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Integrated weed control in okra using pendimethalin and selected cover crops

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Abstract Weed interference reduces okra productivity. Most farmers use the highly expensive and labor-intensive manual weeding. The use of herbicides decreases the requirements of manual labor; with time herbicides decrease in weed control efficacy, especially in situations where the crop stays long on the farm. The study's main objective is to measure the complementary effect of selected cover crops to pendimethalin in prolonged control of weed in okra plots. The treatments were: Pendimethalin at 1.0 kg a.i./ha + Akidi at 40,000 plants/ha, Pendimethalin at 1.0 kg a.i./ha + cowpea at 40,000 plants/ha, Pendimethalin at 2.0 kg a.i./ha (High Pend) + Akidi at 40,000 plants/ha, High Pend +cowpea at 40,000 plants density per ha, Hoe-weeded at 3+6+9 weeks after sowing (HWC), plus Weedy check. Weed biomass, Weed Control Rating (WCR), cover crop grain yield, number of okra pods per plant, and okra pod yields were assessed. Weed biomass was less in plots that received hoe-weeding and integrated weed control treatments. Integrated weed control treatments involving High Pend provided a superior WCR and okra pod yield than the ones involving the application at 1.0 kg a.i. /ha of pendimethalin. Average WCR at 10 Weeks After Sowing (WAS) was in the order of 89.0 (hand-weeded control)> 78.0 (pendimethalin 2.0kg a.i./ha+cover crop at 40,000/ha) > 45.5 (pendimethalin 1.0kg a.i./ha+cover crop at 40,000/ha) > 0.0% (un-weeded). Integrated weed control with higher herbicide concentration provided greater okra pod yield (3.4 t/ha) than with the lower herbicide concentration (2.5 t/ha). Integrated weed control with High Pend significantly controlled weed in okra with 76.2% okra pod yield relative to HWC, therefore, integrated use of pendimethalin plus cover crop should be considered for weed control in okra.

Keywords Akidi, cowpea, weed biomass, weed control rating, okra pod yield

Introduction

Okra is commonly grown throughout Nigeria under rain-fed and irrigated conditions. Production of vegetables, especially tomatoes, okra, and amaranthus plays a critical role in the economies of developing countries, in terms of rural employment, source of raw materials for industries, and sources of food for people (Tindall, 1986). Young immature okra pods are important fresh fruit-vegetable that could be fried, boiled, or cooked. In Nigeria, okra is usually boiled in water resulting in slimy soups and sauces, which are relished. The pods also serve as soup thickeners (Schippers, 2000). Okra is sliced and dried, to be stored for later use (Tindall, 1983).

Many factors work against the successful production of crops such as climatic factors, weed interference, pests, and diseases. The outcome of agricultural productivity is mostly guided by factors of climate, so that a little disadvantageous change in climate, brings about a significant hurtful result in agricultural proceedings (Ofuoku and Obiazi, 2021). The extent of using the services of agro-meteorological stations in Nigeria is small because of the delay in making data available to farmers who need the information from NIMET (Ofuoku and Obiazi, 2021). Weeds are always present in plots where they considerably decrease the yield and quality of crops (Obiazi, 2022, Obiazi 1991). Weeds do not only have to be controlled timely but also effectively, especially in the first six to nine weeks of okra growth. The uncontrolled growth of weeds causes yield losses ranging from 63 to 91% (Adejonwo et al., 1987). It was reported that uncontrolled weed infestation resulted in loss in okra yield of 50.7 % (Adeyemi et al., 2014). Okra, like most other vegetable crops, suffers from weed infestation that can be particularly serious at the early crop growth stage because of the slow growth. Weed interference with okra affects its vegetative and reproductive development (Smith, 1997). The crop does not develop a canopy that sufficiently shades the ground.

The use of live mulch in vegetable production should be looked into as a sustainable system that will bring about an increase in okra yield (Akintoye et al., 2011). Research is being encouraged into the usage of cover crops as a viable component in weed management and soil protection. Live mulches also play a major role in reducing expenditure on weed control (Hamma et al., 2012). The use of radiation not intercepted by the main crop and better utilization of soil for nutrients and moisture are certain advantages in the usage of cover crops as weed control agents (Ikeorgu and Ezumah, 1991).

Okra is listed among some subtropical and tropical vegetables that do not grow well in the temperate zone and which have found regular markets in developed countries (Rehm and Espig, 1991). Due to the labor cost, time, and drudgery involved in manual control of weeds, efforts are being made either to reduce the frequency of weeding by establishing cover crops or through the application of herbicides (Obiazi and Ojobor, 2013). The herbicide involved in this study, pendimethalin, is commonly known as stomp (Oworu, 1988). Pendimethalin used in this study has been applied successfully for chemical weed control in eggplant (Obiazi et al., 2024). They equally established the suitability of pendimethalin application at 2.0 kg active ingredient per hectare and noted that weed biomass at 10 WAS was significantly reduced in eggplant pots and provided a weed control efficacy of 83.2% at 10 weeks after transplanting. Pendmethalin has also been used successfully for weed control in okra (Obiazi et al., 2020).

Frequency of weeding is high in okra because it does not develop a canopy that efficiently gets the ground shaded at any stage in its life cycle. Mulch materials are known to help in shading the ground, thereby smothering the weeds; cover crops play the role of mulch materials by smothering emerging weeds. Akobundu (1987) indicated that growing mucuna or other legume cover crops in situ as field crops considerably reduces the cost of mulching, which by implication reduces the cost of weeding. Integrated weed control is important in vegetable crop production since no single method of weed control can provide a lasting solution to most weed problems (Akobundu, 1987).

The objective of the study was the evaluation of how effective, in okra plots is in the integrated use of pendimethalin and cover crops for management of weeds.

Materials and Methods

A study was established in the Agronomy Departmental farm situated in Asaba on the previous Delta State University Campus in Nigeria. The beginning of rainy season is April and it ends in November. Asaba is in the rainforest ecology.

Cutlass was used to slash the vegetation in the experiment, and the tree stumps were removed manually using a hoe and spade before the land was marked into plots. Cowpea seeds, locally known as iron brown, were purchased from the Ogbeogonogo market in Asaba and used. Seeds of akidi (Vigna unguiculata subsp. sesquipedalis L.) were bought at Onitsha main market.

Water was used to soak okra seeds overnight, air dried underneath shade, and sprinkled with Apron star for protection from pests and diseases, it is made up of both fungicide and insecticide. Apron star was used at the application rate of ten grams for every four kg of seeds before sowing. Seeds of akidi and cowpea were similarly dressed. The seeds of okra were planted at an average depth of 2 cm in rows spaced 50 cm apart and within-row spacing of 50 cm, as recommended by Nihort (1986), resulting in 40,000 stands ha-1. Three okra seeds were sown per hole in May 2016, and the experiment was repeated in May 2017. There were 16 stands of okra per plot. In the case of the cover crops, iron brown cowpea and akidi (cover crops) were sown with 3 seeds per hole at a spacing of 50 cm x 50 cm and 16 stands per plot. Thinning of okra and cover crops to one per stand took place after taking data at 3 WAS.

A. Application of fertilizer

The sandy loam soil had 814 g kg^{-1} of sand and 76 g kg^{-1} of silt, and the clay value was 110 kg^{-1}. The slightly acidic soil had a pH of 5.7. Urea was applied at 50 kg of N/ha to supply okra with nitrogen; field application took place at 3 and 6 Weeks's growth stages, as recommended by the Federal Fertilizer Department (2002).

B. Data collection on weeds

The weed control rating was collected as described by Willard (1958) on a "0" to "100" rating system, where "0" means no weed control, no effect, and "100" means complete weed destruction, complete effect. Some of the rates within these extremes have deficient weed control and moderate effects.

The weeds located within each quadrat were collected by cutting at the soil surface. At 4, 6, 8, and 10 WAS weeds were collected for weed biomass data with the use of a 50 cm x 50 cm quadrat by obtaining all the weeds collected within the quadrat and oven drying at 70 ºC to a constant weight and expressed in kg/ha. The data collection on weed was carried out six and nine WAS before the hoe-weeding for plots that required hoe-weeding at 6 and 9 WAS.

C. Phytotoxicity evaluation of pendimethalin on okra

Visual okra injury ratings were performed on a scale from 0 (no injury) to 10 (injury equivalent to a complete kill of okra) three weeks after sowing.

D. 4.4.10 Data analysis

Data collected on weed dry matter production were analyzed using ANOVA. The comparison of the treatment means using DMRT was done at 5 % probability level when the F-value was significant (Gomez and Gomez, 1984).

Results and Discussion

The integrated weed control treatment effects were significant on weed biomass, Weed Control Rating (WCR), cover crop grain yields, and number of okra pods per plant and okra fresh pod yields.

A. Biomass of weeds

The use of pendimethalin and cover crops affected weed biomass from 4 to 10 WAS (Table 1). At four weeks, the integrated treatments were similar in weed biomass, and they were similar to the one obtained in hoe-weeded plots, but weedy plots had much more weed biomass in. There was a similar trend at six WAS in 2016, but in 2017, the higher concentration of pendimethalin started providing greater weed suppression and therefore had less weed biomass compared with treatments involving a lower concentration of the herbicide. Similar weed biomass were observed at eight WAS among the integrated treatments, apart from when a higher concentration of pendimethalin was combined with cowpea where it had significantly lower biomass than the rest integrated methods in 2016. At ten WAS, highest weed biomass was in weedy check, weed biomass, as similarly reported by Obiazi (2022), weedy check plots was highest in weed biomass; while hoe-weeded control had the least weed biomass. The weed control methods with the higher pendimethalin concentration had lower weed biomass compared to the lower herbicide concentration was employed.

Table 1: Effects of integrated use of pendimethalin and cover crops on weed biomass from four to eight week's growth stage

	Weed biomass (g/m^2)			
	4 WAS	6 WAS	8 WAS	10 WAS
		2016		
Pend (1.0)+*Akidi* (40,000)	2.4 b	12.9 c	56.6 b	117.1 b
Pend (1.0)+Cowpea (40,000)	2.3 b	13.7 c	52.6 b	122.1 b
Pend (2.0)+*Akidi* (40,000)	2.3 b	12.7 c	54.7 b	85.9 c
Pend (2.0) +Cowpea(40,000)	2.5 b	11.9 c	47..7 c	92.4 c
HWC	2.2 b	18.6 b	18.4 d	11.5 d
Weedy check	26.0 a	66.3 a	125.8 a	233.8 a
		2017		
Pend (1.0)+*Akidi* (40,000)	2.3 b	13.5 c	51.3 b	122.1 b
Pend (1.0)+Cowpea (40,000)	2.4 b	15.0 c	54.4 b	120.6 b

Pend (2.0)+*Akidi* (40,000)	2.3 b	11.3 d	53.4 b	85.6 c
Pend (2.0) +Cowpea (40,000)	2.4 b	10.9 d	54.4 b	89.4 c
HWC	1.8 b	21.1 b	22.9 c	15.2 d
Weedy check	21.1 a	69.3 a	129.9 a	228.4 a

WAS = Weeks After Sowing, Pend = Pendimethalin

Highest WCR was constantly observed in HWC, and least WCR was in the weedy. For each of the integrated weed control treatments, the WCR decreased from week four to the week ten growth stage. The hoe-weeded plots did not fluctuate in WCR throughout the experimentation; it ranged from 75.0–93.7% in 2016 and 78.3–90.0% in 2017, from four to ten WAS. At 4 weeks of the growth stage, there was no distinct difference in WCR based on pendimethalin concentration or based on akidi or iron brown cowpea. The WCR of the integrated treatments ranged from 78.0–89.0% in the first year and 76.3–82.7% in the second year at 4 WAS. At 8 WAS, there was a distinction in WCR based on herbicide concentration in 2016 where the weed control methods involving higher rates of the herbicide had greater weed control ratings than the ones involving the lower rate of the herbicide (87.7–90.3%) than the ones with lower rates (66.0–67.0%) in the first year; this was not the situation in the second year trial because a higher dosage of pendimethalin and akidi had similar WCR with lower herbicide concentration. At 10 weeks of the growth stage, herbicide concentration had started playing out a superior effect in the field; they had significantly better weed control than the ones involved with lower concentrations of herbicide. Generally, the integrated methods had a superior WCR than weedy check.

Table 2: Effects of using pendimethalin and cover crops on weed control rating

Weed control treatment	Weed control rating (%)			
	4 WAS	**6 WAS**	**8 WAS**	**10 WAS**
		2016		
Pend (1.0)+*Akidi* (40,000)	78.0 c	67.3 d	66.0 b	48.8 c
Pend (1.0)+Cowpea (40,000)	82.7 bc	70.0 c	67.0 b	42.7 c
Pend (2.0)+*Akidi* (40,000)	89.0 ab	85.0 ab	90.3 a	75.3 b
Pend (2.0)+Cowpea (40,000)	82.0 c	88.0 a	87.7 a	77.0 a
HWC	93.7 a	75.0 bc	86.3 a	90.3 a
Weedy check	0.0 d	0.0 d	0.00c	0.0 c
		2017		
Pend (1.0)+*Akidi* (40,000)	79.0 b	72.0 b	64.3 b	48.3 c
Pend (1.0)+Cowpea (40,000)	76.3 bc	73.3 b	63.3 b	43.0 c
Pend (2.0)+*Akidi* (40,000)	77.0 bc	78.0 b	75.0 ab	78.0 b
Pend (2.0)+Cowpea(40,000)	82.7 b	80.0 a	74.0 ab	81.7ab
HWC	90.0 a	78.3 ab	85.0 a	87.7 a
Weedy check	0.0 d	0.0 c	0.0 c	0.0 d

WAS = Weeks After Sowing, HWC= How Weeded Control, Pend = Pendimethalin

B. Grain yields of akidi and cowpea grains in integrated weed control plots

The concentration of applied pendimethalin had a significant effect on cover crop grain yields (Table 2). Integration of 2.0 kg a.i./ha of pendimethalin and akidi or cowpea resulted in greater yields of grain than when the lower rate of herbicide concentration of 1.0 kg a.i./ha was used. Integration of pendimethalin at 1.0 kg a.i./ha resulted in grain yields of 177.1 to 194.3 kg/ha for akidi and cowpea.

C. Effects of weed control on the number of okra pods

Integrated use of pendimethalin at 1.0 or 2.0 kg a.i./ha and akidi or cowpea at 40,000 plants/ha significantly affected the number of fresh okra pods per plant (Table 3). Okra plants that were sown HWC and all the other integrated weed control treatments had okra plants with a significantly higher number of okra pods per plant than the one grown in weedy check.

D. Effects of weed management on okra fresh pod yield

All the integrated weed control methods evaluated in both years of this experiment resulted in significantly higher yields of okra fresh pod (Table 3). Plants in hoe-weeded plots produced significantly higher okra fresh pod yields than any of the integrated weed control methods involved in this study.

Table 3: Effects of integrated use of pendimethalin and cover crops cover crops grain yields, number of pods/plant, and okra fresh pod yield

	Grain yield (kg/ha)		No. of pods/okra plant		Okra fresh pod yield (t/ha)	
Weed control treatment	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Pendimethalin (1.0)+*Akidi* (40,000)	180.8 b	194.3 b	6.5 b	6.3 b	2.3 c	2.7 c
Pendimethalin (1.0)+Cowpea (40,000)	177.1 b	188.5 b	5.0 b	7.4 b	2.2 c	2.6 c
Pendimethalin (2.0)+*Akidi* (40,000)	338.0 a	346.7 a	7.5 a	8.4 a	3.2 b	3.4 b
Pendimethalin (2.0 kg)+Cowpea(40,000)	333.3 a	342.0 a	7.3 a	9.0 a	3.4 b	3.6 b
HWC	-	-	7.8 a	10.3 a	3.9 a	4.5 a
Weedy check	-	-	1.3 c	2.2 c	0.9 d	1.2 d

WAS = Weeks After Sowing, HWC= How Weeded Control

E. Effects of herbicide concentrations on weed control rating, number of pods per plant, and fresh pod yield

Weed control rating was affected by herbicide concentrations; the number of pods per plant and fresh pod yield in the study were also affected (Figures 1a, b, and c). Bari (2010) noted that recommended rates of pendimethalin provided greater weed management and fresh okra yields relative to lower rates of the herbicide. There was maximum difference in the rate of weed control at 10 WAS, all the treatments had significantly different WCR. An increase in fresh okra pod yields with a rise in the dosage of pendimethalin occurred, while the weedy check had the lowest average values for okra fresh pods.

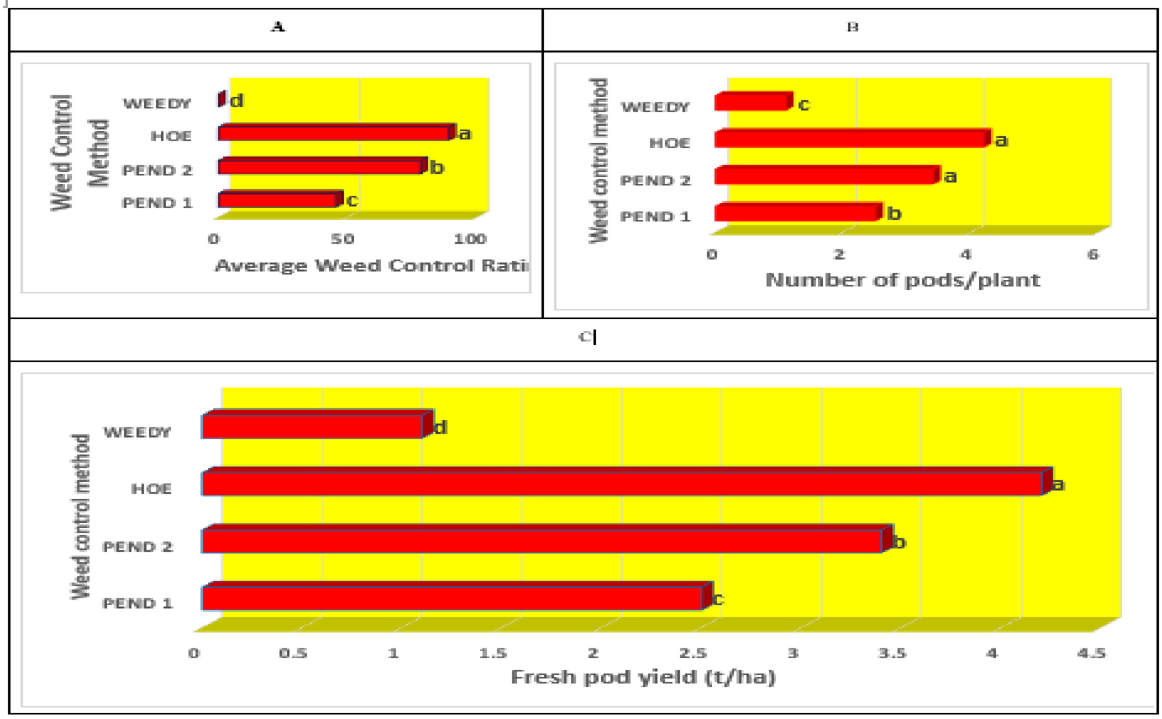

Figure 1: Effects of herbicide concentrations on WCR (A), number of pods per plant (B), and fresh pod yield (C).

Figure represents the average of the two years.

PEND 1 = Mean performance of pendimethalin applied at 1 kg a.i./ha, + akidi/cowpea at 40,000 plants/ha

PEND 2 = Mean performance of pendimethalin applied at 2 kg a.i./ha + akidi/cowpea at 40,000 plants/ha
HWC = Hoe Weeded Control; Average WCR was at 10 WAS; WAS = Weeks After Sowing; WCR = Weed Control Rating

Conclusion

The appropriateness of integrated pendimethalin application at 2.0 kg a.i./ha plus akidi or cowpea for weed control in okra has been established, especially at the higher concentration, because the herbicide higher rate reduced weed biomass with 78.0% WCR and 80.95% fresh okra pod yield relative to hoe-weeded controls. The number of pods per plant in the integrated plots with the high herbicide concentration was as much as that of the hoe-weeded control. Pendimethalin should be part of an integrated weed control program in okra production.

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