Effect of polybag size and foliar application of urea on cocoa seedling growth

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ABSTRACT

The effects of different polybag sizes and foliar application of urea on the growth of cocoa seedlings in the nursery were studied at the Cocoa Research Institute of Ghana substation at Afosu in the Eastern Region of Ghana between June 2004 and May 2005. Hybrid cocoa seeds were sown in polybags measuring 17.5 cm × 25 cm, 12.5 cm × 25 cm, 12.5 cm × 20 cm, and 12.5 cm × 15 cm filled with top soil. From the four-leaf stage, half of the seedlings in the different polybags received fortnightly foliar application of 2 per cent urea solution, while the other half did not receive foliar application of urea. Each treatment consisted of 50 cocoa seedlings. There were significant differences ($P \leq 0.01$) in girth and height between the cocoa seedlings in the different sizes of polybags at 3, 4 and 5 months after sowing. Leaf number and tap root length were also significantly influenced by polybag size at 4 and 5 months after sowing. Generally, seedlings raised in 17.5 cm × 25 cm polybags produced bigger and taller seedlings, more leaves, longer tap root length, and had significantly higher ($P \leq 0.01$) total dry matter per seedling than those raised in 12.5 cm × 15 cm polybags. Foliar application of 2 per cent urea improved the growth of cocoa seedlings in all the different polybag sizes. The results suggest that smaller polybag sizes (12.5 cm × 25 cm, 12.5 cm × 20 cm, and 12.5 cm × 15 cm) could be used to nurse cocoa seedlings and transplanted early at 3 months after sowing instead of the recommended practice of nursing in 17.5 cm × 25 cm polybags and transplanting at 5 to 6 months after sowing. More cocoa seedlings raised in smaller polybags could, therefore, be transported per trip for field planting at reduced cost to the farmer.

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RÉSUMÉ

OPPONG, F. K., OFORI-FRIMPONG, K. & FIAKPORNU, R.: *Effets de la dimension du sac en plastique et de l'application foliaire d'urée sur la croissance de semis de cacao.* Les effets de différentes dimensions de sac en plastique et d'application foliaire d'urée sur la croissance de semis de Cacao dans les pépinières étaient étudiés à Afosu, une sous-station de l'Institut de Recherche en Cacao du Ghana dans la région de l'Est du Ghana entre juin 2004 et mai 2005. Les fèves de cacao hybride étaient semées dans les sacs en plastique qui mesuraient 17.5 cm × 25 cm, 12.5 cm × 25 cm, 12.5 cm × 20 cm, et 12.5 cm × 15 cm remplis de couche arable. De la phase de 4-feuille, une demie de semis dans les différents sacs en plastique recevaient tous les quinze jours l'application foliaire de 2% de solution d'urée alors que l'autre demie ne recevaient pas d'application foliaire d'urée. Chaque traitement consistait en cinquant de semis de cacao. Il y avaient des différences considérables ($P \leq 0.01$) en circonférence et en taille entre les semis de cacao dans les différentes dimensions de sacs en plastique à 3, 4 et 5 mois après la semaille. Nombre de feuille et la longueur de racine pivotante étaient aussi considérablement influencés par la dimension du sac en plastique à 4 et 5 mois après la semaille. En général les semis élevés dans les sacs en plastique de 17.5 cm × 25 cm produisaient des semis plus gros et plus grands, plus de feuilles, de longueur de racine pivotante plus longue et avaient une totalité de matière sèche par semis considérablement plus élevées ($P \leq 0.01$) que ceux élevés dans les sacs en plastique de 12.5 cm × 15 cm. L'application foliaire de 2% d'urée améliorait la croissance de semis de cacao dans toutes les différentes dimensions de sacs en plastique. Les résultats suggèrent que les sacs en plastique de dimensions plus petites (12.5 cm × 25 cm, 12.5 cm × 20 cm, et 12.5 cm × 15 cm) pourraient être utilisés pour soigner les semis de cacao et repiqués précoces à 3 mois après la semaille plutôt que la pratique actuelle recommandée de soigner dans les sacs en plastique de 17.5 cm × 25 cm et repiquer à 5-6 mois après la semaille. Plus de semis de cacao élevés dans les plus petites sacs en plastique pourraient donc être transporter par trajet pour le repiquage sur le terrain à coût réduit à l'agriculteur.

Introduction

Field planting of cocoa is usually done by sowing fresh seeds at stake, transplanting 3 to 6-month-old bare-root seedlings raised on beds or in polythene bags; or transplanting 5 to 6-month-old seedlings raised in polythene bags with 'ball of earth' around the roots. However, transplanting cocoa seedlings using the polybag method ('ball of earth' method) is considered the best method because it ensures high survival and rapid seedling establishment (Benstead, 1950; Freeman, 1965; Esan, 1981; Amoah *et al.*, 1999; Oppong *et al.*, 1999). However, inspite of the advantages of the polybag method over the other methods of field planting, the adoption rate by Ghanaian cocoa farmers is low (Henderson & Jones, 1990; Donkor, Henderson & Jones, 1991). This is attributed to the high cost of nursing cocoa seedlings in polybags in the nursery for 5 to 6 months before transporting them to the farms, which may be several kilometres away (Esan, 1981). In Ghana, polybags measuring 17.5 cm × 25 cm filled with top soil are used for nursing cocoa seedlings. This size enables about 10 to 15 seedlings to be transported per person by head portage at a time to the farm; thus, increasing the cost and time of transporting the seedlings for transplanting.

However, information is lacking on the possibility of raising cocoa seedlings for transplanting using smaller polybags to enable farmers derive the benefits of low seedling mortality and rapid establishment associated with the polythene bag method of transplanting. Information is also lacking on the use of inorganic fertilizers on cocoa seedlings at the nursery.

The objective of this study was, therefore, to investigate the feasibility of using smaller-sized polythene bags and urea application to raise cocoa seedlings in the nursery over a shorter period to reduce the cost and time for transporting cocoa seedlings for transplanting.

Materials and methods

Experiment 1

The trial was set up at the Cocoa Research Institute of Ghana substation at Afosu in the Eastern Region of Ghana between June 2004 and May 2005. Fresh, mixed hybrid cocoa seeds were sown in four different sizes of polybags measuring 17.5 cm× 25 cm (control), 12.5 cm × 25 cm, 12.5 cm × 20 cm, and 12.5 cm × 15 cm filled with top soil collected from an old rubbish dump. The chemical properties of the soil used for the experiment were determined. Beginning from 4 weeks after sowing when the seedlings had reached the four-leaf stage, 2 per cent urea solution was applied to the leaves of half of the seedlings every fortnight. The other half did not receive foliar application of urea. The trial was designed as randomized complete block (4 × 2 factorial) with 50 plants per treatment. At 3, 4 and 5 months after sowing, 16 seedlings were randomly sampled from each treatment and the girth, height, number of leaves, length of tap root, and dry weight of the seedlings were determined.

Experiment 2

The trial was repeated using the same procedure (Experiment 1), but without foliar application of urea to the seedlings. The girth, height, and number of leaves of the seedlings were determined at 3 and 4 months after sowing.

The data recorded in both trials were analysed using Minitab Version 12 statistical package.

Results

Table 1 shows some chemical properties of the soil used for the experiments.

TABLE 1

Some Chemical Properties of Top Soil Used for Nursery Trial

*p*H	% C	%N	Avail. P (µg g^{-1})
7.04	1.47	0.15	1076.25

Experiment 1

The size of bag in which the seedlings were nursed significantly ($P<0.01$) influenced the growth of the cocoa seedlings after 4 months, irrespective of the fertilizer treatment. Mean seedling girth in Treatment 4 (12.5 cm × 15 cm) was significantly smaller than those recorded in Treatment 1 (17.5 cm × 25 cm) at 4 and 5 months after sowing (Table 2).

The height of the seedlings also showed significant differences between the different polythene bag sizes after 4 months. Contrary to the observations recorded for the girth after 3 months, the mean height of the seedlings in T1 (17.5 cm × 25 cm) was lower than those of the other treatments, but this trend was reversed in the subsequent months (Table 3). There were no significant girth and height differences between the seedlings in the different polythene bags with or without the application of urea, 3 months after sowing (Tables 2 and 3).

The production of leaves and length of tap root of the seedlings followed the same trend as the girth, with significantly higher ($P\leq0.01$) number of leaves produced in T1 (17.5 cm × 25 cm) than in T4 (12.5 cm × 15 cm), 4 months after sowing. There were, however, no significant differences between the treatments in leaf production after 5 months, although there were more leaves in T1 than in the other treatments (Table 4).

Significantly longer tap roots were recorded in

TABLE 2

Mean Girth (mm) of Cocoa Seedlings in Different Polythene Bag Sizes With or Without Foliar Application of Urea at 3, 4 and 5 Months After Sowing

Polythene bag size	*Months after sowing*					
	3		*4*		*5*	
	0% urea	*2% urea*	*0% urea*	*2% urea*	*0% urea*	*2% urea*
Treatment 1–17.5 cm × 25 cm	3.49	3.43	7.13	7.52	8.36	9.60
Treatment 2–12.5 cm × 25 cm	3.31	3.43	6.84	7.46	7.89	8.66
Treatment 3–12.5 cm × 20 cm	3.35	3.31	6.46	6.81	8.07	8.91
Treatment 4–12.5 cm × 15 cm	3.03	3.14	6.49	6.79	7.03	8.04
Significance level: bag size	ns		$P\leq$ 0.01		$P\leq$ 0.01	
: urea	ns		$P\leq$ 0.01		$P\leq$ 0.01	
SED (341 df): bag size	-		0.14		0.20	
: urea	-		0.10		0.14	

TABLE 3

Mean Height (cm) of Cocoa Seedlings in Different Polythene Bag Sizes With or Without Foliar Application of Urea at 3, 4 and 5 Months After Sowing

Polythene bag size	*Months after sowing*					
	3		*4*		*5*	
	0% urea	*2% urea*	*0% urea*	*2% urea*	*0% urea*	*2% urea*
Treatment 1–17.5 cm × 25 cm	17.9	17.5	24.6	26.3	30.3	37.6
Treatment 2–12.5 cm × 25 cm	19.6	19.6	23.9	24.1	28.0	28.8
Treatment 3–12.5 cm × 20 cm	18.2	18.9	23.7	25.9	30.6	31.9
Treatment 4–12.5 cm × 15 cm	18.6	18.9	22.2	24.5	24.8	30.5
Significance level: bag size	ns		$P\leq$ 0.01		$P\leq$ 0.01	
: urea	ns		$P\leq$ 0.01		$P\leq$ 0.01	
SED (341 df):bag size	-		0.66		1.43	
:urea	-		0.47		1.01	

TABLE 4

Mean Leaf Number of Cocoa Seedlings in Different Polythene Bag Sizes With or Without Foliar Application of Urea at 4 and 5 Months After Sowing

Polythene bag size	*Months after sowing*			
	4		*5*	
	0% urea	*2% urea*	*0% urea*	*2% urea*
Treatment 1–17.5 cm × 25 cm	15.8 (3.93)	16.9 (3.94)	16.2 (3.94)	19.0 (4.15)
Treatment 2–12.5 cm × 25 cm	11.1 (3.27)	14.1 (4.91)	13.0 (3.52)	11.2 (3.26)
Treatment 3–12.5 cm × 20 cm	14.0 (3.69)	14.8 (3.79)	13.6 (3.51)	17.8 (4.17)
Treatment 4–12.5 cm × 15 cm	7.0 (2.63)	9.1 (2.98)	11.8 (3.38)	14.8 (3.80)
Significance level: bag size	$P \leq 0.01$		ns	
: urea	$P \leq 0.01$		ns	
SED (341 df): bag size	(0.11)		-	
: urea	(0.08)			

* Values in bracket are square root transformation of actual values

T1 (17.5 cm × 25 cm) than in T4 (12.5 cm × 15 cm) at 4 and 5 months after sowing. However, no significant differences were recorded in tap root lengths of the seedlings between T1 (17.5 cm × 25 cm), T2 (12.5 cm × 25 cm), and T3 (12.5 cm × 20 cm) with or without foliar application of urea, 4 and 5 months after sowing (Table 5).

Foliar application of 2 per cent urea solution improved the growth of cocoa seedlings at 4 and 5 months after sowing. Seedlings that received foliar application of urea were significantly bigger and taller ($P<0.01$) than those that were not treated with urea. However, foliar application of urea did not significantly improve the growth of the seedlings at 3 months after sowing (Tables 2 and 3). Leaf production and length of tap roots of the seedlings were also significantly influenced by foliar application of urea at 4 months after sowing (Tables 4 and 5).

The application of urea significantly increased ($P<0.01$) the dry weight of the seedlings in T1 (17.5 cm × 25 cm) than in T4 (12.5 cm × 15 cm) with or without the application of urea at 4 and 5 months after sowing. However, no significant differences were observed between the seedling dry weights of T1 (17.5 cm × 25 cm), T2 (12.5 cm × 25 cm), and T3 (12.5 cm × 20 cm) when urea was not applied to the seedlings (Table 6).

Experiment 2

In the second experiment, polythene bag size did not significantly affect seedling girth and height and number of leaves at 3 months after sowing (Table 7). However, at 4 months after sowing, significantly bigger seedling girths were recorded in T1 than in the other treatments, but the seedlings in T4 were taller than those in T1. There were no significant height differences between T1 (17.5 cm × 25 cm), T2 (12.5 cm × 25 cm), and T3 (12.5 cm × 20 cm) after 4 months. At 3 months after sowing, there were no significant differences in leaf production, but seedlings in T1 had more leaves than those in the other treatments at 4 months after sowing (Table 7).

Discussion

All the growth parameters measured in Experiments 1 and 2 indicated that nursing cocoa seedlings in polythene bags, smaller than the normal size of 17.5 cm × 25 cm, for 4 months or more resulted in less vigorous seedlings being produced. However, cocoa seedlings nursed in the smaller-sized polythene bags (12.5 cm × 25 cm, 12.5 cm × 20 cm or 12.5 cm × 15 cm) had similar vigour at 3 months after sowing as those nursed in 17.5 cm × 25 cm polythene bags. The superior growth of the cocoa seedlings in 17.5 cm

TABLE 5

Mean Tap Root Length (cm) of Cocoa Seedlings in Different Polythene Bag Sizes With or Without Foliar Application of Urea at 4 and 5 Months After Sowing

Polythene bag size	*Months after sowing*			
	4		*5*	
	0% urea	*2% urea*	*0% urea*	*2% urea*
Treatment 1–17.5 cm × 25 cm	27.2	30.4	31.3	35.6
Treatment 2–12.5 cm × 25 cm	27.4	29.7	28.4	28.0
Treatment 3–12.5 cm × 20 cm	23.9	26.0	29.2	30.7
Treatment 4–12.5 cm × 15 cm	17.3	21.3	23.9	27.4
Significance level: bag size	$P \leq 0.01$		$P \leq 0.01$	
: urea	$P \leq 0.05$		ns	
SED (65 df): bag size	1.77		2.55	
: urea	1.25		-	

TABLE 6

Mean Dry Weight (g) of Cocoa Seedlings in Different Polythene Bag Sizes With or Without Foliar Application of Urea at 4 and 5 Months After Sowing

Polythene bag size	*Months after sowing*			
	4		*5*	
	0% urea	*2% urea*	*0% urea*	*2% urea*
Treatment 1–17.5 cm × 25 cm	8.9	14.0	16.6	25.2
Treatment 2–12.5 cm × 25 cm	7.0	8.1	11.6	13.2
Treatment 3–12.5 cm × 20 cm	8.0	8.8	15.2	15.6
Treatment 4–12.5 cm × 15 cm	5.2	6.8	8.8	12.4
Significance level: bag size	$P \leq 0.01$		$P \leq 0.01$	
: urea	$P \leq 0.05$		$P \leq 0.05$	
SED (65 df): bag size	0.84		1.47	
: urea	0.59		1.13	

× 25 cm polybags after 4 months in the nursery could be attributed to the relatively large volume of soil in the bags as compared to the other treatments. The roots of the seedlings in the 17.5 cm × 25 cm polythene bags were, therefore, exposed to more nutrients and water, resulting in better growth compared to those in the smaller polythene bags when the duration of nursing was extended beyond 3 months. However, reducing the length of time for nursing the seedlings to 3 months did not adversely affect the growth of the seedlings in the smaller polythene bags. Possibly, competition for nutrients by the roots of the cocoa seedlings in the smaller polythene bags was not critical at 3 months after sowing. Based on the results of this trial, it would be reasonable to suggest that the critical time for transplanting cocoa seedlings nursed in small- sized polybags as used in this experiment is 3 months.

Amoah *et al.* (2000) recorded over 80 per cent survival when 2-month-old bare-root cocoa seedlings were transplanted in the field. In subsequent studies, over 85 per cent survival was recorded when 3-month-old bare-root cocoa seedlings were transplanted in the field. The girth and height of those seedlings were not

TABLE 7

Mean Girth, Height and Leaf Number of Cocoa Seedlings in Different Polythene Bag Sizes at 3 and 4 Months After Sowing

Polythene bag size	*Girth (mm)*		*Height (cm)*		*Leaf number*	
	3 months	*4 months*	*3 months*	*4 months*	*3 months*	*4 months*
Treatment 1–17.5 cm × 25 cm	4.65	7.02	28.2	33.8	10.9 (3.30)	15.0 (3.87)
Treatment 2–12.5 cm × 25 cm	5.28	6.35	28.2	34.6	11.0 (3.31)	12.7 (3.54)
Treatment 3–12.5 cm × 20 cm	5.03	6.30	30.1	35.9	10.4 (3.24)	12.7 ((3.54)
Treatment 4–12.5 cm × 15 cm	4.69	5.86	27.8	37.9	10.6 (3.28)	13.6 (3.68)
Significance level	ns	$P \leq 0.01$	ns	$P \leq 0.05$	ns	$P \leq 0.05$
SED (57 df)	-	0.24	_	1.28	_	(0.12)

significantly different from 6-month-old transplanted seedlings (Amoah *et al.,* 2003). Considering the consistently high field survival rate of polybag-nursed seedlings as compared to bare-root-transplanted seedlings (Benstead, 1950; Freeman, 1965; Esan, 1981; Amoah *et al.,* 1999; Oppong *et al.,* 1999; Amoah *et al.,* 2000; Amoah *et al.,* 2003), high seedling survival would possibly be recorded after field planting of 3-month-old cocoa seedlings nursed in smaller polybags.

Although foliar application of urea improved growth of seedlings in all the different sizes of polybags, it did not result in prolonging and sustaining the vigour of the seedlings in the smaller-sized polybags (particularly, 12.5 cm × 15 cm polybag) beyond 3 months. The fact that foliar application of urea did not significantly improve growth of cocoa seedlings at 3 months after sowing implies that, depending on the fertility of the soil used for nursing, foliar application of urea may only increase nursery costs if the seedlings are transplanted at 3 months after sowing. The lack of significant differences in seedling growth between the different bag sizes at 3 months after sowing without foliar application of urea in the second experiment confirms this assertion.

Conclusion

Evidence from this study suggests that cocoa seedlings could be nursed in small-sized polythene bags and transplanted in the field at 3 months after sowing. The use of small-sized polythene bags for nursing cocoa seedlings may be an attractive option for cocoa farmers and may culminate in high adoption of the polythene bag ('ball of earth') method of transplanting, because the cost of nursing, portage or transporting the polybag-nursed seedlings could be drastically reduced.

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