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Influence of pendimethalin-based weed management systems on weed flora composition in Indian spinach (*Basella alba* L.) and okra (*Abelmoschus esculentus* (L.) Moench) in a humid tropical environment

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1 SUMMARY

Crop growth habit complements weed management effects on weed emergence and growth patterns. In particular, pendimethalin-based integrated weed management systems (P-IWM) are beneficial in both okra [*Abelmoschus esculentus* (L.) Moench cv. Jokoso] and Indian spinach (*Basella alba* L.). This study compared the preliminary influence of P-IWM systems, namely P1 (pendimethalin at 0.33 kg a.i./ha applied pre-emergence, PE), plus weeding once at 3 weeks after sowing (WAS) (P1 + W3), weeding once at 5 WAS (P1 + W5), or PE atrazine at 2.05 kg a.i./ha (P1 + A1), P1 alone, weeding once at 3 + 5 WAS (W2) and no weeding (Wy), on relative weed growth in okra and *B. alba* in a humid tropical environment. A randomized complete block design using three replications per treatment was used. Both crops compared well in ecological weed growth, in terms of weed dominance/relative importance value (RIV) and diversity (*H'*). However, weeds were slightly more important, diverse and varied more widely with P-IWM in okra than in *B. alba*. Okra had distinctly more weed associates (58.8%) and perennial weeds (20%) than *B. alba* (41.2 and 7.1%, respectively) during crop establishment. Annual broadleaves and grasses were considerably more in *B. alba* (64.3 and 28.6%, respectively) than in okra (50 and 25%, respectively). Weed associates of crops were diverse but *Synedrella nodiflora* was distinctly persistent in both crops and more important in *B. alba* (RIV= 42.5%) than in okra (33.1%). It is concluded that differences in ecological weed growth arising from P-IWM were due to crop growth habit, especially canopy cover.

2 INTRODUCTION

Herbicides may be selective to both crop and weed species. Susceptible weeds are eliminated and/or stunted while tolerant or resistant weeds persist to varying degrees over time, and this influences weed flora diversity. Also, crop growth habit and crop vigour modify the growth environment of associated weeds (Akobundu, 1987) through reduction of light supply or intensity, influence of shade on light wavelength and red:far-red (R:FR) ratio, among other factors. Modified light conditions influence weed seed germination, seedling emergence and species diversity. , Weeding influences weed seed germination, regenerative capacity, seedling emergence and species survival and/or persistence. Preliminary research indicates that pendimethalin-based weed management systems (P-WMS) could be effectively applied for weed control and optimum production of both *B. alba* and *Abelmoschus esculentus* in a humid tropical agro-environment (Oloyede, 1997; Dabo, 1998; Smith, 2004, 2006). The objective of the current study was to compare the effects of P-WMS on the weed flora dynamics in both *B. alba* and *A. esculentus*. .

3 MATERIALS AND METHODS

The experiment was located at the Teaching & Research Farm of the Federal University of Technology, Akure (327 m above sea level; Long. 7^0 16'E, Lat. 5^0 12'N) in the tropical rainforest agro-ecozone of southwestern Nigeria. The experimental site was under a one-year fallow before the land was cleared and pulverized to create a suitable tilth for crop growth and herbicide activity. Okra seeds (var. NHAE 47-4, soaked in fairly warm water for 24 h. to facilitate field germination) and Indian spinach seeds (treated with Apron Plus^R) were sown at two seeds per hill at a spacing of 60 x 30 cm, in individual plots measuring 2.5 x 1 m. Alleyways of 1 m and 0.5 m were left between blocks and adjacent plots, respectively. Fully-emerged seedlings were thinned to one stand/hill. The treatments, namely weed free (plots hoe-weeded at 3 + 5 weeks, Wf), no weeding (Wy), 0.33 kg a.i./ha pendimethalin (P1) applied pre-emergence (PE) one day after sowing the crop seeds, supplemented by weeding once at 3 weeks after treatment, WAT (P1 + W3), weeding once at 5 WAT (P1 + W5), or PE atrazine at 2.05 kg a.i./ha (P1 + A1), were arranged in a randomized complete block design using three replications per treatment. Fully-established okra plants were sprayed with Cymbush^R at the rate of 5 L/ha when infestations of *Podagrica uniformis* and *P. sjostedti* were observed.

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. The relative importance value (RIV) of weeds was calculated from the equation: RF + RD/2, where RF= relative frequency of weed occurrence and RD= relative weed density, according to Wentworth *et al.* (1984). Weed diversity index was calculated as Shannon $H' = -\sum p_i \ln p_i$ (Pielou, 1979), where p_i= number of individuals of each weed species. All data recorded were analysed using ANOVA techniques and means separated using the standard error of means at $P \leq 0.05$, where necessary.

4 RESULTS

4.1 Weed flora composition: The cumulative weed flora in both crops comprised of 22 weed species distributed over 11 plant families (Table 1). Annual broadleaved weeds were predominant in both crops, and these consisted of 10 species in okra (45.5%) and 9 species (40.9%) in Indian spinach. Across P-IWMs, weed families were more diverse in okra (11) than in Indian spinach (8). Okra had considerably more annual weeds (14 species), perennial weeds (6 species; *Commelina benghalensis, Momordica charantia, Mimosa pudica, Leptochloa caerulescens, Portulaca, oleracea, Talinum triangulare*), broadleveas (13 species) and slightly more grasses (5 species) than Indian spinach which had 12 annual weeds, two perennial weeds (*L. caerulescens, T. triangulare*), 10 broadleaves and four grasses. Both crops had similar number of early-emerged major weeds (7 species) but late-emerged major weeds were distinctly more in Indian spinach (8 species, *Aspilia africana, Synedrella nodiflora, Euphorbia heterophylla, Desmodium tortuosum, Corchorus corchorifolia, Digitaria horizontalis, L. caerulescens, T. triangulare*) than in okra which had only *Celosia argentea*.

4.2 Weed density: Weed density was higher in plots of okra subjected to P-IWMs than in those of Indian spinach (Table 2). In Indian spinach, a delay in supplementary hoe-weeding from 3 to 5 weeks after PE pendimethalin application resulted in a marked reduction in the density of late weeds, contrasting the marked increase in late weed emergence in okra. Generally, although P + A considerably reduced the emergence of both early and late weeds in both crops, weed densities were much lower in Indian spinach than in okra.

4.3 Weed diversity: Weeds were considerably more diverse in plots of okra treated with P-IWMs than in those of Indian spinach (Table 3), regardless of weed emergence patterns. In okra, a spontaneous increase in weed diversity was recorded from P1 + W3 and P1 + W5 to a peak in P1 + A1. On the other hand, in Indian spinach weed diversity increased moderately from P1 + W3 to a peak in P1 + W5, followed by a marked decrease in P1 + A1, which had comparable value to the least value in Wf.

4.4 Weed Relative Importance Value: The most dominant weeds in both crops were *Synedrella nodiflora*, *E. heterophylla* and *D. horizontalis* (Table 4). However, *S. nodiflora* was more important in established Indian spinach, and *E. heterophylla* in established okra. Across treatments, okra had considerably more minor weeds (8 species) than Indian spinach (4 species). In both crops, P1 + A1 reduced weed RIV most followed by P1 + W3 and P1 + W5 (Table 4). However, P1 + W3 and P1 + W5 reduced weed RIV more in okra than in Indian spinach, and *vice versa* for P1 + A1.

Table 1: Weed flora composition of experimental plots of *Basella alba* and A*belmoschus esculentus*.

Plant family	Weed species	Growth form	*B. alba*		*A. esculentus*	
			3WAT[1]	5 WAT	3WAT	5 WAT
Amaranthaceae	*Amaranthus spinosus*	ABL	b	b	-	b
	Celosia trigyna	ABL	a	b	b	b
	Celosia argentea	ABL	-	-	b	a
	Corchorus corchorifolia	ABL	b	a	-	-
Asteraceae	*Aspilia africana*	ABL	b	a	b	b
	Synedrella nodiflora	ABL	a	a	a	a
Commelinaceae	*Commelina benghalensis*	PSp	-	-	b	-
Cucurbitaceae	*Momordica charantia*	PBL	-	-	b	-
	Euphorbia heterophylla	ABL	a	a	a	a
	Calopogonium mucunoides	ABL	b	b	a	a
	Desmodium tortuosum	ABL	a	a	-	-
	Mimosa pudica	PBL	-	-	-	b
Lamiaceae	*Piliostigma africanum*	ABL	-	-	b	-
Malvaceae	*Corchorus olitorius*	ABL	-	-	b	b
Poaceae	*Digitaria horizontalis*	AG	a	a	a	a
	Eleusine indica	AG	-	b	-	b
	Leptochloa caerulescens	PG	a	a	b	b
	Rottboellia cochinchinensis	AG	b	-	b	b
	Sorghum arundinaceum	AG	-	-	a	a
Portulacaceae	*Portulaca oleracea*	PBL	-	-	a	a
	Talinum triangulare	PBL	a	a	a	a
Solanaceae	*Physalis angulata*	ABL	b	b	b	-

[1]ABL= Annual broad-leaved, PSp= Perennial spiderwort, PBL= Perennial broadleaved, AG= Annual grass, PG= Perennial grass. WAT= Weeks after treatment. a= major weed (≥ 30 plants per m^2), b= minor weed (< 30 plants per m^2

5 DISCUSSION

The weed spectrum recorded in this study is characteristic of tropical agro-ecosystems where frequent soil disturbance creates safe sites for weed emergence, growth and survival (Ayeni *et al.*, 1984; Hakansson, 1995; Smith *et al.*, 2001a, b). However, okra canopy is more extensive and coherent as to ensure light obviation and high suppressive efficiency on weed emergence. This primarily accounted for the predominance of perennial weeds in the shaded okra plots, contrasting the scanty canopy cover of the ground surface in Indian spinach which enhances light stimulation of weed seeds. In spite of these, the crops exhibited variable responses to pendimethalin and atrazine phytotoxicity, especially okra (Sinha *et al.*, 1996;

Omole, 1997; Smith, 2006). With respect to individual weeds, the differential dominance patterns of *S. nodiflora*, *E. heterophylla* and *D. horizontalis* reflect the combined influence of crop growth habit, weed growth form and weed response to P-IWMs (Omole, 1997; Aluko, 1997; Dabo, 1998; Smith *et al*., 2009). In particular, the consistent dominance of *S. nodiflora* in both crops could be partially attributed to local weed distribution in the site and micro-agrocozone under study (Smith & Akinade, 2000).

The findings from this study indicate wide variations in the response of the weed flora to P-IWMs in okra and Indian spinach, due primarily to differences in crop canopy efficiency in weed suppression. Indian spinach is more susceptible to weed infestation due to its slower establishment and ground cover than okra. The partial contribution of crop canopy efficiency in weed suppression is more important in okra than in Indian spinach, judging from the higher weed dominance arising from a delay in supplementary hoe-weeding after PE pendimethalin application and the more severe atrazine injury to okra.

Table 2: Mean weed density (no./m2) in experimental plots of *Basella alba* and *Abelmoschus esculentus*.

Weed management method	*B. alba*			*A. esculentus*		
	3 WAT[1]	5 WAT	Mean	3 WAT	5 WAT	Mean
Weedy	22.3	34.9	28.6	48.5	39.6	44.1
Weedfree	5.8	45.5	25.7	28.2	17.5	22.9
Pendimethalin @ 0.33 kg a.i./ha (P1)	47.5	21.3	34.4	109.5	71.6	90.6
P1 + Weeding once @ 3 WAT	19.1	35.8	27.5	23.7	27.0	26.4
P1 + Weeding once @ 5 WAT	45.3	23.4	34.4	38.4	47.4	42.9
P1 + Atrazine @ 2.05 kg a.i./ha (A1)	8.5	6.3	7.4	10.7	15.4	13.1
SE±	7.31	5.63	4.07	6.17	8.57	11.24

[1]WAT= Weeks after treatment.

Table 3: Weed species diversity in experimental plots of *Basella alba* and *Abelmoschus esculentus*.

Weed management method	*B. alba*			*A. esculentus*		
	3 WAT[1]	5 WAT	Mean	3 WAT	5 WAT	Mean
Weedy	0.66	0.38	0.52	3.41	1.71	2.06
Weedfree	0.29	0.32	0.31	2.33	2.74	2.54
Pendimethalin @ 0.33 kg a.i./ha (P1)	0.88	0.41	0.65	1.70	0.59	1.15
P1 + Weeding once @ 3 WAT	0.71	0.55	0.63	2.20	2.97	2.09
P1 + Weeding once @ 5 WAT	0.84	0.66	0.75	2.36	2.68	2.52
P1 + Atrazine @ 2.05 kg a.i./ha (A1)	0.55	0.29	0.42	3.38	4.77	4.03
SE±	0.09	0.06	0.07	0.28	0.57	0.38

[1]WAT= Weeks after treatment.

Table 4: Weed relative importance value (RIV) and cumulative RIV in *Basella alba* and *Abelmoschus esculentus.*

Weed species	*B. alba*		*A. esculentus*	
	3 WAT[1]	5 WAT	3 WAT	5 WAT
Weed RIV (%)				
Digitaria horizontalis	16.9	33.4	27.2	24.4
Euphorbia heterophylla	17.8	22.7	27.2	28.6
Synedrella nodiflora	99.3	70.3	66.7	65.6

Cumulative RIV (%)		
Weed management method	*B. alba*	*A. esculentus*
Weedy	17.9	12.1
Weedfree	18.8	20.6
Pendimethalin @ 0.33 kg a.i./ha (P1)	20.1	27.4
P1 + Weeding once @ 3 WAT	15.6	12.3
P1 + Weeding once @ 5 WAT	19.5	18.3
P1 + Atrazine @ 2.05 kg a.i./ha (A1)	8.2	10.5

[1]WAT= Weeks after treatment.

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