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Effect Of Crop Spacing And Weed Control Methods On The Emergence Pattern And Density Of Mimosa Invisa Mart. In Cassava Production Systems.

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Abstract
A field trial was conducted at the National Root Crop Research Institute, Umudike during 2015 and 2016 cropping seasons to evaluate the impact of crop spacing and weed control methods on the emergence pattern and density of Mimosa in cassava fields. The study site was predominately infested with M. invisa Mart. The trial was laid out in split-split plot in randomized complete block design with three replications. The main plot treatments were three crop spacing; 1 m × 0.6 m, 1 m × 0.8 m, and 1 m x 1 m. The sub-plot treatments were two cassava varieties of contrasting morphology (TME 419 and NR 8082) while the sub-sub-plot treatments were 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 checks). Data collected were subjected to analysis of variance and means separated using least significant difference. The results obtained showed that reduction in plant spacing from 1m x 1m to 1 m x 0.6 m significantly ($P \leq 0.05$) reduced weed density, while plots treated with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by trifloxysulfuron sodium (8 g/ha) effectively controlled M. invisa in the cassava varieties of contrasting morphotypes.
Keywords: *Mimosa invisa, Crop spacing, Cassava weed management.*

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I. Introduction

Cassava (*Manihot esculenta* Crantz), which is a root-tuber crop, belong to the family: Euphorbiaceae. It is mainly grown for its edible roots which are rich in starch (Lokko *et al*., 2007; Howeler *et al.*, 2013). Globally, after wheat (*Triticum aestivum*), rice (*Oryza sativa*), maize (*Zea mays*), potato (*Solanum tuberosum*), and barley (*Hordeum vulgare*), it is regarded as the sixth most important crop (Lebot, 2009; Prochnik *et al*., 2012). In the tropics, it is ranked third most important source of calories after rice and maize (Okogbenin *et al*., 2013). In Africa, about 88 percent of its production is consumed by humans and the remainder used for animal feed mixtures and production of starch-based products by industries (Plucknett *et al*., 2000; Adelekan, 2010). In Nigeria, it is regarded as one of the major source of income for farmers. In 2016, its production level was estimated at 59,565,916 metric tonnes per hectare (t/ha) in Nigeria alone (FAO, 2018). Due to its initial early slow growth, it is faced with numerous constraints in the tropics which has made it difficult for the crop to reach its full potential (Fermont, 2009; Jarvis *et al*., 2012). According to literatures, weeds, pests and diseases are reported to be the most important constraint to cassava production (Hillocks, 2002; Jarvis *et al*., 2012). Among the three major factors listed, weed interference is the most critical to the growth and development of the crop because of its initial slow growth at the early stage; thus it usually suffer serious yield loss if not adequately weeded (Tongglum *et al.*, 1992; Howeler *et al*., 2013).

In Nigeria, most farmers especially women and children spend more time on weeding than on any other aspect of crop production (Pypers *et al.*, 2011) and most times sustain serious injuries from noxious weeds like *Mimosa invisa*. The giant sensitive plant (*Mimosa invisa* Mart.) is also known to cause serious production constraint and reduction in the yield of cassava (Alabi *et al.*, 2001; 2004; Gbadamosi, 2015). The weed is a perennial, thorny, and scrambly leguminous weed which produces large quantities of seeds that persistent in the soil seed bank (Barneby, 1991; Ekhator *et al.*, 2013). It forms large swathes of dense prickly usually difficult-to-remove stands that can take over native vegetation (Burgers and William, 2000; MacLean *et al*., 2003). It has all-year-round periodic dormancy breakage, germination and seedling emergence pattern under favourable moist soil conditions (Parsons and Cuthbertson, 1992). The periodic seed dormancy breakage and seedling emergence pattern of the weed makes long-term effective weed control measures on a long-cycle crop like cassava very difficult and has become a major problematic weed of economic importance in most cassava fields in Nigeria (Melifonwu, 1994 b; Lebot, 2009).

Several weed control methods such as hand weeding, mechanical weeding, use of herbicides, cover cropping, and mixed cropping, burning of slashed vegetation residue, mulching with plant residues, etc. individually and in combinations, have been used to control this weed (Chikoye *et al.*, 1999; Melifonwu *et al.* 2000; Ekeleme, 2013; Dan *et al*., 2016). Yet, the weed has kept multiplying and colonizing more cassava fields in Nigeria to the extent that many farmers tend to avoid fertile arable lands suitable for cassava production because of *M. invisa* infestation (Ekhator *et al.*, 2008; Aigbokhan *et al.* 2010). As weed control methods attempt to limit the deleterious effect of weeds growing with crop plants, understanding the biology and growth habits of weed species, as well as the crop plants, is critical to formulating effective weed management on farms (Adigun, 1984). 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 hoe weeding) could prove satisfactory management of the weed in both large- and small-holder cassava farms (Jayasree, 2005; Melifonwu *et al.*, 2012). According to Singh and Singh (2006), proper reduction in plant spacing leads to an increase in crop density which directly reduces weed density, abundance. The level of canopy formed by crops, as a result of plant spacing, influences weed composition and seed germination (Aluko *et al.*, 2015). The authors also reported that the level of canopy formed by crops are influenced by plant spacing and plant architecture/morphology. Thus, crop microclimate is generated under a dense crop canopy, which directly influences weed germination and emergence, their survival, growth, development and composition which in turn affect the weed flora type and amount of weed seeds in the soil seed bank (Aluko *et al.*, 2015). Previous studies on the control of this weed in Nigeria appear to have focused on short-term control in cassava fields alone; neglecting the long-term control methods. Therefore, there is need to study the effect of selected crop spacing, weed control methods, and cassava variety of different morphology on *M. invisa* in order to underscore the dynamics of the weed in response to different weed control methods in other to develop weed management methods for both short and long-term effective control of *Mimosa* in cassava production systems.

II. Materials And Methods

Study location: The trial was conducted at the National Root Crops Research Institute, Umudike, Research Farm, 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 area has bimodal rainfall pattern. It 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 while, 2016 had 2166.8 mm.

Land preparation, planting materials, planting, and field maintenance: The site for this experiment was cleared (slashed), ploughed and harrowed before making ridges 1 m apart.

The stems of two cassava varieties; a profuse branching variety (NR 8082) and sparse branching variety (TME 419) were sourced from the NRCRI, Umudike. Cassava stem cuttings of 23 cm long were planted at different spacing namely: 1 m x 1 m, 1 m x 0.8 m and 1 m x 0.6 m (according to treatments). The stem cuttings were planted at about 45^0 angles to the horizontal along the crests of the ridges. In the first year (2015), planting was done in June while in the second year (2016), planting was done in the month of May.

Weed control was done according to treatment. Hoe weeding was carried out using locally fabricated small hand hoe while the 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 designed in randomized complete block design (RCBD) and replicated three times.

Treatments: The main plot consisted of three crop spacing [1m x 0.6m, 1m x 0.8m, and 1m x 1m]. 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 – (Hoe weeding at 4+8+12 WAP), (S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence, followed by two 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 Collection: The following parameters were collected from the experiment;

Weed density and biomass: A 0.5 m^2 quadrat was diagonally placed in two areas in each plot at 4, 8, 12, 14 and 16 WAP before hoe and chemical weeding was done (Zimdahl *et al*., 1988). The number of *M. invisa* and other weeds that fell within each quadrat was counted according to species and recorded. The weed samples were then carefully uprooted, oven-dried to a constant weight at a temperature of 80 ^{0}C and weighed using a precision standard weighing balance (ATOM-120).

***Mimosa* pod and seed yield (Collected at 7 MAP):** *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 checks. A quadrat of 0.5 m^2 was randomly placed in two areas in each plot at 7 MAP 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.

III. Results

Effect of spacing, cassava variety, and weed control methods on *Mimosa invisa* density

The interaction between plant spacing and cassava variety on *M. invisa* density at 12 WAP in 2015 and 2016 is presented in Table 1. The highest *M. invisa* density was obtained in plots planted with NR 8082 at plant spacing of 1 m x 0.8 m followed TME 419 planted at 1 m x 1 m spacing in both cropping seasons. The lowest *M. invisa* density was recorded in plots with TME 419 with plant spacing of 1m x 0.8 m followed by TME 419 planted at 1m x 0.6 m spacing.

At 10 MAP in 2015 cropping season (Table 2) interaction of cassava variety and weed control methods showed significant ($P \leq 0.05$) influence on *M. invisa* density. S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence with two hoe weedings (W2) in TME419 plots had the highest *M. invisa* (31.78/m^2) density followed by hoe weeded plots (W1) that recorded 28.89/m^2. The *M. inivisa* density was relatively lower in 2016 cropping season.

Effect of spacing and weed control methods on *Mimosa invisa* emergence Pattern

The effect of plant spacing on *M. invisa* emergence in 2015 and 2016 cropping seasons is presented in Figure 1. The result obtained in both cropping seasons showed that plant spacing did not significantly ($P \leq 0.05$) affect *M. invisa* emergence. In the 2015 cropping season, the number of emerged *M. invisa* plants showed a continuous increase from 4 WAP to 12 WAP except at spacing of 1m x 0.6m where it decreased after 8 WAP and sharply increased from 12 WAP to 10 MAP for all the plant spacings. But in 2016 Cropping season, there was a sharp increase in the number of emerged M. invisa from 4 WAP to 8 WAP and dropped sharply at 12 WAP before sudden increase at 10 MAP. The effect of cassava variety on M. invisa emergence is presented in Figure 2, M. invisa emergence in 2015 cropping season was relatively higher under TME 419 compared to NR 8082 especially at 8 WAP and 10 MAP whereas the reverse was the case in 2016 cropping season where it sharply decreased at 12 WAP and increased at 10

Table 1: Plant spacing and cassava variety interaction effect on *Mimosa invisa* density at 12 WAP in the 2015 and 2016 cropping seasons.

		Cropping season and *Mimosa* density (no./m^2)	
Plant spacing	Cassava variety	2015	2016
1m x 0.6m	TME 419	5.25	2.67
	NR 8082	3.67	2.92
1m x 0.8m	TME 419	5.50	2.58
	NR 8082	8.25	4.25
1m x 1m	TME 419	7.08	3.92
	NR 8082	4.75	3.42
LSD $_{(0.05)}$		NS	1.72
NS = Not significant.			

Table 2: Cassava variety and weed control method interaction effect on *Mimosa* density at 10 months after planting (MAP) in the 2015 and 2016 cropping season.

			Cropping seasons and *Mimosa* density (no./m^2)		
Cassava variety	Weed control methods		2015		2016
TME 419	W0		3.78		1.00
	W1		28.89		3.89
	W2		31.78		8.56
	W3		10.44		2.89
NR 8082	W0		5.00		1.22
	W1		14.22		9.00
	W2		25.22		10.89
	W3		7.22		5.33
LSD $_{(0.05)}$			6.31		4.30

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.

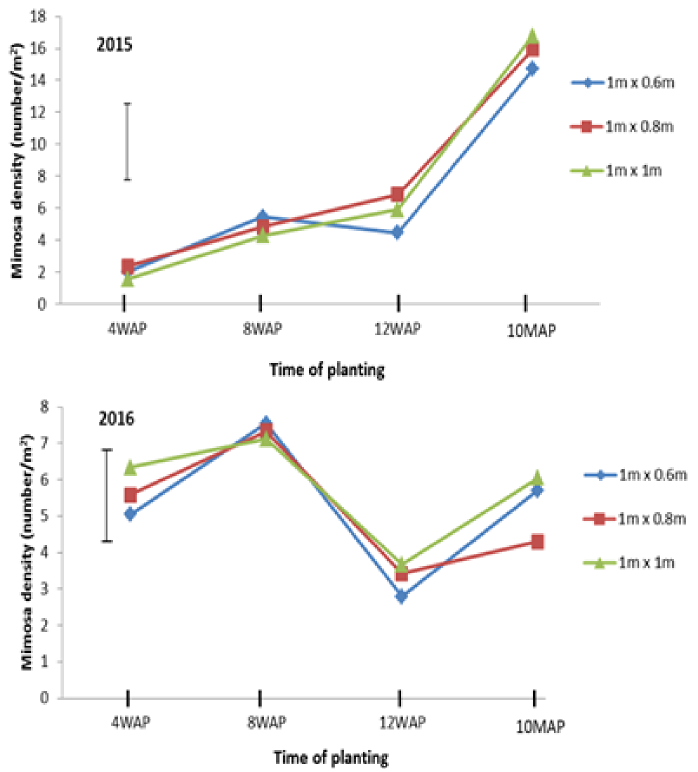

Figure 1: Effect of plant spacing on *M. invisa* emergence pattern in 2015 and 2016 cropping seasons. Vertical bar represents LSD at 0.05 probability level.

MAP. The result indicated that higher *M. inivsa* emergence was observed under NR 8082 compared to TME 419 in this cropping season as against 2015 cropping season where the emergence pattern was more under TME 419.

M. invisa emergence as influenced by weed control methods is shown in Figure 3. Weed control methods had no significant effect on *M. invisa* population at 4 and 8 WAP in 2015 cropping season but was significantly higher (P≤0.05) at 12 WAP with W2 method of weed control and 10 MAP with W2 and W1 control methods but W0 at 8 and 12 WAP in 2016 cropping seasons was significantly (P≤0.05) higher than the other weed control methods. *Mimosa* seedling emergence 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 (W3) at 12 WAP in both cropping seasons. At 10 MAP more *Mimosa* seedling emergence was recorded in hoe weeded plots (W1) at 4, 8 and 12 WAP, and from plots treated with S-metolachlor (1160 g/ha)

+ atrazine (1480 g/ha) applied pre-emergence with two hoe weedings (W2) which decreased and increased respectively at 10 MAP in both cropping seasons compared to the other treatments.

At 10 MAP in both cropping seasons, the result obtained indicated that the population of *M. invisa* was significantly (P≤0.05) higher in plots hoe weeded (W1), and in plots where S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence with two hoe weedings (W2) was used to control weeds (Figure 4). The weedy check 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) were used to control weeds, had significantly (P≤0.05) lower population of *M. invisa* at 10 MAP compared with other treatments in both cropping seasons. However, in the 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) was used to control weeds, *M. invisa* was effectively controlled compared with other weed control methods.

Effect of spacing and weed control methods on *Mimosa* pod and seed yield

The effects of plant spacing, cassava variety, and weed control methods on *M. invisa* pod and seed production at 7 MAP in 2015 and 2016 cropping seasons are presented in Table 3. Cassava varieties did not have any significant (P≤0.05) effect on *M. invisa* pod weight, seed

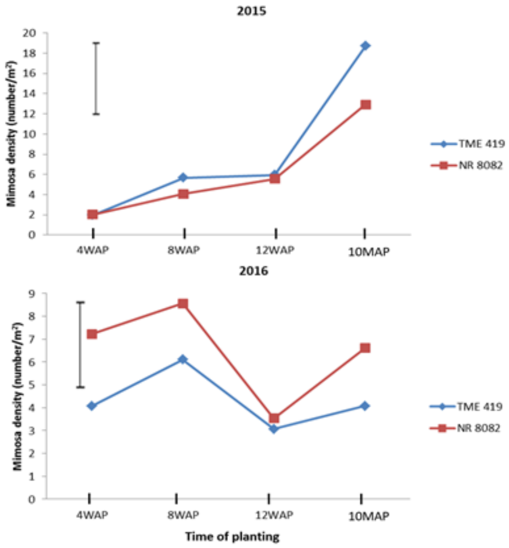

Figure 2: Effect of cassava variety on *M. invisa* emergence pattern in 2015 and 2016 cropping season. Vertical bar represents LSD at 0.05 probability level.

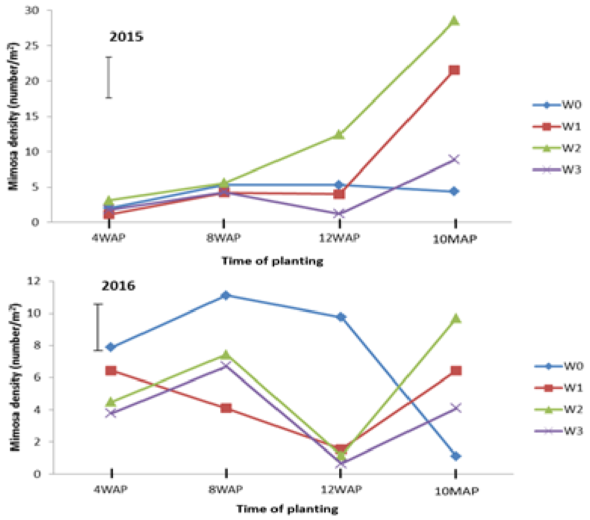

Figure 3: Effect of weed control methods on *M. invisa* emergence pattern in 2015 and 2016 cropping seasons. Vertical bar represents LSD at 0.05 probability level. W0 = Weedy check, W1 = Hoe weeding (HW) at 4, 8 and 12 WAP (weeded control), W2 = S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied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

weight as well as the number of *Mimosa* seeds in both cropping seasons. Plant spacing significantly (P≤0.05) affected the pod weight in 2015 cropping season whereas *M. invisa* seed weight and number were not significant (P≤0.05) in both cropping seasons. The weed control methods significantly (P≤0.05) affected *M. invisa* pod weight, seed weight and number of seeds in both cropping seasons at 7 MAP in both cropping seasons when compared with the weedy checks where all the plots recorded significant (P≤0.05) pods, weight of seeds and number of seeds under different weed control methods with little or no presence of *M. invisa* seedlings in them.

At 7 MAP in 2015 cropping season, the interaction between cassava variety and weed control methods significantly affected *M. invisa* pod dry weight (Table 4). *M. invisa* in the weedy checks where TME419 was planted had substantially higher number of pod dry weight. Similar trends were observed under seed dry weight and number of seeds (Table 4).

The interaction among plant spacing, cassava variety and weed control methods on number of *M. invisa* seeds at 7 MAP in 2015 cropping season is presented in Table 5. TME 419 and NR 8082 at 1m x 0.8 m plant spacing in 2015 and 2016 cropping seasons respectively in the weedy checks produced the highest number of mimosa seeds whereas the lowest number of seeds was obtained in plots planted to NR 8082 at 1 m x 0.8 m and 1 m x 0.6 m spacing in 2015 and 2016 cropping seasons respectively. There was no *Mimosa* seed recorded in plots with the cassava varieties at different plant spacing under the different weed control methods in both cropping seasons.

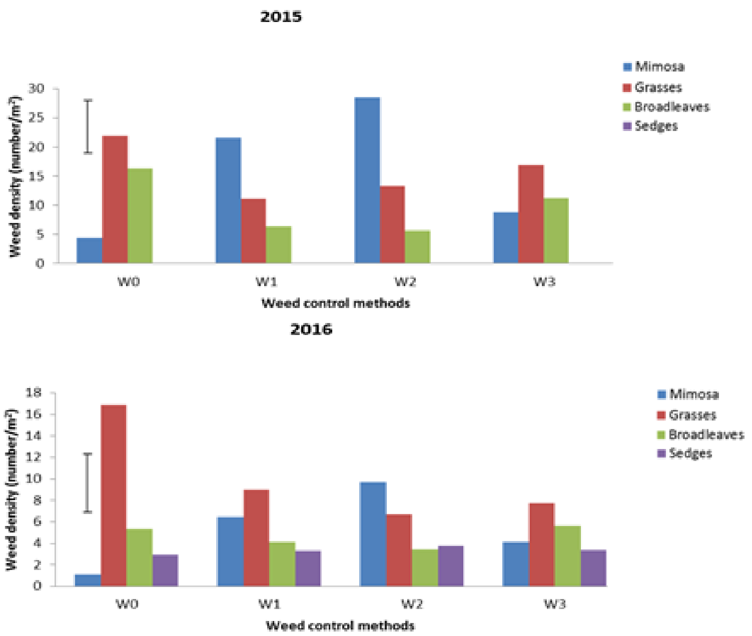

Figure 4: Effect of weed control methods on emergence pattern of class of weeds at 10 MAP in 2015 and 2016 cropping seasons. Vertical bar represents LSD at 0.05 probability level. W0 = Weedy check, W1 = Hoe weeding (HW) at 4, 8 and 12 WAP (weeded control), W2 = S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied as pre-emergence + hoe weedings at 12 and 16 WAP, W3 = S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence + trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP.

IV. Discussion

Effect of plant spacing and weed control methods on *M. invisa* density

The interaction effect of plant spacing, cassava variety, and weed control methods on *M. invisa* density (Table 1 and 2) showed that lower *M. invisa* density was recorded in plots that had less soil surface disturbance caused by hoe weeding irrespective of the plant spacing and cassava variety. This could be an indication that level of soil surface disturbance through tillage practices and hoe weeding under different plant spacings and cassava variety, encouraged *M. invisa* emergence and density.

Effect of plant spacing and weed control methods on *Mimosa invisa* emergence pattern

The *M. inivsa* emergence was not significantly (P≤0.05) affected by the plant spacing (Fig. 1), cassava variety (Fig. 2) and weed control methods (Fig. 3) indicating that even at closer cassava spacing irrespective of the cassava variety, *M. invisa* can still thrive. This could also be attributed to the quick germination and emergence of M. invisa compared to initial slow growth of cassava thus making M. invisa a better competitor. This supported the findings of Melifonwu (1994b) who reported that once the M. invisa had germinated and emerged, the canopy formed by cassava variety or canopy developed as a result of cassava spacing does not suppress M. invisa growth and development since it tends to climb the cassava stands and creates swaths at the top to suppress the cassava and other weeds.

Table 3: Effect of plant spacing, cassava variety, and weed control methods on *Mimosa* number of seeds and dry weight and pod dry weight at 7 MAP in 2015 and 2016 cropping seasons at Umudike.

	Mimosa pod dry weight (g)		Mimosa seed dry weight (g)		Number of seeds /m^2	
Treatment	2015	2016	2015	2016	2015	2016
Plant Spacing (PS)						
1m x 0.6 m (S1)	7.26 (1.8)*	4.67 (1.5)*	5.26 (1.6)*	2.78 (1.3)*	959 (15.5)*	645 (17.3)*
1m x 0.8 m (S2)	5.35 (1.5)	6.29 (1.7)	3.74 (1.4)	3.64 (1.4)	827 (13.4)	852 (14.8)
1m x 1 m (S3)	8.50 (1.9)	6.92 (1.8)	6.14 (1.7)	3.80 (1.4)	879 (14.8)	899 (11.5)
LSD $_{(0.05)}$	2.325 (0.1)	NS	NS	NS	NS	NS
Cassava Variety (CV)						
TME 419 (V1)	8.91 (1.9)	5.80 (1.7)	6.32 (1.7)	3.38 (1.4)	1137 (17.0)	796 (15.7)
NR 8082 (V2)	5.16 (1.5)	6.12 (1.7)	3.77 (1.4)	3.43 (1.4)	640 (1.7)	801 (13.4)
LSD $_{(0.05)}$	NS	NS	NS	NS	NS	NS
Weed Control methods (WC)						
W0	28.14 (5.0)	23.83 (4.7)	20.19 (4.2)	13.62 (3.5)	3554 (56.0)	3194 (18.5)
W1	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0 (0.7)	0 (0.7)
W2	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0 (0.7)	0 (0.7)
W3	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0 (0.7)	0 (0.7)
LSD $_{(0.05)}$	5.246 (0.5)	3.440 (0.3)	3.820 (0.4)	2.313 (0.3)	608.8 (6.1)	529.6 (17.4)
Interaction						
PS x CV	NS	NS	NS	NS	NS	NS
PS x WC	NS	NS	NS	NS	NS	NS
CV x WC	**	NS	**	NS	**	NS
PS x CV x WC	NS	NS	NS	NS	**	NS

*Values in parenthesis are square root (√x + 0.05) transformed values, W0 = Weedy check, W1 = Hoe weeding 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 as pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP, ** = Significant at 0.05 % and NS = Not significant.

Table 4: Interaction effect of cassava variety and weed control methods on *Mimosa* pod dry weight, seed dry weight and number of seeds at 7 months after planting (MAP) in 2015 and 2016 cropping season at Umudike.

Cassava variety	Weed control methods	*Mimosa* pod dry weight (g)		*Mimosa* seed dry weight (g)		Number of seeds of *Mimosa* /m^2	
		2015	2016	2015	2016	2015	2016
TME 419	W0	35.63 (5.8)*	23.20 (5.8)*	25.28 (4.8)*	13.52 (3.56)*	4547 (65.8)*	3183 (27.8)*
	W1	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)
	W2	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)
	W3	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)
NR 8082	W0	20.66 (4.2)	24.47 (4.2)	15.10 (3.6)	13.72 (3.59)	2560 (46.3)	3205 (9.2)
	W1	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)
	W2	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)
	W3	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)	0.00 (0.7)
LSD $_{(0.05)}$		7.46 (0.7)	4.66 (0.7)	5.42 (0.6)	3.08 (0.45)	920.1 (4.1)	NS

*Values in parenthesis are square root (√x + 0.05) transformed values, W0 = Weedy check, W1 = Hoe weeding 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 as pre-emergence followed by trifloxysulfuron sodium (8 g/ha) applied post-emergence at 8 WAP, NS = Not significant.

The different results recorded 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 and S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by two hoe weeding at 12 and 16 WAP indicated that weed control methods that involve any form of soil disturbance through hoe weeding stimulated the germination and emergence of *M. invisa*. This observation supported the findings of Norgrove and Hauser (2015) and Cordeau *et al.* (2015) who reported that tillage (as well as light-tillage in the form of hoe weeding) is one of the main drivers of weed community and stimulates the germination of weed seeds.

At 10 MAP in both cropping seasons, the population of *M. invisa* was significantly (P≤0.05) higher in plots hoe weeded at 4, 8 and 12 WAP, and in plots treated with S-metolachlor (1160 g/ha) + atrazine (1480 g/ha) applied pre-emergence followed by two hoe weeding at 12 and 16 WAP (Fig. 4). On the other hand, the weedy check and 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 had significantly lower (P≤0.05) population of *M. invisa*. The reduction in the population of *M. invisa* in the weedy check alone could be attributed to the fact that majority of the *M. invisa* in these plots had died during the dry season after shedding its seeds into the soil seed bank. However, *M. invisa* was effectively controlled 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, suggesting that the canopy created by the cassava cover and plant spacing as well as the ground cover created by few grasses during the dry season, contributed to the reduction in *M. invisa* population. Furthermore, the significant (P≤0.05) increase recorded in the population of *M. invisa* in plots hoe weeded at 4, 8 and 12 WAP and in plots treated with 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 left the soil surface bare during the dry season thereby creating favourable conditions for *M. invisa* to quickly recolonize the space at the onset of the rains before the other weeds could emerge (Derakhshan and Gherekhloo, 2013). Cordeau *et al.* (2015) reported that tillage and hoe weeding are one of the main drivers of weed community assembly which confirmed earlier report by Froud-Williams *et al.* (1984) that tillage operations stimulate weed seeds to germinate. The observation in this study, indicated that the soil disturbances via hoe weeding and tillage in plots with these treatments stimulated *M. invisa* germination even under cassava of different morpho-types and plant spacing (Pugnaire *et al.*, 1996) confirming the invasiveness of *M. invisa* in ecological environments where they are found (Derakhshan and Gherekhloo, 2013; Mesquita *et al.*, 2015).

Effect of plant spacing and weed control methods on *Mimosa* pod and seed yields

The weedy checks were the only plots where *M. invisa* produced matured pods at 7 months after planting (MAP) in both cropping seasons. The plots under different weed control methods had little or no presence of *M. invisa* in them because they had already been hoe weeded two to three times.

At 7 MAP in 2015 copping season, the interaction of cassava variety and weed control methods on *M. invisa* pod dry weight showed that *M. invisa* in the weedy checks under TME 419 recorded significantly ($P \leq 0.05$) higher number of pod dry weight, seed dry weight, and number of seeds (Table 4). This may be attributed to the lack of sufficient ground cover by the TME 419 cassava variety at the early stage of the cassava development which encouraged more *M. invisa* germination due to good quantity of solar radiation reaching the soil surface. In addition, the result of the interaction of plant spacing, cassava variety and weed control methods on number of *M. invisa* seeds at 7 MAP in 2015 cropping season (Table 5), indicated that TME 419 cassava variety under 1 m x 0.8 m plant spacing in the weedy checks recorded the highest number of seeds (5269 seeds/m^2) whereas the lowest number of seeds (1346 seeds/m^2) was obtained from NR 8082 cassava variety under 1 m x 0.8 m spacing. This result supported the findings of Parson and Cuthbertson (1992) who reported that *M. invisa* is a prolific seed producer with seeds ranging from 8000 to 12, 000 seeds/m^2 per plant. Forcella *et al.* (2000) reported that the periodicity of weed emergence is primarily controlled by biological characteristics of the weed species like seed dormancy, field management practices such as weed control methods and environmental conditions which may be responsible for the significant variation in the *M. invisa* pod dry weight, seed dry weight and the number of *Mimosa* seeds observed in both cropping seasons.

V. Conclusion

The findings in this study also revealed that reduction in plant spacing from 1 m x 1 m to 1 m x 0.6 m reduced weed density, enhanced ground cover to reduce the level of weed emergence in both cropping seasons. The combination of proper weed control methods, cassava variety and reduced plant spacing of 1 m x 0.6 m in this study, gave excellent weed control in both 2015 and 2016 cropping seasons. Plant spacing of 1m x 0.6 m and 1m x 0.8 m should be adopted for optimum canopy coverage resulting to weed suppression in cassava production in the study area. The application of pre-emergence herbicide (1160 g/ha S-metolachlor + 1480 g/ha atrazine) followed by hoe weeding at 12 and 16 WAP is recommended for effective suppression of weed growth and stimulation of high *M. invisa* emergence after harvest.

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