International Journal of Agriculture, Environment and Bioresearch

Vol. 10, No. 01; 2025

ISSN: 2456-8643

EFFECT OF RESIDUE MANAGEMENT PRACTICES AND WEED CONTROL METHODS ON THE EMERGENCE PATTERN AND DENSITY OF MIMOSA INVISA MART. IN CASSAVA FARM

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https://doi.org/10.35410/IJAEB.2025.5962

ABSTRACT

A field experiment was conducted during 2015 and 2016 cropping seasons at the National Root Crop Research Institute, Umudike to evaluate the effect of vegetation residue management and weed control methods on the emergence pattern and density of mimosa under two cassava varieties of contrasting morpho-types. The sites used for the experiments were predominately infested with M. invisa Mart. The experiment was laid out in split-split plot in randomized complete block design with three replications. The main plot consisted of two residue management practices (burning and no burning). The sub-plot consisted of two cassava varieties of contrasting morphology (TME 419 and NR 8082) and the sub-sub-plot consisted of four weed control methods (hoe weeding at 4, 8 and 12 weeks after planting (WAP), S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by hoe weeding at 12 and 16 WAP, S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP and Weedy check). Data collected were subjected to analysis of variance and means separated using least significant difference. The results obtained indicated that the different vegetation residue management practices had no significant effect on the emergence pattern and density of M. invisa in cassava farms. However, burning of vegetation residue in-situ caused rapid germination of M. invisa before tillage operations compared to when the residues were incorporated into the soil whereas, M. invisa density was excellently controlled by all the three weed control methods used in this study up to 10 months after planting.

Keywords: Residue management, Mimosa invisa, Cassava weed control methods.

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz), is a tuber crop that belong to the Euphorbiaceae family grown mainly for its edible roots; rich in starch (Howeler *et al.*, 2013). In Nigeria, it is regarded as one of the major source of income for both subsistent and commercial cassava farmers.

However, the production of cassava (*M. esculenta*) is faced with numerous constraints in Africa and Nigeria in particular. Studies have shown that weed interference is the most critical since the crop is a poor competitor and usually suffer serious yield loss if not adequately weeded during the early stages of the plant growth (Howeler *et al*., 2013). Among the weeds known to cause serious production constraint and reduction in the yield of cassava is the giant sensitive plant (*Mimosa invisa* Mart.) (Alabi *et al.*, 2004; Gbadamosi, 2015).

Mimosa invisa Mart is a perennial, thorny leguminous weed which produces large quantities of seeds at an early age and has a persistent seed bank (Willson and Garcia, 1992). Although it is used in the Philippines to restore soil fertility in systems of reduced or short fallow periods, it has become an invasive and noxious weed that can take over native vegetation and form large swathes of dense prickly normally difficult-to-remove, stands (MacLean *et al.*, 2003). The weed has a hard or tough impermeable seed which allows some seeds to remain viably dormant in the soil for a very long time (Melifonwu, 1994a, b). Hence, *Mimosa* has all-year round periodic dormancy breakage, germination and seedling emergence pattern under favourable moist, but not flooded, soil condition with most germinations occurring at the start and end of the wet seasons, representing the critical periods of the weed's interference in crop fields.

The periodic seed dormancy breakage/germination and seedling emergence pattern of *Mimosa* makes long-term effective control measures on a long-cycle crop like cassava difficult. Consequently, its infestation of cassava field has been found to reduce the root yield by 80 percent at harvest (Alabi *et al*., 2001). It has also been reported to disturb the harvest as well as lower the quality of the stakes of the future crop (Lebot, 2009). It would appear therefore, that any *Mimosa* control measure that could achieve a long-term effect must consider, among other things, factors that affect its seed germination and seedling emergence into the more vulnerable vegetative stage and time of intervention of the control measures.

Agronomic experience has shown more extensive *Mimosa* seedling emergence on fields where the residues are burnt than where they are not. Additionally, field observation has also shown extensive *Mimosa* seedling flushes in fields where dry *Mimosa* vegetative residues were burnt than where they were not; suggesting that *Mimosa* seed dormancy could be broken by high temperatures generated from burning dry vegetative residues in *Mimosa* infested fields. It is possible that the heat of burning may have hastened the seed dormancy breakage of *Mimosa* thus, enabling the seeds to germinate quicker and emerge into the more vulnerably manageable vegetative seedling stage. At this seedling stage, when contact and/or systemic herbicides in a pre- and/or post-emergence application method with or without supplemental manual weeding is enough to weed out the weed. Therefore, imposing seed scarifying conditions of appropriate land preparation methods (burning of residues and conventional tillage) could be a critical factor in depleting the seed bank of *Mimosa* in the soil. This in conjunction with optimal cropping systems (use of cassava of ideal morphological characteristics and spacing) and correct timing of intervention measures (herbicide application and /or manual weeding) could prove satisfactory to both large-scale and small-holder cassava farmers. Previous studies in Nigeria appear to have over sighted these considerations which could prove decisive in the efforts at controlling *Mimosa* in cassava fields. There is need to develop management strategies for long-term effective control of *Mimosa* in a cassava-based farming system.

2. MATERIALS AND METHOD

Study area

The study was carried out at the Research Farm of National Root Crops Research Institute, Umudike, Abia State, in 2015 and 2016 cropping seasons. Umudike is located on latitude $5^0$29' N, longitude $7^0$33' E and altitude 122 meters above sea level. The rainfall lasts between March and November with peaks in July and September while a short dry period is usually observed during August. The total annual rainfall in 2015 was 2076.6 mm and 2166.8 mm in 2016.

In order to ascertain the relative weed composition and level of dominance of *M. invisa* at the study site, pre-weed sampling was carried out in both years. A quadrat of 1 m^2 was randomly placed five times in both study sites, and each weed that fell within each quadrat was identified to species level, using the second edition of a handbook of West African weeds by Akobundu and Agyawka (1998), and Akobundu *et al.* (2016). The percentage dominance was determined by the ratio of the mean number of each weed and the total mean number of all the weeds identified multiplied by 100.

Land preparation

The piece of land used for this study was divided into two halves. In one part of the land, the fallow vegetation was cleared (slashed), the resultant residue burnt *in-situ* then, the land was ploughed, harrowed and ridges made. While the other portion of the land was cleared, the existing vegetation residue was incorporated into the soil by ploughing and harrowing before making ridges 1 m apart. The parts that had burnt residue and the remaining part of the land that the residues were incorporated into the soil were divided into experimental units (plots) of 5 m x 4 m (20 m^2). The blocks and plots within each block were separated from each other by 1m pathway.

Soil temperature during the burning of vegetation residues

During burning of the existing vegetation residues, soil thermometer was used to ascertain the temperature range of the portions of the soil in the plots where the residues were burnt at 0 – 5 cm soil depths. The average temperature of different depths which was taken at various points in the field during the burning operations ranged from 60 – 120 ^{0}C.

Planting materials, planting, and field maintenance

Stem cuttings of two cassava varieties; the profuse branching variety (NR 8082) and the sparse branching variety (TME 419) were obtained from the NRCRI, Umudike. Cassava stakes of 23 cm long were planted at an angle of about 45^0 to the crests of the ridges at a spacing of 1m x 1m. The cassava cuttings were planted in June in 2015 cropping season and end of May in 2016 cropping season.

Weed control (both manual and chemical) was done according to treatment. Hoe weeding was carried out using locally fabricated small hand hoe while chemical weed control was achieved using pre-emergence and post-emergence herbicides. They included S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence at 2 days after planting and trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP. The pre-emergence herbicide treatments were applied using a knapsack sprayer (Cooper Pegler CP-15). The nozzle was fitted with a red flat fan plastic nozzle, and calibrated to spray at a volume rate of 300 L/ha. At 8 weeks after planting, NPK (15:15:15) fertilizer was applied to all plots by hand at 600 kg/ha (Chude *et al.*, 2012).

Experimental design

This experiment was conducted in a split-split plot design in randomized complete block design (RCBD) replicated three times.

Treatments

The main plot consisted of two (2) residue management practices – No burning and burning residues *in-situ*.

The sub-plot consisted of two cassava varieties of contrasting morphology – TME 419 - sparse branching variety and NR 8082 - profuse branching variety.

The sub-sub plot consisted of four (4) weed control methods –

i. Hoe weeding at 4, 8 and 12 WAP (W_1).
ii. S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence, followed by two hoe weedings at 12 and 16 WAP (W_2).
iii. S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied as pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied as post-emergence at 8 WAP (W_3).
iv. Weedy check (W_0).

***Mimosa* pod and seed yield**

Mimosa pod and seed were collected at 7 months after planting (MAP) when the pods are ripe for harvesting before the seeds are shaded on the surface of the soil in the weedy check plots. A quadrat of 0.5 m^2 was randomly placed in two areas in each plot and the number of *M. invisa* pods that fell within each quadrat was carefully handpicked (harvested) weighed and recorded. After one month of air drying the dried pods, the seeds were extracted from the pods, countered and weighed using a precision standard weighing balance (ATOM-120).

Statistical model and Analysis

All data collected were subjected to analysis of variance (ANOVA) using GenStat Discovery Edition Version 4, GenStat Release 10.3DE. Significant treatment means differences were separated using the least significant difference (LSD) at 5% level of probability.

3. RESULTS

Pre-weed sampling was conducted at the experimental sites in both cropping seasons to determine the relative weed composition and dominance of M. invisa (Table 1). The results obtained showed that weeds at the experimental site comprised of 11 families and 19 different species which is typical of weed composition in tropical regions. The site was mostly dominated by Mimosoideae and Poaceae families. The two major species at the study site were M. inivsa and Panicum maximum. M. invisa, contributed 23.4% and 14.8% to the total weed population in 2015 and 2016 cropping seasons, respectively whereas P. maximum contributed 18.2% and 17.2% in 2015 and 2016 cropping seasons, respectively. This result indicated that there was a sufficient number of M. inivsa at the experimental site to carry out this study in both cropping seasons.

Table 1: Weed composition and relative abundance of weed species of the experimental site in 2015 and 2016 cropping seasons.

Family	Species	Mean Number/m^2		% Dominance	
		2015	**2016**	**2015**	**2016**
Asteraceae	*Chromolaena odorata* (L.) R.M. King & Robinson	9.7	10.2	4.1	8.6
Asteraceae	*Aspilia africana* (Pers.) C.D. Adams	2.3	9.0	1.0	7.6
Commelinaceae	*Commelina benghalensis* L.	7.0	-	3.0	-
Convolvulaceae	*Ipomoea involucrata* P. Beauv.	4.5	5.3	1.9	4.5
Cyperaceae	*Mariscus alternifolius* Umbellatus V.	12.8	-	5.4	-
Cyperaceae	*Mariscus flabelliformis* Kunth var. flabelliformis	-	8.0	-	6.8
Cyperaceae	*Cyperus rotundus* Linn.	-	10.0	-	8.4
Euphorbiaceae	*Phyllanthus amarus* Schum. & Thonn.	-	8.5	-	7.2
Fabaceae	*Calopogonium mucunoides* Desv.	7.3		3.1	
Fabaceae	*Centrosema pubescens* Benth.	-	4.5	-	3.8
Malvaceae	*Sida garckeana* Polak	1.0	-	0.4	-
Malvaceae	*Sida rhombifolia* L.	1.0	-	0.4	-
Mimosoideae	*Mimosa invisa* Mart.	55.2	17.5	23.4	14.8
Nyctaginaceae	*Boerhavia difussa* L.	-	5.0	-	4.2
Poaceae	*Panicum maximum* Jacq.	43.0	20.4	18.2	17.2
Poaceae	*Paspalum conjugatum* Berg.	24.0	15.0	10.2	12.7
Poaceae	*Axonopus compressus* (Sw.) Beauv.	36.5	5.0	15.5	4.2
Poaceae	*Brachiaria deflexa* (Schumach.)	27.0	-	11.4	-
Rubiaceae	*Mitracarpus villosus* (Sw.) DC.	5.0	-	2.1	-
Total		**236.2**	**118.4**		

Mimosa invisa density as influenced by residue management, cassava variety, and weed control methods

The interaction between residue management and weed control methods significantly affected the M. invisa density at 12 WAP in both years (Table 2). Plots, where burning was carried out with no weeding (W0), had the highest M. invisa density (22.8/m2) in 2015 cropping season. On the other hand, plots where the residues were incorporated into the soil and S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence (W3) had the lowest M. invisa density in 2015 and 2016 (1.3/m2 and 0.33/m2 respectively) cropping seasons.

The interaction between residue management and cassava variety did not significantly influence M. invisa density at 10 MAP in 2015 cropping season but was significant (P≤0.05) in 2016 cropping season (Table 3). However, the plots where the residues were burnt under the two cassava varieties had the highest M. invisa density in both cropping seasons, except in 2016 cropping season where TME 419 recorded a higher M. invisa density (7.75/m2) when the residues were incorporated into the soil.

Table 2: Interaction between residue management and weed control methods on *Mimosa invisa* density at 12 weeks after planting (WAP) in 2015 and 2016 copping seasons.

		Cropping seasons and *Mimosa* density/m^2	
Residue management	Weed control methods	2015	2016
No burning	W0	4.30	7.00
	W1	4.80	2.17
	W2	20.50	2.33
	W3	1.30	0.33
Burning	W0	6.30	13.17
	W1	6.20	1.33
	W2	22.80	0.50
	W3	1.30	0.83
LSD $_{(0.05)}$		9.21	2.43

WAP = Weeks after planting, W0 = Weedy check, W1 = Hoe weeding (HW) at 4, 8 and 12 WAP (weeded control), W2 = S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by two hoe weeding at 12 and 16 WAP, W3= S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied as post-emergence at 8 WAP.

Table 3: Interaction between residue management and cassava variety on *Mimosa invisa* density at 10 months after planting (MAP) in 2015 and 2016 cropping seasons.

		Cropping season and *Mimosa* density (No./m^2)	
Residue management	Cassava variety	2015	2016
No burning (B0)	TME 419	6.90	7.75
	NR 8082	8.60	6.58
Burning (B1)	TME 419	7.60	6.50
	NR 8082	10.60	9.42
LSD $_{(0.05)}$		NS	3.76

NS = not significant.

M. invisa emergence pattern as influenced by residue management, cassava variety and weed control methods

Emergence pattern of M. invisa at 4, 8, 12, and 10 MAP as influenced by residue management is shown in Figure 1. The result obtained showed that burning of flora residue as part of land preparation increased M. invisa density in both cropping seasons. A higher density of M. invisa was recorded in 2016 cropping season than in 2015 cropping season at 4WAP. There was very sharp increase in M. invisa density under the two residue management methods from 12 WAP to 10 MAP in both cropping seasons.

The effect of cassava variety on M. invisa emergence pattern at 4, 8, 12 and 10 MAP is presented in Figure 2. In 2015 cropping season, number of Mimosa that emerged under NR 8082 cassava variety was lower at 4 WAP which gradually increased at 8 and 12 WAP, with a peak emergence at 10 MAP. In 2016 cropping season, high number of Mimosa seedlings emergence was observed at 4 WAP which reduced sharply at 12 WAP and also increased drastically at 10 MAP. Field observations showed that M. invisa which had already germinated before the different cassava varieties formed canopy grew above the cassava canopy and thus, were not affected by cassava canopy.

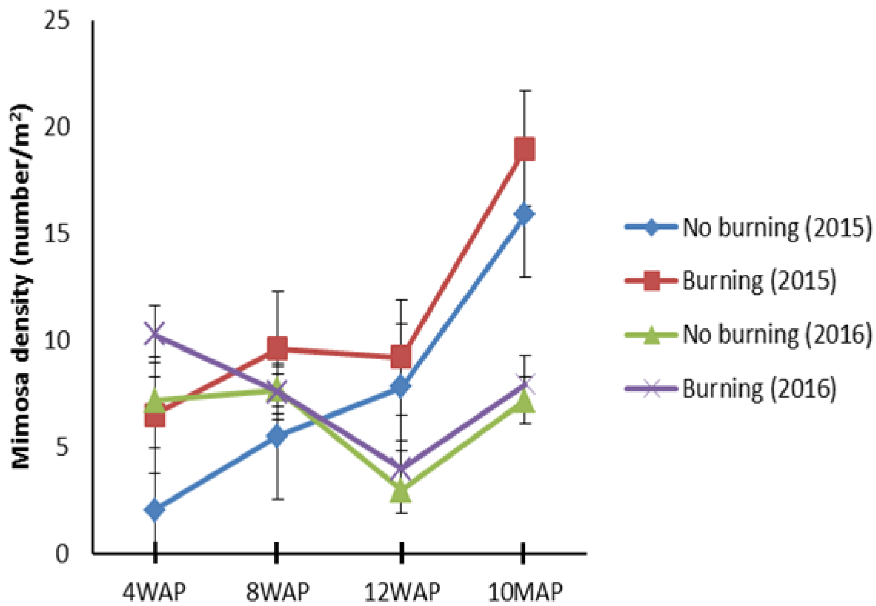

Figure 1: Effect of residue management on *M. invisa* emergence pattern in 2015 and 2016 cropping seasons. Vertical bar represents LSD at 0.05 probability level.

The emergence pattern of M. invisa was significantly influenced by weed control methods (Figure 3). At 4 WAP in 2015 cropping season, the emergence of M. invisa was low among all the weed control methods. At 8 WAP, M. invisa emergence was highest in the plots hoe weeded (W1) followed by W3. At 12 WAP in 2015, M. invisa emergence was highest (11.7/m2) in plots treated with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by two hoe weedings (W2) (5.5/m2) whereas the lowest weed emergence (1.3/m2) occurred in plots treated with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence, followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence (W3). But at 10 MAP, M. invisa emergence was significantly (P≤0.05) higher in plots treated with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by two hoe weeding (W2), and plots hoe weeded (W1) whereas M. invisa emergence was lowest in the weedy check (W0) and

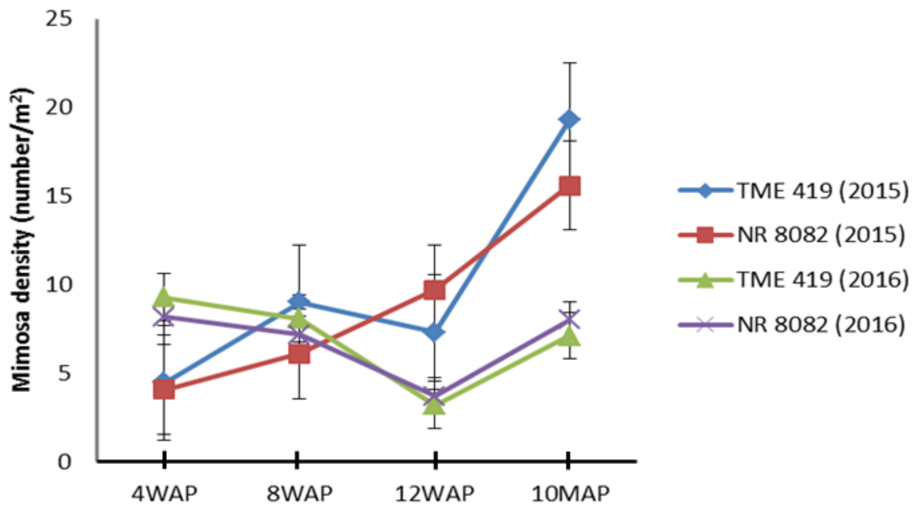

Figure 2: Effect of cassava variety on *M. invisa* emergence pattern in 2015 and 2016 cropping seasons. Vertical bar represents LSD at 0.05 probability level.

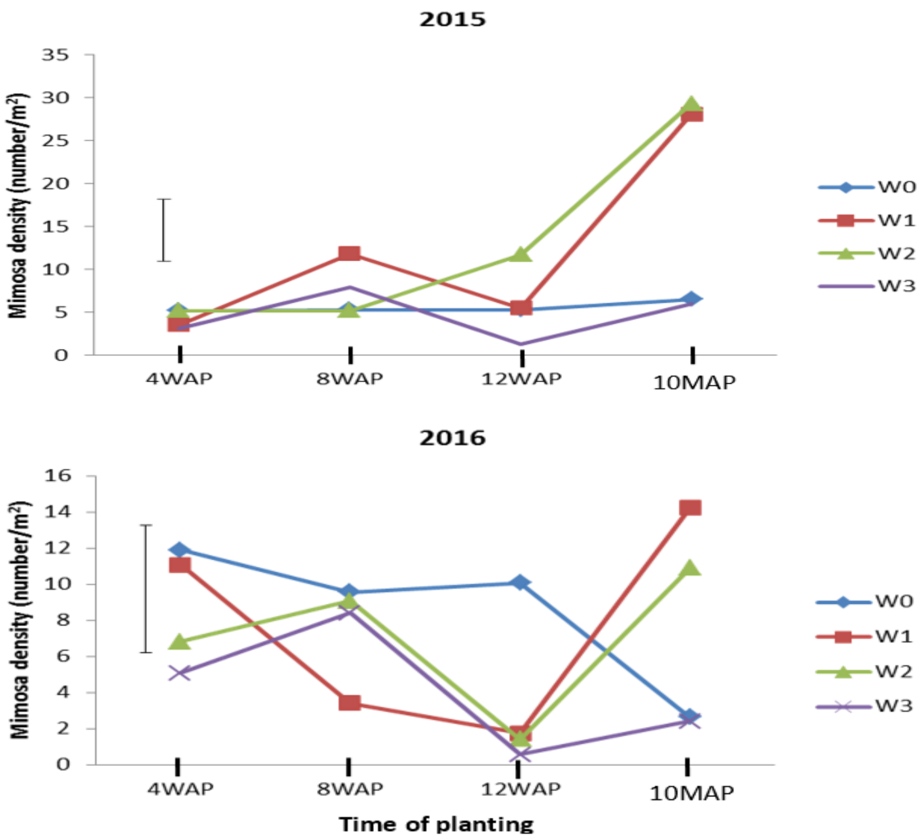

Figure 3: Effect of weed control methods on *M. invisa* emergence pattern in 2015 and 2016 cropping seasons. Vertical bar represents LSD at 0.05 probability level and W0 = Weedy check, W1 = Hoe weeding (HW) at 4, 8 and 12 WAP (weeded control), W2 = S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by two hoe weedings at 12 and 16 WAP, W3 = S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP.

in the plots treated with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence (W3) and the difference was significant ($P \leq 0.05$). But in 2016 cropping season at 4 WAP, M. invisa emergence was higher compared to 4 WAP in 2015 cropping season. There was sharp reduction in M. invisa emergence at 8 WAP to 12 WAP in the plots that received the weed control measures when compared with the weedy check (W0) where the weed emergence increased significantly. At 10 MAP, M. invisa emergence was significantly ($P \leq 0.05$) highest (29.3/m2) in the plots that were weeded (W1) and the plots treated with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by two hoe weedings (W2), compared with the weedy check (W0) and the plots treated with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence

ISSN: 2456-8643

followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence (W3) which had the lowest M. invisa emergence (6.0/m2 and 2.42/m2 respectively) in 2015 and 2016 cropping seasons.

At 12 WAP in both cropping seasons, the emergence pattern of major class of weed species as influenced by weed control methods showed that weed control methods significantly (P≤0.05) affected the weed composition and emergence (Figure 4). The result obtained indicated that all the three weed control methods, significantly (P≤0.05) controlled M. invisa and broadleaves at 12 WAP in both cropping seasons except sedges and broadleaves in 2015 and 2016 cropping seasons respectively. The result also indicated that application of S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence (W3), did not significantly (P≤0.05) control grass weeds when compared with the weedy check (W0) at 12 WAP in both cropping seasons (Fig. 4).

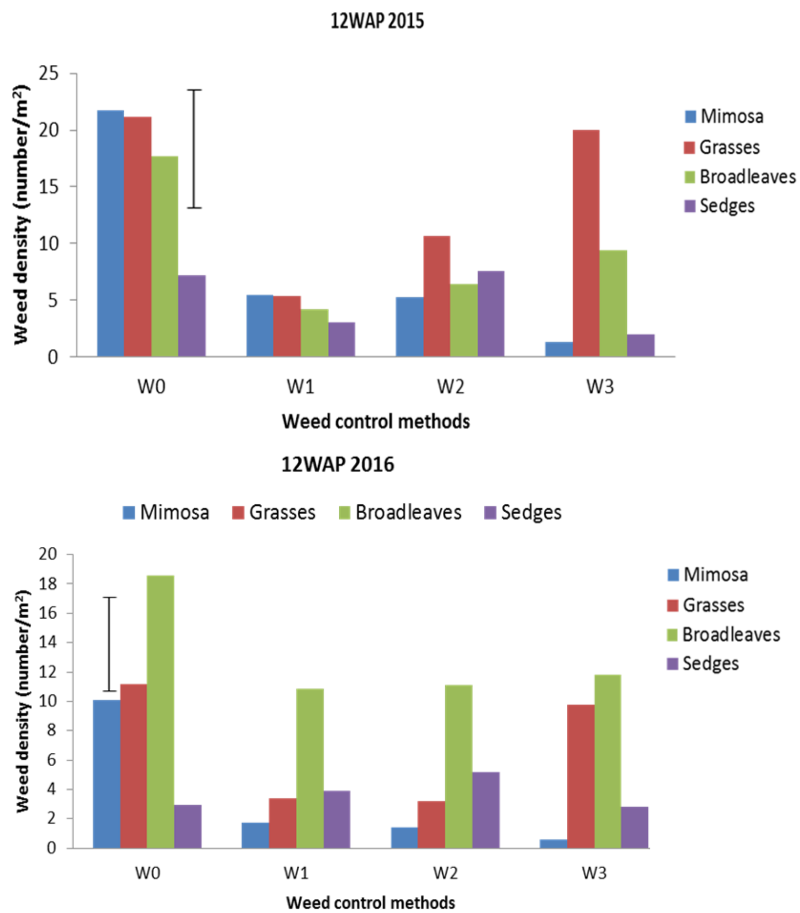

Figure 4: Effect of weed control methods on emergence pattern of class of weeds at 12 WAP in 2015 and 2016 cropping seasons. Vertical bar represents LSD at 0.05 probability level and W0 = Weedy check, W1 = Hoe weeding (HW) at 4, 8 and 12 WAP (weeded control), W2 = S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by two hoe weedings at 12 and 16 WAP, W3 = S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP.

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ISSN: 2456-8643

However, at 10 MAP in both cropping seasons, the population of M. invisa was significantly ($P \leq 0.05$) higher, when compared with the weedy check (W0) (6.5/m2), in plots hoe weeded (W1) (28.1/m2) as well as in plots where S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied as pre-emergence followed by two hoe weeding (W2) (29.3/m2) (Figure 5). The weedy check (W0) (23.3/m2) and plots where S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence (W3) (17.3/m2), recorded significantly ($P \leq 0.05$) higher population of grasses whereas the M. invisa population was significantly ($P \leq 0.05$) reduced by W3 in both cropping seasons when compared with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by two hoe weedings (W2) and the hoe weeded (W1) plots.

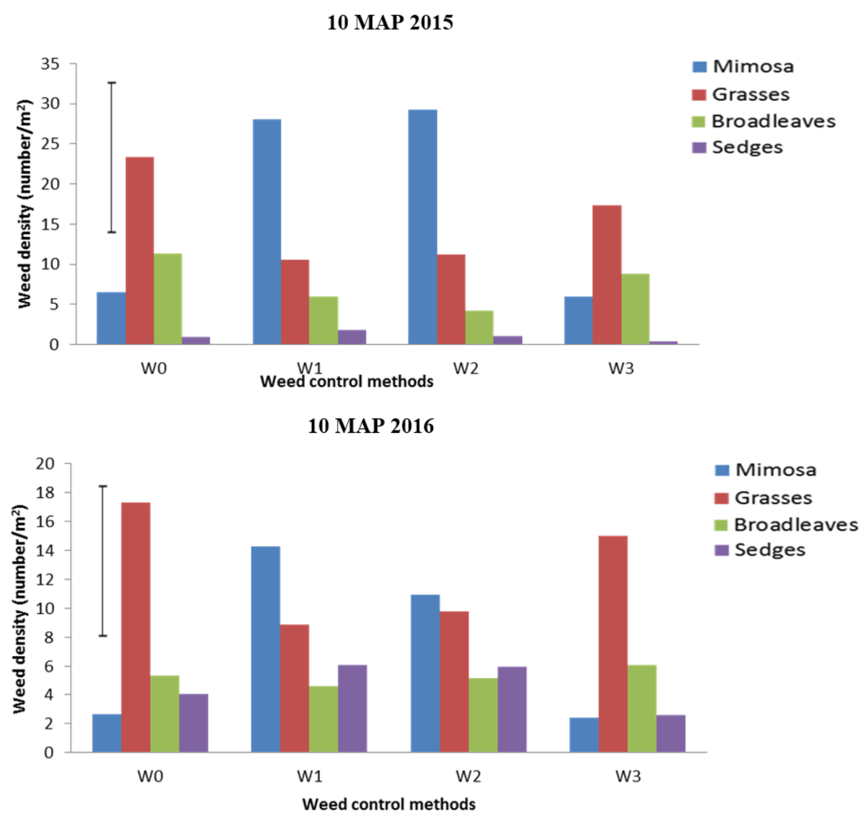

Figure 5: Effect of weed control methods on emergence pattern of class of weeds at 10 MAP in 2015 and 2016 cropping seasons. Vertical bar represents LSD at 0.05 probability level and W0 = Weedy check, W1 = Hoe weeding (HW) at 4, 8 and 12 WAP (weeded control), W2 = S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence

Mimosa pod and seed yield as influenced by residue management, cassava variety and weed control methods

Residue management and cassava variety in both cropping seasons did not have any significant (P≤0.05) effect on the yield of M. invisa pod dry weight, seed dry weight and number of seeds whereas weed control methods significantly (P≤0.05) affected seed yield in both cropping seasons (Table 4). In the weedy checks, M. invisa had significantly (P≤0.05) more pod weight, seed dry weight and number of seeds compared to the plots where different weed control methods were used to control weeds. At 7 months after planting (MAP) (which was the period that the mature pods of M. inivsa have turned brown in colour indicating that the seeds are ready to drop in the weedy plots), there were little or no M. invisa present in the plots that received weed control measures.

The interaction of residue management, cassava variety, and weed control methods on number of M. invisa seeds at 7 MAP in 2016 cropping season is presented in Table 5. The highest number of M. invisa seeds (6141/m2) was recorded in plots where the residues were not burnt under TME 419 in the Weedy checks. Also, the plots where the residues were incorporated into the soil under NR 8082 cassava variety in the Weedy checks had the least number of seeds (1508/m2) On the average, the result showed that plots, where the residue was burnt relatively, had more of M. invisa seedlings irrespective of cassava varieties in both cropping seasons.

3. DISCUSSION

Composition and relative dominance of weeds at the experiment site

Pre-cropping weed sampling conducted at the experimental sites in 2015 and 2016 cropping seasons showed that M. invisa, and four species of Poaceae family dominated the experimental sites. This implied that the M. invisa over the years must have periodically shed thousands of seeds into the soil annually since the site was dominated by the weed and P. maximum. These seeds released by Mimosa mostly during dry seasons have been reported to usually remain dormant or germinate periodically until favourably conditions return or the canopy cover created by P. maximum and other species are removed (Leavold et al., 2007). According to Melifonwu (1994a), M. invisa seeds can remain viable in this dormant state for many years. This adaptive feature enables mimosa to competitively dominate and colonize sites where they are found (APFISN, 2010).

The general weed composition of the experimental site followed a similar trend in weed class composition as reported by Melifonwu (1994b). He noted that broadleaved weed species are usually the most frequent weeds in SouthEast Nigeria. Unamma and Ene (1984) and Toure et al. (2013) have also reported similar trends in weed class composition for different zones in Nigeria and Africa. The weed composition at the experimental site corroborated earlier reports by Zimdahl et al. (1988) and Ekeleme et al. (2004) that the high weed seed population in tropical soils are only composed of few dominant weed species and many other minor species present in low numbers which differentially respond to crop management, fallow period and environmental factors (Mulegeta and Stoltenberg, 1997) which might explain the variation in weed composition and dominance over the years at the experimental site.

Effect of residue management, cassava variety and weed control methods on Mimosa invisa density

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The results obtained and field observations indicated that in both cropping seasons, M. invisa density was significantly ($P \leq 0.05$) higher in plots where hoe weeding was carried out which is what most farmers in Africa depend on to produce cassava (Labrada, 1992; Melifonwu, 1994a, b; Akobundu, 1997). This is an indication that soil surface disturbance(s) caused by hoeing, enhance(s) the emergence of more M. invisa seedlings which supports the findings of Sattin et al. (1997) and Takim and Fadayomi (2013).

The interaction effect of residue management and weed control methods significantly ($P \leq 0.05$) affected the M. invisa density at 12 WAP in the 2016 cropping season which indicated that the plots where the vegetation residue was burnt with no weeding at all recorded the highest number of M. invisa population. This may be attributed to scarification of Mimosa seeds and breaking of dormancy by the heat generated by residue burning. On the other hand, plots where the vegetation residues were incorporated into the soil and treated with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP had the lowest M. invisa population.

Table 4: Effect of residue management, cassava variety and weed control methods on Mimosa invisa pod and seed yields at 7 MAP in 2015 and 2016 cropping seasons.

Treatment	*M. inivsa* dry pod and seed weight (g), and cropping season					
	Mimosa pod dry weight(g)		*Mimosa* seed dry weight(g)		Number of seeds /m^2	
	2015	2016	2015	2016	2015	2016
Residue management (RM)						
No burning (B0)	7.6 (1.7)*	7.2 (1.7)*	5.4 (1.5)*	4.12 (1.4)*	956 (14.5)*	956 (14.0)*
Burning (B1)	13.4 (2.3)	7.5 (1.8)	9.0 (2.0)	4.11 (1.4)	1549 (20.0)	967 (14.5)
LSD $_{(0.05)}$	NS	NS	NS	NS	NS	NS
Cassava Variety (CV)						
TME 419 (V1)	12.8 (2.2)	9.0 (1.9)	8.9 (1.9)	5.20 (1.6)	1497 (18.7)	1211 (16.4)
NR 8082 (V2)	8.2 (1.9)	5.6 (1.5)	5.5 (1.6)	3.03 (1.3)	1007 (15.8)	712 (12.1)
LSD $_{(0.05)}$	NS	NS	NS	NS	NS	NS
Weed Control methods (WC)						
W0	42.0 (6.1)	29.3 (4.9)	28.9 (5.0)	16.45 (3.7)	5008 (66.9)	3847 (59.9)
W1	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0 (0.7)	0 (0.7)
W2	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0 (0.7)	0 (0.7)
W3	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0 (0.7)	0 (0.7)
LSD $_{(0.05)}$	12.13 (0.8)	7.75 (0.9)	8.67 (0.7)	3.96 (0.6)	1501.4 (9.9)	977.2 (11.7)
Interaction						
RM x CV	NS	NS	NS	NS	NS	NS
RM x WC	NS	NS	NS	NS	NS	NS
CV x WC	NS	NS	NS	NS	NS	NS
RM x CV x WC	NS	NS	NS	NS	NS	**

MAP = Months after planting, W0 = Weedy check, W1 = Hoe weeding (HW) at 4, 8 and 12 WAP (weeded control), W2 = S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by two hoe weedings at 12 and 16 WAP, W3 = S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP, ** = Significant at 0.05 % and NS = Not significant. *Values in parenthesis are square root transformed data.

Table 5: Interaction of residue management, cassava variety, and weed control methods on number of Mimosa seeds at 7 months after planting (MAP) in 2015 and 2016 cropping seasons.

Residue management	Cassava variety	Weed control methods	Cropping seasons and number of *Mimosa* seeds	
			2015	2016
No burning	TME 419	W0	5401 (64.7)*	6141 (77.9)*
		W1	0 (0.7)	0 (0.7)
		W2	0 (0.7)	0 (0.7)
		W3	0 (0.7)	0 (0.7)
	NR 8082	W0	2243 (46.9)	1508 (29.6)
		W1	0 (0.7)	0 (0.7)
		W2	0 (0.7)	0 (0.7)
		W3	0 (0.7)	0 (0.7)
Burning	TME 419	W0	6575 (80.8)	3548 (49.0)
		W1	0 (0.7)	0 (0.7)
		W2	0 (0.7)	0 (0.7)
		W3	0 (0.7)	0 (0.7)
	NR 8082	W0	5813 (75.2)	4189 (63.1)
		W1	0 (0.7)	0 (0.7)
		W2	0 (0.7)	0 (0.7)
		W3	0 (0.7)	0 (0.7)
LSD $_{(0.05)}$			NS	1969.9 (24.4)

*Values in parenthesis are square root transformed data, W0 = Weedy check, W1 = Hoe weeding (HW) at 4, 8 and 12 WAP (weeded control), W2 = S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by two hoe weedings at 12 and 16 WAP, W3 = S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP, NS = Not significant.

Similarly, in the 2016 cropping season at 10 MAP, the interaction effect of residue management and cassava variety significantly influenced M. invisa density with residue burning and plots planted with NR 8082 having the highest M. invisa density followed by plots planted with TME 419. This may be an indication that once the M. invisa has germinated, the canopy cover provided by NR8082 was not adequate to cover Mimosa seedling from the sun. Similar observations were reported by Melifonwu et al. (2012) in cassava fields infested within Mimosa in Eastern Nigeria.

Effect of residue management, cassava variety, and weed control methods on Mimosa invisa emergence pattern

Burning of vegetation residue as part of land preparation in this study slightly enhanced M. invisa emergence compared with the unburnt fields in both cropping seasons. In a related study, Aigbokhan et al. (2010) reported that the act of burning positively enhanced the germination ability of M. diplotricha (Syn. M. invisa) seeds which confirmed earlier findings that M. diplotricha seeds germinated more when exposed to simulated heat generated by oven heating (Chauhan and Johnson, 2008). In this study, the heat generated from the vegetation residue burning may not have been adequate to cause significant emergence of M. invisa which supported earlier studies that Mimosa species germinate over a wide range of temperatures (Baskin et al., 1998; Hermansen et al., 2000; Cordeau et al., 2017). In another related study, Silveira and Fernandes (2006) reported that the temperature of 35°C seems to be optimum germination temperature of M. foliolosa seeds a family member of M. invisa.

Effect of cassava variety on M. invisa emergence pattern showed that there was no definite pattern in M. invisa emergence pattern under the different cassava varieties in both cropping seasons. Field observations showed that M. invisa which had already germinated before the different cassava varieties formed canopy found their way up and their growth was not significantly affected by the cassava canopy. This supported the finding of Melifonwu (1994 a, b) who reported that canopy formed by cassava does not prevent Mimosa seeds from germinating provided there are sunlight and moisture. Orozco-Almanza et al. (2003) also reported that there was no significant difference in the emergence between seeds of Mimosa species from four arid zones of Central Mexico under plant canopy when compared to open areas with more intense photosynthetically active radiation.

Mimosa emergence pattern was significantly affected by all the three weed control methods at 12 WAP in 2015 and 2016 cropping seasons especially plots treated with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP indicating that the level of soil disturbance via tillage and hoe weeding over time greatly stimulated the germination and emergence of M. invisa. According to Colbach et al. (2005), soil tillage directly affects weed germination and emergence, and their distribution in the soil.

The emergence pattern of major class of weed species was significantly influenced by the weed control methods in both cropping seasons (Fig. 4). M. inivisa was lowest in plots treated with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP indicating that the treatment was effective in the control of M. invisa but was not effective on grasses especially P. maximum suggesting that no single herbicide is totally effective in controlling a wide range of weed flora in a particular cropping systems as reported by Mienwipia (2013) but can eliminate early crop-weed competition and cut down the time farmers spend on weeding (Gatsi et al., 2001).

The weedy check plots and other plots treated with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP, recorded significantly higher population of grasses whereas the M. invisa population was significantly reduced at 10 MAP in both cropping seasons (Fig. 5). The reduction in the population of M. invisa in the weedy check may be attributed to the fact that majority of the M. invisa in these plots had completed their lifecycle and died during the dry season after shedding its seeds to the soil seed bank whereas in the plots where S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) followed by trifloxysulfuron sodium (8 g/ha) was applied, M. invisa was effectively controlled by the herbicide because the soil surface was not disturbed by hoeing resulted in the reduction of Mimosa density. However, the significant increase recorded in the population of M. invisa in plots hoe weeded at 4, 8 and 12 WAP and in plots where S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by two hoe weedings at 12 and 16 WAP could be attributed to the effect of hoe weeding which removed most weeds before the dry season thereby creating favourable conditions for M. invisa to quickly recolonize the space as soon as the rains started before the other weeds could emerge (Derakhshan and Gherekhloo, 2013). According to Cordeau et al. (2015), tillage and hoe weeding are one of the main drivers of weed community assembly. This confirmed the earlier report by Froud-Williams et al. (1984) who reported that tillage operations stimulate weed seeds to germinate. Therefore, the soil disturbances via hoe weeding and tillage in these experimental plots may have stimulated and enhanced M. invisa germination even with minimal soil moisture (Pugnaire et al., 1996). Some studies have shown that this attribute confers M. invisa the ability to easily colonize ecological environment where they are found (Derakhshan and Gherekhloo, 2013; Mesquita et al., 2015).

Effect of residue management, cassava variety, and weed control methods on Mimosa pod and seed yield

Residue management and cassava variety did not significantly ($P \leq 0.05$) affect M. invisa pod and seed dry weight, and the number of seeds (Table 4). However, weed control methods significantly ($P \leq 0.05$) affected M. invisa number of seeds, pod and seed dry weights. The result showed that Mimosa in the weedy check had significantly ($P \leq 0.05$) higher number of seeds, pod, and seed dry weights compared to the other weed control methods. Field observation showed that at 5 - 6 months after planting (MAP), M. inivsa in the weedy checks had already produced pods whereas very few M. invisa in plots that received other treatments were at their seedling tender stage. This indicated that any form of weed control method used in cassava fields up to 8 weeks after planting could delay M. invisa germination and flowering up to 10 MAP, as observed in this study.

ISSN: 2456-8643

The highest number of M. invisa seed obtained in plots where the vegetation residue was incorporated into soil under TME 419 in the weedy checks, could be attributed to the inability of TME 419 cassava variety to create enough ground cover thereby allowing much solar radiation to reach the surface of the soil thus favouring M. invisa growth and development. While the least number of M. invisa seeds (1508) obtained in plots where the vegetation residue was incorporated into the soil under NR 8082 cassava variety in the weedy checks could be attributed to the effect of ground cover created by both NR 8082 cassava variety and other weed species thereby limiting the amount of light radiation reaching the soil surface which affected the germination, emergence and growth of M. invisa adversely (Melifonwu, 1994b; Ekhator et al., 2008; Aigbokhan et al., 2010).

Generally, burning of vegetation residue in this study appears to generate heat that favoured the germination of M. invisa seeds on the soil surface which explained why the plots where the vegetation residue was burnt relatively recorded number of M. invisa in both cassava varieties suggesting that the heat from the fire may have scarified the weed seeds thereby inducing more germination of M. invisa seeds in the soil seed bank. This corroborated the report of Gashaw and Michelsen (2002), Sheley et al. (2007) and Aigbokhan et al. (2010) on the effect of burning on Mimosa seed germination.

4. CONCLUSION

The results obtained indicated that the effect of different vegetation residue management practices (burning and no burning) on the emergence pattern and density of M. invisa in cassava farms were not significant ($P \leq 0.05$) from each other. However, burning of vegetation residue in-situ caused rapid germination of M. invisa before tillage operations compared to when the residues were incorporated into the soil.

M. invisa density was excellently controlled by all the three weed control methods used in this study up to 10 months after planting. S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP, significantly ($P \leq 0.05$) recorded higher densities of grasses which implied that the herbicide did not effectively and efficiently control the grass weeds especially P. maximum. At 10 MAP in both cropping seasons, significantly ($P \leq 0.05$) higher densities of M. invisa were recorded in plots hoe weeded at 4, 8 and 12 weeks after planting (WAP) and plots treated with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence and hoe weeded at 12 and 16 WAP indicating that a lot of M. invisa seeds must have been produced and deposited into the soil through seed rain before the beginning of the following cropping season. This suggests that soil disturbance(s) through tillage and weeding encouraged the emergence and germination of M. invisa before and after harvest.

ISSN: 2456-8643

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