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Research Article

EFFECT OF INTEGRATING WEEDING AND HAND PICKING REGIMES ON CONTROL OF IMPERATA CYLINDRICA (L) BEAUV.), GROWTH AND YIELD OF MAIZE (ZEA MAYS L.) IN SIERRA LEONE

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ABSTRACT

A field study was conducted at Njala University (80o 07'north-latitude and 012o 05' west-longitudes), Moyamba district, southern Sierra Leone; between August 2014 and October 2014 to determine the effect of integrating weeding and hand picking regimes on the control of *I. cylindrica*, growth and yield of maize. All treatments were arranged in randomized complete block design and replicated 3 times. Results showed that weeding 4 times and rhizomes handpicked either once or twice significantly ($P<0.05$) suppressed I. *cylindrica* infestation, and consequently increased the growth and yield of maize. It is therefore concluded that an integrated approach, through weeding 4 times and rhizomes handpicked twice; though labour intensive has the potential to control *I. cylindrca,* and at the same time support better growth and yield of maize.

INTRODUCTION

Considering the noxious nature of *Imperata cylindrica*, and its negative impact on landscape and crop productivity, it is important that strategies be identified for combating this weed. Research reports indicate that the weed is aggressive, pernicious and threatens the livelihood of over 200 million people in West Africa (Chikoye *et al*., 1999). At the moment, there is no report on studies conducted to manage *I. cylindrica* in Sierra Leone, although several management strategies have been tested in several other countries where the weed is considered as noxious and menace to crop production.

Knowledge of weed control practices employed by farmers is vital in developing control measures for a country like Sierra Leone, where most of the farmers are resource-poor. The management options available to the farmers in Sierra Leone include; brushing, burning, tillage and hoe weeding; but these practices have not completely helped in reducing the level of infestation of *I. cylindrica*. Though chemical control has been widely recommended, its high cost, toxicity and none eco-friendly nature are factors limiting its acceptance among smallholder and resource-poor farmers in Sierra Leone. In addition, most farmers in Sierra Leone are illiterates, meaning they cannot read and understand label information on pesticide containers. Brushing with cutlass only succeed in cutting the above ground parts leaving the active rhizomes underground.

Most farmers in Sierra Leone delay weeding, and often weed their crops only once; a practice that has led to even further increase in the infestation of weeds in crop fields. The situation is even worse where noxious weeds like *I. cylindrica* are found. Though depending only on hoe weeding alone may not totally control *I. cylindrical*; however, increasing the weeding frequency to more than once has been reported to help reduce the level of infestation. Akobundu *et al.* (2000) reported that at least weeding four timed is required to prevent reduction in maize yields due to *I. cylindrica* interference in the derived savanna of Nigeria. Their study did not however address the issue of hand picking of rhizomes, which is crucial to effective control of the weed. In the midst of these challenges, it is imperative that a low cost, sustainable and eco-friendly management strategy be identified. The main goal of this study therefore is to determine effect of integrating weeding and hand picking regimes on the control of *I. cylindrica,* growth and yield of maize. Adoption of this strategy, particularly in *I. cylindrica* prone regions dominated by resource-poor farmers will be beneficial. If accepted, based on observations made, this will reduce the burden on farmers to purchase expensive chemicals or abandon their crop fields due to high *I. cylindrica* infestations. High crop yields and better quality products are expected, creating room for better way of generating high income from sale of produce.

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MATERIALS AND METHODS

Description of study area

The trial was conducted during 2014 cropping season at the back of Mr. Sheku Max Kanteh's quarter (LQ 015), Njala Campus, Njala University, Kori chiefdom, Moyamba district, southern Sierra Leone. The dominant weed species in the study location include; *Imperata cylindrica* (commonly known as La Lang grass (krio) or Letie (mende) in Sierra Leone), *Diodia scandens* and *Croto hirtus,*. GPS reading of the study site indicates it is situated at 80o 06.710' 'north-latitude and 012o 04.091' west-longitudes, at an elevation of 61 m above sea level. The rainy season starts from May and ends in November; while the dry season commences in December and ends in April. Average rainfall is about 2,750 mm annually.

Field layout and experimental design

The experimental treatments, comprising of four weeding regimes (W_1, W_2, W_3 and W_4), two hand picking of rhizomes (H_1 and H_2) and a control (unweeded) are as shown below:
T1 = W_1 - weeding once at 2 WAS (weeks after sowing) + H_1-hand picking of rhizomes once
T2 = W_2 - weeding twice at 4 WAS + H_1-hand picking of rhizomes once
T3 = W_3 - weeding thrice at 6 WAS +H_1-hand picking of rhizomes once
T4 = W_4 - weeding four times at 6 WAS + H_1-hand picking of rhizomes once
T5 = W_1 - weeding once at 2 WAS (weeks after sowing) + H_2-hand picking of rhizomes twice
T6 = W_2 - weeding twice at 4 WAS + H_2-hand picking of rhizomes twice
T7 = W_3 - weeding thrice at 6 WAS +H_2-hand picking of rhizomes twice
T8 = W_4 - weeding four times at 6 WAS + H_2-hand picking of rhizomes twice
T9 = W_0 - Unweeded (control) + no hand picking of rhizomes
Note: WAS = Weeks after sowing

All treatments were laid out in a randomized complete design, replicated three times and separated 1m apart between blocks. Hoe-weeding was done at 2 weekly intervals, commencing at 4 weeks after sowing (WAS), and terminated at 10 WAS. There were 9 plots per block, given a total of 27 plots for the three replications. Experimental units measured 3.5m x 2.45m (8.575m^2), while the experimental field measured 19.5m x 9.35m (182.325m^2).

Maize seeds (three per hole) were planted on 03/08/2014 on flat land after ploughing and harrowing, with 0.75 m between rows and 0.5 m between plants. Germination count was determined at 2 weeks after sowing (WAS), and thinned to two plants per hill during the same period. Harvesting of maize was done on 25/10/2014.

Data collection procedure

A square quadrat of 0.25m^2 was randomly placed at two different locations in each plot, and the number of *Imperata cylindrica*/quadrat recorded. The percent cover (%) was visually estimated based on a 1-4 visual rating scale; where 1 = 0–25% (low), 2 = 26–50% (moderate), 3 = 51–75% (heavy) and 4 = > 75% (very heavy) (Hughes *et al.,* 2009). The shoot length of 5 randomly selected *Imperata cylindrica* plants was determined by measuring the shoot from soil level to the tip of plant,, using a calibrated meter rule. All data on *I. cylindrica* were collected at 2, 4, 6, 8, and 10 WAS (weeks after sowing). Data on maize plant included; plant height (cm), leaf number, stem diameter (cm), leaf area (cm^2) (collected at 4, 6, 8 and 10 WAS); cob/ear number, cob weight (fresh and dry) and 200 seeds weight (collected at harvest). The average value of the 5 plants measured for growth parameters represented the height, leaf number, stem diameter and leaf area per plant.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using Genstat Statistical Package (Version 3). Treatment significance was measured by significant difference test at 5% probability level (P<0.05).

RESULTS

Mean weed cover score (%), weed count (estimated number per quadrat) and shoot length (cm) of *I. cylindrica* as influenced by weeding regimes and handpicking of rhizomes

Table 1 illustrates significant (P>0.05) differences in the percent (%) cover, weed count and shoot length of *Imperata cylindrica* as influenced by the treatments investigated. Except for the mean weed count, the percent (%) cover and shoot length of *I. cylindrica* appeared to have increased significantly only in the control treatment (unweeded + no hand picking of rhizomes) [2.278 = equivalent to 26–50% (moderate), 66.7cm]. The mean weed count of *I. cylindrica* increased in plots weeded twice and rhizomes handpicked twice (13.94) and also

Table 1 Mean % cover, weed count and shoot length (cm) of *I. cylindrica* as influenced by weeding and handpicking regimes

Treatments	% Cover	Weed count	Shoot length (cm)
Weeding 1+ Hand picking of rhizomes 1	2.056	10.50	52.7
Weeding 2+ Hand picking of rhizomes 1	2.056	9.78	42.0
Weeding 3+ Hand picking of rhizomes 1	1.833	10.67	32.4
Weeding 4+ Hand picking of rhizomes 1	1.556	6.95	41.3
Weeding 1+ Hand picking of rhizomes 2	1.833	8.89	49.7
Weeding 2+ Hand picking of rhizomes 2	2.056	13.94	42.1
Weeding 3+ Hand picking of rhizomes 2	1.389	6.95	34.9
Weeding 4+ Hand picking of rhizomes 2	1.333	3.17	30.3
Unweeded + No hand picking of rhizomes	2.278	13.72	66.7
Significance	*	*	*
CV%	33.5	53.1	39.8
$LSD_{0.05}$	0.4019	3.315	11.48

*** = Significant at 5 %**

in unweeded plots (13.72). The least minimum mean percent weed cover [(1.333, 1.389 (equivalent to 0–25% (low)] and weed count (3.17, 6.95) were respectively recorded in plots weeded three (3) and four times (4), and rhizomes handpicked twice; while plots weeded four times and rhizomes handpicked twice recording the least. The lowest shoot length of 30.3cm was recorded in plots weeded four times (4) and rhizomes hand picked twice.

Effect of weeding and hand picking regimes on growth parameters of maize

Table 2 shows the result of effect of weeding and hand picking regimes on growth parameters of maize (*Zea mays* L.); including plant height (cm), leaf number, stem diameter (cm) and leaf area (cm^2)/plant. Based on results obtained, the mean plant height (cm), leaf number, stem diameter (cm) and leaf area (cm^2) of maize appeared to have varied significantly (P>0.05) between the treatments investigated. The mean maximum plant heights were recorded in plots weeded four times and rhizomes handpicked once (82.6cm) and twice (82.4cm) respectively; while the mean minimum plant heights were recorded in plots weeded twice and rhizomes handpicked once (58.2 cm) and twice (59.0cm) respectively.

The mean maximum leaf number of maize plant (6.617) was recorded in plots weeded four times and rhizomes handpicked once, while the mean minimum leaf numbers (5.383, 5.467 and 5.550) were respectively recorded in plots weeded twice and rhizomes hand-picked once and twice, and in control plot (unweeded + no hand picking of rhizomes). The mean maximum stem diameter (4.225cm) and leaf area/plant (301.2cm^2) were respectively recorded in plots weeded four times and rhizomes handpicked only once, while the mean minimum stem diameter of 2.551cm was recorded only in control plot (unweeded + no hand picking of rhizomes). The mean minimum leaf area values of 150.7cm^2 and 153.2cm^2 were respectively recorded in plot weeded twice and rhizomes hand-picked once; and in control plot (unweeded + no hand picking of rhizomes).

Effect of weeding and hand picking regimes on yield parameters of maize

Table 3 shows result of effect of weeding and hand picking regimes on yield parameters of maize; including cob/ear number/plant, fresh cob weight (kg)/plant, dry cob weight (g)/plant and 200 seeds weight (g)/plot. Based on the analysis of variance, there was no significant (P<0.05) differences between cob/ear number and dry cob weight of maize as influenced by the treatments investigated. Weeding regimes and hand picking of rhizomes had significant (P<0.05) effect on fresh cob/ear weight and the weight of 200 seeds of harvested maize (Table 3). The highest value for fresh cob/ear weight (0.613kg) was recorded in plot weeded four times and rhizomes handpicked once, while the minimum value of 0.109kg was recorded in control plot (unweeded + no hand picking of rhizomes). The mean maximum 200 seeds weight (g) of maize (40.75g) was recorded in plot weeded twice and rhizomes hand-picked twice, while the least values of 28.79g and 28.82g were respectively recorded in plot weeded thrice and twice, and rhizomes hand-picked twice in both cases.

DISCUSSION

This study indicates the importance of *Imperata cylindrica* as a troublesome weed, how difficult it is to be effectively managed and its impact on growth and yield of maize. Studies by several researchers have indicated that most of the methods of *I. cylindrica* control (tillage, hoe and hand weeding, burning and slashing) employed by rural farmers in Africa are not effective (Eussen *et al.,* 1976; Ogunyemi, 1977; Akobundu and Fagade, 1978; Dozier *et al.,* 1998). It was evident from the study that weeding more than once followed by hand picking of rhizomes helped in reducing the level of infestation of *I. cylindrica*. The cover score (%), relative abundance and shoot length of the weed measured during the experimental period appeared to have been significantly influenced by weeding and hand picking regimes. Weeding four times and hand picking of rhizomes twice significantly reduced the % cover, weed count and shoot length of *I. cylindrica,* but increased in the weedy check. This observation is generally obvious in the sense that weedy check received no weeding and no hand picking of rhizomes throughout the period of the experimentation, and therefore likely to have more weed cover score (%), weed count and high shoot length than the rest of the treatmests investigated.

Table 2 Effect of weeding and hand picking regimes on growth parameters of maize

Treatments	Height (cm)/plant	Leaf number/plant	Stem diameter (cm)/plant	Leaf area (cm^2)/plant
Weeding 1+ Hand picking of rhizomes 1	77.3	6.050	3.847	267.0
Weeding 2+ Hand picking of rhizomes 1	58.2	5.383	2.766	150.7
Weeding 3+ Hand picking of rhizomes 1	71.6	5.867	3.468	246.6
Weeding 4+ Hand picking of rhizomes 1	82.6	6.617	4.225	301.2
Weeding 1+ Hand picking of rhizomes 2	65.7	6.000	3.149	227.0
Weeding 2+ Hand picking of rhizomes 2	59.0	5.467	2.822	196.2
Weeding 3+ Hand picking of rhizomes 2	69.1	5.783	3.384	221.1
Weeding 4+ Hand picking of rhizomes 2	82.4	5.900	3.742	265.3
Unweeded + No hand picking of rhizomes	61.7	5.550	2.551	153.2
Significance	*	*	*	*
CV%	26.1	11.4	19.7	38.2
$LSD_{0.05}$	14.73	0.5387	0.5339	70.90

*** = Significance at 5 %**

The high impact of weeding (2-4) times and hand picking of rhizomes (1-2 times) of *I. cylindrica* may have been responsible for the increased in growth and certain yield parameters of maize. This observation is in conformity with what was reported by Akobundu *et al.* (2000) in Nigeria. Their study was however limited only to hoe weeding, but devoid of hand picking of rhizomes.

Table 3 Effect of weeding regimes and hand picking of rhizomes of *I.* on yield parameters of maize

Treatments	Cob/Ear number/plant	Fresh cob weight (kg)/plant	Dry cob weight (kg)/plant	200 seeds weight(g)/plot
Weeding 1+ Hand picking of rhizomes 1	6.00	0.605	0.117	29.56
Weeding 2+ Hand picking of rhizomes 1	4.67	0.302	0.058	36.20
Weeding 3+ Hand picking of rhizomes 1	6.00	0.480	0.104	30.81
Weeding 4+ Hand picking of rhizomes 1	6.00	0.613	0.197	36.42
Weeding 1+ Hand picking of rhizomes 2	5.32	0.422	0.099	36.75
Weeding 2+ Hand picking of rhizomes 2	5.32	0.422	0.099	40.75
Weeding 3+ Hand picking of rhizomes 2	5.32	0.422	0.099	28.79
Weeding 4+ Hand picking of rhizomes 2	5.32	0.422	0.099	28.82
Unweeded + No hand picking of rhizomes	3.92	0.109	0.018	32.35
Significance	NS	*	NS	*
CV%	20.2	36.4	80.8	5.5
$LSD_{0.05}$	2.077	0.2963	0.1594	4.758

*** = Significance at 5 %**
NS = Non significant at 5 %

It is clear from this study that relying alone on hoe weeding may not give successful control of *I. cylindrica,* until the rhizomes are properly remove or handpicked. The aggressive and invasive nature of *I. cylindrica* is attributed to its rhizomes, and thus must not be ignored. Ivens (1980) reported that rhizomes are normally concentrated in the upper 15–20 cm of soil, where they can remain dormant but viable for a long time. Rhizomes have a high reproductive potential under permissive growth condition, due to the numerous buds that readily sprout into new shoots. On the basis of the findings in this study, information on integration of weeding and hand picking regimes may be useful for developing and implementing effective integrated management programs for *I. cylindrica* and increased yield of maize. This practice is particularly useful to smallholder farmers in Sierra Leone and other countries in sub-Saharan Africa, where majority are illiterates and resource-poor.

CONCLUSION

The study indicates a strong advantage of weeding and hand picking of rhizomes, as an integrated approach to help reduce the level of infestation of *Imperata cylindrica*. Weeding four times and hand picking of rhizomes twice emerged as the most effective method of managing the aggressive weed. This positively impacted the growth and yield of maize, due mainly to low infestation level compared with the weedy check, where infestation was noted to be extremely high.

Recommendations

Based on the findings in this study, the following are strongly recommended:

1. a repeat of the trial is needed to confirm the results obtained.
2. cost benefit analysis of the management practices should be investigated in future work. This will show cost involved, and whether it is sustainable for adoption by resource-poor farmers in Sierra Leone.

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