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RESEARCH ARTICLE

EVALUATION OF EMERGENCE AND SEEDLING GROWTH OF MIMOSA DIPLOTRICHA UNDER THE INFLUENCE OF RICE HUSK AND PALM KERNEL SHELL MULCH AND ITS INTERACTION WITH GARDEN EGG PLANT

Akalazu Jacinta*, Onu Martin Onu and Ohazurike Nathaniel Chukwu

Department of Plant Science and Biotechnology, Imo State University, Owerri, Nigeria

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Corresponding Author:* **Akalazu Jacinta

ABSTRACT

The proliferation of the invasive *Mimosa diplotricha* weed species on agricultural lands within humid tropical agroecosystems necessitates the implementation of sustainable management measures. The present study investigated the impact of varying quantities of rice husk(RH) and palm kernel shell(PKS) mulch (0, 1.5, 3.0, and 4.5 tonnes per hectare) as well as an unmulched control on the emergence and growth of *Mimosa diplotricha* weed in a garden egg farm. The quantification of the impact of two different mulches on the performance and yield of garden egg was also conducted. A randomized block design was implemented, consisting of three replicates conducted over the course of two growing seasons. This study presents the initial evidence of the efficacy of palm kernel shell mulch in mitigating the growth of *M. diplotricha* The percentage emergence of the weed under PKS treatment was much lower (20.0%) when compared to the unmulched control group (87%) in the year 2018. In the year 2019, the control group exhibited a percentage emergence of 90%, while the PKS group demonstrated a percentage emergence of 23%. The study observed the shoot and root growth, as well as biomass accumulation, were reduced, in both experimental years for the weed. Conversely, the utilization of palm kernel shell mulch resulted in a significant enhancement in garden egg biomass, leaf area, and fruit yield. The efficacy of the mulch on the performance of *M.diplotricha* and garden egg remained consistent over both research years, indicating no significant effect. However, the application of different mulch volumes had a discernible impact on their growth. The findings ofthis study will serve as a guiding framework for future research endeavors focused on investigating the impacts of bioherbicides on the control of tropical weeds.

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INTRODUCTION

The incorporation of diverse strategies for pest and soil management is a distinguishing characteristic of sustainable agriculture systems. Weeds and aggressive plant species pose a significant danger to both agriculture and biodiversity on a global scale (Oerke, 2006). Invasive weeds exhibit rapid growth rates, possess a high degree of adaptability to diverse climatic conditions, and engage in competitive interactions with crops for essential resources such as nutrients, light, and water. As a consequence, their presence can lead to a reduction in crop growth and overall yield (Pimentel et al., 2005). *Mimosa diplotricha* C. Wright ex Sauvalle belongs to the family Mimosaceae. It is indigenous to the Americas (Holm *et al.*, 1977). It has successfully spread to extensive regions in Asia and Africa, causing significant ecological and agricultural concerns (Ekhator et al., 2013). The presence of *Mimosa diplotricha*exerts a significant adverse impact on commercially significant crops, animals, and forest flora within the Nigerian context. The sharp and curved thorns inflict painful injuries to cattle and humans, hence impeding their ability to access essential resources on the farm. It has the capacity to generate a maximum of 10,000 seeds during a single year, which may remain dormant in the soil for many years. (Kuniata and Korowi, 2004).

The occurrence of this particular plant in Nigeria has been documented by several researchers (Alabi et al., 2004; Ekhator et al., 2013). Several countries, such as Australia and certain Pacific Islands, have implemented numerous eradication or control strategies for this particular plant (Uyi,2020). However, these methods are not deemed sustainable. Leafy and fruit vegetables are cultivated in numerous regions of Sub-Saharan Africa. The plant known as garden egg, scientifically classified as Solanum macrocarpon (BBS 119), is a member of the Solanaceae family. The species is found in regions with moderate and tropical climates, and it is native to sub-Saharan Africa (Lock et al., 2004). It is a herbaceous species that possesses several economical, cultural, high-demand, nutritional, and therapeutic attributes (Omotesho et al., 2017). One of the limiting factors in vegetable output is the presence of weeds, therefore prompting an investigation into the impact of mulch on the growth and yield of garden egg plant. Weeds are a prominent factor that hinders crop production, leading to substantial decreases in both plant yield and quality (Naeem et al., 2022). Weeds engage in competition with agricultural plants for essential resources such as nutrients, water, light, and space, leading to a subsequent decrease in crop productivity (Zimdahl, 2018). The cultivation of garden egg, similar to other crops, has a distinct critical period that necessitates the implementation of weed management measures in order to mitigate potential reductions in yield (Khaliq et al., 2019). The utilization of mulch offers numerous advantages, including the enhancement of plant health and crop productivity (Kader et al., 2019). Additionally, it contributes to the improvement of soil's physicochemical and biological qualities (Qu et al., 2019; Khan et al., 2022). Furthermore, it has been observed that deceased organic mulch emits certain phytotoxins that impede the process of seed germination and early plant growth (Naeem et al., 2022). The presence of mulch serves as a physical obstruction to sunlight, which is essential for the physiological processes, germination, and growth of plants (Khan et al., 2022). Nevertheless, natural mulch options such as palm kernel shells (PKS) and rice husks (RH) exhibit favourable characteristics in terms of affordability, waste management suitability, biodegradability, environmental friendliness, and year-round availability. An integral component of the comprehensive strategy for weed management is enhancing the capacity of crops to effectively inhibit the growth of weeds in close proximity to, or immediately following the establishment of the crop. To date, despite the commendable endeavours of certain nations such as Australia and select Pacific Islands (Uyi, 2020), the eradication or effective management of this weed has yet to be achieved, particularly in tropical regions which face the greatest obstacles posed by the weed. Various approaches are being implemented in order to effectively control the proliferation of this weed. However, it is important to acknowledge that each method is accompanied by its own set of constraints and shortcomings (Templeton, 1990). Therefore, the objective of this field trial was to evaluate the effects of RH and PKS mulch on the emergence and early growth features of *M.diplotricha*, as well as the growth and production of garden egg. This study hoped to contribute to sustainable weed management practices in Nigeria.

MATERIALS AND METHODS

Study area: The study, spanning two years, was conducted in the humid tropical agroecosystems of Nigeria. Specifically, the research was carried out at the research farm of Imo State University, Owerri, which is situated within the same agroecosystems. The study took place during the cropping seasons of 2017/2018 and 2018/2019. The humid tropical agroecosystems in Nigeria are situated between longitude 3° E to 12° E and latitude 4° N to 9° N, encompassing the Guinea Coast region of West Africa. Nigeria's rainforest, southern Guinea savanna, and derived savanna agroecological zones are recognised for their significant prevalence and wide distribution of *M. diplotricha* species are situated within the specified geographic area as documented by Ogbe and Bamidele, 2006 and Ekhator et al. (2013). The selection of the metropolitan state holds significance due to the dispersal of seeds facilitated by regular animal transportation, contaminated plants, soil materials, and machinery from various areas to the metropolitan state. Nevertheless, the entire region exhibits comparable climate conditions and soil properties. The selection of *Solanum macrocarpon* is also influenced by its socioeconomic significance, high demand, as well as its nutritional and therapeutic properties (Omotesho et al., 2017). The initial soil structure of the study area was determined to be loam. Prior to the commencement of the experiment, the soil samples were subjected to processing and analysis in accordance with the techniques outlined by Harasim et al. (2016). The physicochemical parameters of the soil were examined, revealing a composition of 830 kg–1 sand, 330 kg–1 silt, and 90g kg–1 clay. The soil profile within the top 0-3cm exhibited the following characteristics: moisture content of 17.83%, pH level of 6.01, organic matter content of 20 g kg–1, organic carbon content of 20 g kg–1 with a carbon to nitrogen ratio of 0.96, cation exchange capacity of 23.32 Ca/mg, sodium concentration of 1.59 mg/kg, potassium concentration of 6.69 mg/kg, magnesium concentration of 7.41 mg/kg, calcium concentration of 7.62 mg/kg, sulphate concentration of 121.73 mg/kg, phosphate concentration of 4.21 mg/kg, and nitrate concentration of 12.6 mg/kg.

Seed collection and treatments: Mature pods of *Mimosa diplotricha* were collected from over 20 plants in various locations within Imo State University, Owerri, Nigeria, during the months of November 2017 and 2018. These collections were made in order to conduct experiments in 2018 and 2019, respectively. In order to break dormancy, the outer layer of the seeds was sacrificed by cutting the outer layer with a scalpel(Silveira and Fernandes, 2006). The seeds were stored in a plastic container under ambient conditions, specifically at a temperature of 25°C, until they were utilised in the tests. The garden egg seeds were procured from the Imo State Agricultural Development Programme.

Experimental design: The field study was conducted in two phases, employing a randomised block design with three replicates, three treatments, and two consecutive growth seasons. The experimental treatments encompassed varying quantities of rice husk and palm kernel shell mulch, specifically 0, 1.5, 3.0, and 4.5 tonnes per hectare. These mulch levels were applied to the soil, with decomposed mulch being left on the surface, while the control treatment consisted of unmulched soil. The initial phase of the experiment involved observing the emergence and establishment of *M.diplotricha* seedlings within a garden egg field, while the subsequent phase focused on examining the rivalry between *M.diplotricha* and garden egg plants. In both tests, a sample size of 50 garden egg and *M. diplotricha* seeds were manually planted on March 8, 2018 and April 10, 2019. Each plot has dimensions of 6 metres in length and 3.5 metres in width. The spacing between each row was measured to be 0.5 metres. The garden egg population density was recorded as 10 plants per square metre, equivalent to 215 plants per hectare. Nevertheless, a total of 50 fully developed and treated *M. diplotricha* seeds were manually planted at a soil depth of 3cm in perforated plastic boxes measuring 50 45 40 cm. These boxes were placed within the garden egg field, positioned between two rows. Subsequently, the two degraded mulch materials were evenly distributed onto the surface of the soil and subjected to irrigation in order to facilitate the process of germination both immediately after planting and on a weekly basis thereafter. In the experimental study on competition, *M. diplotricha* seeds were planted at a depth of 3cm in the spaces between the rows of garden egg plants. Additionally, varying amounts of RH and PKS mulch were applied to the surface. The seedlings of M. have emerged. The population of *M. diplotricha* plants was reduced to a density of 12 plants per square metre, followed by regular irrigation on a weekly basis and monthly weeding. The selection of these two types of mulch is based on their ability to act as physical cover and the phytotoxins production that impedes weed performance (Loydi et al., 2013). Additionally, these mulches are cost-effective, biodegradable, environmentally friendly, and readily accessible year-round.

Emergence and performance of *M. diplotricha* and development of the garden egg: In order to assess the suppressive impacts of two types of mulch on the emergence and seedling performance of *Mimosa diplotricha* seeds , a study was conducted as described by Kebrom et al., (2019). The emergence of *M.diplotricha* seeds was observed at the point where the cotyledons became visible at the soil surface. This observation was made at two-day intervals over a period of 30 days following planting, in order to determine the cumulative percentage of seed emergence. The measurement of the length of the main root and shoot was conducted using a ruler, while the biomass was assessed using a 72-hour process of oven drying at a temperature of 30°C, followed by weighing on a precision scale. To evaluate the effects of *M.diplotricha* and two types of mulch on the performance and yield of garden egg plants, a total of ten mature garden egg plants were harvested from the central area of each plot. The leaf area of garden egg plants was measured at the flowering stage, specifically 65 days following germination. These measurements were taken every two weeks using a ruler. The leaf area was determined by calculating the product of the length and width of the terminal leaflet, which was afterwards multiplied by a correction factor of 2.88. Subsequently, the specific leaf area per plant was determined by aggregating the surface areas of individual leaves present on each plant. The garden egg fruit production was determined through the process of pre-labeling and quantifying the quantity of fruits present in each plant within a square metre area. The aggregate quantity of fruits was converted into grammes per square metre.

Data and statistical analysis: The data pertaining to the performance of *Mimosa diplotricha* under the influence of mulch and the performance of garden egg under the impact of weed and mulch treatments were subjected to analysis using one-way ANOVA with the aid of MINITAB 19 software.

RESULTS

Mimosa diplotricha percentage emergence: A comparative analysis using a one-way ANOVA on the impact of rice husk and palm kernel shell mulch, as well as control treatments, on the weed emergence, in both experimental years significantly ($p \leq 0.05$) altered *M.diplotricha* emergence. The untreated (control) group had the highest percentage of emergence, whereas the PKS treatments resulted in the lowest emergence. The results revealed that different mulch quantities, ranging from 0.0 to 4.5 tonnes per hectare, significantly hindered seedling emergence. This finding was consistent across both experimental years (Tables 1 and 2). The experimental years did not have a significant effect on the percentage of emergence (Tables 1 and 2).

***Mimosa diplotricha* root and shoot growth:** Mulching treatments yielded a significant impact on root growth. In the 2018 cropping season, no significant difference in root growth was identified between the RH and PKS treatments. However, a significant difference in root growth was observed during the 2019 cropping season. The untreated (control) group had the greatest root length, whereas the PKS treatments resulted in the shortest root length. An increase in the amount of mulch resulted in a decrease in root growth. The experimental years did not have a statistically significant impact on root growth. (Tables 1 and 2).A greater abundance of lateral roots and damaging taproots were observed on mulch treatments compared to the control. The analysis of variance (ANOVA) yielded statistically significant among different treatments on the shoot growth of *M. diplotricha*. The untreated (control) group had the maximum shoot growth, whereas the application of PKS treatments led to the lowest shoot growth. The shoot growth exhibited a linear decline as the quantity of mulch increased. The study found that the duration of the study did not have a statistically significant impact on shoot growth (Tables 1 and 2).

***M.diplotricha* seedling biomass:** No significant difference in biomass accumulation was seen between the RH and PKS treatments during the two experimental years. However, a significant difference was observed between the treated and untreated (control) groups. A drop in biomass was observed as the amount of mulch increased. The duration of the study does not have a statistically significant impact on the accumulation of biomass (Tables 1 and 2). With the exception of the RH4.5 tonnes per hectare level of mulch, varying levels of RH did not yield any statistically significant impact on biomass (Tables 1 and 2).

Competition between *M.diplotricha* and garden egg

Garden egg leaf area: The analysis of variance (ANOVA) findings indicated a statistically significant disparity in leaf area across all treatments during both experimental years. The PKS treatment exhibited the highest recorded leaf area, whereas the untreated control treatment displayed the lowest recorded leaf area. Leaf area increased as the quantity of mulch increased. There is no statistically significant relationship between the duration of the study and the leaf area (Tables 3 and 4).

Garden egg biomass: There was a significant difference observed in the buildup of garden egg biomass across all the treatments. The PKS treatment exhibited the highest biomass, whereas the untreated control treatment displayed the lowest biomass. Furthermore, the findings indicate that the duration of the study does not have a statistically significant impact on the leaf area (Tables 3 and 4).

The garden egg yield: The analysis of variance (ANOVA) revealed significant differences in garden egg yield when comparing the treatments in both experimental years. The PKS treatment exhibited the maximum yield, whereas the untreated (control) treatment displayed the lowest yield. Nevertheless, the experimental duration does not exhibit any noteworthy impact on the crop yield (Tables 3 and 4).

DISCUSSION

Mimosa diplotricha percentage emergence: The observed outcomes on emergence can be ascribed to the presence of mulch, which acts as a physical obstruction for crucial resources such as oxygen, light, nutrients, and water (Khan et al., 2022). The findings presented in our study are supported by previous research conducted by Altland et al. (2016), who observed the inhibitory effects of rice husk extracts on the germination and growth of Barnyard grass, Bittercrest, and Woodsorrel. Phytotoxins contents in mulch, have been found to impact different phases of plant emergence and seedling growth (Scavo and Mauromicale, 2021). The observed decrease in shoot and root length indicates a potential decline in the plant's ability to absorb and transport water and nutrients.

M. diplotricha root and shoot growth: The present investigation reveals a correlation between the injurious tap root, increased lateral roots, and the suppression of shoot and root length. However, current findings support the reduced shoot and root length in rice plants subjected to wheat straw mulch Yan et al., (2018). In addition, these findings align with previous observations of unhealthy and morphological abnormalities in lettuce (Lactuca sativa L.) and popping pod (*Ruellia tuberosa* L.) seedlings when exposed to *Mimosa pigra* L(Koodkaew et al., 2018).

M. diplotricha biomass: The observed reduction in biomass accumulation in the present study could potentially be attributed to diminished growth of both root and shoot seedlings, which may have been a consequence of inadequate absorption of water and nutrients.
Previous studies (Nwosisi et al., 2019) have documented that mulch treatments decreased weed biomass and weed density, and improved sweet potato yield.

The garden egg leaf area: Increased garden egg leaf area can be ascribed to the heightened availability of water and nutrients resulting from the decomposition of the mulch, which was then assimilated by the garden egg plant. The observed uniformity in leaf area between the two years of study may be attributed to the potential absence of meteorological factors impacting leaf area. Our findings align withthe increased leaf area index, crop growth rate, and root length of maize (*Zea mays* L.) and sunflower (*Helianthus annuus* L.) treated with plastic mulch, sorghum mulch, and paper mulch Hussain et al. (2022).

Means that do not share a letter are significantly different at $p \leq 0.05$.Values in brackets are standard deviation

The garden eggbiomass: The findings of our study on garden egg biomass aligned with those of Sarkar et al. (2019), who observed that the application of mulch enhances the photosynthetic activity of crops, leading to improved buildup of dry matter and increased yield.

The garden egg yield: The observed increase in yield in this study can potentially be attributed to the augmentation of leaf area, which facilitates photosynthesis, the influence of decomposed mulch that releases nutrients, and the suppression of weed populations facilitated by the application of mulch. Our result collaborates withIke et al., (2019) who observed that sawdust and grass mulches effectively decreased weed infestation and enhanced vegetative development and yield of garden egg plant.Many studies have documented enhanced crop establishment, improved vegetative growth, and increased yield (Li et al., 2018)) resulting from the mulch treatments.

Table 1. Effects of Rice husk and palm kernel shell mulch and control, on *M. diplotricha* emergence and growth during 2018 and 2019 cropping seasons

Treatments(t/ha) and Years	% Emergence	Root length(cm)	Shoot length	Seedling biomass(g)
2018				
Control	87.10(2.11)a	7.33(0.42)a	17.50(0.70)a	3.10 (0.38)a
Rice husk:	28.66(5.10)b	4.04(0.61)b	14.23 (0.44)b	0.70(0.65)b
Palm kernel shell	20.00(2.73)c	3.71(0.77)b	12.20 (0.83)c	1.23(0.16)b
2019				
Control	90.00(4.00)a	8.00 (0.46)a	18.20(0.85)a	2.70(0.39)a
Rice husk:	30.33(5.17)b	5.40(0.51)b	15.30 (0.49)b	0.78 (0.44)b
Palm kernel shell	23.00(2.65)c	3.60 (0.90)c	13.411(0.92)c	1.11(0.40)b

Means that do not share a letter are significantly different (p≤0.05).Values in brackets are standard deviation

Table 2. Effects of different quantities of rice husk and palm kernel shell mulch on *M. diplotricha* Emergence and growth during the 2018 and 2019 cropping seasons

	Year 2018				Year 2019			
Treatments	% Emergence	Root length	Shoot length	Seedling biomass(g)	% Emergence	Root (cm) length	Shoot length	Seedling biomas
RH1.5	40.73(2.0)a	5.73(0.31)a	15.33(0.70)a	2.4700(0.09)a	38.00(1.37)a	5.997(0.447)a	15.13(0.40)a	2.40 (0.37)a
RH3.0	34.00(2.04)b	4.71(0.60)b	14.33(087)ab	2.09(0.186)a	34.40(0.90)b	4.933(0.404)abc	14.53(0.40)ab	2.20(0.49)a
RH4.5	26.40(2.10)c	4.267(1.10)bc	13.63(0.40)b	1.33(0.499)b	26.60(2.09)c	5.633(0.321)ab	13.60(0.530)b	1.21(0.20)b
PKS 1.5	22.30(075)d	3.90(0.46)bc	12.10(0.62)c	1.14(0.212)bc	24.13(1.40)c	4.700(1.217)bc	11.70(0.70)c	1.30(0.40)b
PKS3.0	19.63(0.51)de	3.40 (0.16)cd	11.70(0.30)c	0.743(0.12)c	20.97(1.79)d	4.000(0.200)c	11.83(0.60)c	0.90 (0.12)b
PKS4.5	18.10(0.702)e	2.5433(0.15)d	10.20 (0.55)d	0.69(0.219)c	19.05(1.77)d	2.60(0.40)d	10.23(0.80)d	0.80 (0.21)b

Means that do not share a letter are significantly different (p≤0.05). Values in brackets are standard deviation.

Table 3. Effects of Rice husk and Palm kernel shell mulch on Garden egg leaf area under competition with *M. diplotricha* during the 2018 and 2019 cropping years

Treatments (t/ha)	Leaf area	Biomass	Yield
The year 2018			
Control	30.60(3.57)c	9.45(0.60)c	9.40 (0.60)c
Rice husk:	34.90(1.70)b	10.56(0.42)b	10.92 (0.42)b
Palm kernel shell	45.11(1.273a	14.42(0.51)a	14.42(0.51)a
The year 2019			
Control	34.27(1.81)c	9.17(0.24)c	9.17(0.24)c
Rice husk:	40.53(2.04)b	13.26(1.04)b	11.22 (1.04)b
Palm kernel shell	44.90(1.50)a	14.64(0.57)a	14.64(0.57)a

Means that do not share a letter are significantly different at (p≤0.05).Values in brackets are standard deviation

Table 4. Effects of different quantities of rice husk and palm kernel shell mulch onGarden egg leaf area, biomass and yield

	Year 2018			Year 2019		
Treatmens	Leaf area	Biomass	Yield	Leaf area	Biomass	Yield
RH1.5	34.20 (0.85)d	10.70 (0.40)c	10.70 (0.35)c	33.05(1.23)d	10.97 (0.25)c	10.90(0.36)b
RH3.0	35.70 (0.76)c	10.70(0.60)c	10.60 (0.47)c	34.63(0.25)c	10.70 (0.44)c	10.70(0.90)b
RH4.5	36.90(0.35)b	11.13(0.47)c	11.10(0.97)c	35.03(0.25)bc	10.97 (0.64)c	11.03(0.95)b
PKS 1.5	37.97(0.9)b	12.73(0.15)b	13.17(0.35)b	35.700(0.90)abc	13.50 (0.50)b	13.73(0.49)a
PKS3.0	38.00(0.40)b	12.80(0.70)ab	14.60(0.513)a	36.33(0.65)ab	14.53 (0.42)a	14.767(14.80)a
PKS4.5	39.83(0.42)a	13.63(0.60)a	14.80 (0.50)a	37.10 (1.14)a	14.83 (0.50)a	14.90(0.62)a

CONCLUSION

This research is the first time we used agronomic techniques to evaluate the effect of mulch on *M.diplotricha* weed suppression and improvement of garden egg growth and yield.Mulch, especially palm kernel shells up to 4.5 tons per hectare for both experimental years caused a significant decrease in *M.diplotricha* weed emergence and seedling growth but was not enough to completely inhibit its emergence and at the same time, enhanced garden egg performance and yield.Therefore, increased rice husk and palm kernel shell mulch greater than 4.5 tons per hectare is imperative for sustainable and eco-friendly management of *M.diplotricha* weed and soil fertilization in humid tropical agroecosystems in Nigeria.Future studies should involve the identification of bioherbicide compounds present in the rice husk and palm kernel shell that will be formulated as preemergence bioherbicide to reduce the *M. diplotricha* seed bank in the soil.To prevent further spread of, and invasion by the *M.diplotricha* weed, governments and institutions in Nigeria and other affected nations should work together on its management.

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