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Full Length Research Paper

Efficacy of intercropping pattern in reducing weeds infestation in okra, maize and pepper intercrop

***Ubini C. Thomas, Jaymiwhie Obanna and Ikogho B. Patrick**

Department of Crop and Soil Science, University of Port Harcourt, P. M. B 5323 Port Harcourt, Nigeria.

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Field study was conducted to evaluate the efficacy of intercropping pattern in reducing weed infestation in okra, maize and pepper intercrop; at the teaching and research farm of Rivers State University of Science and Technology Port Harcourt, Nigeria during 2009 and 2010 cropping season. Three intercropping pattern namely; alternate row intercropping, strip row intercropping and mixed intercropping were compared to sole cropping in a randomized complete block design replicated three times. The result reveal that weed biomass were significantly lower in both years in all forms of intercropping pattern compared to sole cropping or mono-cropping. Weed smothering efficiency in both years showed that mixed pattern (45.7%) >alternate row pattern (33.4%) > strip row pattern (11.5%). Crop yield were better in an intercrop system for maize and pepper in both years compared to sole crop. However, mean okra fruit yield was highest in sole cropping (3253 kg ha^{-1}) when compared to intercropping pattern. Maize yield was highest in mixed pattern (8,987 kg ha^{-1}) and lowest in sole cropping (6,955 kg ha^{-1}) while pepper fruit yield was highest in strip row pattern (5,435 kg ha^{-1}) and lowest in mixed pattern (1,562 kg ha^{-1}). The results from this study have shown that intercropping pattern has a great potential in reducing weed infestation in cropping systems especially in farming system with low external input. However, the effect of the intercrop pattern on yield may be variable, because viability may depend on the adaptation of planting pattern and selection of compatible crops.

Key words: Intercropping pattern, weed infestation, land equivalent ratio (LER).

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench), is a member of the family Malvaceae widely cultivated mostly by peasant farmers in Nigeria as a fruit vegetable. It is found in almost every market in Nigeria (Akoroda et al., 1985) and Africa (Schippers, 2000). Okra is cultivated over a total area of about 1.5 million ha (Adejonwo et al., 1989). Smallholders in the tropics face the problem of maintaining productivity, due to a range of factors which factors which include weeds. Many crops grown in the the first 3 to 4 months after planting. For increased tropics are susceptible to early weed competition during within the first 6 to 9 weeks of planting. Weed competition productivity of okra, weeds must be controlled timely reduces canopy development in most crops, and predisposes the crop to pest and disease infestation. Absence of weed control in crop farm may lead to crop losses of up to 100% (Nyam, 2005). Uncontrolled weeds cause okra yield losses ranging from 63 to 91% (Adejonwo et al., 1989). Weed control is by far the most labor-demanding field operation in okra production and

*Corresponding Author. Email: tomas.ubini@hotmail.com

the control is currently the cornerstone of increased production in Nigeria. The smallholders groups of farmers rely heavily on the traditional hand weeding for weed control. Hand weeding is probably the oldest method of weed control which has consistently proved inefficient and costly too (Agahiu et al., 2011). It is the popular weed control method used by more than 80% of the resource poor farmers who produces bulk of the food eaten in developing nation. Okra is popularly grown in mixtures with staple food crops such as yam, maize, cassava, cowpea and pepper or with various vegetable crops on small farm holdings (Muoneke and Asiegbu, 1996; Olasotan, 2001; Odeleye et al., 2005). The use of herbicides for weed control in such an intercropping system has not been found workable or popular, especially in small farm holdings, where various crops are planted simultaneously. The use of intercrop to smother weeds has been successful (Rao and Shetty, 1976). Recent studies have also addressed intercropping as an option for an integrated weed management, particularly in farming systems with low external inputs (Liebman and Davis 2000; Rana and Pal, 1999). It seems when used in conjunction with correct timing of hoe-weeding, the practice could prove satisfactory to smallholder farmers (Agahiu et al., 2011). Its appeal is enhanced by the added food value obtained from the component crops. The choice of the method must, however, be based on the optimum economic returns and resources available. Studies have indicated that weed population density and biomass production may be markedly reduced using crop intercropping (spatial diversification) strategies (Liebman and Elizabeth, 1993). Intercrop system, light interception and soil cover are usually increased compared with a monoculture, and yield loss due to weed competition is seen to be reduced. Therefore, intercropping can be seen as one option for reducing weed problems through non-chemical methods (Vandermeer, 1989).This study was designed to assess the efficacy of intercropping pattern in reducing weed infestation in okra, maize and pepper intercrop.

MATERIALS AND METHODS

Study area

The study was conducted at the teaching and research farm of the Rivers State University of Science and Technology, Port Harcourt, during the planting season of March, 2009 and April, 2010. Port Harcourt falls within latitude of 4° to 6°N and longitude of 7.010E with an elevation of 18 m above sea level (FAO, 1984). The rainfall pattern is essentially bimodal with peaks in June and September, while in April and August there are periods of lower precipitation. The annual rainfall averaged between 2000 mm and 4500 m (Ukpong, 1992; University of Uyo, 1997). The long rainy season is between April and October, while the dry season lasts from November to March with occasional interruption by sporadic down pours (Anderson, 1967). The mean monthly temperature ranges from 28 to 33°C. The highest temperature is experienced during the months of December through March and coincides with the overhead passage of sun (Enwezor et al., 1990). The experiment was carried out on a Typic paleudult soil. The soil of the experimental site had the following characteristics: pH, 4.10, total nitrogen, 0.05%; available-P' 28.0 ppm; and K, 21.10 ppm (Allen et al., 1974). Soil analysis revealed the following texture: sand 85.6%, silt 9.0%, and clay 5.4%.

Planting

Three crops, maize, pepper and okra, were the component for the intercropping pattern. The maize cultivar used was Bende white, a local variety. The pepper cultivar NHV_4, a high yielding and early maturing variety and okra variety, NIHORT 47-4 were obtained from National Horticultural Research Institute (NIHORT) Ibadan. The experimental design was randomized complete block (RCB) design. Three types of intercropping pattern of okra with maize and pepper was studied to evaluate their influence on weed infestation. The cropping patterns were alternate rows, strip rows, mixed pattern and sole crop of okra as control. The alternate rows pattern was made up of two rows of maize followed by two rows of okra, followed by two rows of pepper, and this arrangement repeated three times to give a plot size of 9 × 3 m. The strip row pattern was made up of six rows of okra, six rows of pepper and six rows of maize. The mixed pattern was made up of a group containing six stands of each crop and randomly planted at six stands on the plot. There were replicated three times. However, the planting distance and number of stands were the same as in other plots. The sole cropping pattern (control) was made up of okra plants as six grown stands and contained a total of 108 stands per plot replicated three times. All crops were planted at 50 × 50 cm in both years, a nursery bed was prepared and pepper seeds planted a month before clearing the main field and were later transplanted. Okra, maize seeds and pepper seedlings were planted the same day. The plots were weeded at 6 weeks after planting (WAP) for all cropping pattern and at 9 WAP for sole cropping pattern only. It was not necessary again to weed the intercropping pattern due to ground cover, this is because the level of infestation will not have any effect on yield whether weeded or not.

Weed species abundance and cover estimate

The determination of weed infestation was made with a quadrat measuring 1 × 1 m, three random sample per plot were taken and the weed cover estimated by means of weed ground cover rate using a scale of 1-6 [where 1(0 to 5% weed cover), 2(5 to 25%), 3(25 to 50%), 4(50 to 75%), 5(75 to 95%) and 6(5 to 100%), Daubenmire, 1968; Ossom, 1986a]. In this scale, 1 represented the minimum weed density; 5 and 6 (all ground space completely covered by weeds) represented the maximum weed coverage. The weed species, and relative abundance were also recorded in each plot. In both years, above-ground weed biomass was determined by taking three quadrats samples of 1 × 1 m long a diagonal transect in each treatment plot at 6 WAP. The weeds were oven- dried at80°C for 48 h for biomass determination. Weed smothering efficiency of the different intercropping pattern was determined based on weed control efficiency according to Subramanian et al.
(1991) as follows:

$$\text{WSE (\%)} = \frac{\text{WDWT in monocrop - WDWT in intercrop pattern}}{\text{WWDT in monocrop}} \times 100$$

Where, WSE = Weed smothering efficiency; WDWT = Weed dry weight.

Crop yield and land equivalent ratio (LER)

All crop yield and yield components were determined to evaluate

Table 1. Effect of intercropping pattern on relative abundance of weed at Port Harcourt in 2009 and 2010.

Species	Relative abundance (%)							
	2009				2010			
	Sole	Alternate row	Strip	Mixed	Sole	Alternate row	Strip	Mixed
P. maximum	50	35	40	32	46	35	40	30
A. compresssus	30	10	20	5	15	35	20	25
Asphilia africana	16	4	2	8	7	0	5	8
Tridax procumbens	7	7	5	10	10	0	6	7
Sida acuta	6	5	4	2	8	0	7	4

performance from a net plot of 27 m^2. The LER was calculated as:

LER = (Yio/Yso) + (Yim/Ysm) + (Yip/Ysp) Where, Yio and Yso are the yields of okra in intercropped and monocrop, Yim and Ysm are the yields of maize in intercropped and monocrop, and Yip and Ysp are the yields of pepper in intercropped and monocrop, respectively. Where LER was more than 1.0, this indicates a positive intercropping advantage which shows that interspecific facilitation is higher than interspecific competition (Vandermeer, 1989).

Data analysis

Data from the trial were subjected to analysis of variance (ANOVA), and differences between means were separated using least significant difference (LSD) at 5% level of probability.

RESULTS

Weed species abundance and weed cover estimate

Guinea grass (*Panicum maximum)* was the dominant species at the experimental site followed by carpet grass (*Axonopus compressus*). The sole okra plot had the highest number of weed species cover with 3.5 score in 2009 and 3.0 in 2010 (Table 1). *P. maximum* was more abundant in the sole okra plot in both years compared to the various intercrop patterns with 50% (2009) and 46% (2010), respectively. The least weed cover in both years was found in mixed intercrop pattern plots with 2.0 (≤25%) and 1.0 (≤ 5%) weed ground cover, respectively (Figure 1).

Weed biomass and weed smothering efficiency

Weed biomass was significantly affected by cropping pattern (Figure 1). Weed biomass in sole cropping pattern of okra was significantly ($P < 0.05$) greater than in intercropping pattern with maize and pepper.

The sole okra cropping pattern (control) had the highest weed biomass (330.23 gm^{-2}) in 2009 and (310.85 gm^{-2}) in 2010. The mixed intercropping pattern had the least weed biomass, 185.2 and 163.57 gm^{-2} in 2009 and 2010, respectively (Figure 2). Weed smother efficiency (WSE) was highest in mixed pattern in both years compared to the other forms of intercrop pattern (Table 2).

Crop yield

The okra fruit yield showed significant differences between cropping pattern in both years (Figure 3). The sole okra had the highest yield in both years 2009 (2857 kg ha^{-1}) and 2010 (3648 kg ha^{-1}) followed by strip row pattern 2453 and 2470 kg ha^{-1} in 2009 and 2010, respectively.

The mixed intercrop pattern was not different from alternate rows intercrop pattern in 2009. Averaged over the years okra fruit yield was as follows: sole okra crop (3253 kg ha^{-1}) > strip row (2462 kg ha^{-1}) > mixed intercrop pattern (2213 kg ha^{-1}) > alternate row pattern (1933 kg ha^{-1}) (Figure 3). Maize yield generally was higher in 2009 than in 2010, and was lower in sole pattern in both years (Figure 4). Maize yield when averaged over the years was as follows: mixed pattern (8,987 kg ha^{-1}) > alternate row pattern (8,220 kg ha^{-1}) > strip row pattern (7,853 kg ha^{-1}) and the least sole maize crop (6,955 kg ha^{-1}) (Figure 4). Averaged over the years pepper fruit yield on the other hand, was highest with the strip row pattern (5,435 kg ha^{-1}) and lowest with mixed pattern (1562 kg ha^{-1}). The year average for yields of alternate row and sole pepper patterns were 1693 and 1683 kg ha^{-1}, respectively (Figure 5).

Land equivalent ratio (LER)

The mean LER values were greater than 1.0 in all intercropping pattern. This means that intercropping pattern showed an advantage over sole cropping in reducing weed dry matter. In both years, strip rows pattern had the highest LER, 4.67 and 5.98, respectively (Table 3). From literature, the pepper yield in the present study is not abnormal.

DISCUSSION

Despite okra wide leaves and low growing canopies, in sole cropping it had the highest weed population and

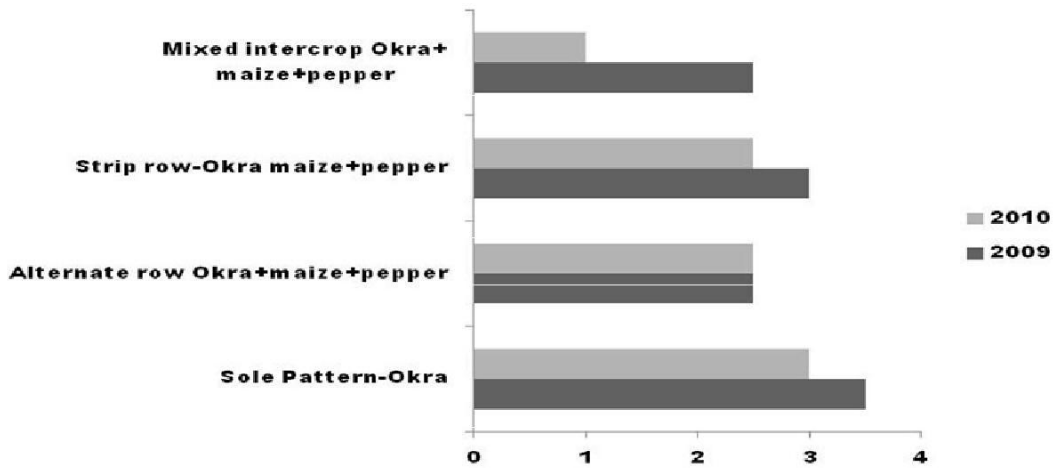

Figure 1. Weed cover estimate [(Cover scale (1-6): 1 = 0 to 5%, 2 = 5 to 25%, 3 = 25 to 50%, 4 = 50 to 75%, 5 = 75 to 95% and 6 = 95 to 100%) Daubenmire cover scale, 1968].

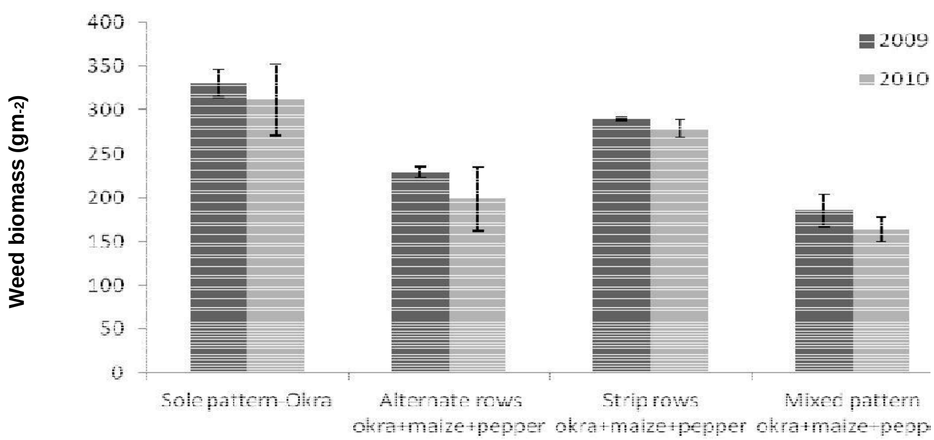

Figure 2. Effect of intercropping pattern of okra with maize and pepper on weed biomass [Error bars are standard error bars (±)].

Table 2. Weed smothering efficiency (WSE) of intercrop pattern.

Intercrop pattern	2009(%)	2010 (%)	Year average
Sole pattern okra	-	-	-
Alternate row - Okra + maize + pepper)	30.65	30.14	33.40
Strip row with- Okra + maize + pepper)	12.45	10.44	11.45
Mixed-pattern with Okra + maize + pepper	43.92	47.38	45.65

biomass in both years. This result corroborates the findings of McGill-Christ and Trenbath (1984) that sole cropping encourages weed growth and development, due mainly to sparse canopy. The low weed incidence in mixed intercropping pattern clearly showed the advantages of dense canopy and close covering of soil surface by crops of different leaf shapes and heights. The results of this work are also in conformity with those reported by Jones (1983), Hague et al. (2008).

The relatively low incidence of weeds in the intercrop plot irrespective of planting patterns in this trial could also be attributed to more photosynthetic active radiation (PAR) interception and possible interference from the component crops, in addition to ground cover effect. This finding corroborates the results of Eskandari and Ghanbari (2010), Eskandari and Kazemi (2011), Tripathi et al. (2008), Chikoye et al. (2006), Hugar and Palled (2008) and Agahiu et al. (2011) on the efficacy of intercrop

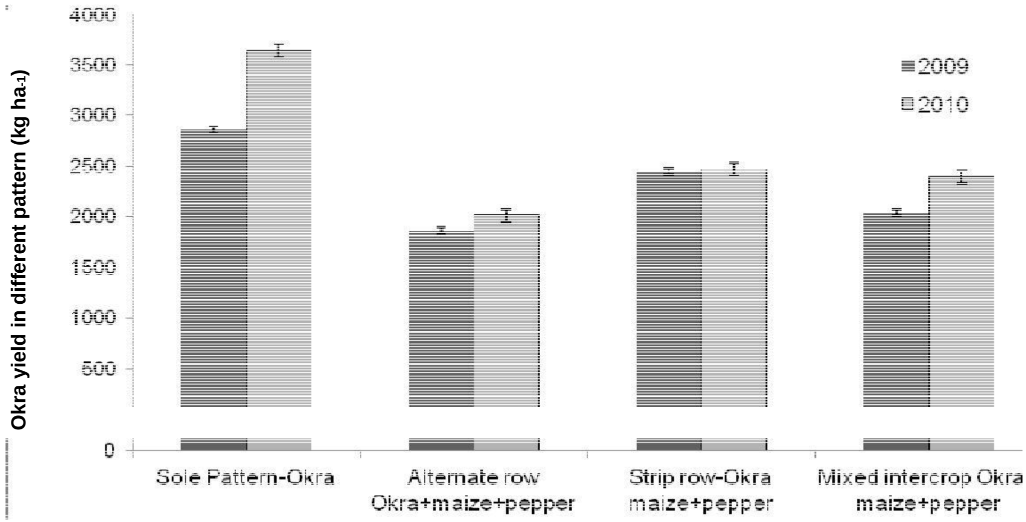

Figure 3. Okra yield in sole and in an intercrop pattern with maize and pepper.

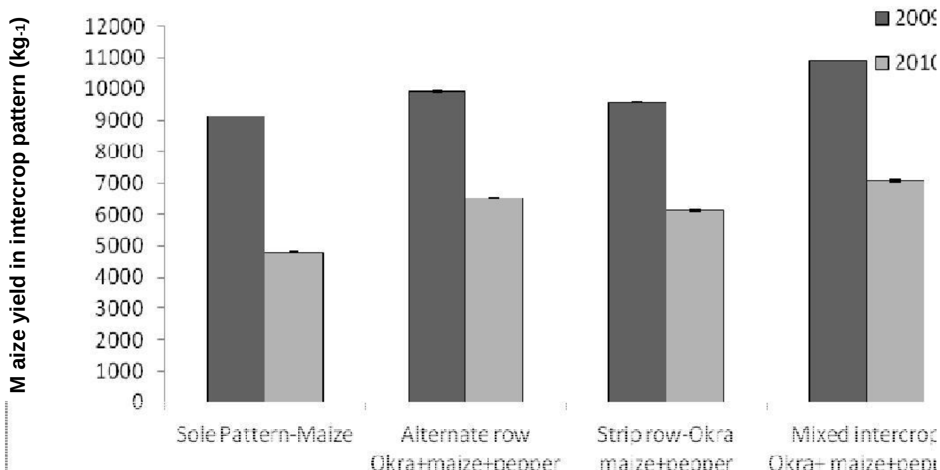

Figure 4. Maize yield in sole and in an intercrop pattern with okra and pepper.

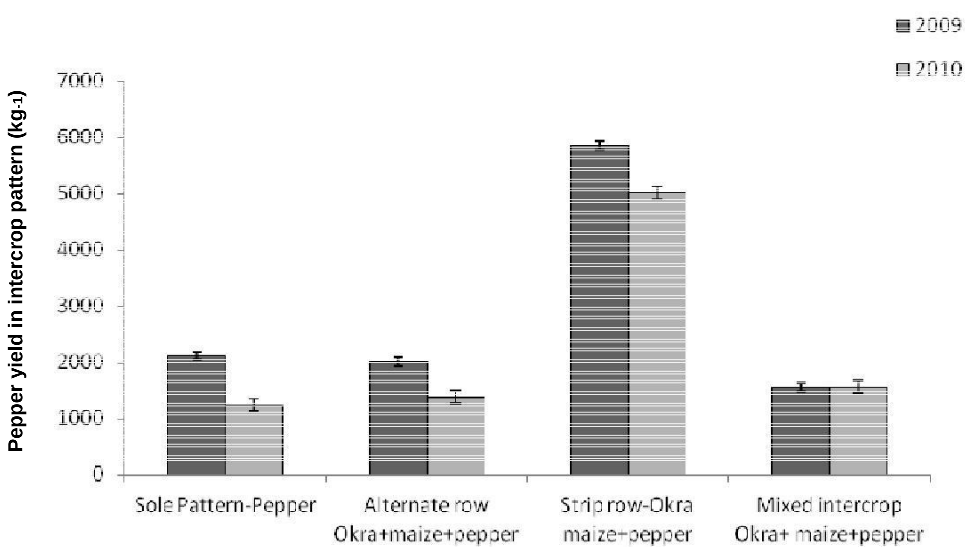

Figure 5. Pepper yield in sole and in an intercrop pattern with okra and maize.

Table 3. Intercropping pattern relative yield and LER.

Intercropping pattern	2009				2010			
	Relative yield of crops			LER	Relative yield of crops			LER
	Okra	Maize	Pepper		Okra	Maize	Pepper	
Alternate row	0.652	1.086	0.947	2.69	0.549	1.364	1.107	3.02
Strip row	0.858	1.049	2.762	4.67	0.677	1.280	4.027	5.98
Mixed	0.712	1.196	0.736	2.64	0,655	1.475	1.257	3.39

intercrop in reducing weed incidence. Similarly, the low weed biomass recorded in intercrop pattern agrees with earlier reports on reduced weed dry weight in intercropping systems (Eskandari and Ghanbari, 2010). Weed smothering efficiency calculated at 6 WAP clearly showed that all types of intercropping pattern had advantage or potentials of smothering weeds compared to sole cropping pattern. This result agrees with Singh et al. (2005), and Shah et al. (2011), on the weed smothering efficiency of intercropping. However, weed smothering efficiency was highest with the mixed intercropping pattern at 6 WAP. Low weed pressure experienced in this study can be attributed to intercropping effect. This result agrees with Maerek et al. (2009), who reported on reduced amount of resource consumption by weeds, in a productivity and weed suppression study of maize-pumpkin intercrops. The morphological and physiological differences among intercrop components may have resulted in their ability to occupy different niches, thus, causing more efficient utilization of natural resources by mixed stands than by pure stands.

In terms of okra fruit yield, the sole pattern had the highest fruit yield in both years followed by strip row intercrop pattern. This result agrees with the findings of Andrews (1972), that sole cropping may promote high productivity in some crops. However, it disagrees with Muoneka and Asiegbu (1996), who reported that in maize-okra intercropping yield, yield components of okra was increased. The high productivity due to sole cropping in okra is as a result of several agronomic factors like easier agronomic operations, plant population, little shading effect and non-competitive and non-interference effect from more aggressive crop competitors like maize (Rosenthal and Janzen, 1979). Shading effect especially from maize may have curtail efficient utilization of natural resources and restrict growth of okra from initial stages to harvest which resulted in yield competition in intercrop. Similar results were obtained by Hussain et al. (2003) and Haque et al. (2008). On the other hand, maize yield were noted higher under intercrop patterns than the sole crop.

This could be as a result of intraspecific competition from maize. During both years, the strip rows pattern clearly outperformed other treatments in terms of pepper fruit weight. This still agrees with the report of Okigbo and Green (1976) on the advantages of an intercropping system in giving high yields through beneficial interactions from nearby intercrops. Andrews (1972) had consistently obtained yield increase from crops grown in mixture compared with crops grown sole.

Land utilization efficiency of intercrop patterns measured by LER values at all intercrops were higher than 1.0.

This means that land utilization efficiency for okra-maize-pepper intercropping pattern was more advantageous than sole cropping. Averaged over the years, the strip rows intercrop pattern had the best LER, while the alternate row intercrop pattern had the least. However, there was an overall advantage due to intercropping, as the LER in each intercrop pattern was greater than one (>1).

LER greater than one (LER > 1.0) have been reported with various maize intercropping (Saban et al., 2007; Carr et al., 1995). At about 70 DAP, the sole crop of okra showed some signs of senescence that depicted water stress or temperature stress.

This could suggest exposed soil surface and subsequent high soil temperature and moisture loss, unlike in the intercrop plots that had a better soil covering due to crops of different leaf canopies (Cobley, 1976). Therefore, it is proper to say that in addition to weed control advantage due smothering effect on weeds, the intercrop pattern also has the advantages of lowering soil temperature and conserving soil moisture.

Conclusion

Weed smothering efficiency with okra, in an intercropping pattern with maize and pepper suggest that the intercropping pattern achieved acceptable weed suppression benefits than do sole cropping pattern. Also, that the LER of greater than one recorded with the intercropping patterns shows that resource consumption or land utilization efficiency for intercropping pattern was more advantageous than for sole cropping. Choosing of the crop combinations and those crops best able to exploit soil nutrients will plays vital role in harnessing the efficiency of intercropping pattern in smothering weeds. The efficiency and sustainability of intercropping pattern as non-chemical method of weed management especially at the small farm level will depend on the choice of compatible crops and the optimum population to minimize interference. It will form a good component of integrated weed management at the low input farm level.

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