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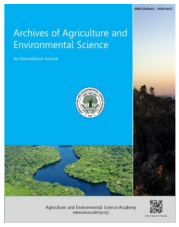

ORIGINAL RESEARCH ARTICLE

Impact of weeding frequency in controlling flea beetles (*Podagrica* spp.) and yield of three varieties of okra (*Abelmoschus esculentus* L. Moench) in Gombe State, Nigeria

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ABSTRACT

Field studies were carried out at School of Agricultural Technology Teaching and Research Farm of Federal College of Horticulture, Dadin Kowa, Gombe State, Nigeria during 2014 and 2015 cropping seasons to assess the impact of weeding frequencies in controlling flea beetles (*Podagrica spp.*) using three varieties of Okra. Three varieties of Okra (NGAE-96-1; NHAE-47-4 and Challawa) and four weeding frequencies (no weeding, one weeding at 3 WAS, two weedings at 3 and 6 WAS and three weedings at 3, 6 and 9 WAS) were assessed using split plot laid out in randomized complete block design replicated three times. Results showed that the flea beetle (*Podagrica* spp.) populations, leaves and fruit damaged weight were significantly ($P \leq 0.05$) reduced while okra plant height and fruit yield were improved on plots that were weeded three times compared to other weeding frequencies. The result further showed that NGAE-96-1 and NHAE-47-4 reduced flea beetle (*Podagrica* spp.) populations, leaves and fruit damage than challawa. The results indicated that flea beetle control could be effectively achieved and okra production improved through the manipulation of weeding frequencies and selecting the appropriate okra varieties in the study area.

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INTRODUCTION

Okra (*Abelmoschus esculentus* L.) Moench) is an erect herbaceous plant and is one of the most important vegetable crops grown for its nutritional and economic value (Alao *et al.,* 2011; Chopra *et al.,* 2013). It is grown both in the tropical and subtropical regions of the world (Tindall, 1983; Anitha, 2007; FAO, 2012). In Nigeria okra is mainly grown for its leaves, fibers and immature pod which are used for consumption and commercial purpose (Anaso, 2008). The pod is rich in vitamins, minerals and fibre (Anaso and Lale, 2002). Okra cultivation is gaining popularity because of its high demand and economic return, being driven by both youth and woman (Anaso, 2008).

Despite the economic and nutritional value of okra, its production in Nigeria is hampered by weed, pests and wrong choice of varieties. In the tropics, weeds are major pest of okra because they interfere with its production (Kumar, 2014). Weeds interference may reduce plant vigour, delay development and growth or suppression of specific characters but the ultimate effect of weed and wrong choice of variety is reduction of crop yield. Weeds reduce crop yield by interfering with crop growth through competition with crops for sunlight, water and nutrients (Takim and Uddin, 2010). Crop yield losses of annual crops due to weed in dry land environment could be as high as 7.2 million tons in fiber crops (Some and Sanon, 2009) thus leading to yield loss of about 50-90% (Das, 2011; Kumar and Chopra, 2013)

Presence of weeds on crop land has also been found to increase insect pests' damage probably because weeds provide a favourable environment for the insects (Anaso, 2008; Lado and Hussaini, 2010). Previous researchers have shown that alteration of tillage practices that give poorer weed control increase the density and diversity of insect pest populations within the habitat (Altieri and Todd, 1981; Altieri *et al*., 1981; Shelton and Edwards,

1983). Also, the choice of good variety with proven ability of pest resistance has shown to withstand insect pest attack both in the field and store (Youdeowei, 2004). Weeding frequencies and varietal difference have shown to have great influence on the population of insect pests and yield (Yusuf *et al*., 2015). Three hoe-weeding regimes at 2, 4 and 6 weeks after sowing were found to be more effective in controlling weeds, reducing the population of insect pests and increasing cowpea yield (Takim and Uddin, 2010). Although previous studies showed that regular weeding is very vital in weed and pest control, little is known about the impact of weeding frequency and varietal differences on okra leaf beetle. Therefore, the present study was conducted to assess the impact of weeding frequencies on the yield of three varieties of okra in the field.

MATERIALS AND METHODS

Experimental site: The experiment was carried out at the School of Agricultural Technology Teaching and Research Farm of Federal College of Horticulture, Dadin Kowa, Gombe State, Nigeria under rainfed condition during 2014 and 2015 cropping seasons. Dadin Kowa is located in the Sudan Savannah ecological zone of Nigeria within latitude $10^0$11' N and Longitude $11^0$52'E of the equator, and altitude of 185.8m; the mean annual rainfall is between 800 -1100 mm; annual minimum and maximum temperature of 20-40^0 C, respectively. The length of the rainy season ranges from 120-160 days usually from May to October.

Sources of experimental materials: The three varieties of okra sown (NGAE-96-1; NHAE-47-4 and Challawa) were obtained from Gombe State Agricultural Development Programme (GSADP) farm input store at Bogo, Gombe. Compound fertilizer N.P.K 15:15:15 was purchased from Gombe main market.

Experimental design: The experiment was laid out in split plots with three replications. The main plots were the weeding frequencies (zero weeding, one weeding at 3 WAS; two weedings at 3 and 6 WAS and three weedings at 3, 6 and 9 WAS) while the subplots were the three different varieties (NGAE-96-1; NHAE-47-4 and Challawa). Each subplots size was 3.0m x 4.0m (12m^2) separated by 1.5m wide border margin and an alley of 2.0m to allow for data collection and observation.

Experimental procedures and cultivation practices: The selected experimental field was cleared of debris, ploughed, harrowed and ridged with the help of a tractor when the rainfall has established in June. The experimental field was then mapped out into plots and blocks using a plastic measuring tape of 100m long and pegs according to experimental design.

Okra seeds of the three varieties were dressed with Apron Star 42 WS (Imidacloprid 20% + metalaxyl-M20% +Tebuconzole 2%) and soaked in water overnight. The seed dressing was done at the rate of one sachet per kg of seed before sowing in order to ensure good seed germination, establishment and protection against soil borne and seed borne arthropod pests. The seeds were sown at the rate of 3-4 seeds per hole on the prepared ridges. The intra -row spacing was 30 cm while inter-row spacing was 60 cm and sowing depth was 2.5cm.

Weeding was carried out based on the weeding frequencies experimented (zero weeding as control; one weeding at 3 WAS; two weeding at 3 and 6 WAS and three weeding at 3, 6 and 9 WAS. Okra seedlings were thinned to one plant per stand after 3 WAS. Compound fertilizer N.P.K 15:15:15 was applied as basal application at the rate of 60 kg/ha at 3 weeks after seed emergence (WAE).

Collection of data: The following parameters were collected and analyzed; number of flea beetles for the two years, number of leaves and leaves damaged per plant (number of leaves having holes or feeding punctures); plant height (taking the measurement from the plant base to the plant apex); damaged fruits (fruits with feeding punctures/holes); undamaged (fruits without feeding punctures/holes); percentage damaged fruit weight all fruits of the tagged okra plants were examined visually and those with feeding punctures or holes) and those without feeding punctures/holes (percentage undamaged fruit and fruit yield were recorded.

Data analysis: The data generated were subjected to analysis of variance (ANOVA) and the treatment means were separated at 5% level of probability using New Duncan multiple range test (NDMTR) (Duncan, 1955).

RESULTS AND DISCUSSION

Effects of weeding and varieties on number of *Podagrica* species: Result on the effects of weeding frequency and okra variety on the number of *Podagrica* spp. is shown on Table 1. The result showed that *Podagrica* species number was significantly (P<0.05) higher in Challawa during the two years (9.01 and 9.04) than in NGAE-96-1 (3.45 and 3.41) and NHAE-47-4 (4.03 and 4.32) varieties. The number of *Podagrica* species were influenced by okra varieties and differed significantly across the weeding treatments. Three weeded plots had significantly (P<0.05) lower (3.80 and 3.69). *Podagrica* species population than two and one weeded while the zero (non-weeded) control plots had the highest (6.28 and 5.97) *Podagrica* spp. in both years.

Effects of weeding frequency and varieties on number of leaves and damaged leaves: Table 2 shows the effects of weeding frequencies and okra varieties on the number of leaves and damaged leaves per plant. The result indicates that there was significant difference in the number of leaves between Challawa okra variety (7.05 and 7.13) and other two varieties. Weeded plots also showed significant different in the number of leaves and damaged leaves. Three weeded plots produced significantly (P<0.05) higher number of leaves than two and one weeded plots while non-weeded (control) plots had significantly the lowest number of leaves per plant.

There were also significant difference among the weeded frequencies and varieties in terms of damaged leaves/plant. *Podagrica* Species damaged more leaves on zero, one and two weeded plots than three weeded plots. Two and one weeded plots were statistically at par with each other. The weeded control plots had significantly higher (4.11 and 4.14) damaged leaves than the other plots. Challawa variety had significantly higher leaves damaged (5.62 and 5.48) in both years than NGAE-96-1 and NHAE47-4 varieties.

Effects of weeding frequency and varieties on plant height: Table 3 showed that there were significant difference among the weeding frequencies and varieties. NGAE -96-1 and NHAE-47-4 okra varieties grew taller than Challawa variety during the two years study. The weedy check plot had significantly lower plant height (60.58 cm and 61.20 cm) followed by one weeded plots (84.51 cm and 82.87 cm) while three weeded plots had significantly the highest okra plant height (131.96 cm and 132.73 cm) during the study period.

Effects of weeding frequency and variety on damaged and undamaged fruits: The result of damaged and undamaged fruits as affected by *Podagrica* species infestation is presented in table 4. There was significant difference amongst the treatments during the study period. Zero (non-weeded) plots had significantly ($P<0.05$) higher damaged fruits weigh (0.97 kg and 0.95 kg) followed by one weeded plot (0.83 kg and 0.78 kg) while three weeded plots had significantly (0.41 kg and 0.40 kg) lowest damaged fruit weight. The result on undamaged fruit weight indicates that the zero (non-weeded) plots had significantly lowest (0.2 kg and 0.41 kg) undamaged fruit weight while three weeded plots had the highest (1.42 kg and 1.38 kg) undamaged fruit weight during the study. The effect of varietal difference on the damaged and undamaged fruit weigh indicates that Challawa Okra variety recorded significantly higher damaged fruit weight (1.89 kg and 1.81kg) than NGAE-96-1 (1.08 kg and 1.10 kg) and NHAE-47-4 (1.23 kg and 1.21 kg) varieties. The trend was reversed in terms of undamaged fruit weight during the study. Oka varieties NHAE-47-4 had higher (1.38 kg) undamaged fruit weight followed closely by NGAE-96-1 (1.30 kg and 1.35kg) while Challawa okra variety had significantly lower (1.24 kg and 1.22 kg) undamaged fruit weight.

Effects of weeding frequency and variety on percentage weight damaged and fruit yield: Results on the effects of weeding frequencies and okra varieties on percentage damaged weight and fruit yield are presented in Table 5. There was significant difference among the treatments when they were compared. Zero weeded plots recorded highest percentage damaged fruits weight (6.78% and 64.81%) while three-weeded plots recorded the lowest (23.11% and 22.54%) in both years. Challawa okra variety recorded the highest (27.07% and 26.92%) damaged fruit weight compared with NGAE-96-1 (23.48% and23.10%) and NHAE-47-4 (23.17% and 23.68%). Results on okra fruit yield showed that there was a significant difference among the treatments. Three weeded plots had consistently recorded the highest fruit yield (769.97 kg/ha and 783.14 kg/ha) in both years followed closely by two weeded plots (656.41 kg/ha and 696.05 kg/ha). The non weeded plots had significantly recorded the lowest fruit yield (314.70 kg/ha and 309.76 kg/ha) in both years. The result also indicated that Challawa variety being a local variety recoded the lowest fruit yield (548.18 kg/ha and 539.06 kg/ha) during the study while the improved okra varieties NGAE-96-1 (681.87 kg/ha and 678.54 kg/ha) and NHAE-47-4 (670.91 kg/ha and 682.18 kg/ha) had higher fruit yield in both years.

The results of this study showed that weeding frequencies and okra varietal selection are two most important components of cultural methods of controlling weeds and insect pests. Weed competition in okra can lead to two important consequences. The first is weed competition with okra in harbouring of insect pests by weed species and these insect pests feed on both vegetative and reproductive plant parts causing economic damage to the crops (Takim and Uddin, 2010). In this study, *Podagrica* spp. populations were higher in Challawa okra variety than unweeded control and one weeded plots. The weeded plots and other varieties had lower number of *Podagrica* spp. because they provided unfavourable environment for the pest. The two varieties (NGAE -96 -1 and NHAE-47-4) probably had some degree of resistance to the pest then challawa variety. This indicates that weeding can help greatly in reducing the population of the pest in the field. Weeds create good habitat for a number of Crop Pests, notably leaf feeding insect pests like the okra flea beetle (Anaso, 2008, Altieri *et al.*, 1981; Kanteh *at al.*, 2014).

The other impact of weed competition on okra crop is the higher number of damaged leaves on unweeded and one weeded plots. This implies that the presence of weed provided shelter for *Podagrica* species in the okra field that were unweeded or not regularly weeded hence the increase in the number of damaged leaves. The higher number of *Podagrica* species did not find the crop environment favourable for their habitation (Takim and Uddin, 2010).

Weed removal improved the growth performance of okra because competitive ability of weed species and harbouring of *Podagrica* spp. were reduced in the regularly weeded plots than the unweeded in the regularly weeded plots (Anaso, 2008; Adeniyi and Ayandiji, 2011; Kanteh *et al.*, 2014). Total removal of weeds in the three weeded plots could have effectively reduced competition between the weeds and the crop and made more assimilates available to support okra growth and development and consequently its yield. That is the reason okra plant height and fruit yield were significantly higher in two and three weeded plots. This is in agreement with the findings of Takim and Uddin (2010) who reported that regularly weeded plots had higher yield compared to unweeded and one-weeded plots.

Results from the present study showed that okra plant growth and fruit yield can also be improved by appropriate varietal selection. NGAE-96 -1 and NHAE – 7-4 had significantly higher okra plant height and fruit yield than challawa variety. This suggested that these two varieties probably had some degree of resistance to *Podagrica* spp. than challawa variety. This agreed with the findings of Yusuf *et al.* (2015) who reported hat safer insect pest control could be achieved and crop productivity improved through the simple manipulation of weeding regimes and appropriate selection of crop varieties. The same trend follows with respect to damaged and undamaged fruit. The improved NGAE – 96 -1 and NHAE -47 -4 varieties had lower damaged and higher undamaged fruit weight than challawa variety due to their degree of resistance. The two and three weeded plots had lower damaged and higher undamaged fruits than the non-weeded and single weeded plots.

The reasons are similar to the one given by Lado and Hussaini, 2010; Kanteh *et al.* (2014) and Yusuf *et al.* (2015) who reported separately that regular weeding is essential to maintain high level of sanitation so that they do not harbor pests that will reduce infestation and damage to the crops.

Table 1. Effects of weeding frequency and okra variety on (*Podagrica* spp.) population in 2014 and 2015 cropping seasons.

Treatment	Number of flea beetle/plant	
	2014	2015
Variety (V)		
Challawa	9.01	9.05
NGAE-96-1	3.45	3.40
NHAE-47-4	4.03	4.32
SE±	0.95	0.59
Weeding frequency (WF)		
One weeding	5.33	5.20
Two weeding	4.30	4.48
Three weeding	3.80	3.69
No weeding	6.28	5.97
SE±	0.70	0.82
Interaction (V × WF)	NS	NS

Table 2. Effects of weeding frequency and Okra variety on number of leaves and leaves damaged in 2014 and 2015 cropping seasons.

Treatment	Mean number of leaves/plant		Mean number of damaged leaves/plant	
	2014	2015	2014	2015
Variety (V)				
Challawa	7.05	7.13	5.62	5.48
NGAE-96-1	8.09	8.12	3.64	3.51
NHAE-47-4	8.11	7.98	3.65	3.58
SE±	0.14	0.65	0.43	0.51
Weeding frequency (WF)				
One weeding	6.11	6.13	3.03	3.12
Two weeding	7.08	7.10	3.06	3.04
Three weeding	8.10	8.11	2.02	2.01
No weeding	5.12	5.09	4.11	4.14
SE±	0.48	0.51	3.16	3.14
Interaction (V × WF)	NS	NS	NS	NS

Table 3. Effects of weeding frequency and okra variety on okra plant height in 2014 and 2015 cropping session.

Treatment	Mean plant height (cm)	
	2014	2015
Variety (V)		
Challawa	128.50	124.70
NGAE-96-1	132.90	132.69
NHAE-47-4	133.61	133.11
SE±	0.56	0.61
Weeding frequency (WF)		
One weeding	84.51	82.87
Two weeding	112.49	113.00
Three weeding	131.96	131.92
No weeding	60.58	61.20
SE±	5.36	5.34
Interaction (V × WF)	NS	NS

Table 4. Effects of weeding frequency and Okra variety on damaged and undamaged fruits weight in 2014 and 2015 cropping season.

Treatment	Damaged fruits weight (Kg/plot)		Undamaged fruits weight (Kg/plot)	
	2014	2015	2014	2015
Variety (V)				
Challawa	1.89	1.86	1.24	1.22
NGAE-96-1	1.08	1.10	1.30	1.28
NHAE-47-4	1.23	1.21	1.38	1.38
SE±	0.04	0.06	0.02	0.03
Weeding frequency (WF)				
One weeding	0.83	0.78	0.98	1.07
Two weeding	0.62	0.63	1.29	1.31
Three weeding	0.41	0.39	1.42	1.38
No weeding	0.97	0.95	0.42	0.41
SE±	0.6	0.5	0.6	0.7
Interaction (V × WF)	NS	NS	NS	NS

Table 5. Effects of weeding frequency and okra variety on percentage weight damaged and fruit yield of okra in 2014 and 2015 copping seasons.

Treatment	% damaged fruit weight		Mean fruit yield (Kg/ha)	
	2014	2015	2014	2015
Variety (V)				
Challawa	22.07	26.91	548.18	539.06
NGAE-96-1	23.48	23.10	681.87	678.54
NHAE-47-4	23.17	23.68	679.91	682.18
SE±	0.51	0.55	12.61	13.55
Weeding frequency (WF)				
One weeding	50.52	51.48	489.87	478.92
Two weeding	25.42	25.31	656.41	696.05
Three weeding	23.11	22.54	769.97	783.14
No weeding	65.78	64.81	314.70	309.76
SE±	10.20	9.23	12.07	11.65
Interaction (V × WF)	NS	NS	NS	NS

Conclusions

This study showed that challawa variety was more susceptible to the beetle (*Podagrica* spp.) infestation as opposed to NGAE – 96 -1 and NHAE -47 -4. It also showed that weeding frequencies have great impact on the population of flea beetle, growth of okra, damaged and fruit yield of okra. Three weeding frequency at 3, and 9 WAS were found to be more effective in controlling weed, reducing the population of *Podagrica*_spp., fruit damaged and increasing okra fruit yield. Three weeding frequency if properly carried out with the appropriate selection of variety would reduce *Podagrica* spp. attack and enhance okra fruit productivity and be a friend of the environment.

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