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Research Article
Evaluation of Mixed Planting and Weeding Regime for the Control of Iroko Gall Bug on *Milicia excelsa*

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Abstract

Background and Objective: Iroko gall bug, *Phytolyma lata* Scott. is a major insect pests of *Milicia excelsa* (Iroko) which has hampered the establishment of *Milicia* plantation in many West African countries. This study was conducted to assess the effect of planting *M. excelsa* with companion plants and weeding regimes for the control of *P. lata*. **Materials and Methods:** Six months old *M. excelsa* seedlings were planted in mixed stands with companion plants (*Cedrela odorata*, *Azadirachta indica* and *Pierreodendron africanum*) seedlings in a separate sub plots in five replicates. Weeding regimes (2, 4, 6 and 12 weeks) were allotted in a separate plot planted with pure stands of *M. excelsa* seedlings at the spacing of 2×2 m in three replicates. The experiments were laid in a Randomized Block Design (RBD), growth parameters (height, stem diameter and number of branches) and *P. lata* infestation (number of galls and size of galls) on *M. excelsa* were observed at two weeks intervals. Infestation and seedling survival were used as indices of effectiveness by subjecting data collected to one way analysis of variance (ANOVA) followed by Turkey's test. **Results:** Field infestation by *P. lata* was significantly ($p<0.01$) lower on *M. excelsa* seedlings mixed with *C. odorata* and *A. indica* by 26.43 and 17.37%, respectively compared to control. Similarly, the plots mixed with *C. odorata* and *A. indica* had the highest percentage *Milicia* seedling survival 24 months after transplanting. The results were recorded as 52.23% of *M. excelsa* seedling survival, followed by plot mixed with *P. africanum* (28.02%) while 24% sole plantation was recorded. *Phytalyma lata* infestation on *M. excelsa* seedling was lower in 12 weeks weeding regime by 15% as compare to 2 weeks regime. **Conclusion:** It is concluded that planting *M. excelsa* in mixture with companion plants was promising for *P. lata* management and 12 weeks weeding regime reduced *P. lata* attack on *Milicia excelsa*.

Key words: *Phytolyma lata*, *Milicia excelsa*, infestation, companion plants, insect pests, control, seedling survival

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Milicia excelsa (Welw) C.C. Berg Moraceae is an important economic tree species in West Africa. Two species of *Milicia* are found in Africa; *M. excelsa* and *M. regia.* They are recognized together as Iroko. *Milicia excelsa* is widely spread across Africa, *M. regia* are found mainly in the wet forest zone while *M. excelsa* have a preference for the dry zones[1].

The timber is very strong, quite hard and long-lasting and the most important timber in international trade[2]. It is also very resistant to treatments with preservatives although the sapwood is porous to water. They are very valuable to the community and are used to cure human diseases in traditional medicine, to make furniture in carpentry and joinery and to protect cultural values in local religions[3]. The timber is used for construction of ships and barrels because of its high resistance to bad weather[4]. *Milicia* species also play important roles in erosion control and in enhancement of soil fertility. The leaves of are used as mulch and the tree serves a good shade or shelter and sometimes used as an avenue tree[5]. Harvesting of *Milicia* species is mainly done from the natural forest, however, replacement has proven to be insufficient to match the rate of exploitation mainly due to their susceptibility to *Phytolyma* gall attack[6]. According to IUCN[7], *Milicia* species is categorized as one of the endangered valuable timber species. Attempt to establish *Milicia* plantation has been constrained by *Phytolyma lata* attack on the young plants which subsequently result to gall formation and dieback of the plant[8]. Their activities interrupt plant physiological processes causing growth reduction and killing the seedlings in most cases[9,8].

Control of *Phytolyma* pests through the use of chemical pesticide has been found ineffective due to its hidden nature. Use of companion crops or mixed planting has been reported by several authors as a potential tool for insect pest management. Iverson *et al.*[10] and Castagneyrol *et al.*[11] reported that more diverse plant associations are less prone to insect damage including in the forests. Guyot *et al.*[12] confirmed that tree diversity has the potential to reduce the impact of invasive forest pests at the stand level. Similarly, Bosu *et al.*[13] also reported that planting *Milicia excelsa* and *M. regia* with a mixture of *Terminalia superb* was found effective in reducing damage from *P. lata* attack. Likewise, Wagner *et al.*[14] observed that mixed planting of other tree species and use of different shades environments reduced the pest population, abundance of galls and enhanced growth of *Milicia* species. Ofori and Cobbinah[15] also reported that planting *Milicia* with *Gliricidia sepium* minimizes the abundance and damage caused by *P. lata*. Root[16] has earlier reported that diverse plantings provides more resources for natural enemies to build up including non-pest prey species, pollen and nectar thus build natural enemy communities and strengthen their impacts on pests. This study will help divulge the impact of companion plants on *P. lata* infestation. Therefore, this study assessed the effect of mixed planting and weeding regime on the infestation of *P. lata* on *Milicia excelsa* in Southwest Nigeria.

MATERIALS AND METHODS

Experimental site: Field trials were conducted at the Teaching and Research Farm of Federal College of Forestry Ibadan, for two years (2010-2011). The Federal College of Forestry Site is located on the latitude 7.50 N and longitude 3.90 E. The climate condition of the area is tropical with an annual rainfall range of 180-700 mm per annum while the annual temperature is 34.40°C the daily humility is about 60%[17].

Evaluation of mixed planting with other tree species for the control of *P. lata* on *M. excelsa*: The method for evaluating the effect of mixed planting of tree species with *M. excelsa* for control of *P. lata* infestation was adopted from Forrester *et al.*[18]. An experimental plot 30×30 m^2 was cleared manually with cutlass and divided into four sub plots. Six-months old *M. excelsa* seedlings of uniform heights (20 cm) collected from screen house and six months old seedlings of *Azadirachta indica*, *Cedrela odorata* and *Pierreodendron africanum* collected from Forestry Research Institute of Nigeria (FRIN) nursery were planted in binary mixture.

A row consisted of five seedlings and was replicated five times giving a total 25 *Milicia* plants and 25 plants of other tree species in each sub plot in a Randomized Block Design (RBD) The control plot was mono plantation of *Milicia excelsa* at the same spacing of 3×3 m^2. The plots were maintained by weeding manually at 6 weeks intervals. Data were collected on the plant height (cm), stem girth (mm), number of branches at monthly intervals and on number of galls and *P. lata* population at 2 weeks interval until two years.

Plant height (cm) was measured from the soil level to the terminal bud using meter rule. Stem girth (mm) was measured with the aid of veneers caliper. A mark was made on the plant at 5 cm from the ground level and all the measurements were taken at that marked portion until the end of the experiment. The number of branches was assessed by direct counting of the number of branches observed on each *M. excelsa* plant. Number of galls on the test plants was assessed by direct

counting of the galls at 2 weeks intervals while size of gall was measured with the aid of thread which was later stretched on meter rule to determine the actual length. The population of *P. lata* was assessed by close observation on the leaves, stem and branches of the *Milicia* plant and direct counting of *P. lata* adult.

Evaluation of weeding regimes for the control of *Phytolyma lata* on *Milicia excelsa*: Six-months old healthy seedling of *M. excelsa* raised in the screen house were transplanted in a 10×30 m^2 experimental plot at the spacing of 2×2 m at the rate of one seedling per stand and five seedlings per row in three replicates. The experiment was laid out in Randomized Block Design (RBD) in four replicates. The treatments were four weeding regimes: Two weeks weeding regime, 4 weeks weeding regime, 6 weeks weeding regime and control (3 months weeding interval). Each block was allotted to one weeding regime and labeled accordingly. The plots were weeded manually with hoe and cutlass according to the weeding regime stipulated for it. Horse dung manure collected from polo club Ibadan when horses were fed fresh grasses only were applied to the *M. excelsa* seedlings after 2 weeks of transplanting at the rate of 5.0 t ha^{-1}. Data were collected on *Milicia* height, stem girth and number of branches at monthly intervals and on number of galls and *P. lata* population density at 2 weeks interval until the end of the experiment following the same procedure applied on the previous experiment.

Statistical analysis: Data collected on growth parameter were analyzed by one way analysis of variance (ANOVA) followed by Turkey's test while data on number of galls and population density of *P. lata* were transformed using square root transformation. All the analysis were performed using ASSISTAT version 7.6 beta statistical assistance[19].

RESULTS

Effect of mixed planting with companion plants on *P. lata* infestation on *M. excelsa*: Field infestation by *P. lata* was significantly ($p<0.01$) lower on *M. excelsa* seedlings mixed with *Cedrela odorata* and neem compared to control. The percentage infestation of *M. excelsa* mixed with *C. odorata*. and neem were 12.94 and 22.01%, respectively (Fig. 1).

Mixed planting of *M. excelsa* with different tree crops also showed a significant difference ($p<0.05$) on the growth of *M. excelsa.* The highest plant height, stem girth and number of branches of *Milicia* was obtained on plot mixed with *Cedrela odorata* with mean value of 72.80 cm, 0.94 mm and 1.79, respectively (Table 1). Similarly, the plots mixed with

Table 1: Mean growth of *M. excelsa* inter-planted with companion plants 2 years after transplanting

Treatments	Height (cm)	Stem girth (mm)	No. of branches
M. excelsa+Cedrela	72.80^{a}	0.94^{a}	1.70^{a}
*M. excelsa+*neem	36.80^{b}	0.60^{b}	1.15^{a}
M. excelsa+Pierreodendron	37.80^{b}	0.66^{b}	1.08^{a}
Control	58.40^{ab}	0.66^{b}	1.19^{a}
Significance levels	*	*	Ns
CV (%)	30.61	24.99	55.54

^{a,b}Mean values followed by the same letter in a column are not significantly different at 5% level of probability. *Significant at 5% level of probability, CV (%): Percentage coefficient of variation, NS: Non-Significant

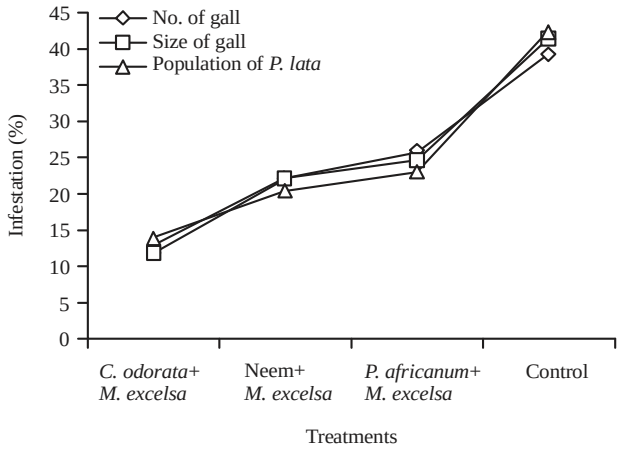

Fig. 1: Effect of mixed planting on the *Phytolyma lata* infestation on *Milicia excelsa*

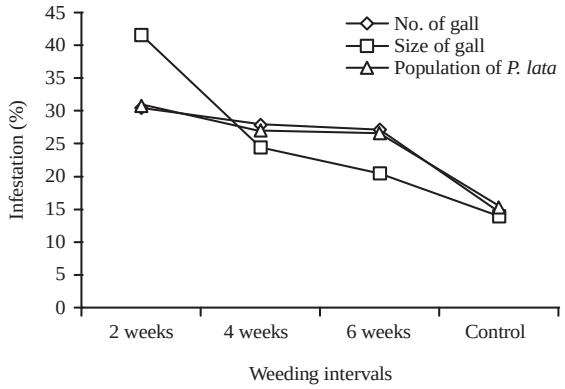

Fig. 2: Effect of weeding regimes on the *Phytolyma lata* infestation on *Milicia excelsa*

Table 2: Percentage survival and mortality of *M. excelsa* 2 years after transplanting with three companion plant species

Treatments	Survival (%)	Mortality (%)
M. excelsa+Cedrela	52.23[a]	47.77[b]
M. excelsa+neem	52.23[a]	47.77[b]
M. excelsa+Pierreodendron	28.02[b]	71.98[a]
Control	24.10[b]	75.90[a]

[a,b]Mean values followed by the same letter in a column are not significantly different at 5% level of probability

Table 3: Mean growth of *M. excelsa* on different weeding regimes 16 weeks after transplanting

Treatments	Plant height (cm)	Stem girth (mm)
2-weeks interval	48.62[a]	0.58[a]
4-weeks interval	41.62[b]	0.44[b]
6-weeks interval	34.02[c]	0.45[b]
Control	26.29[d]	0.35[b]
Significance levels	**	**
CV (%)	23.27	30.56

[a,d]Mean values followed by the same letter in a column are not significantly different at 5% level of probability. **Significant at 1% level of probability. CV (%): Percentage coefficient of variation

C. odorata and neem had the highest percentage survival 24 months after transplanting. Approximately 52.23% of *M. excelsa* survival was recorded while the least *M. excelsa* survival recorded in sole plantation (control) was 24% (Table 2). There was no significant difference ($p>0.05$) between the effect of mixed planting with *C. odorata* and neem on the percentage mortality and survival of *M. excelsa.* There was a significant ($p<0.05$) increase in plant height of transplanted seedlings of *M. excelsa* weeded at 2 weeks interval (48.42 cm) at 16 weeks after transplanting, followed by 4 weeks weeding interval (41.62 cm). These translated to an increase of 14.83 and 10.18% in seedlings weeded at 2 weeks and 4 weeks weeding regime (interval) respectively above the control by 16 weeks after transplanting.

Similarly, there were significant differences ($p<0.01$) among the treatments on the stem girth . Two weeks weeding regime had the highest stem girth (0.58 mm), followed by 6 weeks weeding regime (0.45 mm) and the least was the control (0.35 mm) (Table 3). Field infestation by *P. lata* in *M. excelsa* seedling was lower in 12 and 6 weeks weeding interval by 15.6 and 3.34%, respectively compared to 2 weeks weeding interval (Fig. 2). The control experiment had the least number of galls, sizes of galls and population density of *P. lata.* However, there were not significant differences ($p<0.05$) among the different weeding intervals and the control.

DISCUSSION

In this study, mixed planting of *Milicia* with *Cedrela odorata*, *A. indica* (neem) and *Pierreodendron africanum* did not have significant effect in reducing *P. lata* infestation. There was no significant difference ($p<0.05$) on *P. lata* infestation between mono plantation and mixed plantation. This corroborate report by Ratnadass *et al.*[20] that vegetation diversification does not necessarily reduce the incidence of pests and diseases. Similarly, Plath *et al.*[21] reported that higher herbivore damage to *Tabebui rosea* was found in mixed tree diversity than in mono plantation/stands. In contrast, Wagner *et al.*[14] reported that *Milicia* planted in mixture with *Gliricidium sepium* reduced gall formation in the mixed plots compared to the pure *Milicia* stands (Mono plantation). Also, Bosu *et al.*[13] found that planting *M. excelsa* or *M. regia* in a mixture with *Terminalia superba* was effective in reducing damage from *P. lata* attack. On arable crops, Mutisya *et al.*[22] reported that agronet covers and companion cropping with a row of basil planted between adjacent tomato rows significantly ($p<0.05$) lowered *B. tabaci* infestation in tomatoes by 68.7%. Legaspi *et al.*[23] also reported that intercropping mustard (*Brassica juncea*) as a companion crop for collards (*Brassica oleraceae* var. acephala) successfully reduced whitefly infestation. *Milicia excelsa* planted in mixture with *C. odorata* significantly ($p<0.05$) showed higher plant height and stem diameter than those in pure stands. This is in support with report by Paul and Weber[24] that Astronium graveolens, Cedrela odorata and Terminalia amazonia planted in mixture with *Zea mays* and *Cajanus cajan* showed significantly superior growth performance over those in pure plantation.

Mixed planting of *Milicia* could probably reduce the *P. lata* infestation as reported by earlier researchers if transplanted in existing/old mono plantation of other tree crops not in a new plantation where the mixed trees are of the same age with the *Milicia* plant. The existing tree crop which provides shade environment will serve as deterrence to *P. lata* from locating its host plant *Milicia* and consequently reduce infestation. This

assumption corroborate the report by Jonsson *et al*.[25] that of coffee berry borer infestation on cocoa were reduced in shade plantation than on sun-exposed plantations. Similarly, Wagner *et al*.[14] also reported that mixed planting with other trees species and the use of different shade environments reduces the pest population, activity, abundance of galls and enhance growth of *Milicia* spp. Wagner *et al*.[26] reported that agro forestry and mixed species plantation approach could be used to successfully manage *Phytolyma lata*, implying that the over story shade is beneficial to *M. excelsa* at some stages. Wagner *et al*.[14] also reported that deep over story shade during the early stages of growth can reduce *Phytolyma* gall formation, prevent dieback and associated loss of seedlings. In contrast, Bosu *et al*.[13] reported that deep shade can minimize the quantum of photosynthetic radiation needed for growth, which can result in seedlings becoming etiolated and eventually dying.

Moreover, this study showed that 12 weeks weeding regime reduced the incidence of *P. lata* infestation. This indicates that shading effects of different vegetation affect the population of *P. lata*, their activity, abundance of galls and growth of *Milicia excelsa*. Guyot *et al*.[12] reported that infestation by *Dryocosmus kuriphilus* on chestnut trees *Castanea sativa* was lower on stands with higher tree species richness or diversity .

On the contrary, Nowak *et al*.[27] reported that competing vegetation was an important factor in population stability of some insect species such as the pine tip moths. Moreover, Sun *et al*.[28,29] reported that low levels of competing vegetation are often associated with higher tip moth infestation rates. Similarly, *Pinus silvestris* and *Quercus humilis* were found favored by the presence of a dense under storey, particularly when shrubs were higher than seedlings[30,31]. This implies that companion plants encourages development of some insect pests infestation rather than reduction.

CONCLUSION

This present study reveals that planting of *M. excelsa* with companion plants of the same age was not highly promising in reducing *Phytolyma lata* infestation on *Milicia* seedlings. Twelve (2 week) weeding intervals minimized *P. lata* attack on *Milicia excelsa* during early growth. Therefore, 12 weeks weeding interval can be recommended to reduce *P. lata* infestation on *Milicia* plantation at the early stage and further studies on planting of *Milicia* in mixture with old companion plants in plantation is required to confirm their potential in reducing *P. lata* infestation.

SIGNIFICANCE STATEMENTS

This study revealed the potential of using companion plants as a control option for *Phytolyma lata* infestation on *Milicia excelsa* at the early stage of plantation establishment. The study will help the researchers to expose the ecological relationship between *P. lata* and *Milicia* and its cryptic nature that contributes to their complexity in management. Thus a new assumption for their control may arrive.

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