments consisted of three levels of the cropping system (CS) viz: sole maize (CS1), sole egusi-melon (CS2) and maize + Egusi melon intercrop (CS3), and four levels of weeding regime (WF), namely, no weeding or control (WF1), weeding at 3WAP (WF2), weeding at 6WAP (WF3) and weeding at 3, 6 and WAP (WF4). Weeding regime levels WF2 and WF3 represented early and late weeding respectively, while WF4 represented frequent weeding. The three cropping systems and four weeding regimes were combined in a 3 x 4 factorial experiment set up in randomized complete block design with three replicates. The additive intercropping system was used in this experiment. All maize and melon crops were planted on the field at a spacing of 90cm x 30cm both in sole and intercrop plots. Individual plot size was 3m by 2.7m.

At 12 weeks after planting (12 WAP), the following data were collected for maize and these include vegetative growth characteristics consisting of plant height, number of leaves per plant, unit leaf area. The unit leaf area was obtained using the length-width method

Leaf area =0.75 (L x W) where L= leaf length and W= maximum leaf width

The total leaf area was obtained through product of number of leaves per plant and unit leaf area, while the leaf area index (LAI) was calculated from the ratio of total leaf area to ground area occupied by plant (Palanisamy and Gomez, 1974). Data on days to 50% tasseling (D-50-T) was obtained when tassels appear on half of the maize plants in each plot. The number of cobs per plant, weight per cob, number of grains per cop, 1000 grain weight and grain yield (t/ha) were obtained from the net plot after harvest.

Data collected for Egusi-melon were vine length, number of leaves, unit leaf area. The leaf area of Egusi-melon was determined from the linear model described by Wahua (1985) using the relationship with the mid-rib length as follows:

Y = 7.41X-30.53, where Y = leaf area; X= mid-rib length of the central lobe
The total leaf area and LAI were obtained using the methods earlier described for maize. Other data obtained for egusi-melon include days to 50% flowering, number of fruits per plant, weight of fruit per plant (g), number of seeds per fruit, 100 seeds weight, weight of fruit per plant (kg) and seed yield (kg/ha). Productivity of the maize-egusi melon system was assessed using relative yield (RY), land equivalent ratio (LER

A 50cm x 50cm quadrant thrown randomly in each plot was used to obtain weed count at 6 and 10 weeks after planting. Weeds were cut at ground level and oven dried at 65^0C to a constant mass to obtain weed biomass. The weed control efficiency was calculated using the formula stated by Thakral *et al*.., (1988).

WCE (%) = [(DMC- DMT)/DMC] x 100, where

WCE = weed control efficiency (%); DMC = weed dry matter of unweeded plot (control)

DMT = weed dry matter of treated plots

Data obtained were subjected to analysis of variance (ANOVA) procedures described for factorial design in an RCBD pattern. Separation of treatment means was carried out using the least significant difference (LSD) at 0.05 level of probability.

Results and Discussion

Vegetative performance and yield of maize

The effect of weeding frequency and cropping system on vegetative growth parameters and days to tasseling of maize are presented in Table 1. Weeding frequency significantly affected plant height of maize. Taller maize plants (170.6cm) were recorded in plots with frequent weeding, while the unweeded control had the shortest plants (129.2cm). Sole maize plants were found to be taller than those intercropped with egusi-melon, with a reduction of 8.9%. All the foliage characters of maize in this study were at their maximum values when crops were frequently weeded. The unweeded control and late weeding (6 WAP) indicated the least number of leaves with values of 9.8 and 11.0. Comparing the unweeded control and frequent weeding, it was observed that weeds reduced unit leaf area and total leaf area per plant by 22.4% and 49.6% respectively, while intercropping reduced same foliage attributes by 9% and 19.5% respectively. The more the delay in weeding of the maize plants the lower the leaf area index (LAI), with maximum LAI (4.6) observed on frequently weeded maize plants, while the unweeded control had 2.3. This result was consistent with the findings of James *et al*.. (2000) and Larbi *et al*.. (2013) who reported reduced foliage attributes of maize due to suppression of lower leaves by weed, resulting in premature leaf senescence and subsequent leaf area reduction. Though no significant difference ($P > 0.05$) was observed, the delay in weeding and intercropping also delayed days to tasseling of maize, hence the unweeded control recorded highest number of days to 50% tasseling (47.1).

Table 1: Plant height, foliage attributes and days to tasseling of maize as influenced intercropping with Egusi-melon and weeding regime

	Plant height (cm)	No. of leaves/plant	Leaf area/leaf (cm^2)	Total leaf area/plant (cm^2)	LAI (cm)	D-50-T
Weeding regime						
Control	129.2^c	9.8^c	640.4^d	6275.9^d	2.3^b	47.1^a
Weeding 3WAP	163.4^a	13.6^{ab}	780.1^b	10609.4^b	3.9^a	46.2^a
Weeding 6WAP	149.6^b	11.0^{bc}	690.6^c	7596.6^c	2.8^b	46.7^a
Frequent weeding	170.6^a	15.1^a	825.3^a	12462.0^a	4.6^a	46.0^a
CD (5%)	12.7	2.8	44.1	147.3	1.8	Ns
Cropping system						
Sole maize	160.3^a	13.8^a	768.8^a	10235.0^a	3.7^a	46.3^a
Maize +melon	146.1^b	11.0^b	699.4^b	8241.0^b	3.1^a	46.7^a
CD (5%)	14.8	2.1	51.3	136.2	ns	Ns
W x CS	*	*	**	**	ns	Ns

With exception of number of cobs per plant, weeding frequency and intercropping significantly affected all components of yield and grain yield of maize (Table 2). Number of cobs was slightly reduced by delayed and non-frequent weeding frequency and intercropping. Least weight per cob was obtained in unweeded control (80.1g) while frequent weeding recorded the maximum cob weight (101.7g). However, intercropping reduced cob weight by 9.1%. The number of grains per cob and 1000 grain weight also showed similar trend with weight per cob. Relative to unweeded control, weeding at 3WAP, 6WAP and frequent weeding, increased number of grains per cob by 17.7%, 6.5% and 26% respectively. Intercropping reduced number of grains and 1000 grain weight by 2.8% and 9.1% respectively. Significantly maize grain yield reduction was observed with weeding regime and intercropping. Maize yield was at its maximum in plants that were frequently weeded with yield of 904.6kg/ha. Relative to other regimes, frequent weeding increased grain yield of maize by 85.9%, 52.9% and 69.6% in 6WAP, 3WAP and unweeded control, while intercropping reduced maize yield by 32.5%. Earlier reports by Liebman and Dyck (1993) and (Mashingaidze, 2004) confirm these findings. Muoneke and Mbah (2007) also reported reduced yield of okra in cassava/okra intercropping.

Table 2: Yield and yield components of maize as influenced intercropping with egusi-melon and weeding regime

	No. of cobs / plant	Weight per cob (g)	No. of grains per cob	1000 grain weight (g)	Grain yield (kg/ha)
Weeding frequency					
Control	1.3^a	80.1^d	281.3^d	231.7^d	534.9^d
Weeding 3WAP	1.4^a	92.8^b	342.0^b	272.3^b	650.4^b
Weeding 6WAP	1.3^a	88.3^c	300.9^c	249.5^c	586.5^c
Frequent weeding	1.5^a	101.7^a	380.2^a	290.9^a	994.6^a
CD (5%)	ns	5.8	23.9	16.9	24.8
Cropping system					
Sole maize	1.4^a	95.1^a	330.8^a	273.5^a	825.7^a
Maize +melon	1.3^a	86.4^b	321.4^b	248.7^b	557.6^b
LSD (5%)	ns	3.7	7.5	12.3	63.1
W x CS	ns	*	**	*	**

Vegetative performance and yield of egusi-melon

The vine length and number of branches were affected significantly ($P < 0.05$) by weeding frequency and intercropping (Table 3). Weeding frequency significantly affected vine length of egusi-melon. Longest vines (171.6cm) were found with egusi-melon plants that were frequently weeded, with frequent weeding increasing vine length by 22.3% relative to unweeded plants. Sole egusi melon had longer vines than intercrops. The number of branches were lower with delayed weeding and intercropping. Unweeded control indicated least number of branches with mean value of 3.5. The greater competition for soil and above ground growth resources between the component crops and the crop versus weeds would have contributed to reduction in plant height and branch number of egusi-melon (Iyagba *et al..*, 2012).

The results showed significant differences in foliage attributes measured (Table 3). The number of leaves produced by egusi-melon plants that were frequently weeded were significantly higher than the unweeded control and weeding at 3WAP, but 6WAP and unweeded control did not significantly differ from each other. The unit leaf area, total leaf area per plant and Leaf Area Index (LAI) were significantly reduced by delayed weeding, hence the maximum values of 111.7cm^{-2}, 7956.6cm^{-2} and 2.9cm were respectively achieved with frequently weeded plants, and compared to unweeded control, reduction of 31.3% (number of leaves), 32.5% (unit leaf area), 53.7% (total plant leaf area) and 51.7% (LAI) were observed. The decrease in number of leaves per plant, unit leaf area, total plant leaf area and LAI of egusi melon under maize intercrop may be due the varying canopy architecture of both crops. Maize being a taller plant with erectophile canopy would have intercepted radiant light needed for photosynthesis by the prostrate creeping egusi-melon with planophile canopy. Reduced vegetative growth of egusi-melon has been also observed when planted with erectophile crops such as maize (Makinde *et al..*, 2001; Ekwerre *et al..*, 2009; Ijoyah *et al..*, 2012a), okra (Ijoyah *et al..*, 2015), cassava and maize (Ijoyah *et al..*, 2012b).

Delayed weeding and intercropping with maize increased days to 50% flowering of egusi-melon, though results did not differ significantly (Table 3). Longer days to 50% flowering of egusi-melon has been reported in maize/egusi-melon intercrop (Ijoyah *et al..* 2012a).

Table 3: Plant height, branch number, foliage attributes and days to flowering of egusi-melon as influenced intercropping with maize and weeding regime

	Vine length (cm)	No. of leaves/plant	Leaf area/leaf (cm^2)	Total leaf area/plant (cm^2)	LAI (cm)	No. of branches	D-50-F
Weeding regime							
Control	140.3^d	48.9^c	75.4^c	3687.1^d	1.4^c	3.5^c	45.8^a
Weeding 3WAP	156.2^b	60.1^b	94.0^b	5649.4^b	2.1^b	4.0^{ab}	43.5^a
Weeding 6WAP	148.2^c	56.4^c	81.4^c	4591.0^c	1.7^{bc}	3.8^{bc}	44.2^a
Frequent weeding	171.6^a	71.2^a	111.7^a	7956.0^a	2.9^a	4.5^a	42.1^a
CD (5%)	7.3	8.1	10.5	100.8	0.6	0.6	Ns
Cropping system							
Sole maize	158.4^a	63.1^a	95.5^a	5783.1^a	2.3^a	4.3^a	44.7^a
Maize +melon	149.8^b	55.2^b	85.7^b	5308.7^b	1.8^a	3.6^b	43.1^a
CD (5%)	7.9	5.4	6.4	111.5	ns	0.4	Ns
W x CS	**	*	*	*	*	*	Ns

*Significant at 5% **significant at 1%, NS- Not significant

Components of yield of egusi-melon such as number of fruits , fruit weight, number of seeds, 1000 seeds weight recorded their maximum values of 6.3, 780.2g, 4.9kg, 182.7 and 196.3g respectively under frequent weeding (Table 4) and were significantly affected by weeding regime. Relative to frequent weeding, reduction of 63.3%, 36.7% and 55.1% in weight of fruits per plant were respectively observed in unweeded control, weeding at 3 WAP and weeding at 6WAP. Introducing egusi-melon into maize plants significantly reduced the individual yield components by 10% (number of fruits), 18.2% (weight of fruits per plant), 10% (number of seeds) and 10.7% (1000 seeds weight). The least and highest melon seed yield were observed from the unweeded control (580.7kg/ha) and frequent weeding (802.7kg/ha). Unweeded control, weeding 3WAP and weeding 6WAP when compared with frequent weeding, reduced melon seed yield by 27.7%, 10.2% and 25.1%. Sole melon was significantly reduced by the component maize crop in the mixture. This result was in line with the findings of Olasanatan and Lucas, (1992); Mbah *et al..*, (2007); Law-Ogbomo and Ekunwe, (2011) who observed depressed yield in maize-melon intercrop relative to the corresponding sole crop. Sole crop usually take full advantage of harnessing all resources available within the agro ecosystem for its use since there is no competition from another crop.

Table 4: Yield and yield components of egusi-melon as influenced by intercropping with maize and weeding regime

	No. of fruits per plants	Weight per fruit (g)	Weight of fruits per plant (kg)	No. of seeds/fruit	1000 seeds weight (g)	Seed yield (kg/ha)
Weeding regime						
Control	3.8[c]	481.2[d]	1.8[c]	138.5[c]	118.1[d]	560.8[d]
Weeding 3WAP	4.8[b]	651.3[b]	3.1[b]	160.4[b]	160.2[b]	700.2[b]
Weeding 6WAP	4.1[bc]	530.9[c]	2.2[c]	149.7[c]	145.5[c]	632.7[c]
Frequent weeding	6.3[a]	780.2[a]	4.9[a]	182.7[a]	196.3[a]	898.4[a]
CD (5%)	1.5	45.6	1.2	13.8	28.9	49.7
Cropping system						
Sole maize	5.0[a]	638.5[a]	3.3[a]	166.2[a]	163.8[a]	809.3[a]
Maize +melon	4.5[a]	583.3[b]	2.7[a]	149.5[b]	146.3[b]	586.3[b]
CD (5%)	ns	18.9	Ns	10.8	11.3	38.2
W x CS	**	*	*	*	*	*

*Significant at 5% **significant at 1%

Productivity in maize + egusi-melon intercrop

From the relative yield of the individual component crops in the mixture as shown in Table 5, it can be clearly stated that melon contributed more to the land use efficiency (as indicated in the LER) in the intercrop, when compared to maize. The LER values obtained from the intercropping system were all above unity. With frequent weeding 63% more land would be required in sole crops of either melon or maize to produce same yield in maize + melon intercrop. The LER values decreased with delay in weeding, hence the unweeded control recorded the least LER.

Table 5: Productivity indices in maize+egusi melon intercrop

Weeding regime	Relative yield		LER
	Maize	melon	
Control	0.57	0.62	1.19
Weeding 3WAP	0.65	0.72	1.31
Weeding 6WAP	0.61	0.69	1.30
Frequent weeding	0.80	0.83	1.63

The weed density and weed biomass were more pronounced in the unweeded control with values of 97.5 per m^2 and 218.6g m^{-2} respectively at 10WAP (Table 6). Decrease in weed density and the corresponding biomass was observed with frequent weeding and weeding at 6WAP when the two periods of weed count were compared. Mixture populations of maize and melon significantly reduced weed density and biomass relative to sole crop components. The denser canopy produced from a combination of a prostrate, vining growth and large foliage melon with the high foliage canopy of the maize on the intercropped plots would reduce radiant light to the weeds below the canopy, thus resulting in suppressing weed growth and reducing their competition with the crops. Akobundu (1993) and Obiefuna (1989) have reported the capacity of melon to suppress weeds when planted with other crops as smoother crop. In this study maize-melon intercropping reduced weed biomass by 48.9% (6WAP) and 66% (10WAP) using the mean values. Weed biomass of maize-pumpkin and maize-bean mixtures was depressed in intercrops by 50-66% (Mashingaidze, 2004),

Table 6: Weed density, weed biomass and weed control efficiency as influenced by weeding regimes in maize-melon intercropping

	6WAP	10WAP	6WAP	10WAP	6WAP	10WAP
	Weed density (no. m^{-2})		Weed biomass (g m^{-2})		Weed control efficiency	
Weeding regime						
Control	69.3a	97.5a	164.0a	218.6a	-	-
Weeding 3WAP	33.4c	63.7b	70.4c	126.6b	57.1	42.1
Weeding 6WAP	63.4b	28.9c	143.8b	55.4c	6.1	74.7
Frequent weeding	11.8d	9.6d	27.2d	21.5d	83.4	90.2
CD (5%)	5.8	9.7	11.5	13.3		
Cropping system						
Sole maize	59.7a	68.7a	146.1a	191.1a		
Sole melon	45.8b	49.8b	93.7b	157.5b		
Maize + melon	28.6c	31.8c	64.3c	73.5c		
CD (5%)	11.2	7.9	10.3	14.6		
W x CS	*	*	*	*		

Conclusion

The study has shown that frequent weeding along with intercropping with melon has the potential of suppressing weed growth and improving not only the growth and yield of the main crop, maize, but also created a conducive environment for the smoother crop, melon. A combined performance of the component crops in the mixture helped to reduce competition from weeds.

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