IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 10, Issue 9 Ver. II (September 2017), PP 40-46
www.iosrjournals.org

Effect of intercropping on weed suppression and maize (Zea mays L.) yield in a humid forest agro-ecology of South – Eastern Nigeria

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Abstract: *Field experiments were conducted at the Teaching and Research Farm of University of Port Harcourt, Port Harcourt, during the wet seasons of 2013 and 2016 to evaluate the effect of intercropping on weed suppression and maize yield. The experiment consists of seven treatments namely: sole maize, sole egusimelon, sole watermelon, sole pumpkin, maize + egusimelon, maize + watermelon, and maize + pumpkin. The treatments were laid out in a Randomized Complete Block Design (RCBD), and replicated three times. Results showed that at 12 weeks after planting (WAP), intercrops reduced weed density by 43.22% and 59.66% in 2013 and 2016 cropping seasons. Average over the years at 12WAP showed that the highest weed smothering efficiency was in maize intercropped with egusi-melon (84.15%) while the lowest was in maize intercropped with pumpkin (60.37 %). In addition, maize intercropped with egusi-melon had the best land equivalent ratio (LER) of 1.70 while maize intercropped with pumpkin had the least LER of 1.22. Since, egusimelon had the best weed smothering efficiency and LER in both years of the study; it is thus, recommended to farmers as a mean of weed suppression in maize.*
Keywords: *Intercropping, land equivalent ratio, maize yield, weeds smothering efficiency,*

Date of Submission: 31-08-2017 Date of acceptance: 06-10-2017

I. Introduction

Maize (*Zea mays* L.) belongs to a class of crop known as cereal and family of Poaceae. Maize is a major food staple for majority of people in Sub Saharan Africa (SSA)[1], especially in Nigeria. It is a very popular arable crop in almost all the states in Nigeria because it forms the dominant staple food crop. Maize is adapted to a very wide range of environments and is more extensively distributed over the earth than any other cereals. It is essentially a crop of warm countries with adequate moisture [2]. Statistics show that Nigeria in 2013 produced about 11.3 million tons of maize, hence placing Nigeria first in Africa in terms of production [3] . Apart from maize serving as staple human food, it also serves as feed for livestock and raw material for industries. The important role of maize in Nigeria has put a lot of pressure on its production with the attendant limitations to increase productivity. This has pushed production to marginal land infested with weeds.

Weeds infestation has become one of the most famous limitations to maize production in Nigeria. In Nigeria, weeding takes between 21-32% out of the total period dedicated for the production of maize [4]. Several maize in grain yield reduction in the range of 40-100 % due to weed interference have been reported [5], depending on the agroecosystem, weed species and cultural practices adopted [6]. Besides it production being in the hands of the resource poor farmers, weed infestation and its control is key to low productivity. For majority of the farmers especially the smallholder farmers, weed infestation is the most important factor limiting productivity.

Weed control refers to those actions that seek to restrict the spread of weeds and destroy or reduce their population in a given location [5] and is at present the mainstay of boosting maize production in Nigeria. The peasant farmers rely strongly on the traditional hand weeding for weed control. The popular weed control method used by more than 80% of the resource poor farmers produces bulk of the food eaten in developing nation is hand weeding [7]. Several scientists such as [8], [9] and [10] noted that hand weeding is probably the oldest method of weed control. These Scientists noted this method has consistently proved inadequate and expensive because of its ability to infest, spread and colonize native vegetation.

Maize is commonly cultivated in mixtures with staple food crops (yam and cassava) and cover crops (cowpea, melon, sweet potatoes, egusi melon watermelon and vegetables. In most case the main objective of intercropping is for food, and a form of cropping system insurance for a possible failure of one crop in the system. The minor crops in the intercrop system provide food and additional income to farmers. However, the unintended benefit in most cases is seen in the area of weed suppression. [7] noted that using herbicides to control weed in an intercropping system on small farm holdings has not been found workable or popular. .However, weed smothering by the use of intercrop has been successful [11]). .[12] noted that intercropping (spatial diversification) reduced weed density and biomass performance. However, in monocrop system, sunlight interception and soil cover decreases when compared to intercrop and yield loss due to competition also tend to increase.

Farmers in Nigeria spend most of their time in curbing the menace of weeds in their farms than any other farm enterprises. [13] reported the simultaneous cropping of cover crops with staple food crops has the inherent capacity for reducing weed control cost and crop production. [12] noted that intercropping (spatial diversification) reduced weed density and biomass performance. In monocrop system, sunlight interception and soil cover are usually decrease when compared to intercrop and yield loss due to competition is seen to be increase. Intercropping can be used for decreasing the dependency on chemical herbicides in weed control [14] .This benefit has not been properly harnessed by majority of the farmers. For weed suppression objective intercropping can be properly harnessed with appropriate density of regular vegetables that will enhance maize yield due to reduced weed pressure.

Hence, this study was carried out to assess effect of intercropping on weed suppression and maize yield by using selected vegetable cover crops as means of weed control in a humid forest agro-ecology of South- Eastern

II. Materials and Methods

2.1 Experimental site

The experiment was conducted between May and August 2013 and repeated in an adjacent field in the same season of 2016 at the Teaching and Research Farm of the Faculty of Agriculture, University of Port Harcourt. The University of Port Harcourt lies on latitude 4^0 3" N to 5^0 N and longitude 6^0 45" E to 7^0 E, with average temperature of 27^0C, relative humidity of 78% and average rainfall that ranges from 2500-4000mm [15]. The area had distinct wet and dry seasons. The wet season has double rainfall peaks. There are two cropping season early from March to July and late from August to December in the area. The area was previously cropped with maize before the start of the experiment. The predominant weed species where mainly Siam weed (*Chromolaena odorata*) and guinea grass (*Panicum maximum*). Soil samples were collected randomly from 10spots across the experimental area at a depth of 15cm using soil auger before the commencement of the experiment in 2013 and 2016 cropping seasons respectively. They were bulked together into composite sample and were taken and to the laboratory for physicochemical analysis using standard procedure. Rainfall data were obtained from Department of Geography for each of the cropping season throughout the duration of the experiment.

2.2 Source of planting material

Planting materials used for the experiment were maize (Zea mays (L.); watermelon (*Citrillus lanatus* var *lanatus)*, pumpkin (*Telfaria occidentalis*) and egusi melon [*Citrillus colocynthis* (L.) Schrad]. Maize variety used was Oba supper II and it was obtained from Rivers State Agricultural Development Program (R.A.D.P), Watermelon variety used was Pasteque Kaolack and it was obtained from Institute of Agricultural Research (IAR) Samara Zaria, Kaduna State. Fluted pumpkin and egusi-melon seeds were sourced from a local market in Choba, Port Harcourt, Nigeria.

2.3 Treatments and Experimental Design

The experiment consisted of seven treatments namely:

1. sole maize
2. sole egusi melon
3. sole watermelon
4. sole pumpkin
5. maize + egusi melon
6. maize + watermelon
7. maize + pumpkin .

The seven treatments were laid out in a randomized complete block design (RCBD) and replicated three times

2.4 Cultural practices

Land measuring 33 x 17.5m; that is area of 577.5m^2 (0.057ha) was manually cleared and the debris was packed. The area was divided into three blocks of 7 plots each giving a total of 21plots. A part way of 2m was created between experiment unit and between block in order to prevent crop cover vine interference.

Planting of crops were done on 30^{th} April 2013 and 23^{rd} May 2016. Sole maize was planted at a spacing of 75 x 25cm, sole watermelon; sole pumpkin and sole egusi melon were planted at spacing by 75 x50cm while each cover crop was planted in between two maize rows at spacing of 50x50cm with cropping pattern 1:2. Three seed of individual crops was planted per hole and later thinned to one seedling per hole at two weeks after planting give a population of sole crop of 53,333 and 26,667 for intercrop cover crops

The plots were hoe weeded with hole at three (3) weeks after planting (WAP) and 7WAP after planting. Two days after the first weeding, urea fertilizer containing 46% Nitrogen was applied uniformly in the entire treatment plots at the rate of 97.83 kg N/ ha in both cropping seasons to make up for the critical level of nitrogen.

2.5 Data collection

2.5.1 Weed

Weed parameters assessed were weed density, weed dry weight and weed smothering efficiency. Weed smothering efficiency of the different intercropping systems was determined based on weed control efficiency according to [16] as follows;

$$\text{WSE (\%)} = \frac{WDWT\ in\ monocrop\ - WDWT\ in\ intercrop}{WDWT\ in\ monocot} \text{ X } 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

Where WSE = weed smothering efficiency, WDWT = weed dry weight.

This assessment was carried out at 3, 6, 9 and 12 weeks after planting (WAP).

2.5.2 Crop

Data collected were dry matter yield of maize and the component crops in intercrop. This was used to determine the land equivalent ratio. The LER was determined according to [16] formula, LER= (ya + yb)/(la + lb), where ya and yb are the individual crop dry matter yields in intercrop and la and lb are their dry matter yields as sole crop. . A ratio > 1, signals yield advantage, a ratio < 1, signal yield disadvantage and a ratio = 1, no differences in yield.

2.6 Statistical analysis

All data were subjected to analysis of variance at 5% level of probability using the least significant difference (LSD) to test for mean separation.

III. Results

3.1 Soil characteristics and rainfall data of the experimental sites

The physiochemical properties of the experimental site are presented in Table1. The soil textural class of the experimental site in both years was sandy loam, and had a pH of 6.20 and 6.30 in 2013 and 2016 respectively. Total organic carbon was moderate and it ranged from 18.70 to 14.6 in 2013 and 2016. The nitrogen contents of the soils were low. The nitrogen content in 2013 was higher than that of 2016. Available phosphorous (P) were quite adequate in both years of experimentation but the content obtained in 2016 was higher than that of 2013.The Calcium (Ca), Magnesium (Mg) and Potassium (K) Sodium (Na) content of both soils were quiet adequate. Nevertheless, the values of Ca, Mg, and K were higher in 2013 than 2016. Na content was higher in 2016 than 2013 while exchange acidity was lower in 2016 than in 2013. Base saturation was slightly higher in 2016 than 2013. Table 2 shows the amount of rainfall data during the experimental period in 2013 and in 2016. The total amount of rainfall in 2016 cropping season (1079.60mm) surpassed that of the 2013 cropping season (865mm) by 24.81 %.

3.2 Weed suppression

The Effect of intercropping systems on weed growth characteristics are presented in Table3. Weed density and dry weight were significantly $p< 0.05$ higher in sole maize than in the intercrops system throughout the sampling periods in both years of study except at 3WAP. At 6WAP, weed density was significantly reduced in maize + egusimelon by 42.65% and 48.48%, maize + watermelon 34.62% and 44.59% while maize +pumpkin 13.98% and 15.79% in 2013 and 2016 respectively. Averaged over the intercrops at 6 WAP, and compared with the sole maize (control) our result showed that intercrops reduced weed density by 30.42% and 36.92% in 2013 and 2016 cropping seasons respectively. At 9WAP, weed density was significantly reduced in maize + egusimelon by 44.44 % and 55.17%, maize + watermelon 25.33% and 45.11% while maize +pumpkin 12% and 25.58% in 2013 and 2016 respectively. On the average,, weed density was reduced by 27.27% and 41.96% at 9 WAP in 2013 and 2016 cropping seasons respectively.

At 12 WAP, weed density was significantly reduced in maize + egusimelon by 45.61 % and 50.91%, maize + watermelon by 30.77% and 37.46% while maize +pumpkin reduced weed density by 9.89% and 16.36% in 2013 and 2016 respectively. On the averaged when intercropping was compared with sole maize cropping at 12WAP, results showed that intercropping reduced weed density by 43.22% and 59.66% in 2013 and 2016 cropping seasons respectively. Weed smothering efficiency was higher in maize intercropped with egusimelon when compared to other intercropped in both years. At 6WAP weed smothering efficiency differed significantly ($P < 0.05$) among the intercropping system (Table3) and it ranged from 33.27 % for maize +pumpkin to 60.77 % for maize + egusimelon in 2013 and 48.98% to 61.15% for the same inter crops in 2016.

At 9WAP, it ranged from 44.90% to 60.65% and 52.05 % to 61.94% in the 2013 and 2016 for same intercrops respectively. At 12WAP, maize intercropped with egusimelon had the highest weed smothering efficiency of 81.55% (2013) and 86.74% (2016) while the lowest weed smothering efficiency of 58.93% (2013) and 61.80% (2016) was obtained in maize intercropped with pumpkin.

3. 3 Yield of the selected crops and their productivities

Intercropping reduced the yield of maize, egusimelon, watermelon and pumpkin comparable to their sole crops in both 2013 and 2016 cropping seasons Table 4. Total plant yield was higher in intercrop than in sole crops in both years. Maize intercropped with egusi melon had the highest total plant yield of 4.90t/ha and 12.98t/ha in 2013 and 2016 for the intercrop while in sole crop, pumpkin produced the lowest yield of 1.02 and 2.53 in 2013 and 2016 respectively The land equivalent ratio*s (*LER) of intercrops were above unity (1.00) (Table 4) which implied that intercropping system had yield advantages over sole maize crop in both years of study. The LER ranged from 1.13 to 1.57 with yield advantage of 13% to 57% in 2013 while in 2016, the LER ranged from 1.3 to 1.83 with yield advantage of 30% to 83% in 2016.

IV. Discussion

Table 1 revealed that the nitrogen value of the soil were low in both years of study compared to it critical value of 0.15% (1.5g/kg) as reported by [18], hence the need for the urea applied. All other elements such as Phosphorus (P), Potassium (K), Calcium (Ca) and Magnesium (Mg) had their values above critical levels of 8.5mg/kg, 0.16 cmol/kg, 1.5cmol/kg and 0.28cmol/kg respectively established by [18]. Sodium value was also above the critical level of 0.02 cmol /kg [19].

One of the advantages of intercropping system is weed suppression. Result obtained from weed suppression in both years of study showed that intercrop were able to control weed effectively compared to sole maize throughout the observation periods except at 3WAP. At 3WAP, there were no significant differences between the maize intercrop and sole maize on weed density and dry weight in both years of experimentation. This could be attributed to poor weed germination, growth, establishment, development as cover canopy was still low by this period. Weed density and weed dry weight were generally low in 2013 cropping season than in 2016 throughout the observation periods. The first reason for this could be due to differences in weed flora of the two sites where the study was carried out. The second reason might be due to rainfall variation present in the two sites, rainfall was low in 2013 than 2016. The third reason could be the type of weed management system that was adopted at both sites prior the experimentation. These probable reasons for the seeming differences in weed density and dry weight in both years have also been reported in a similar study [20]. Weed smothering efficiency followed the same pattern observed with weed density and dry weight in both years. The variation in the weed smothering efficiency in both years of study could be attributed to variation in weed growth and dry matter accumulation. Among the cover crops used for the study, egusimelon controlled weed better than other cover crops judging from its low weed density and dry weight.. [11] reported similar findings that egusimelon smothered weeds better than sweet potatoes and pumpkin. The authors attributed their findings to faster, earlier ground canopy cover, and aggressiveness of the vines.

Total yield was higher in sole cropping than intercropping system in both cropping seasons. This could be as result of better utilization and less competition for growth resource such as water, light, nutrients and space. Researchers like [21],. [22], had also reported higher aggregate yield of sole maize than in intercrop

The Land Equivalent Ratio (LER) in both cropping seasons was above unity, which implied firstly, that intercropping system had yield advantage over sole crop, that sole cropping needed more land area to attain similar yield that was produced by intercropped. Secondly, in terms of weed suppression, intercropping system had an advantage over sole cropping in reducing weed dry matter. [21], [22]), had also reported LER greater than unity in maize intercropping system. Apparently, LER was higher in 2016 than in 2013. This could be as a result of the better environmental condition experienced during the period of growth; there was higher rainfall in 2016 compared to 2013. Averaged over the years, maize intercrop with egusimelon had the best LER while the maize intercrop with pumpkin had worst The best LER obtained in maize intercrop with egusimelon could be attributed to its early vine spread while the worst LER in maize intercrop with pumpkin could be due to late vining and ground canopy cover .

V. Conclusion

The findings from this study revealed that egusimelon was more effective in weed suppressing than watermelon and pumpkin in the intercropping systems in both years of study. In addition, Land equivalent ratio was generally above one indicating that the crops perform better in intercrop than in sole crop. Since, egusimelon had the best weed smothering efficiency and LER in both years of the study; it is therefore, recommended to farmers as a mean of weed control in maize in a humid forest agro-ecology of South- Eastern Nigeria.

Table 1. Physicochemical properties of the experimental site in 2013 and 2016cropping seasons

Soil parameters	Value	
	2013	**2016**
Physical properties (g/kg)		
Sand	945.0	872.0
Silt	9.00	48.00
Clay	46.00	80.00
Textural class	loamy sand	Loamy sand
Chemical properties		
pH in H_2O	6.20	6.30
Organic carbon (g/kg)	18.70	14.6
Total Nitrogen (g/kg)	1.14	0.73
Available P (mg/kg)	13.63	35.00
Exchangeable bases		
Ca (cmol/kg)	3.90	1.26
Mg (cmol/kg)	2.90	1.01
K (cmol/kg)	1.93	1.20
Na (cmol/kg)	0.32	0.82
Exchangeable acidity (cmol/kg)	0.20	0.09
ECEC (cmol/kg)	9.25	4.38
Base saturation (%)	97.84	97.95

Table 2. Rainfall (mm) data at the experimental sites during 2013 and 2016 cropping seasons

Months	2013	2016
April	125	–
May	145	341.50
June	300	217.50
July	295	353.60
August	–	167.00
Total	865.00	1079.60

Source: Department of Geography and Environmental Management, University of Port Harcourt, 2013 and 2016.

Table 3. Effect of intercropping systems on weed growth characteristics

Treatment/Weeks after planting(WAP)	**Weed density (no/m^2)**		**Weed dry weight (g/m^2)**		**Weed smothering efficiency (%)**	
	2013	**2016**	**2013**	**2016**	**2013**	**2016**
3WAP						
Sole maize	118.00	123.33	19.00	22.00	-	-
maize + egusi-melon	117.33	122.33	18.00	20.33	3.33	7.24
maize + watermelon	117.00	122.67	18.33	21.00	3.33	4.55
maize + pumpkin	116.67	123.00	18.67	21.33	1.67	2.9
LSD (P= 0.05)	1.596^{NS}	1.104^{NS}	1.104^{NS}	2.470^{NS}	7.555^{NS}	13.693^{NS}
6WAP						
maize	95.33	120.33	13.00	16.33		
maize + egusi-melon	54.67	62.00	5.10	6.33	60.77	61.15
maize + watermelon	62.33	66.67	6.67	7.00	48.72	57.15
maize + pumpkin	82.00	101.33	8.67	8.33	33.27	48.98
LSD (P= 0.05)	1.661	2.806	1.15	2.606	9.483	2.999
9WAP						
maize	75	116	10	14.00		
maize + egusi-melon	41.67	52	4.4	5.33	60.65	61.94
maize + watermelon	56	63.67	5	6.00	51.26	57.16
maize + pumpkin	66	86.33	6	6.67	44.90	52.05
LSD (P= 0.05)	1.912	1.970	1.665	1.600	16.373	13.282
12WAP						
maize	60.67	91.67	7.33	11.33	———	
maize + egusi-melon	33.00	45.00	1.33	1.5	81.55	86.74
maize + watermelon	42.00	57.33	2.00	2.67	68.45	76.33
maize + pumpkin	54.67	76.67	3.33	4.33	58.93	61.80
LSD (P= 0.05)	2.026	2.209	1.526	1.212	20.372	12.111

NS=Not significant at 5% level of probability

Table4. Yield of maize, egusi melon, watermelon and pumpkin intercrop and land equivalent ratios (LER)

Treatment	**Yield (t/ha)**					**Partial LER**				**Total LER**
	Mz	**Em**	**Wm**	**Pum**	**Total**	**Mz**	**Em**	**Wm**	**Pum**	
2013										
Maize	3.90	———	———	———	3.90	———	———	———	———	———
Egusi melon	———	2.5	———	———	2.5	———	———	———	———	———
Watermelon	———	———	1.63	———	1.63	———	———	———	———	———
Pumpkin	———	———	———	1.02	1.02	———	———	———	———	———
Maize + egusi melon	2.7	2.2	———	———	4.9	0.69	0.88	———	———	1.57
Maize + water melon	1.82	———	1.2	———	3.02	0.47	———	0.74	———	1.21
Maize + pumpkin	0.65	———	———	0.98	1.63	0.17	———	———	0.96	1.13
LSD(P =0.05)	0.198	0.237	0.14	0.152^{NS}	0.470	———	———	———	———	0.129
2016										
Maize	9.27	———	———	———	9.27	———	———	———	———	———
Egusi melon	———	5.17	———	———	5.17	———	———	———	———	———
Watermelon	———	———	3.58	———	3.58	———	———	———	———	———
Pumpkin	———	———	———	2.53	2.53	———	———	———	———	———
Maize + egusi melon	7.99	4.99	———	———	12.98	0.86	0.97	———	———	1.83
Maize + water melon	6.12	———	3.26		9.38	0.66	———	0.91	———	1.57
Maize + pumpkin	4.08	———	———	2.17	6.25	0.44	———	———	0.86	1.3
LSD(P =0.05)	1.460	0.24^{NS}	0.4^{NS}	0.287	2.011	———	———	———	———	0.205

Mz = Sole maize, Em=sole egusi melon, Wm= sole watermelon, Pum =sole pumpkin, LER= land equivalent ratio, NS=Not significant at 5% level of probability

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