

Appraisal of some methods of weed control during initial establishment of cocoa in a semi-deciduous forest zone of Ghana

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ABSTRACT

In appraising the effects of the quantum and quality of weed control required in establishment of young cocoa, six manual methods of controlling weeds were compared with chemical weed control at two stations of the Cocoa Research Institute of Ghana. Growth of cocoa seedlings after 2 years in the field was superior ($P \leq 0.05$) in plots which were clean-weeded two or four times per year or treated with paraquat four times per year than when plots were slashed two or four times per year. There was strong evidence to suggest that treatments which ensured a weed-free environment to the cocoa over a long period were favourable to girth increments in the seedlings. Death of seedlings during establishment was generally lower in plots which were either clean-weeded or treated with paraquat. Labour requirement for controlling weeds with paraquat was considerably lower than that required for the other treatments. Considering the equipment and chemical input, paraquat application was expensive compared to high slashing with or without clean-line weeding two times a year, or clean weeding two times a year; but by virtue of its efficacy, it is recommended for cocoa establishment.

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RÉSUMÉ

OPPONG, F. K., OSEI-BONSU, K. & AMOAH, F. M. : *Évaluation de quelques méthodes de désherbage pendant la culture initiale de cacao dans la zone de la forêt semi-décidue du Ghana.* En évaluant les effets du quantum et de la qualité de désherbage exigé dans la culture de jeune cacao, six méthodes de désherbage manuel étaient comparées avec le désherbage chimique à deux stations de l'Institut de Recherche en cacao du Ghana. La croissance de semis de cacao, après deux années, dans le champ était supérieure ($P \leq 0.05$) dans les lots qui étaient complètement désherbés 2 ou 4 fois/an ou traités avec le paraquat 4 fois/an que dans les lots qui étaient entaillés 2 ou 4 fois/an. Il y avait de nombreuses preuves qui laissent penser que les traitements qui assuraient un environnement sans mauvaise herbe pour le cacao sur une longue période étaient favorables aux augmentations de circonférence des semis. La mort de semis pendant la culture était dans l'ensemble plus faible dans les lots, qui étaient soit complètement désherbés soit traités avec le paraquat. L'exigence de main-d'œuvre pour maîtriser les mauvaises herbes avec le paraquat était considérablement plus faible que celle exigée pour les autres traitements. En ce qui concerne les matériels et les intrants chimiques, l'application de paraquat était chère que les entaillages élevés avec ou sans le désherbage complet en ligne deux fois par an ou le désherbage complet deux fois par an mais en vertu de son efficacité il est recommandé pour la culture de cacao.

Introduction

Weed control is one of the most important factors in successful cocoa establishment. By their fast regenerative capacity and wide adaptation to the environment, weeds affect the temporary shade needed to create a congenial environment for optimum growth of the cocoa and the cocoa itself. Cocoa growth retardation arising from the competitive stress of weeds at establishment has

been well documented (Mc Kelvie, 1956; Kowal, 1959; Ruinard, 1966; Oppong, Osei-Bonsu & Amoah, 1993). Good establishment in the form of increased girth of seedlings has also been associated with the use of herbicides in cocoa (Walmsley, 1961; Kasasian & Donelan, 1965; Freeman & Ashiru, 1966; Bonaparte, 1966; Brown & Boateng, 1972; Bonaparte, 1977, 1981; Oppong *et al.*, 1995, 2003). However, the practice of

weeding along the cocoa lines and leaving the intervening bush, especially over the dry season (Anon., 1954), is widely advocated by research and extension. Ampofo (1987) has shown that the financial benefit arising from applying paraquat in mature coffee could be as much as 31 per cent over manual weed control. Opong *et al.* (2003) also compared different options for managing weeds during cocoa establishment and had high benefit-cost ratios when paraquat or glyphosate was used for weed control. Bonaparte & Toseafa (1975) found that weed control in rehabilitating cocoa was the most expensive operation, accounting for 23 per cent of total labour input.

This study reports investigations into the effect of frequency, quality, and benefits of some methods of weed control during the early years of cocoa establishment.

Materials and methods

The plot for this study was prepared by stumping old cocoa and clear-felling *Gliricidia sepium* and overgrown forest tree shade on a cocoa plot at the Cocoa Research Institute, Tafo in the Eastern Region of Ghana. The coppiced *Gliricidia* rejuvenated to provide permanent shade. A second trial plot was prepared at Afosu (about 130 km North-West of Tafo) from secondary forest vegetation, but with selective tree-felling to leave about 20 saplings per hectare. At both sites, temporary shade of plantain was planted at 3 m × 3 m in February/March, and 6-month-old mixed hybrid cocoa seedlings were also planted at 3 m × 3 m in June 1988. A completely randomised block design involving seven treatments on 0.0324-ha plots were replicated eight times at Tafo and five times at Afosu. The treatments, which were superimposed 3 months after planting the cocoa, were as follows:

- Treatment 1 – high slashing (15 cm above the ground) of plots, 2 times per year
- Treatment 2 – clean weeding of plots, 2 times per year

- Treatment 3 – high slashing (15 cm above ground) of inter-row bush, 2 times per year followed each time by clean weeding of cocoa lines (1 m wide)
- Treatment 4 – clean weeding of cocoa lines (1 m wide) 4 times a year followed each time by high slashing (15 cm above ground) of the inter-row bush
- Treatment 5 – high slashing (15 cm above ground) of whole plot 4 times per year
- Treatment 6 – clean weeding of whole plot 4 times per year
- Treatment 7 – paraquat (200 SC) applied at 0.4 kg a.i./ha in 300 l of water 4 times per year

Girth measurements were taken with the John Bull portable calipers at 15 cm from the ground. Seedling height was measured from the base of the plant to the apex. These growth measurements were recorded in February, May, August and November each year. Seedling losses arising from death and accidental damage during treatment application were also recorded for the different treatments. Labour used to perform each field operation and the cost of the herbicide and depreciation on the Knapsack spraying machine were also recorded.

Results

Table 1 summarizes data on seedling growth. Generally, height of the seedlings was unaffected by the treatments applied to the young cocoa, except at Afosu where clean weeding two times per year resulted in significantly taller ($P \leq 0.05$) plants than in the high slashing two times per year plus clean-line weeding plots. The quality of weed control, however, significantly influenced ($P \leq 0.05$) girth of the cocoa seedlings. Paraquat application recorded very good weed control and, hence, bigger seedlings. At Tafo, except for clean weeding four times per year, paraquat-treated

plots produced significantly bigger seedlings than those produced from all the other treatments. However, at Afosu, clean weeding two or four times per year produced as much bigger seedlings as those produced from paraquat-treated plots. Girth of seedlings from clean-line weeding four times a year followed by high inter-row slashing was not significantly different from the clean-weeding treatments at Tafo and Afosu. Generally, the Afosu seedlings grew better than the Tafo

cocoa because of insect and weather problems.

Table 2 assesses the relative merit of the different maintenance regimes in successful cocoa seedling establishment. Although, initially, seedling losses seemed to be negligible at both sites in 1988, high slashing two times a year was worse than the other treatments. By 1989, seedling losses in all except paraquat-treated plots at Tafo were over 60 per cent, whilst at Afosu high slashing two times a year with or without

TABLE 1

Establishment of Cocoa Under Different Maintenance Regimes: Seedling Growth Increments (cm), 1988-1990

Treatment	Tafo		Afosu	
	Girth	Height	Girth	Height
T1 - High slashing 2 times year ⁻¹	4.15	26.3	6.66	58.1
T2 - Clean weeding 2 times year ⁻¹	5.56	31.6	10.26	76.1
T3 - High slashing 2 times year ⁻¹ + clean-line weeding	4.41	32.1	7.03	55.2
T4 - Clean-line weeding 4 times year ⁻¹ + high inter-row slashing	5.13	26.2	8.11	67.0
T5 - High slashing 4 times year ⁻¹	4.75	23.2	7.30	61.1
T6 - Clean weeding 4 times year ⁻¹	7.08	26.0	9.78	73.7
T7 - Paraquat applied at 0.4 kg a.i ha ⁻¹ 4 times year ⁻¹	8.59	29.2	10.02	56.9
LSD 5%	2.71	14.2	2.87	20.8

TABLE 2

*Establishment of Cocoa Under Different Maintenance Regimes: Percentage Seedling Losses**

Treatment	Tafo			Afosu		
	1988	1989	1990	1988	1989	1990
T1 - High slashing 2 times year ⁻¹	7.8	70.7	46.9	2.5	22.5	30.0
T2 - Clean weeding 2 times year ⁻¹	3.9	62.1	46.1	0	11.3	33.8
T3 - High slashing 2 times year ⁻¹ + clean-line weeding	2.3	66.8	41.4	0	22.5	36.9
T4 - Clean-line weeding 4 times year ⁻¹ + high inter-row slashing	2.3	68.0	25.8	0	29.4	18.8
T5 - High slashing 4 times year ⁻¹	3.9	63.7	45.7	0	15.0	26.6
T6 - Clean weeding 4 times year ⁻¹	0.8	63.3	19.1	1.3	11.9	25.6
T7 - Paraquat applied at 0.4 kg a.i ha ⁻¹ 4 times year ⁻¹	2.3	33.6	5.5	1.3	13.8	18.8

*Losses computed on complete cocoa stands 2 times during the year (i.e., May-June and August-September)

clean-line weeding recorded the highest losses of 23 per cent. The lowest seedling deaths at Afosu in 1989 were from plots that were clean-weeded two or four times per year, followed by the paraquat-treated plots.

The pattern of seedling losses in 1990 followed a similar trend as in the previous years, with the slashing treatments at Tafo and Afosu recording losses above 40 and 30 per cent, respectively. Clean-line weeding four times a year, followed by inter-row brushing, caused seedling losses of 26 and 19 per cent at Tafo and Afosu, respectively. The paraquat-treated plot at Tafo recorded 6 per cent seedling losses whilst 19 per cent were lost at Afosu. The cumulative losses of seedlings over the 3-year period indicated that, except for the paraquat-treated plots, all other treatments lost over 80 per cent of the planted seedlings in the Tafo trial. However, all lost seedlings were replaced at the beginning of each season to obtain a complete stand in each plot.

Table 3 presents costing over the initial 2-year period of establishing the different treatments at Tafo, based on prices of inputs as at January 2005. High slashing two times a year, with or without clean-line weeding, was the least expensive operation. Clean weeding two times a year was also marginally cheaper than weed control with paraquat. The most expensive method of weed control was clean weeding four times a year.

Discussion

Cocoa, as a perennial crop, has a slow growth habit compared to annuals. Consequently, cocoa demands intensive care during the relatively long establishment period. Although fertilizer and other inputs may be used during this period, weed control has been found to be essential for establishing the temporal shade of food crops and the cocoa. Weed competition as a retardatory factor in cocoa establishment has been reported (Mc Kelvie, 1956; Kowal, 1959; Ruinard, 1966;

TABLE 3

*Establishment of Cocoa Under Different Maintenance Regimes at Tafo: Cost of Application of Treatments During the Initial 2 Years of Establishment**

<i>Treatment</i>	<i>Total no. of applications for 2 years</i>	<i>Total labour (days) treatment⁻¹ for 2 years</i>	<i>Total labour (days) ha⁻¹ for 2 years</i>	<i>Total cost of treatment application ha⁻¹ for 2 years (cedis)</i>
T1 - High slashing 2 times year ⁻¹	4	14.4	55.4	1,108,000
T2 - Clean weeding 2 times year ⁻¹	4	22.4	86.2	1,724,000
T3 - High slashing 2 times year ⁻¹ + clean-line weeding	4	16.8	64.7	1,294,000
T4 - Clean-line weeding 4 times year ⁻¹ + high inter-row slashing	8	33.6	129.3	2,586,000
T5 - High slashing 4 times year ⁻¹	8	28.8	110.9	2,218,000
T6 - Clean weeding 4 times year ⁻¹	8	44.8	172.4	3,448,000
T7 - Paraquat applied at 0.4 kg a.i. ha ⁻¹ 4 times year ⁻¹	8	3.2	12.4	1,759,000 ^α

Calculations were based on prices as at January 2005

*Cost of labour per day = ₵20,000

^α Includes cost of paraquat at ₵60,000 litre⁻¹ applied at 0.4 kg a.i ha⁻¹; cost of machine operation at ₵40,000 day⁻¹; water haulage at ₵20,000 day⁻¹; depreciation on spraying machine at ₵55,000 ha⁻¹.

Oppong *et al.*, 1993, 1995, 2003). Similar observations were reported in this trial. Also in agreement with previous findings, girth increment was found to be a more sensitive test for assessing the benefits of weed control in cocoa than plant height (Kasasian & Donelan, 1951; Freeman & Kowal, 1966; Bonaparte, 1981; Oppong *et al.*, 1995, 2003). Better weed-free environments were provided in these trials by clean weeding either two times or four times a year and by using paraquat; hence, the bigger seedlings produced. Clean-line weeding four times a year, followed by high inter-row slashing, probably benefited from a similar but shorter weed-free period.

These results indicate that any form of weed control, be it frequency or quality or both which does not effectively remove competition from weeds, may not be beneficial to the cocoa. Thus, four times high slashing did not produce bigger seedlings than two times high slashing. That may explain why Bonaparte (1981) did not observe any benefit from high slashing six times a year as compared to two times per year. Thus, the common practice of line brushing and leaving intervening bush (WACRI Pamphlet, 1954) could be improved on by clean-line weeding and high slashing as was applied in this trial.

Replacing seedlings during the establishment of cocoa is a prerequisite to a future good cocoa stand. However, the extent of replacements determines the success of establishment. It is reckoned that about 15 per cent loss of seedlings is acceptable during the establishment years. However, depending on the maintenance practice adopted in this trial, only a few treatments would qualify on annual basis. However, the use of paraquat and its associated weed-free environment apparently resulted in lower replacements than the other treatments. The combination of bad weather and insect attack probably explains the heavy seedling losses recorded at Tafo in 1989 from all treatments. Compared to Afosu, clearly the probable cause of seedling losses in 1989 was influenced by the

treatments. However, it was surprising to incur such heavy loss of seedlings 2 years after planting at both sites.

The most important factor to the farmer in these different maintenance regimes is the cost. High slashing two times per year either with or without clean-line weeding seemed to be the cheaper treatment. However, apparently two times clean weeding per year compared favourably with paraquat application as alternative low input treatments. Considering the fact that two times high slashing per year resulted in heavy seedling losses and did not favour cocoa growth in the long-term, this may not be a treatment to recommend. Paraquat application incurred a modest cost input with good seedling growth rate and fewer replacements, and seemed to be the best treatment. This confirmed earlier reports by Friessleben, Pohlen & Franke (1991) and Oppong *et al.* (2003). But herbicide technology is not widespread among rural farmers.

Clean weeding four times a year seems to be the next best treatment in seedling growth and survival, but the cost to the farmer is high; it is almost two times the cost incurred compared to when paraquat is used to control the weeds. Two times clean weeding per year affords good seedling growth and is cheap, but again the survival rate is low. The next alternative then is clean-line weeding four times a year coupled with high inter-row brushing. It is 47 per cent more expensive than the use of paraquat, but gives satisfactory growth compared to clean weeding (2 or 4 times), and seedling survival rate is comparable to clean weeding four times a year. The important factor will then be to ensure that the clean traces have adequate width of 1m or more to effectively remove weed competition from the cocoa.

Conclusion

Clean weeding two or four times per year or applying paraquat four times per year impacted positively on growth of cocoa seedlings after 2 years in the field compared to when plots were

slashed two or four times per year. Paraquat-treated plots had lower seedling mortality than the other treatments. Considerably lower labour was required to control weeds with paraquat than that required for the other treatments. Considering equipment and chemical input, paraquat application was expensive compared to high slashing with or without clean-line weeding two times a year, or clean weeding two times a year; but by virtue of its efficacy, it is recommended for cocoa establishment. Alternatively, clean-line weeding four times a year coupled with high inter-row brushing 1 m wide, although more expensive than paraquat application, could be used because growth of cocoa seedlings was satisfactory as compared to clean weeding (2 or 4 times).

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