

The effect of time of planting at stake on cocoa seedling survival

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SUMMARY

Studies were conducted at the Cocoa Research Institute of Ghana, Tafo and its sub-station at Bunso, from 1994 to 1997 to re-appraise the success of cocoa establishment from seeds sown at stake at specified times of the year before the onset of the dry season. The treatments consisted of four times within the year when seeds were sown at stake, namely April, June, and September. Seedlings raised in polyethylene bags were transplanted to serve as the control. The experiments were repeated every year for 3 years. During the 1995/96 season, the experiments were set up either under shade established one year earlier, or established in the same year as the cocoa seeds were sown at stake. Emergence of germinated cocoa seeds from the soil was generally high and independent of the time of sowing. However, survival of cocoa seedlings from seeds sown in April, June, and July was higher than when seeds were sown in September. Establishing shade one year ahead of sowing seeds at stake improved the survival rate of the cocoa seedlings. Seedling losses due to mammalian or accidental damage during weeding was minimal. The results show that in spite of the unreliable rainfall pattern in Ghana, planting at stake is still feasible in cocoa-growing areas of Ghana with similar climatic conditions as the locations used for this experiment. However, for high percentage survival of seedlings, adequate shade must be established at least one year in advance to protect the young seedlings during the dry season.

RÉSUMÉ

OPPOUNG, F. K., OPOKU-AMEYAW, K., OSEI-BONSU, K., AMOAH, F. M., BREW, K. M. & ACHEAMPONG, K.: *L'Effet du temps de plantation contre le tuteur sur la survie du semis de cacao*. Des études se sont déroulées à l'institut Ghanéen de Recherche en cacao à Tafo et sa sous-station à Bunso, de 1994 à 1997 pour réévaluer le succès de l'enracinement de cacao à partir de graine semée contre le tuteur aux temps spécifiques de l'année avant le début de la saison sèche. Les traitements comprenaient quatre différents temps de l'année pendant que les graines sont semées contre le tuteur à savoir, Avril, Juin, Juillet et Septembre. Les semis cultivés en sacs polyéthylènes étaient transplantés pour servir comme le contrôle. Les expériences étaient répétées chaque année pour 3 ans. Au cours de la saison de 1995/96 les expériences étaient établies soit sous l'ombrage établi une année d'avance soit établi dans la même année où les graines de cacao étaient semées contre le tuteur. L'apparition des graines de cacao poussées du sol était généralement élevée et ne dépendait pas du temps de semences. Cependant la survie du semis de cacao de graines semées en Avril, Juin et Juillet était plus élevée que celle des graines semées en Septembre. La plantation d'ombrage une année à l'avance de semences de graines contre le tuteur améliorait la proportion de survie du semis de cacao. La perte de semis dû au ravage mammifère ou au ravage accidentel, pendant le désherbage, était minimale. Les résultats montrent que malgré le régime pluvial irrégulier au Ghana, la plantation contre le tuteur reste encore faisable dans les zones de la cultivation de cacao du Ghana ayant les conditions climatiques semblables aux emplacements utilisés pour l'expérience en question. Toutefois, pour un pourcentage élevé de la survie des semis, les plantes d'ombrage adéquat doivent être plantées au moins une année à l'avance pour protéger les jeunes semis pendant la saison sèche.

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Introduction

The Cocoa Research Institute of Ghana recommends field planting of cocoa either from seedlings in polybags, raised on nursery beds, or sowing seeds at stake (Manu & Tetteh, 1987). In spite of the latter recommendation, technical advice to farmers has mainly emphasized the use of seedlings for planting. Disadvantages of sowing cocoa seeds at stake include wastage of hybrid seeds, uneven germination, high initial mortality, high incidence of rodent damage, and low vigour in the initial growth. Seedling mortality of cocoa seeds sown at stake at the Cocoa Research Institute of Ghana in the 1940s ranged from 16.7 to 34.5 per cent after the first dry season with very negligible losses of 1-4 per cent during the 2nd year of establishment (Anon., 1948).

Several reports suggest that the survival and subsequent growth of seeds sown at stake depend on the time of sowing. Freeman (1964) had 65.5, 56.9, and 80.6 per cent survival after the first dry season in seeds sown at stake in May, June and July, and survival rates of 60, 54.4 and 75 per cent, respectively, after the second dry season. Brown *et al.* (1971) made similar observations and reported adequate seedling survival rate in April, May, and November. The sowing of cocoa seeds at stake has been advocated for filling gaps in established plantations, since nursery seedlings have to be headloaded for several kilometres (Freeman, 1964; Brown *et al.*, 1971). Apart from the initial advantages of early establishment and growth of polybag-transplanted seedlings, there is inadequate experimental evidence to show that such advantages over plants from seeds sown at stake are maintained in terms of yield potential in the long term (Vernon, 1969).

The production of hybrid cocoa seeds mainly between October and January in Ghana necessitates the raising of cocoa seedlings in the nursery. However, due to the cost involved, most farmers still resort to planting cocoa seeds at stake during the major rainy season with F2 and F3

hybrid materials which are capable of producing pods throughout the year. It is, therefore, possible for the Seed Gardens to produce and supply hybrid pods in the early months of the wet season for farmers interested in planting cocoa at stake.

Owing to the inconsistent rainfall pattern and changes in ecological conditions resulting from the over-exploitation of forest resources in the cocoa-growing areas of Ghana, it is important to reappraise the success of cocoa establishment from seeds sown at stake at specified times of the year before the onset of the harmattan (from December to the end of March).

Materials and methods

The trial was set up at two sites of the Cocoa Research Institute of Ghana, Tafo (Plots G9 and F8) and Bunso (Plots 1, 2 and 3) between March 1994 and March 1997. The treatments consisted of four times within the year when seeds were sown at stake, namely April (T1), June (T2), July (T3), and September (T4). In the 1994/95 season, two seeds were sown per hole at 3.0 m × 3.0 m in plots measuring 324 m², giving 36 stands per treatment. However, in the subsequent years, the seeds were sown at 1.5 m × 1.5 m in 324 m² plots, giving 49 stands per treatment. The treatments were repeated at both locations in the 1995/96 and the 1996/97 seasons. In the 1st year of the trial, 6-month-old seedlings raised in polybags were transplanted in May 1994 as the control (T5). However, in the subsequent years, 49 6-month-old seedlings raised in polybags were transplanted each time seeds were sown at stake, to serve as the control (T5).

In 1995/96, two trials were established at each location. In the 1st trial, the cocoa seeds were planted at different times under *Glyricidia sepium* (spaced at 6 m × 6 m) and *Flemingia macrophylla* (spaced at 1.5 m × 1.5 m) shade which had been established one year earlier. In the 2nd trial, the cocoa seeds were planted under *Glyricidia sepium* shade which was spaced at 6 m × 6 m established

in the same year as the cocoa seeds were sown. The experiments were designed as randomized complete block with five replications. Data on percentage seedling emergence, percentage survival of plants after the first dry season (end of March), 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.

Results

Seedling emergence and survival

Emergence of germinated cocoa seeds from the soil one month after sowing was generally high for all the treatments, ranging from 62 to 95 per cent over the 3-year period, with the exception of the planting at Tafo in July 1994 (33.9 per cent) and at Bunso in September 1994 (26.7 per cent) where percentage emergence of seedlings was very low. Emergence of germinated seedlings from the soil usually continued until the 6th week. After seedling emergence, a gradual reduction in the number of seedlings in all the treatments was observed, with the greatest reduction recorded in the dry months of January, February, and March. In 1994/95, the survival of seedlings after the dry season was very low at both locations, ranging between 8.9 (July planting) and 30.5 per cent (June planting) at Tafo, and 9.2 (September planting) and 33.3 per cent (April planting) at Bunso. However, 6-month-old cocoa seedlings transplanted in May 1994 as the control had 75.6 and 56 per cent survival after the dry season at Tafo and Bunso, respectively (Fig. 1 and 2; Table 1).

In the 1995/96 plantings, seedling

survival was generally higher in plots where shade was established 1 year in advance than in plots where shade was established in the same year when the seeds were sown. The transplanted seedlings used as control also survived better under shade established 1 year ahead (Fig. 3, 4, 5 and 6). At Tafo, in plots where shade had been previously established, survival of seedlings after the harmattan was above 90 per cent for seeds sown in April and June, with plantings in July and September recording 62 and 80 per cent survival, respectively. At Bunso, percentage seedling survival, after the dry season were 78.3, 59.2, 53.3, and 66.7 per cent for seeds sown in April, June,

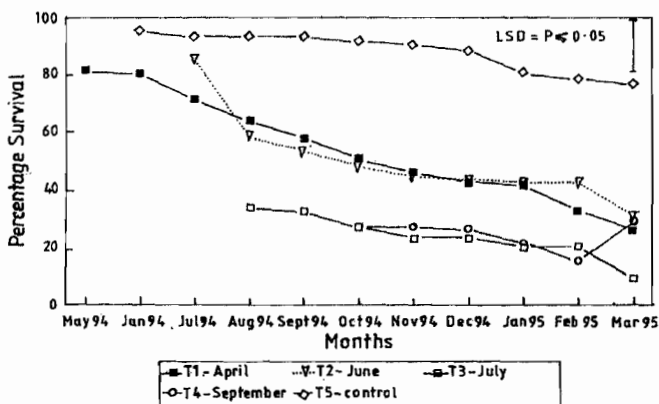


Fig. 1. Percentage survival of cocoa seedlings planted at stake at different times of the year (Plot G9, Tafo, 1994/95).

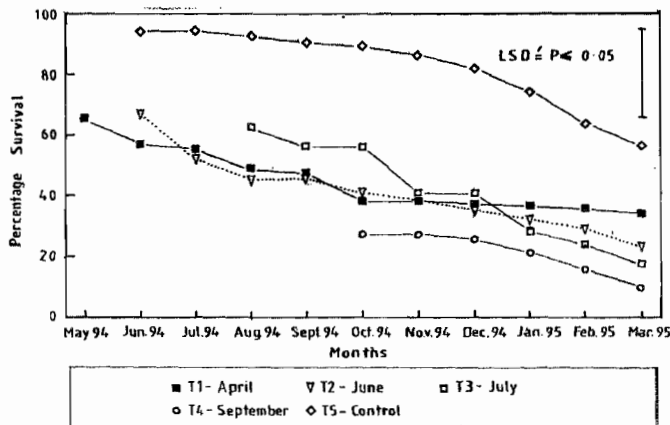


Fig. 2. Percentage survival of cocoa seedlings planted at stake at different times of the year (Plot 1, Bunso, 1994/95).

July, and September, respectively (Fig. 3, 4, 5, 6; Table 1).

In the 1996/97 season, seedling survival after the dry season averaged 75, 72 and 77 per cent for seeds sown in April, June and July, respectively, at Tafo whereas percentage survival of 62.8, 60.8 and 62 for April, June and July, respectively, were recorded at Bunso. Seeds sown in September 1996 had percentage seedling survival of 38.4 and 42.5 at Tafo and Bunso, respectively, after the dry

season (Fig. 7 and 8; Table 1).

Mammalian and accidental damage of seedlings

Damage of seedlings by mammals was mainly by decapitation of the shoot at ground level, and this ranged between 1 and 16 per cent at both locations, but the results for the times of sowing did not follow any definite pattern. The shade levels in the plots had no influence on the degree of mammalian damage to the seedlings. Percentage

TABLE 1
Effect of Time of Planting at Stake on Percentage Seedling Survival after Major Dry Season

Treatment	Percentage survival							
	Bunso Plot 1		Bunso Plot 2	Bunso Plot 3	Plot G9; Tafo		Plot F8; Tafo	Plot F10; Tafo
	1995	1996	1996	1997	1995	1996	1996	1997
T1 (Apr)	33.4 (33.5)	78.3 (62.8)	46.1 (42.4)	62.8 (52.4)	25.6 (29.9)	93.3 (75.5)	23.9 (28.5)	75.9 (61.4)
T2 (Jun)	22.5 (50.9)	59.1 (50.4)	51.7 (45.8)	60.8 (51.3)	30.6 (33.2)	92.2 (75.8)	48.8 (44.2)	72.7 (58.8)
T3 (Jul)	16.7 (23.8)	53.3 (46.9)	71.1 (57.6)	62.0 (52.1)	8.9 (16.9)	80.0 (63.9)	47.2 (26.7)	77.2 (62.5)
T4 (Sep)	9.2 (17.1)	66.7 (61.0)	54.4 (47.6)	42.4 (40.6)	28.9 (29.3)	62.2 (52.5)	26.7 (30.7)	38.4 (38.1)
T5 (May-control)	56.0 (48.6)	97.7 (82.2)	82.8 (65.9)	90.8 (72.7)	75.6 (61.0)	91.7 (73.8)	75.0 (60.3)	85.2 (68.0)
Sig. level	(ns)	(**)	(***)	(***)	(***)	(***)	(***)	(***)
Sed: (12df)	(6.36)		(4.57)	(3.46)	(16.36)	(4.19)	(4.57)	(5.56)
(16df)								

NS = Not significant (** = Significant at $P = 0.05$ (***) = Significant at $P = 0.01$)

Transformed values are in parenthesis

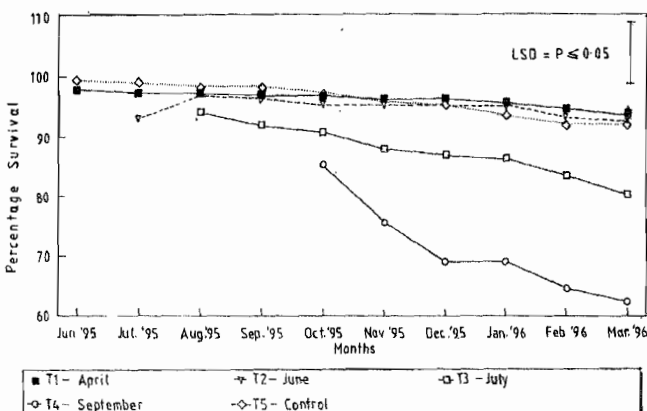


Fig. 3. Percentage survival of cocoa seedlings planted at stake at different times of the year (Plot G9, Tafo, 1995/96).

of seedlings which were accidentally damaged during weeding ranged between 0.4 and 1.3 over the three seasons at both locations.

Discussion

The most important factors which affect the survival of cocoa seedlings raised from seeds sown at stake are the availability of adequate soil moisture and adequate shade during the dry season months of December - March. The severe and prolonged 1994/95 dry season resulted in the poor survival of seedlings. At Bunso,

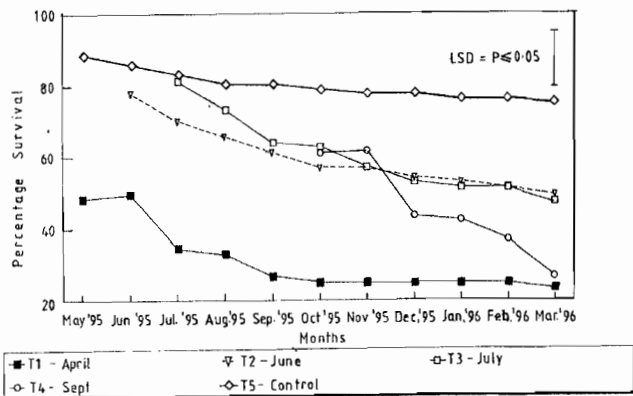


Fig. 4. Percentage survival of cocoa seedlings planted at stake at different times of the year (Plot F8, Tafo, 1995/96).

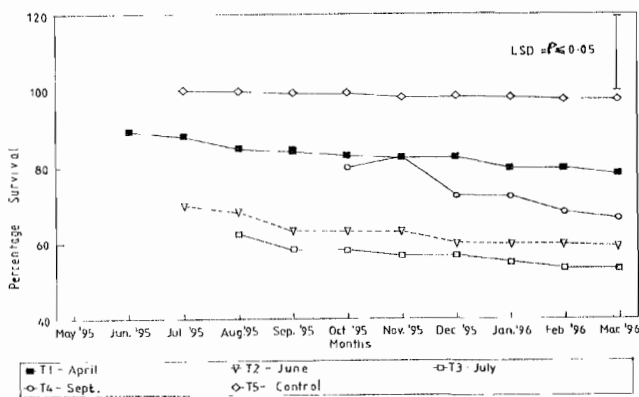


Fig. 5. Percentage survival of cocoa seedlings planted at stake at different times of the year (Plot 1, Bunso, 1995/96).

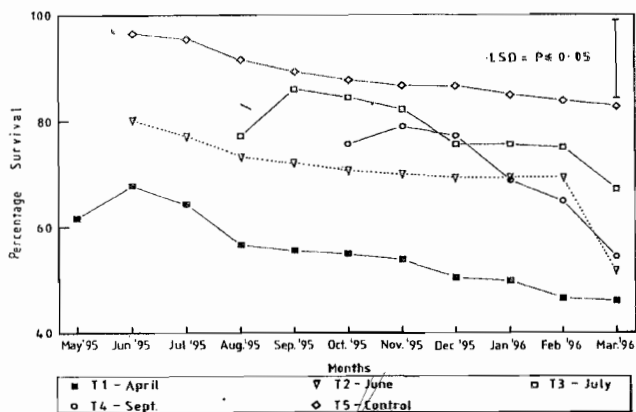


Fig. 6. Percentage survival of cocoa seedlings planted at stake at different times of the year (Plot 2, Bunso, 1995/96).

there was no precipitation in December 1994, and only a total rainfall of 26.5 mm was recorded in January and February with only three wet days over the 3-month dry period (Table 2). Similar conditions were observed at Tafo where there was no rainfall in December 1994 and January 1995, and only 4.9 mm of rain in February 1995 (Table 3). Under such harsh conditions, transpiration from the cocoa seedlings, coupled with inadequate moisture in the soil, might have resulted in the poor survival of seedlings.

The establishment of shade 1 year before sowing the cocoa beans in the 1995/96 season, coupled with the relatively mild dry season, might have accounted for the high percentage survival of seedlings at both locations. This is because the number of seedlings which survived in plots where shade was established in the same year as the seeds were sown were lower at all times of sowing than in plots where shade was well established 1 year in advance before the seeds were sown. In the early days of cocoa cultivation in Ghana, there were enough suitable forest trees to provide shade for young cocoa plants during the dry season. Such conditions are lacking due to the loss of most of the forest trees in cocoa-growing areas of Ghana through indiscriminate exploitation. The results imply that with the present variable rainfall pattern and prolonged dry seasons, there is the need to pre-establish shade for at least 1 year before cocoa beans are sown at stake.

The sowing of cocoa seeds during the major rainy season from April to

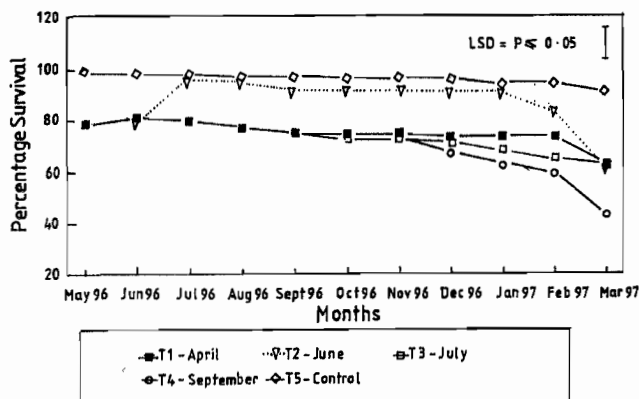


Fig. 7. Percentage survival of cocoa seedlings planted at stake at different times of the year (Plot 3, Bunso, 1996/97).

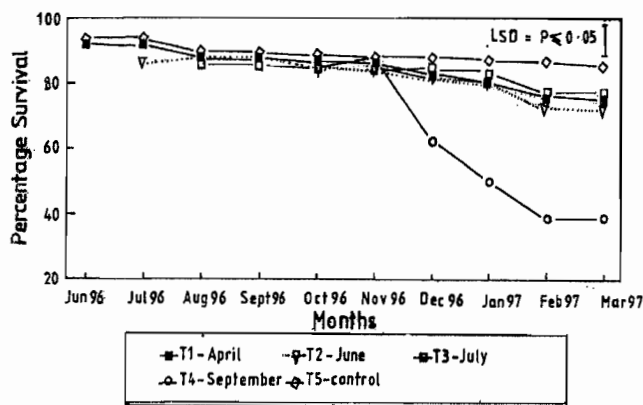


Fig. 8. Percentage survival of cocoa seedlings planted at stake at different times of the year (Plot F10, Tafo, 1996/97).

July, generally resulted in higher percentage seedling survival. With the provision of adequate shade, established 1 year ahead, seeds sown in September 1995 had a relatively high percentage survival as compared to those sown in plots where the shade was not well established. The results for 1996/97 at Tafo and Bunso confirm that sowing seeds in the minor season (September) may lead to high seedling mortality during the dry season. This observation disagrees with those made by Brown *et al.* (1971) who reported high survival rate in seedlings sown in November. But climatic and ecological conditions in the early 1970s when the experiment was conducted by Brown *et al.* (1971) might differ from the conditions at the time of this experiment.

Generally, the survival of transplanted seedlings was high and was consistent with the findings of earlier workers (Anonymous, 1950; Esan, 1991; Amoah *et al.*, 1993). However, with a lot of Ghanaian farmers showing interest in sowing cocoa seeds at stake (Donkor,

TABLE 2

Total Rainfall (mm) and Number of Wet Days Recorded at Bunso

Month	1994		1995		1996		1997	
	Total	Wet days	Total	Wet days	Total	Wet days	Total	Wet days
January	9.4	1	7.0	1	14.0	2	39.2	3
February	33.6	3	19.5	2	128.4	11	12.2	1
March	125.6	9	102.6	7	130.4	9	88.7	9
April	227.0	11	300.5	12	162.0	11	133.0	10
May	185.9	15	114.7	12	164.2	11	122.1	14
June	173.0	12	221.1	13	224.5	12	316.3	21
July	39.0	6	112.5	11	159.7	9	69.4	12
August	83.2	6	198.4	18	76.6	10		
September	269.8	17	133.0	11	33.1	3		
October	244.0	19	139.0	8	139.5	12		
November	64.6	6	20.8	2	39.0	2		
December	0.0	0	31.4	3	47.9	7		

TABLE 3
Total Rainfall (mm) and Number of Wet Days Recorded at Tafo

Month	1994		1995		1996		1997	
	Total	Wet days	Total	Wet days	Total	Wet days	Total	Wet days
January	31.0	5	0.0	0	32.8	4	49.9	4
February	77.5	6	4.9	3	129.5	7	32.0	2
March	74.8	8	140.2	12	86.0	9	113.4	10
April	195.5	11	173.5	10	244.1	10	117.7	9
May	184.8	6	185.6	10	184.7	10	310.8	9
June	104.8	14	198.1	13	261.0	14	562.2	24
July	48.8	9	146.1	14	267.9	12	118.8	11
August	84.7	8	121.9	18	83.5	19		
September	245.4	16	226.2	17	28.8	6		
October	225.3	16	111.1	14	180.4	14		
November	89.8	5	50.8	5	50.8	4		
December	0.0	0	64.5	5	44.1	6		

Henderson & Jones, 1991) due to this method's low capital investment, a relatively good survival rate can bolster the rate of rehabilitating moribund cocoa farms. At an assumed rate of 50 per cent seedling survival, it will take between 2 and 3 years to obtain the final population of cocoa stands on the farm. Since there is no evidence indicating that farms established from seeds sown at stake eventually yield less than when the seedlings are transplanted (Vernon, 1969), sowing cocoa seeds at stake may still be a viable economic option for the resource-poor cocoa farmers. Although some damage may be caused by mammals and also through weeding, the extent of mammalian damage recorded in this study was generally low and within acceptable limits. Hammond (1962) reported that mammalian damage to seedlings from seeds sown in September, October and November was lower than the damage to those sown in May, June and July which coincided with the major rainy season. However, evidence from this study does not support that view and, therefore, suggests that this may not be a major constraint to using planting at stake for cocoa establishment.

Conclusion

In spite of the current unreliable rainfall pattern,

sowing cocoa seeds at stake would still be feasible in cocoa-growing areas with conditions similar to Tafo and Bunso. However, unlike the former years when there was probably no need to establish shade before sowing cocoa seeds at stake, owing to the abundance of forest trees which provided the required shade, nowadays it may be important that shade is established 1 year in advance before seeds are sown at stake. The most suitable period for sowing seeds at stake is the major rainy season, from April to July. The Seed Gardens of the Cocoa Services Division should, therefore, be encouraged to programme their pollinations so that cocoa seeds are available during these periods for farmers interested in planting at stake.

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