Comparison of methods of field planting on cocoa seedling survival and early growth in a marginal cocoa-growing area of Ghana

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ABSTRACT

Cocoa seeds were planted at stake at different times to determine the best time for optimum establishment at the Cocoa Research Institute of Ghana substation at Afosu, considered as a marginal cocoa-growing area owing to its prolonged dry season. The treatments evaluated were planting hybrid cocoa seeds at stake in either April, May, June, July or September; and polythene bag or bare-root transplanting of 5-month-old hybrid cocoa seedlings in May or June, respectively. The trial was laid out as randomized complete block with seven treatments and five replicates. Each plot measured 24 m × 18 m and contained 48 plants. The results recorded over 3 years (1999-2001) showed significantly higher ($P \leq 0.01$) seedling survival rates in the polythene bag-transplanted seedlings than in seedlings from seeds sown at stake. There were no significant differences between the survival rates of seedlings from seeds sown at stake from April to July. The average percentage seedling survival after the first dry season for seeds sown at stake from April to July over the 3-year period (1999-2001) was 60 per cent compared to 57 per cent for bare-root and 81 per cent for polythene bag-transplanted seedlings. There were no significant differences between the girth increments of the seedlings, implying that once established, there may be no differences in the rates of growth of transplanted seedlings and those sown at stake. It is concluded that bare-root transplanting of cocoa seedlings and planting cocoa seeds at stake are feasible options in marginal cocoa-growing areas if such activity is properly timed to coincide with the rains. However, the polythene bag method of transplanting cocoa seedlings remains the best option for field planting of cocoa in marginal cocoa-growing areas of Ghana.

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RÉSUMÉ

OPPONG, F. K. & OPOKU-AMEYAW, K.: *Comparaison de méthodes de plantation au champ sur la survie de semis de cacao et la croissance précoce dans une zone marginale de la culture de cacao au Ghana.* Les féves de cacao étaient semées et soutenues à l'aide d'un tuteur aux moments différents à Afosu, une sous-station de l'Institut de Recherche en Cacao du Ghana qui est considérée une zone marginale de la culture de cacao en raison de la longue durée de sa saison sèche pour déterminer le meilleur temps pour l'enracinement optimum. Les traitements évalués étaient; la plantation de fèves de cacao hybride soutenues à l'aide d'un tuteur soit en avril, mai, juin, juillet soit en septembre et le repiquage à sachet en plastique ou à racine-nue de semis de cacao hybride âgé de 5 mois respectivement en mai ou en juin. L'essai était dessiné comme un bloc complet choisi au hasard avec sept traitements et cinq replicatifs. Chaque lot avait une mesure de 24 m × 18 m et contenait quarante-huit plantes. Les résultats obtenus sur une période de trois ans (1999-2001) montraient un taux de survie de semis considérablement plus élevé (P £ 0.01) dans les semis repiqués à sachet en plastique que dans les semis de fèves semées et soutenues à l'aide d'un tuteur d'avril à juillet. Le pourcentage moyen de la survie de semis après la première saison sèche pour les fèves semèes et soutenues à l'aide d'un tuteur d'avril à juillet sur la pèriode de 3 ans (1999, 2000, 2001) était 60% comparé à 57% et 81% respectivement pour les semis repiqués à racine-nue et à sachet en plastique. Il n'y avaient pas des différences considérables entre les augmentations de circonférence des semis, signifiant qu'une fois établi, il n'y aura pas, peut-être, de différences entre les taux de croissance de semis repiqués et les semis semés et soutenus à l'aide d'un tuteur. La conclusion est tirée que le repiquage de semis de cacao à racine-nue et la plantation de fèves de cacao et soutenue à l'aide d'un tuteur sont des options faisables dans les zones marginales de la culture de cacao si cette activité est bien exécutée avec un bon timing pour coïncider avec la saison des pluies. Toutefois, le repiquage de semis de cacao par la méthode de sachet en plastique reste la meilleure option pour la plantation de cacao sur le terrain dans les zones marginales de la culture de cacao au Ghana.

Introduction

In Ghana and most cocoa-producing countries, it is recommended that field planting of cocoa is done by transplanting 5 to 6-month-old seedlings raised in polythene bags or on nursery beds with a "ball of earth" around the roots (Benstead, 1950; Freeman, 1965; Wood & Lass, 1985; Manu & Tetteh, 1987). However, owing to the high cost of transporting polythene bag-nursed cocoa seedlings for field planting, the bare-root method of transplanting seedlings was recommended to reduce the cost of transporting seedlings to the farm for planting (Esan, 1981; Alvim, Lima Filho & Alfonso, 1981; DeSouza *et al*., 1981a, 1981b; Amoah *et al*., 1999). The survival rate of bare-root transplanted seedlings is, however, highly dependent on accurate weather forecast; with high seedling survival rate if it rains a day or two after transplanting (Amoah *et al.*, 1999).

Although planting cocoa seeds at stake is one of the recommended field planting methods of cocoa (Manu & Tetteh, 1987), extension advice has, over the years, been skewed against its adoption by farmers; because it is perceived to be associated with several disadvantages. These disadvantages include wastage of hybrid seeds as farmers sow more seeds than required as insurance against losses, high seedling mortality due to rodent damage, and low vigour in the initial seedling growth due to competition with weeds for water, nutrients and light. However, in spite of these disadvantages, direct field planting of hybrid cocoa seeds was still prevalent in most resource-poor Ghanaian cocoa-farming communities, because these farmers found the practice more economical, being devoid of nursery work and its attendant labour required for tending seedlings, watering and transporting them from the nursery for field planting (Henderson & Jones, 1990). In studies to re-appraise direct planting of hybrid cocoa seeds in the context of the changing weather pattern in Ghana, Oppong *et al.* (1999) reported that in spite of the unreliable rainfall pattern, direct planting of hybrid cocoa seeds was still feasible in areas considered as very conducive to cocoa production, but emphasized that adequate shade should be established 1 year ahead of field planting of hybrid seeds.

Owing to the over-exploitation of forest resources and the bushfires of the early 1980s that destroyed many cocoa farms in Ghana, areas that were hitherto congenial for cocoa cultivation in Ghana are now considered as marginal with few forest trees to provide shade for cocoa. With the efforts by the Cocoa Research Institute of Ghana to encourage farmers now to reactivate cocoa production in the old cocoa-producing areas instead of migrating to the few remaining forested lands to establish new cocoa farms, it is essential to re-assess the feasibility of direct seeding of hybrid cocoa as against other field planting methods in these areas.

This study was, therefore, aimed at determining the appropriate time for planting cocoa seeds at stake in a marginal cocoa-growing area of Ghana for optimum establishment.

Materials and methods

Site

The trial was set up at the Afosu substation of the Cocoa Research Institute of Ghana in the Eastern Region between February 1998 and April 2001. The location, considered a marginal area for cocoa cultivation because of its uneven rainfall distribution and prolonged dry season, has a soil type classified as Ferric Lexisol (FAO/ UNESCO, 1977).

Cultural practices

Land was prepared in February 1998 and temporary shade of plantain was planted at 3 m × 3 m in mid-March 1998. Additional shade was provided by planting 2-month-old *Flemingia macrophylla* seedlings in March 1998 at 1.5 m × 1.5 m in the inter-rows of the cocoa stands in all the plots. Eight evenly distributed assorted forest tree species provided permanent shade in the experimental plot. Each of the experimental plots was weeded three to four times per annum.

Experimental design and treatments

The trial was laid out in a randomized complete block design with seven treatments and five replicates. Each plot consisted of 48 stands of cocoa. The treatments that were studied included direct planting of hybrid cocoa seeds at different periods within the year, April (T1), May (T2), June (T3), July (T4) and September (T5); bare-root transplanting of 5-month-old seedlings in June (T6); and transplanting of 5-month-old seedlings raised in 17.5 cm × 25 cm polythene bags in May (T7). Treatments 6 and 7 were used as controls. The cocoa in all the treatments were planted at distances of 3.0 m × 3.0 m. The experiment was repeated in 1999 and 2000, using the same methods and experimental design.

Data collection and analysis

Data on seedling emergence of seeds sown at stake, girth and height of seedlings at quarterly intervals, seedling survival after the dry season, percentage of rodent-damaged seedlings, percentage of seedlings damaged during weeding, the amount of rainfall, and the number of wet days per month during the period of the trial were recorded. The data were subjected to statistical analysis using Minitab Version 12.2 statistical package.

Results

Cocoa seedling survival

Table 1 shows the percentage seedling survival of cocoa planted at stake or transplanted in 1998, 1999 and 2000. Seedling survival after the 1999 dry season was highest in the polybag (T7) and bare-root (T6) treatments, followed by T4 in which cocoa seeds were sown at stake in July. The percentage survival of plants from seeds sown at stake in September (T5) was significantly lower ($P \leq 0.01$) than when seeds were transplanted using the polybag (T7) and bare-root (T6) methods, or planted at stake in July (T4). Seeds sown at stake from April to July recorded high percentage survival (over 72%) compared to when seeds were sown at stake in September (Table 1). Rainfall at Afosu for 1998-1999 was high and well distributed (Fig. 1). Seedling survival of cocoa planted in 1998 was monitored for another year until the end of the second dry season in 2000. Afterwards, seedlings transplanted as either bare-root (T6) or from polythene bags (T7) had the highest percentage survival (Table 1). Losses of seedlings after the second dry season were highest (22.9%) in Treatment 5 in which seeds were sown at stake in September 1998. The least number of seedling losses between the first (1999) and second (2000) dry seasons after the 1998 plantings were recorded in the polybag-transplanted seedlings (T7 [3%]) and those planted at stake in July (T4 [4.1%]).

The percentage survival of seedlings after the dry season in March 2000 when the trial was repeated in 1999 was low across all treatments as compared to that of the 1998 trial (Table 1). The highest survival of seedlings was recorded in those transplanted from polythene bags (T7). Significantly lower ($P \leq 0.01$) seedling survival was recorded in the bare-root-transplanted treatment (T6) than in the other treatments. Rainfall in the dry season of 1999 to 2000 was low with a total of only 22.8 mm from December 1999 to February 2000; with only 3 wet days as compared to 170.7 mm for the same period during the 1998-1999 dry season with 8 wet days (Fig. 1 and 2).

Except for Treatment 6 (bare-root method) and Treatment 7 (polythene bag method), the repeat trial of 2000 showed lower seedling survival after the dry season in March 2001 as compared to that of the previous years (Table 1). Seedlings from seeds sown at stake in September (T5) had significantly lower ($P \leq 0.05$) percentage seedling survival than those of Treatments 6 and 7. Rainfall was very low from December 2000 to February 2001 during which only a total of 16.1mm was recorded for the 3-month period (Fig. 1). The mean percentage survival of seedlings after the dry seasons of the 3-year trial confirmed the polythene bag ('ball of earth') method as the most superior treatment. There were no significant differences

TABLE 1

Effect of Time of Planting Cocoa Seeds at Stake on Percentage Seedling Survival After Each Dry Season (1999-2001)

Treatment	*% survival as at*				
	Feb. 1999 after planting in 1998	*March 2000 after planting in 1998*	*March 2000 after planting in 1999*	*March 2001 after planting in 2000*	*Mean 1999-2001*
T1 – Planting cocoa seeds at stake in April	75.4 (60.8)	68.3 (56.1)	56.3 (48.8)	49.3 (44.6)	60.2 (50.9)
T2 – Planting cocoa seeds at stake in May	75.0 (60.1)	61.7 (52.1)	55.0 (47.9)	44.2 (41.6)	59.4 (50.5)
T3 – Planting cocoa seeds at stake in June	72.9 (59.0)	56.2 (48.8)	53.3 (47.1)	54.7 (47.7)	60.7 (51.2)
T4 – Planting cocoa seeds at stake in July	85.4 (68.2)	81.3 (65.1)	50.4 (45.1)	48.9 (44.3)	63.2 (52.8)
T5 – Planting cocoa seeds at stake in September	62.5 (52.8)	39.6 (38.0)	59.2 (50.3)	34.4 (35.5)	52.9 (46.7)
T6 - Bare-root method of planting cocoa seedlings in June	96.3 (79.2)	82.9 (65.3)	19.4 (19.4)	68.0 (55.7)	57.5 (49.3)
T7 – Polythene bag method of planting cocoa seedlings in May	99.2 (85.6)	96.2 (80.8)	73.8 (59.9)	66.0 (54.8)	81.6 (65.6)
Significance level	**	**	**	*	**
SED (24 df)	(4.61)	(6.52)	(4.71)	(5.28)	(3.42)

(**) = significant at $P \leq 0.01$; (*) = significant at $P \leq 0.05$
Values in bracket are angular transformations of percentage seedling survival values

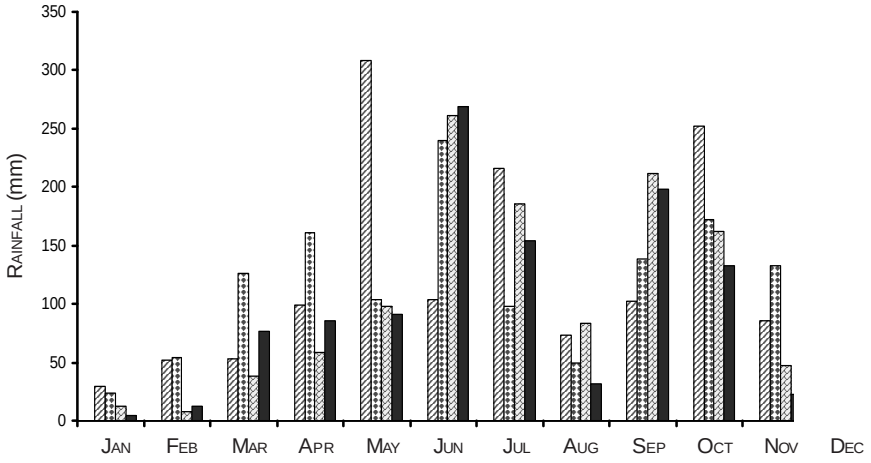

Fig. 1. Total monthly rainfall (mm) recorded at Afosu from 1998 to 2001.

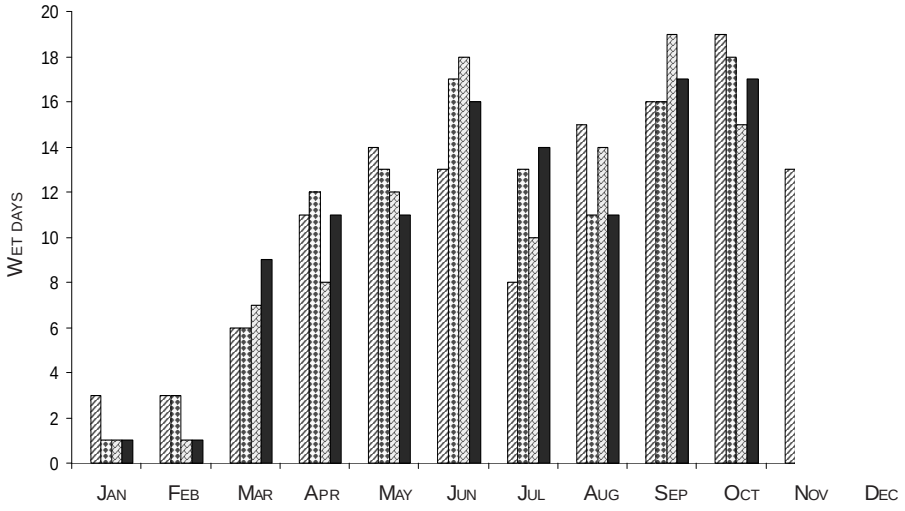

Fig. 2. Number of wet days per month at Afosu from 1998 to 2001.

in seedling survival between the times of planting cocoa seeds at stake from April to July. Planting in September recorded a lower mean percentage survival value than in the other treatments (Table1), although rainfall was high with relatively high number of wet days in September and October from 1998 to 2001 (Fig.1 and 2).

Cocoa seedling growth

Table 2 presents the girth and height increments recorded from April 1999 to March 2000 on the seedlings established in 1998. There were no significant differences between the girth increments of the cocoa seedlings, but the height increments of seedlings were significantly different. Seedlings from seeds sown at stake in April (T1), May (T2) and July (T4), or transplanted in May (T7) or June (T6) were significantly ($P \leq 0.05$) taller than seedlings sown at stake in September (T5).

Discussion

The results for the 3-year period of the trial confirmed earlier observations that the polybag ('ball of earth') method of transplanting cocoa seedlings was a more superior field planting method of cocoa establishment than all the other methods (Benstead, 1950: Freeman, 1965). Averaged over the three trials, percentage seedling survival in the polythene bag method of transplanting in the study area, considered marginal in rainfall distribution required for good cocoa establishment, was over 80 per cent. This compares well with the average of 92.5 per cent seedling survival from polythene bag-transplanted cocoa reported by Amoah *et al.* (1999) in a relatively high rainfall area of Ghana.

Although one would have expected very high adoption of the polybag method of transplanting cocoa to ensure good establishment and low seedling mortality, its use, especially by resource-poor farmers, has been low because of the high capital outlay involved in raising the seedlings at the nursery and then transporting them to the field, which may be several kilometres away, for planting (Henderson & Jones, 1990; Donkor, Henderson & Jones, 1991). The bare-root method of transplanting, which enables easy transportation of many seedlings per trip to the farm at relatively minimal cost was, therefore, recommended as an alternative to the 'ball of earth' method (Esan, 1981; Alvim *et al.*, 1981; DeSouza

TABLE 2

Effect of Time of Planting on Growth (from April 1999 to March 2000) of Cocoa Seedlings Planted in 1998

Treatment	*Girth increment (mm)*	*Height increment (cm)*
T1 – Planting cocoa seeds at stake in April	7.8	59.9
T2 – Planting cocoa seeds at stake in May	7.2	60.5
T3 – Planting cocoa seeds at stake in June	6.9	55.3
T4 – Planting cocoa seeds at stake in July	7.7	66.8
T5 – Planting cocoa seeds at stake in September	5.4	38.9
T6 – Bare-root method of planting cocoa seedlings in June (control)	7.3	54.2
T7 – Polythene bag method of planting cocoa seedlings in May (control)	7.2	45.2
Significance level	ns	*
SED (24 df)	-	8.1

ns = non-significant at $P \leq 0.05$; (*) = significant at $P \leq 0.05$

et al., 1981a, 1981b; Amoah *et al*., 1999).

Esan (1981) and Amoah *et al.* (1999) reported 90 and 69 per cent seedling survival for the bare-root methods of transplanting in Nigeria and Ghana, respectively, in cocoa-growing areas with relatively high rainfall. In this study, an average of 57 per cent was recorded in a marginal cocoa-growing area of Ghana with prolonged dry season and uneven rainfall distribution. This confirmed an earlier caution that the success of the bare-root method of transplanting cocoa was highly dependent on accurate prediction of rainfall, and it is important that transplanting is accurately timed to coincide with the rains a day or two after planting (Amoah *et al.*, 1999). This might well explain the poor establishment of bare-root-transplanted cocoa in the second trial in 1999-2000, because there was a sudden break in rainfall for over 10 days after transplanting in early June 1999. Although rainfall, thereafter, was very heavy with high number of wet days per month up to November 1999 (Fig. 2), the bare-root-transplanted seedlings could not survive the initial transplanting shock when there were no rains immediately after planting.

However, seeds sown at stake in June 1999, at the same time that the bare-root seedlings were transplanted, had over 50 per cent survival after the following dry season. It would, therefore, seem reasonable to suggest that in a marginal cocoa-growing area with similar conditions as the study area, cocoa seeds sown at stake may stand a better chance of having more emerged seedlings surviving, should there be no rains for about a week after sowing, as compared to the bare-root-transplanted seedlings which may adversely suffer without rains for about a week after transplanting.

The poor survival of cocoa seedlings from seeds sowed in September in spite of the relatively high rainfall and high number of wet days may be because the seedlings did not have ample time to harden before meeting the harsh conditions of the dry season from December to February. The average seedling survival rate of 60 per cent (from April to July over the three trials) from seeds sown at stake compared favourably with that of the bare-root-transplanted seedlings over the same period. As suggested by Oppong *et al.* (1999), at this rate of seedling survival from cocoa seeds sown at stake, a farmer would achieve the final population of cocoa stands in 2 to 3 years, which is normal for establishing a new cocoa farm in Ghana.

The lack of significant differences in the girth increments of the cocoa seedlings in the different treatments and the fact that the polybag-transplanted seedlings had lower height increments than those planted at stake from April

to July confirmed earlier observations that, once established, there may be little or no differences in the rate of plant growth. There is no evidence to indicate that farms established from transplanted seedlings eventually yield more than those established from seeds sown at stake (Vernon, 1969).

Conclusion

The results of this study indicated that cocoa seedlings established from seeds sown at stake between April and July in marginal cocoa-growing areas have a better chance of most seedlings surviving the dry season than those sown in September. However, adequate overhead shade should be provided to reduce seedling mortality during the dry season. Planting cocoa seeds at stake in September could result in heavy seedling losses during the following and subsequent dry seasons, and should be avoided. The studies confirmed that the 'ball of earth' method, although perceived as expensive by farmers, is the best method of planting cocoa in the field. Furthermore, the studies confirmed the earlier caution (Amoah *et al.*, 1999) that the success of the bare-root method of transplanting cocoa seedlings depends on the availability of adequate moisture in the soil for a considerable period after planting.

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