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Preliminary evaluation of weed management method x crop variety interaction on weed control and okra yield

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ABSTRACT

Objective: Seedling morphology influences the competitiveness of crop varieties against weeds. This study evaluated the additive effect of weed management method x crop variety interaction on weed control, which is desirable for sustainable yield and produce quality in vegetable crops.

Methodology and results: The effects of weedy (wy), weed free (Wf), pendimethalin at 0.33 kg a.i./ha (P1), P1 + weeding 3 weeks after treatment (WAT, W3), P1 + W5 and P1 + atrazine at 2.05 kg a.i./ha (A1) on weed control and yield of okra (*Abelmoschus esculentus* (L.) Moench) var. NHAE 47-4 and Jokoso were evaluated in a field experiment. Both NHAE and Jokoso carried diverse weed flora, which were predominantly annual broadleaves. More weeds infested Jokoso (75.9%) than NHAE (57.7%). Annual weeds were more in NHAE (85%) while perennial weeds were more in Jokoso (33.3%). Crop variety did not influence weed growth but early weed resurgence, and late weed cover and dry matter differed significantly with weed management method. P1+A1, P1 +W3 and Wf suppressed early-emerged weeds, late weed cover and weed dry matter most, compared to other weed management methods; early weed cover was most extensive in Wf. Crop growth and yield differed widely with both crop variety and weed management method. Seedling emergence, leaf and pod production were better in NHAE than in Jokoso. Emergence was best in P1+W5, followed by P1+W3, P1, Wf and Wy and poorest in P1+A1. Pods per plant and pod yield were highest in P1+W5 and Wf, and lowest in P1+W3, P1+A1, P1 and Wy. Differences in crop growth and yield response were primarily due to crop variety, weed association, effectiveness of weed management method and herbicide injury.

Conclusion and application of findings: It is concluded that the use of pendimethalin-based integrated weed management system (IWM) will enhance production and farmers' livelihood in polyculture-based small farms involving main crops of maize, sorghum, etc. and minor vegetable crops such as okra, Indian spinach, cabbage and onion.

Key words: *Abelmoschus esculentus,* variety, weed management.

INTRODUCTION

Pendimethalin is a popular dinitroaniline herbicide used for weed control in vegetable crops (Akobundu, 1987). In pre-transplanted green peppers, this chemical gave good control of weeds at 3 or 5 L/ha (Palczynski & Anyszka, 1996). When applied pre-emergence (PE) at 5 L/ha, it gave a yield ranging from 379.9 to 628.8 kg/ha with no significant phytotoxic damage to the crop. Also, Sinha *et al*. (1996) obtained effective control of broadleaved weeds in onion when pendimethalin was applied post-transplanting to onion seedlings at 1.0-2.0 kg a.i. /ha on moderately fertile soil.

In Okra (*Abelmoschus esculentus* (L.) Moench), pendimethalin either alone or in mixtures with broadleaf herbicides, and supplemented with other weed control methods, especially hand weeding, has given effective control of weeds (Pandey & Singh, 1983; Dhanappal & Gowda, 1996). In the tropical rainforest zone of southwestern Nigeria, okra exposed to 0.33– 1.32 kg a.i./ha pre-emergence pendimethalin suffered little injury, which was tolerated, and the crop established well after treatment (Omole, 1997). Severe phytotoxicity from the highest application rate (1.32 kg a.i./ha) caused marked reduction and growth of associated weeds. This rate reduced *Euphorbia heterophylla* L. by 95% while in mixture with 8.20-kg a.i./ha atrazine it completely eliminated the weed, although the latter application reduced crop seed germinability and seedling vigour under laboratory conditions and in the field. It was therefore suggested that pendimethalin at 0.066 - 0.33 kg a.i./ha would be optimally effective for weed control while lower rates would cause minimal crop injury. Also, keeping plots weed-free or supportive weeding by manual hoeing at 3-4 weeks after pendimethalin application to okra assures optimum yield.

However, the response of crop varieties to either pendimethalin or pendimethalin-based weed management systems has not been reported for vegetable crops. Hamada *et al*. (1998) reported that the difference in competitive ability of two cotton varieties (Sudac-K, Barac 67/B) with weeds was probably due to initial morphological differences in crop seedling growth; Sudac-K has an open canopy (super okra leaf shape) while Barac 67/B has the normal cotton leaf shape.

The current study was therefore carried out to evaluate the effects of pendimethalin-based weed management method and crop variety on weed control and yield of okra in the tropical rainforest zone of southwestern Nigeria.

MATERIALS AND METHODS

The experiment was carried out at the Teaching and Research Farm of The Federal University of Technology, Akure (327 m above sea level; Long 5^0 12'E, Lat. 7^0 16'N). The experimental site was under a one-year fallow before land clearing.

The experiment was arranged as a 2 x 6 factorial in a randomized complete block design using three replications. The first factor comprised two okra varieties (NHAE 47-4 and Jokoso) while the second factor comprised six weed management methods, i.e. weedy (Wy), weed-free (Wf), pendimethalin at 0.33 kg a.i./ha (P1) or supplemented by hoe-weeding at 3 (P1 + W3), 5 (P1 + W5) weeks after sowing (WAS) or atrazine at 2.05 kg a.i./ha (P1 + A1). Individual plots measured 2.0 x 1.5m in size. Alleyways of 1 m and 0.5 m were left between blocks and adjacent plots, respectively. Seeds of both okra varieties were soaked in water for 24 h. to facilitate field germination after planting. The seeds were sown at two seeds per hill at a spacing of 60 cm by 30 cm, and later thinned after full emergence to one plant per hill. The herbicide treatments were applied PE to crop seeds, 1 day after sowing. Fully established okra plants were sprayed with Cymbush at the rate of 5 L/ha when infestations of *Podagrica uniformis* and *P. sjostedti* were observed. Crop stand counts were recorded at two weeks after treatment (WAT). Weed cover was rated at 2, 3 and 5 WAT using the 0-100 rating scale, where 0 = no weed cover and 100 = complete weed cover. Weed samples were collected from two diagonally placed 0.5 m^2 quadrats at 3 and 5 WAT for the determination of weed flora composition and weed density. Weed dry weight was determined after oven drying weed samples at 80^0C to constant weight. Other observations recorded were okra plant height and leaves/plant at 8 and 10 WAT, and cumulative pod production and fresh yield after final pod harvest. All the data recorded were subjected to ANOVA and means separated using the LSD test at $P \leq 0.05$.

RESULTS

Weed flora composition: The weed flora of both crop varieties covered 26 species spread over 12 plant families (Table 1) and comprised mostly annual broadleaves (52.4%). However, the weed flora varied appreciably with crop variety with slightly more weeds infesting cultivar NHAE (75.9%) than Jokoso (57.7%). Cultivar NHAE was infested predominantly by annual weeds (85%) and less by perennial weeds (15%), than Jokoso (66.7 and 33.3%, respectively).

Weed growth: Weed growth was not significantly influenced either by crop variety or by the interaction between variety x weed control method (Table 2). Similar observations were recorded on the effect of weed management method on late weed resurgence and weed dry matter production. On the other hand, the density of early-emerged weeds, and weed cover and dry matter in late-emerged weeds varied significantly with weed management method. The infestation of early-emerged weeds was greatest in P1+W5 and P1, and smallest in P1+A1, although weed infestation in P1+ W3 and Wf were similarly low. Within the first 3 WAT, Wf and Wy consistently had the greatest weed cover while the smallest weed cover was recorded in P1 + A1. At 5 WAT, however, weed cover in both P1 +W5 and P1 increased considerably compared to that in Wy while weed cover was most effectively reduced in Wf and P1+W3. Weeds accumulated the greatest dry matter in P1 and the lowest in P1 + A1 and P1+ W3.

Table 1: Cumulative weed flora in fields of two okra varieties (Jokoso and NHAE47-4).

Weed family	Weed taxa	Growth form	Okra Variety	
			Jokoso	NHAE47-4
Amaranthaceae	*Amaranthus spinosus*	ABL	X	✔
	Celosia argentea	ABL	X	✔
	C. trigyna	ABL	✔	✔
Asteraceae	*Ageratum conyzoides* *Aspilia Africana*	ABL PBL	✔ ✔	X ✔
	Synedrella nodiflora	ABL	X	✔
Commelinaceae	*Commelina benghalensis*	PSp	✔	X
Cyperaceae	*Mariscus alternifolius*	PS	✔	X
Euphorbiaceae	*Euphorbia heterophylla*	ABL	✔	✔
Lamiaceae	*Platostoma africana*	ABL	X	✔
Fabaceae	*Calopogonium mucunoides*	ABL	✔	✔
	Desmodium scandens	ABL	X	✔
Mimosaceae	*Mimosa pudica*	ABL	X	✔
Poaceae	*Digitaria horizontalis*	AG	X	✔
	Eleusine indica	AG	✔	✔
	Leptochloa caerulescens	AG	✔	✔
	Paspalum orbiculare	PG	✔	X
	Rottboellia cochinchinensis	AG	✔	✔
	Sorghum arundinaceum	AG	X	✔
Portulacaceae	*Portulaca oleracea*	PBL	X	✔
	Talinum triangulare	PBL	✔	✔
Solanaceae	*Physalis angulata*	ABL	✔	X

Key: ABL=Annual broadleaf, PBL= Perennial broadleaf, PSp= Perennial spiderwort, PS= Perennial sedge, PG= Perennial grass, AG= Annual grass. X= absent, ✔ = present.

Crop growth and yield: Stand establishment, number of leaves per plant at 8 WAT and pods/plant were significantly influenced by crop variety (Table 3), and cultivar NHAE performed better than Jokoso. Similar observations were recorded with respect to the effect of weed management method on both stand establishment and pods/plant. On the average, the highest stand counts were recorded in P1+W5, followed by P1, Wy and P1+W3, and the lowest was recorded in P1+A1. Pods/plant were highest in P1+W5, followed by P1 + W3 and Wf, and lowest in P1+A1, P1 and Wy. On the other hand, no significant differences were recorded in respect to the effect of either crop variety on plant height, harvest leaves/plant and cumulative pod fresh yield, or the effect of weed management method on plant height and leaves/plant.

DISCUSSION

A high diversity of weed species was observed on the experimental site. Similar findings have been reported in field studies in a sub-humid tropical environment of southwestern Nigeria (Ayeni *et al*., 1984). The predominance of broadleaved weeds in treated plots however, was due mainly to herbicide selectivity and/or subsequent shift in weed species composition. Pendimethalin is primarily selective on grass weeds, and will therefore be ineffective on broadleaved weeds (Akobundu, 1987). Also, the control of grass weeds leads inadvertently to the resurgence and dominance of broadleaved species.

Table 2: Effect of crop variety and weed management method on weed growth in okra[1].

Okra variety	Weed management method	Weed density, WAP		Weed cover, WAP			Weed dry weight, WAP	
		3	5	2	3	5	3	5
		(no./plot)	(no./plot)	(%)	(%)	(%)	(g/m²)	(g/m²)
NHAE 47-4	Wy	501.3	412.0	50.2	60.5	90.0	93.1	66.4
	Wf	197.3	194.7	56.8	70.8	21.5	215.9	64.6
	P1	760.0	642.7	21.7	27.0	53.9	73.3	80.0
	P1+W3	114.7	238.7	21.5	27.9	13.5	70.9	10.8
	P1+W5	345.3	389.3	16.5	21.6	66.2	35.5	76.9
	P1+A1	94.7	117.3	1.9	4.8	25.7	2.5	29.2
	Mean	168.1	165.2	14.1	17.7	22.6	40.9	28.0
Jokoso	Wy	461.3	872.0	53.9	69.1	90.0	77.3	105.5
	Wf	148.0	980.0	60.0	69.1	17.5	68.3	8.5
	P1	878.7	357.3	22.7	28.1	77.7	65.5	180.1
	P1+W3	261.3	426.7	25.7	31.2	19.5	41.7	8.3
	P1+W5	103.3	329.3	21.6	27.0	81.4	35.7	105.0
	P1+A1	118.7	74.7	1.9	4.8	30.2	5.3	43.2
	Mean	242.1	506.7	31.0	38.2	26.4	24.6	37.9
LSD (0.05)	Okra variety	Ns	Ns	Ns	Ns	Ns	Ns	Ns
	Weed man. Method	456.9	Ns	10.6	11.7	13.6	Ns	65.7

Key: Wy= Weedy, Wf= Weed-free, P1= Pendimethalin at 0.33 kg a.i./ha, P1+W3= P1 + supplementary weeding 3 weeks after treatment, WAT, P1+W5= P1 + weeding 5 WAT, P1+A1= P1 + 2.05 kg a.i./ha atrazine. WAP= Weeks after planting. Ns= Not significant.

The differential weed infestation patterns between okra varieties can be attributed mainly to growth habit. Jokoso produces denser canopy architecture, and this tended to suppress weed growth more than the less dense canopy cover in NHAE (Anon, 1989). A similar observation was suggested for the differential competitive ability of two cotton varieties (Hamada *et al*., 1998). However, shading is more effective in suppressing light-sensitive annual weeds than perennial weeds (Akobundu, 1987). In perennial species, phenotypic plasticity occurs in response to reduced light supply to the shoot apex causing rapid re-growth from buds. This accounts for the higher occurrence of perennial weeds in Jokoso. Similarly, in NHAE the sparse canopy enhanced the resurgence of light-sensitive seeds resulting in higher occurrence of annual weeds. These compensatory mechanisms probably accounted for the similarity recorded in total weed growth in both okra varieties, and in spite of differing effectiveness of weed management method, the absence of a significant interaction of crop variety and weed management method.

In a previous study, Omole (1997) obtained effective weed control with pendimethalin and pendimethalin-based weed management methods in okra cultivar NHAE. The results of the present study confirm these previous reports. The higher infestation of early weeds in P1+W5 and P1 could have resulted from low herbicide activity of pendimethalin (Zimdahl & Gwynn, 1977; Akobundu, 1987). In addition, delayed weeding in P1+W5 increased weed emergence considerably under the favorable environment in which this study was carried out. On the other hand, weed infestation was lower in P1 + A1 due to the broader spectrum of weed control with atrazine and atrazine persistence. The superior effectiveness of Wf and P1+W3 on weed cover is attributed to manual weed removal. Manual weeding is very effective in directly suppressing emerging weeds, especially when regularly carried out or when combined with the initial pendimethalin efficacy in seedling weed control. Furthermore, the similarity in weed suppression efficiencies of P1 + A1 and P1 + W3 relates mainly to atrazine persistence and early supplementary weeding in P1+A1 and P1+W3, respectively. P1+A1 reduced weed survival and weediness to 31% compared to Wy and sole pendimethalin, and completely eliminated *Euphorbia heterophylla* (Omole, 1997). Atrazine is primarily selective, and effectively controls broadleaved weeds (Akobundu, 1987).

Table 3: Effect of crop variety and weed management method on crop growth and yield in okra[1].

Okra variety	**Weeding method**	**Stand counts** (no./plot	**Plant height** (cm)		**Leaves /plant** (no.)	**Pods/ plant** (no.)	**Pod yield** (g/plot)
		2WAT	8 WAT	10 WAT	8 WAT	10 WAT	10 WAT
NHAE 47-4	Wy	3.9	30.4	43.3	2.2	3.0	80.6
	Wf	3.8	33.1	66.0	2.7	4.5	210.9
	P1	4.0	27.9	39.2	2.3	2.9	74.9
	P1+W3	3.8	37.1	56.4	2.6	3.4	153.1
	P1+W5	4.1	34.4	63.4	2.7	4.7	263.0
	P1+A1	2.4	42.2	59.5	2.7	2.4	53.5
	Mean	11.0	17.1	9.1	7.6	10.5	139.3
Jokoso	Wy	2.9	40.1	49.1	2.1	1.7	33.6
	Wf	3.4	36.4	49.1	2.7	3.9	141.8
	P1	3.0	43.4	55.5	2.3	1.8	36.7
	P1+W3	3.3	36.7	50.9	2.4	3.2	133.1
	P1+W5	3.5	36.7	46.7	2.6	2.9	152.5
	P1+A1	1.6	34.0	43.3	1.9	1.2	18.5
	Mean	8.8	19.0	8.2	7.0	7.3	86.0
LSD (0.05)	Okra variety	0.5	Ns	Ns	0.3	0.8	Ns
	Weed man. Method	0.6	Ns	Ns	Ns	1.1	71.4

[1]Wy= Weedy, Wf= Weed-free, P1= Pendimethalin at 0.33 kg a.i./ha, P1+W3= P1 + supplementary weeding 3 weeks after treatment, WAT, P1+W5= P1 + weeding 5 WAT, P1+A1= P1 + 2.05 kg a.i./ha atrazine. WAT= Weeks after treatment. Ns= Not significant.

Crop growth and yield data indicate differential productivity between okra varieties, particularly with respect to leaf and pod production. This could be mainly attributed to the difference in species composition of the weed associates of each crop variety. In the present study, the greater association of shade-loving perennial weeds with cultivar Jokoso probably increased the severity of weed interference compared to cultivar NHAE 47-4, which apparently suffered less competition from the predominantly annual weed associates.

The competitiveness of weeds with crops varies with weed species and their effect on crop growth factors, among other weed features (Akobundu, 1987). Except P1+A1 in which atrazine phytotoxicity severely reduced stand establishment of okra, stand establishment was uniformly similar in pendimethalin and other pendimethalin-based treatments. Pendimethalin is not known to prevent crop seedling emergence (Akobundu, 1987). In *Basella alba*, lower rates of PE pendimethalin enhanced crop seedling emergence (Smith, 2004), suggesting hormesis.

However, the initial crop injury from applied pendimethalin, additional loss of stands due to atrazine phytotoxicity (Smith, 2006) and stress of weed interference reduced crop productivity in these treatments. These probably accounted for the higher cumulative pod production and yield in Wf, P1+W5 and P1+W3 than in P1+A1, P1 and Wy. Also, the higher pod production in NHAE than in Jokoso confirms the differential response of crop varieties to herbicide phytotoxicity, particularly pendimethalin, judging from the significant effect of weed management method on both stand establishment and pod yield. Generally, cultivar NHAE was more tolerant of applied pendimethalin and atrazine than Jokoso, in spite of the slightly higher yield in the latter (Nwanguma & Awoderu, 1989).

It is therefore suggested that further studies be carried out to evaluate the response of cultivated okra varieties to commonly used herbicides, and to characterize these responses with respect to morphological and physiological plant growth.

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