Weed Biology and Management **3**, 158–161 (2003)

RESEARCH PAPER

Comparison of different weed management systems and their effects on yield of coconut plantations in Sri Lanka

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The influence of five different weed management systems on nut yield of coconut were evaluated to determine an economical and effective method of controlling weeds in coconut plantations in the low country, dry zone in Sri Lanka. Treatments imposed included slashing and mulching around the palms with slash (T1), slashing and removing the slash (T2), application of glyphosate (N-(phosphonomethyl)-glycine) alone at 1.44 kg ai ha^{-1} (T3), application of glyphosate alone at 2.88 kg ai ha^{-1} (T4) and cover cropping with *Pueraria phaseoloides* (T5). All treatments were applied twice a year, except for the cover cropping treatment, T5. Based on a reduction in weed biomass, treatments T3, T4 and T5 were found to be significantly effective over other treatments. Coconut yield was increased significantly ($P < 0.05$) in glyphosate-applied plots at both tested rates. Control of weeds with the lower concentration of glyphosate (1.44 kg ai ha^{-1}) resulted in a 25% increase in nut yield over the uncontrolled weed plots. At this rate, it was found to be the most effective and economical method of controlling weeds in coconut plantations. Cover cropping with *Pueraria phaseoloides* was effective in controlling weeds in the long-term, but was not economical compared with the glyphosate application.

Keywords: coconut, glyphosate, *Pueraria phaseoloides*, slashing, weed.

INTRODUCTION

Coconut (*Cocos nucifera* L.) is by far the most extensively cultivated major plantation crop in Sri Lanka (Liyanage & Liyanage 1989). It occupies a total of 0.443 million hectares of land throughout the island (Central Bank Report 2001). The growth habit of the palm and canopy structure requires a wide spacing between palms to allow abundant sunlight to reach the understorey. Consequently, a wide range of perennial and annual weed species occupy the non-utilized space within plantations. Such weeds consistently compete with coconut palms for soil moisture, nutrients and sometimes light, especially when the palms are in the seedling stage. In areas with prolonged dry periods, competition for soil moisture may considerably affect the coconut yield (Liyanage & Liyanage 1989). This competition can result in yield reduction of up to 18–20% (Gunathilake *et al*. 1993). Conversely, the cost of weed management has contributed approximately 15–20% to the total cost of production of coconut (Gunathilake *et al*. 1993). Additionally, weeds obstruct routine estate practices such as manuring, harvesting and collection of nuts.

The major weed species present in coconut plantations are *Imperata cylindrica*, *Panicum repens*, *Pennisitum polistachion*, *Chromalaena odorata*, *Hedyotis auricularia*, *Mimosa pudica*, *Tephrosia purpurea* and *Vernonia zelanica*. Weeds in these plantations are managed in different ways, under the broad categories of mechanical, chemical and cultural methods (Liyanage & Liyanage 1989). However, complete eradication of weeds is not expected and weeds have to be managed to some extent so that they do not compete with coconut. Slashing either by hand or tractor harrowing, use of herbicides, interrow cultivation of fast growing leguminous cover crops and grazing by ruminants are currently popular weed control

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Subsidized by the aid of the Weed Science Society of Japan for publication in *Weed Biology and Management*.

Received 13 December 2002; accepted 1 May 2003

methods in coconut plantations locally. But selection of a suitable herbicide to be used in chemical weed control is very important and glyphosate (N-(phosphonomethyl)-glycine) is a commonly used herbicide in coconut plantations. It is a non-selective postemergence herbicide which controls a wide range of monocotyledonous and dicotyledonous annuals, biennials and perennials, including the major perennials *Cynodon dactylon, Cyperus rotundus* and *Imperata cylindrica* (Boyall 1998). Advantages of this chemical weeding include less time involved, quick results, low labor requirements and effectiveness.

Four-wheel tractor mounted slashers and harrows are the main mechanical methods practised in coconut plantations. Mowing or slashing removes the aerial parts of the weeds, resulting in a depletion of the food supply to the rhizome. Repeated slashing could bring about gradual weakening and the death of weeds. However, slashed aerial parts can serve as a mulch on the ground, and help to conserve soil moisture. Removal of aerial parts also reduces water loss through transpiration. Finally, slashing performed at sufficient frequencies is capable of keeping the growth of ordinary weeds down to an acceptable level (Pethiyagoda 1980). Weeds that do not tolerate shade and competition can be controlled by other faster growing species. In such situations cover crops can be used as fast growing species and they can suppress weed growth effectively. Suitable cover crops such as *Pueraria phaseoloides* and *Centrosema pubescens* can be introduced. At the same time the leguminous cover crops grown for weed suppression can provide additional benefits by supplying nitrogen to the coconut palms (Rolinda *et al*. 1998).

MATERIALS AND METHODS

A field experiment was conducted from 1996 to 2000 at the Coconut Research Institute, Isolated Seed Garden, Ambakele, in the low country intermediate zone of Sri Lanka. The soil was sandy loam with pH 6.5 and organic matter 0.35%. Mean annual rainfall averaged 1600 mm. The trial was established under 45-year-old selected coconut plantation with palms planted at 8 m × 8 m spacing. The palms were regularly fertilized with 3 kg per palm a year of adult palm mixture (800 g urea, 600 g rock phosphate and 1600 g muriate of potash) with 1 kg of dolomite.

The following treatments were used in a randomized complete block design with three replicates. Each plot had six effective coconut palms. The treatments were:

T1: Slashing and slashed materials mulched around palms (twice yearly)
T2: Slashing and slashed materials removed (twice yearly)
T3: Application of glyphosate (1.44 kg ai ha^{-1}, twice yearly)
T4: Application of glyphosate (2.88 kg ai ha^{-1}, twice yearly)
T5: Cover cropping with *Pueraria phaseoloides*
T6: Uncontrolled weeds

Treatments were applied according to the following schedule. Two rates of glyphosate were applied at six-monthly intervals. Slashing (four-wheel tractor mounted slasher) was carried out at six-monthly intervals. Cover crop was established in harrowed plots. Cover crop was fully established after six months of planting and then regularly managed. Weed samples were collected at random using a 1 m × 1 m quadrat every two months, and these were separated into species, counted and weighed.

RESULTS AND DISCUSSION

Effect of different weed control methods on weed biomass

Low weed biomass was recorded in glyphosate-applied plots at both concentrations (1.44 kg ai ha^{-1} and 2.88 kg ai ha^{-1}) as well as in plots with cover crop (Fig. 1). Initially, the two slashing treatments suppressed weed growth, but thereafter fast regrowth was observed. Generally, slashing damaged the aerial part of weeds but with less damage to the root system or underground parts such as stolons and rhizomes. Thus, during favorable weather conditions, underground plant parts produced new shoots or new flushes. For example, the monocotyledonous weeds *Imperata cylindrica, Panicum repens,* and *Cynodon dactylon* and several dicotyledonous

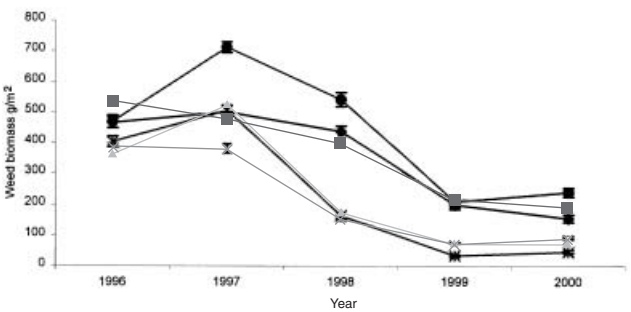

Fig. 1. Weed biomass (g m^2) in five different weed management methods between 1996 and 2000. Verticle bars indicate ± SE of the means. (◆) Slashing and mulching; (■) slashing and removing; (☆) Glyphosate 1.44 kg ai ha^{-1}; (★) cover crop Pueraria; (●) unweeded.

Table 1. Effect of applications of different weed control methods on nuts yield (nuts per palm in a year) of coconut in an isolated seed garden (Ambakele, Sri Lanka)

Treatment	Nuts/palm/year				Cumulative average yield
	1996/1997	1998	1999	2000	
T1 Slashing/mulching	58	106	100	91	99 (06)
T2 Slashing/trash removal	61	93	107	87	97 (04)
T3 Glyphosate 1.44 kg ai ha^{-1}	73	103	135	110	116 (25)
T4 Glyphosate 2.88 kg ai ha^{-1}	72	106	128	116	117 (26)
T5 Pueraria cover	68	105	105	92	101 (09)
T6 Unweeded control	62	90	109	81	93
Significance	NS	NS	⋆	⋆	–
LSD ($P = 0.05$)	–	–	10	19	–

Values in parentheses are the percentage increase of nut yield over the control. ⋆ Significantly different at $P = 0.05$; –, no data; NS, not significant.

weeds *Lantana camara* and *Chromolaena odorata* produced new flushes within a few weeks after slashing. Olaoye (1977) found that slashing of *Chromolaena odorata* caused rapid regeneration. Therefore, repeated slashing and burning resulted in effective control of the weed.

Regarding the establishment of *Pueraria phaseoloides* to control weeds, initially it took several months to fully establish. The weed biomass was very high in the initial stage in cover crop plots but decreased gradually later on. *Pueraria* regenerated with seeds and formed a good cover, thereby suppressing weeds. However, cover crop management is essential to avoid possible competition between coconut and cover crop.

Effect of different weed control measures on coconut yield

Both rates of glyphosate applications significantly increased ($P < 0.05$) nut yield over other treatments. This increase in nut yield commenced from the second year after the first application of glyphosate and the trend continued. Cumulative yield of three years showed 25% yield increase in glyphosate-applied plots over unweeded plots. This could be explained in terms of reduced competition for soil nutrients and water due to the lower weed density in glyphosate-applied plots. Control of weeds with slashing did not produce any yield increase in coconut. This might be a result of the presence of competition by weeds for nutrients and water. It is interesting to note that there was no difference between the two slashing treatments; slashed and weed trash was mulched (no nutrients removed) and slashed followed by weed trash removal (nutrients were expected to be removed out of the system) (Table 1).

This indicates that competition was more for soil moisture rather than soil nutrients, and is further supported by the fact that in areas with inadequate and poor distribution of rainfall, control of weeds with slashing did not produce any yield increase in coconut. However, cover cropping with *Pueraria phaseoloides* was the most effective long-term method for weed control, as indicated by the lowest weed biomass in the experiment. Although cover crops control weeds, they are also expected to compete for soil nutrients and water. In this situation, soil water might be the most critical factor. Hence, cover cropping produced the desired outcome of weed control but failed to show benefits in coconut yield improvement. In this scenario, glyphosate application had an obvious advantage over cover cropping due to minimized weed competition on coconut.

Cost/benefit analysis of different weed control methods under coconut

The costs of different weed control methods are outlined in Table 2. Benefits were calculated as the average incremental yield per year over the unweeded control. The highest nut yield was achieved with application of glyphosate at a concentration of 2.88 kg ai ha^{-1} and the highest return to investment (B/C ratio of 4.41) was given by the application of glyphosate at a lower concentration of 1.44 kg ai ha^{-1}. Therefore, the most cost-effective method of controlling weeds in the present study was glyphosate application at the rate of 1.44 kg ai ha^{-1}. The two slashing methods were not economically viable as indicated by the B/C ratios of 0.86 and 0.64.

Table 2. Cost and benefit analysis of different weed control methods

Control method	Cost (SL Rs/ha per annum)	Average annual incremental yield ha^{-1}	Incremental benefits (SL Rs), (SL Rs 6/nut)	Non-discounted B/C ratio
T1 Slashing/mulching	6720	960	5760	0.86
T2 Slashing/trash removal	6000	640	3840	0.64
T3 Glyphosate 1.44 kg ai ha^{-1}	5000	3680	22080	4.41
T4 Glyphosate 2.88 kg ai ha^{-1}	8200	3840	23040	2.80
T5 Pueraria cover cropping	6300	1280	7680	1.22

Includes material machinery and labor costs for twice a year. Average price of commercial product of glyphosate SL Rs 400/L. Average labor wage: SL Rs 180/day. US 1$ = Sri Lankan (SL) Rs 95.

CONCLUSION

The conclusion from the present study is that the application of glyphosate at 1.44 kg ai ha^{-1} produced the best cost-effective treatment for the control of weeds in coconut plantations. Although cover cropping reduced weed density, economically it was a less viable option than the use of glyphosate.

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