Asian Journal of Research in Agriculture and Forestry

Volume 9, Issue 3, Page 103-111, 2023; Article no.AJRAF.101354
ISSN: 2581-7418

Root Segment Cuttings of *Bombax costatum* Pellegr. & Vuillet: Effects of Diameter and Alignment

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRAF/2023/v9i3212

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/101354

Original Research Article

Received: 04/04/2023
Accepted: 08/06/2023
Published: 16/06/2023

ABSTRACT

Bombax costatum is a very important agroforestry species in the Guinean savannahs highland of Adamawa. The objective of this work is to contribute to the domestication of this species by cuttings of root segment. The cuttings of root segment of this species were carried out according to a split-plot design with three replications. The diameter range of cuttings used (0.5-1.1 cm; 1.2-2 cm and 2.1-3.8 cm) and the alignment of the cuttings (vertical, horizontal and oblique) in the substrate consisting of sand/sawdust represented the main treatment and the secondary treatment respectively. The experimental unit was 10 cuttings. The result showed that cuttings with large diameters between 2.1 and 3.8 cm (62.22±1.75%) are the best for budding. The diameter

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significantly influences the budding of the cuttings (0.0004 < 0.001). Regarding the alignment of the cuttings in the substrate, the maximum budding (52.22±2.01%) is obtained in those placed in an oblique alignment. However, this alignment did not significantly influence the budding of root segment cuttings (0.33 > 0.05). Regarding the rooting of cuttings, a high rate (28.88±1.36%) is observed in cuttings whose diameter class is between 2.1 and 3.8 cm. The diameter range significantly influences rooting (0.002 < 0.01). The alignment of the cuttings in the substrate did not significantly impact the rooting of the cuttings (0.90 > 0.05). These results show that vegetative propagation of *Bombax costatum* from root segment cuttings is possible. This is an important step for the domestication of this species.

Keywords: Bombax costatum; diameter; domestication; alignment; root cuttings.

1. INTRODUCTION

The dry forests of Cameroon constitute an immense reservoir of biological diversity and their socio-economic and ecological functions are essential for the populations. These vegetal formations play an important role in meeting many basic needs of local populations [1,2]. In these areas of dry forests, people depend on these plant resources. Indeed, for mainly rural populations, non-timber forest products are of paramount importance because the different parts of these plants are sold and generate monetary income. This is the case of the fruits of *Borassus aethiopum*, *Detarium microcarpum*, *Tamaridus indica*, *Sclerocarya birrea*, almonds of *Vitellaria paradoxa* and *Parkia biglobosa*, leaves of *Balanites aegyptiaca* and *Adansonia digitata* but also the calyxes of *Bombax costatum* [3]. *B. costatum* is one of the main species of socio-economic interest present in agroforestry parklands in the Sudano-Sahelian and Guinean zones. It is one of the species most valued by local populations [4]. These calyxes are harvested and consumed immediately or dried to be stored, also marketed. Harvesting the calyxes is often destructive by almost complete topping of the crown [5]. Their consumption deprives populations of their seed potential. This situation leads to overexploitation of this species with high socio-economic potential, thus placing the population of *B. costatum* in a regressive dynamic characterized by the scarcity or absence of young individuals [6]. The degradation of this resource is occurring at a very high rate and is accompanied by a growing imbalance between the availability of natural resources and demand for non-timber forest products due to continue population growth [7].

B. costatum is widely used by people in the northern part of Cameroon and its economic, food, nutritional and health importance has been documented in West Africa [8,9,10]. However, despite its widely recognized socio-economic potential, scientific information on vegetative propagation by cuttings is still very limited. These shortcomings hinder the development of strategies for the implementation of domestication programs for this species.

This study aims to contribute to the domestication of *B. costatum* by root segment cuttings by evaluating the effect of diameter and alignment of root segment cuttings on budding and rooting; an important step in the process of implementing a domestication program for this species.

2. MATERIALS AND METHODS

2.1 Description of the Study Site

The site chosen for the sampling of plant material is that of the locality of Karna Manga (LN: 7°47', LE: 13°33', ALT: 1081m). This material consists of fragments of cuttings of *Bombax costatum*. This locality has two seasons, a rainy season from April to October and a dry season from November to March. The climate is of the Sudano-Guinean type [11]. The soil of the region consists mainly of red ferralitic rocks developed on old basalts [12].

2.2 Methodology

Careful excavations of the roots were carried out at the feet of four adult trees of *Bombax costatum* in good sanitary condition in the locality of Karna Manga located a few kilometers from the city of Ngaoundéré. These roots were taken and then cut using a pruner into cuttings of root segment of 20 cm long and their proximal end was marked. The transport of the cuttings from the field of collection to the nursery was done using a cooler containing blocks of ice. At the nursery, these cuttings were divided into three ranges of different diameter: from 0.5 to 1.1cm; from 1.2 to 2cm and from 2.1 to 3.8 cm. Subsequently, they were cultivated in the substrate consisting of the sawdust sand mixture. The cuttings were placed vertically, horizontally and obliquely in the substrate previously stored inside the polypropagator. The cuttings were watered morning and evening using a sprayer that delivers water in very fine droplets.

The diameter of the cuttings was the main treatment and the arrangement of the cuttings in the substrate was the secondary treatment. The experimental unit consisted of 10 root segment cuttings. The experimental design for this study was a split-plot with 3 replications. A total of 270 cuttings or 10x3x3x3 were handled.

2.3 Data Collection and Analysis

Data collection started from the date of the first budding and continued weekly until the end of the experiment. Data collected included: number of root segment cuttings that emitted aerial axes, number of aerial axes, height of aerial axes, and number of leaves/axes. The statistical analyzes carried out relate to the variance. The separation of significant means was done using the Duncan Multiple Range Test. The analysis software used is Statgraphics plus 5.0

3. RESULTS

The root segment cuttings (RSC) were cultured on August 19, and the first aerial shoots appeared on September 7; 20 days after being cultured. Regarding the diameter of the cuttings, this period is approximately three weeks (20 days) for the RSC of 0.5-1.1 cm and 5 weeks for the other two diameters.

3.1 Effect of Diameter on Budding

At the 16th week after cultivation, the budding rate varies from 26.66±1.75% for cuttings of 0.5-1.1 cm to 62.22±1.75% for those of 2.1-3.8cm (Fig. 1). The analysis of variance shows a significant difference between the diameters (0.0004<0.001). The diameters of the RSC have an influence on the budding.

3.2 Effect of Diameter on Rooting

The rooting percentage at the 18th week varies from 7.77±0.97% for cuttings with a diameter of 0.5–1.1 cm to 28.88±1.36% for those with a diameter of 2.1–3.8 cm (Fig. 2). The analysis of variance shows that the difference is significant between the diameters of the RSC (0.002 < 0.01). Large diameter cuttings are more vigorous than small diameter ones.

3.3 Effect of Alignment on Budding

The first budding was noted on the RSC in a vertical alignment at the 3rd week of the experiment. In the following weeks, the development of several leafy cuttings was observed.

At the 16th as well as the 18th weeks, the percentage of budding varies from 41.1±1.03% in the cuttings placed in a vertical alignment to 52.22±2.01% in those in an oblique alignment (Fig. 3). Despite this variation, the analysis of variance shows the absence of a significant difference between the different alignment (0.33 > 0.05). The alignment of the cuttings in the substrate has no influence on budding.

3.4 Influence of Alignment on Rooting

Regarding the alignment of the cuttings, rooting fluctuates between 17.77±1.2% in the cuttings in a horizontal alignment to 20.0±1.87% in those in an oblique alignment (Fig. 4). The analysis of variance does not reveal the existence of a significant difference between the different alignment (0.90 > 0.05).

3.5 Influence of the Diameter*Alignment Interaction on Budding

Budding fluctuates between 20±0.63% in cuttings with a diameter of 0.5–1.1 cm grown in a horizontal alignment to 73.36±1.05% in those with a diameter of between 1.2–2 cm placed in an oblique alignment (Table 1). The analysis of variance shows that the diameter*alignment interaction of the cuttings is significant (0.04 < 0.05).

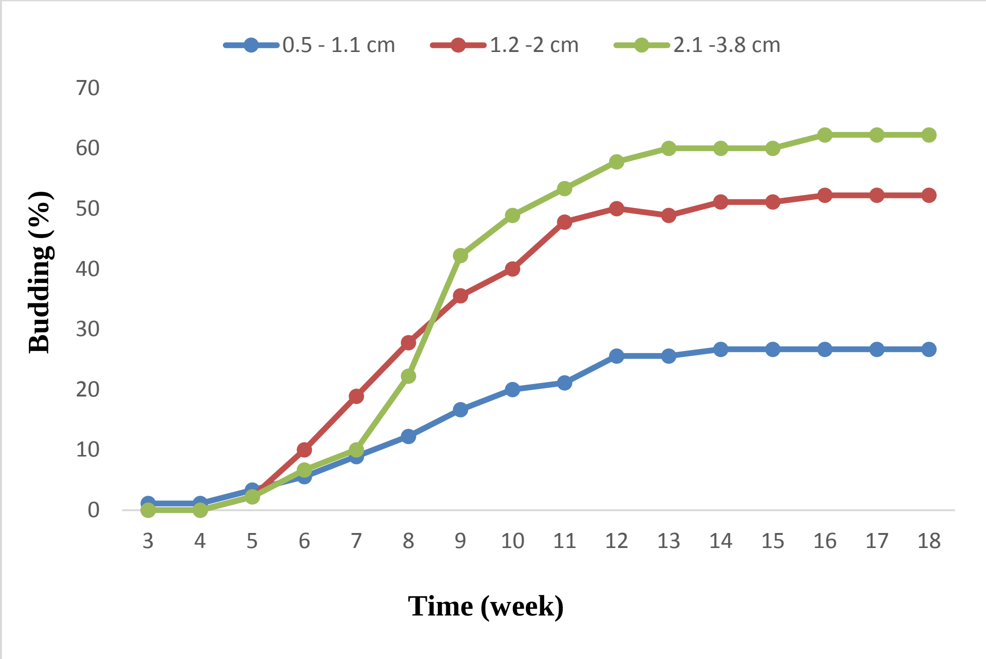

Fig. 1. Evolution of budding rate as a function of time

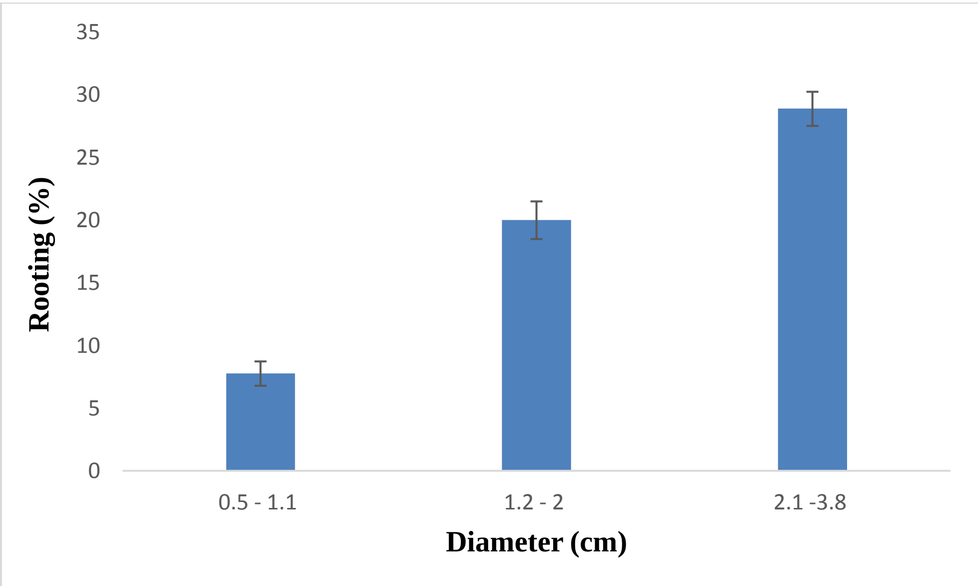

Fig. 2. Percentage of rooting of cuttings according to the class diameter

Table 1. Percentage of budding of cuttings according to diameter and alignment

Alignment of the cuttings in the substrate (%)	Diameter (cm)		
	0.5-1.1	**1.2-2**	**2.1-3.8**
Vertical	36.66±0.57[a]	30±1[c]	56.66±1.52[b]
Horizontal	20±0.63[b]	53.34±1.15[b]	70±1.73[a]
Oblique	23.42±2.51[b]	73.36±1.05[a]	60±2.05[a]

The means followed by the same letter on the columns are statically identical at the 5% threshold

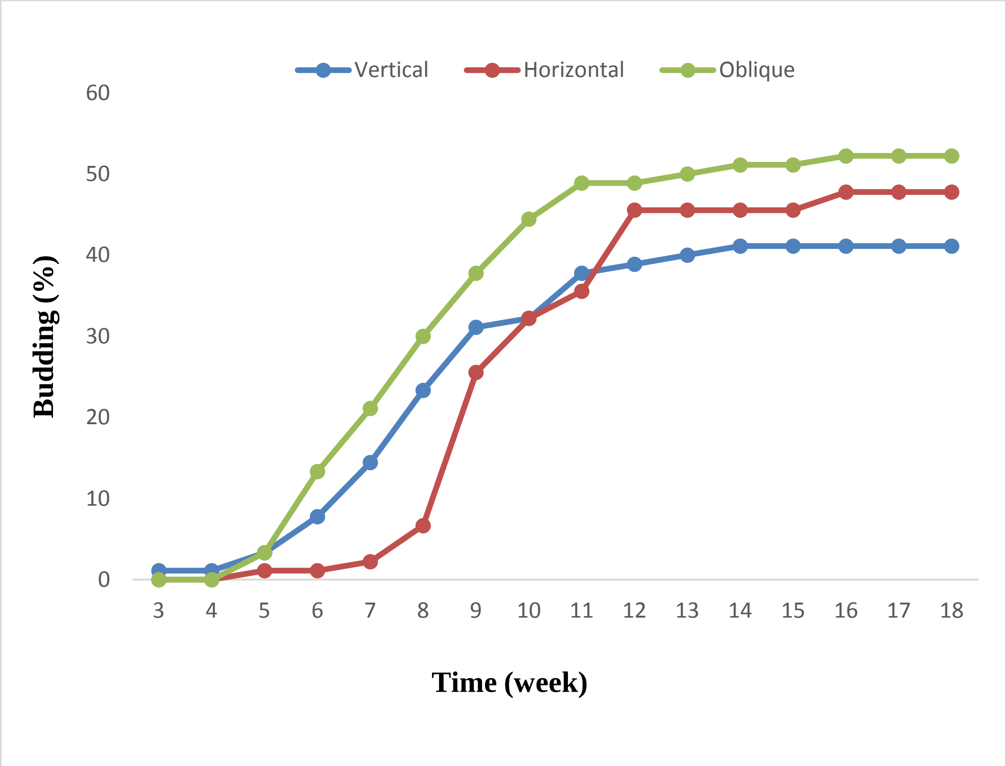

Fig. 3. Evolution of budding rate according to alignment

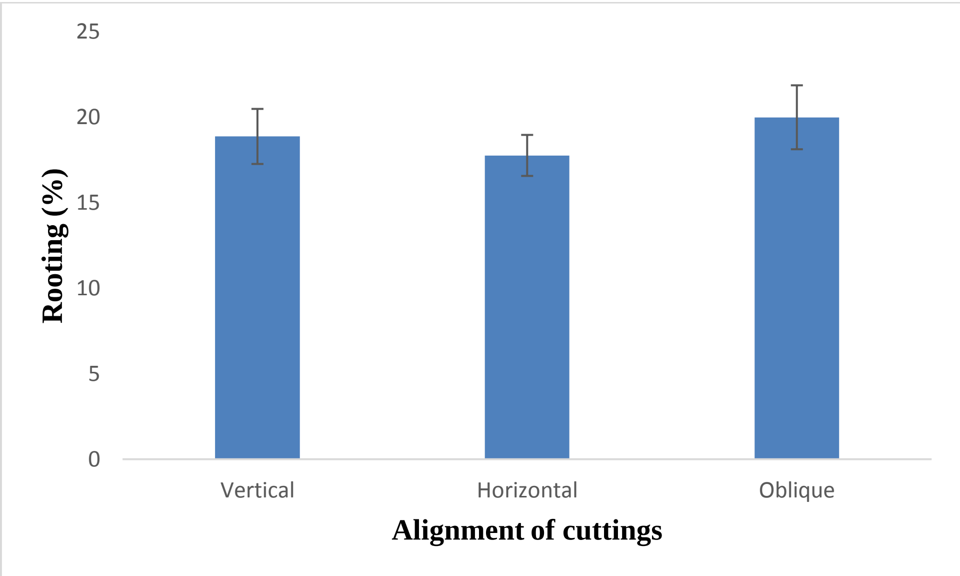

Fig. 4. Percentage of rooting of cuttings depending on the alignment in the substrate

3.6 Interaction of the Diameter*Alignment on Rooting

Regarding the diameter*alignment interaction, rooting varies from 3.43±0.42% in RSCs with diameters of 0.5–1.1 cm placed in an oblique alignment to 36.67±0.45% in those 2.1-3.8 cm cultured in an upright alignment (Table 2). The analysis of variance reveals the existence of a significant difference (0.01<0.05). The diameter*alignment interaction has an influence on the rooting of RSC. Fig. 5 shows cuttings of leafy root segments bearing adventitious roots.

3.7 Position of Appearance of Buds

Depending on the position of appearance of the buds, the percentage of RSC having emitted buds in the proximal position varies from 24.44±14.24% in RSC 0.5-1.1cm in diameter to 38.88±10, 57 for those with a diameter of 2.1–3.8 cm. For the cuttings having emitted axes in the proximal and median position, the percentage varies from 4.44±4.15% for the cuttings with a diameter of 0.5–1.1cm to 15.55±2.06% for those with a diameter 1.2-2cm. A percentage of 5.55±2.12% was observed in the middle position only in the cuttings of 2.1–3.8cm in diameter against 5.55±5% distal position in the same diameter range (Table 3). The analysis of variances reveals no significant difference for the proximal and median (0.18 > 0.05), median (0.17 > 0.05) and proximal (0.058 > 0.05) positions. On the other hand, for the distal position there is a significant difference (0.0004 < 0.001).

Table 2. Rooting percentage of cuttings according to diameter and alignment

Alignment of the cuttings in the substrates (%)	Diameter (cm)		
	0.5-1.1	**1.2-2**	**2.1-3.8**
Vertical	13.33±1.32[a]	6.66±0.67[c]	36.67±0.45[a]
Horizontal	6.69±0.37[b]	16.67±0.61[b]	30±0.96[a]
Oblique	3.43±0.42[c]	36.56±1.15[a]	20±1.24[b]

The means followed by the same letter on the columns are statically identical at the 5% threshold

Fig. 5. Leafy and rooted root segment cuttings

Table 3. Percentage of the position of appearance of aerial axes on cuttings according to their diameters

Diameter (cm)	Proximal	Proximal and median	Median	Distal
0.5–1.1	24.44±14.24	4.44±4.15	00±00	00±00[a]
1.2-2	32.22±12.01	15.55±2.06	4.44±2.12	00±00[a]
2.1–3.8	38.88±10.57	12.22±11.69	5.55±2.12	5.55±5[b]
Means	31.84±12.27	10.74±5.96	3.33±1.41	1.85±1.66
Probability	0.05	0.18	0.17	0.0004

The means followed by the same letter on the columns are statically identical at the 5% threshold

Table 4. Percentage of appearance of the aerial axis according to the position of the cuttings in the substrate

Alignment of the cuttings (%)	Proximal	Proximal and median	Median	Distal
Vertical	35.55±8.81	2.22±1.57[a]	3.33±3.33	00±00[a]
Horizontal	28.88±13.64	10.0±8.66[ab]	6.66±5.77	4.44±2.42[b]
Oblique	31.11±16.91	20.0±4.15[b]	00±00	1.11±0.90[a]
Means	**31.84±13.12**	**10.74±4.79**	**3.33±3.03**	**1.85±1.76%**
Probability	**0.49**	**0.02**	**0.11**	**0.002**

The means followed by the same letter on the columns are statically identical at the 5% threshold

The rate of RSC having emitted buds on the proximal side depending on the alignment fluctuates between 28.88±13.64% for the horizontal alignment to 35.55±8.81% for the vertical alignment. In the proximal and median position the percentage varies from 2.22±1.57% in the vertical alignment to 20.0±4.15% in the cuttings in the oblique alignment. For the median and distal position, the highest percentages are observed in the horizontal alignment, 6.66±5.77% and 4.44±2.4% respectively (Table 4). The analysis of variance shows that there is no significant difference for the proximal (0.49>0.05) and median (0.11>0.05) positions. Contrary to previous observations, we perceive a significant difference that exists between the proximal and median (0.02<0.05) and distal (0.002<0.05) positions.

4. DISCUSSION

4.1 Budding of Cuttings

For several authors, the budding time varies between 5 weeks in *Vitex doniana* [13] and 7 weeks in *Lophira lanceolata* [14]. The latency time varies according to the species and the period of collection of the cuttings [15]. Regarding the diameter of the cuttings, this period varies from about three weeks (20 days) for the RSC of 0.5-1.1cm to 5 weeks for those of 2.1-3.8 cm. This result is contrary to that obtained by [14] on *Lophira lanceolata* and *Vitex doniana* in the high Guinean savannahs of Cameroon. The author noted a superiority of cuttings of large diameters over those of small diameters. This situation would be due to the availability of nutrients especially carbohydrates in the first than in the seconds. The result obtained here can also be explained by the specificity of the species, which is a Malvaceae different from the other species, and by the cuttings collection period which took place in August while the three other species were taken in February.

The studies evaluates the interaction between diameter and substrate on *Lophira lanceolata* and *Vitex doniana* in the high Guinean savannahs and finds that this interaction is not significant [14]. The alignment contrary to the substrate influences the budding when it is associated with the diameter. The oblique alignment would allow the sugars, nutrients and hormones contained in the medium diameters to express themselves better. The diameter and position factors taken together influence the rate of budding in this species.

The proximal pole produces more buds than the distal and medial pole. It is in agreement with that obtained by [16] on the same species in Burkina Faso. It also revealed that the appearance of buds in the distal position is observed only in cuttings with large diameters (2.1–3.8 cm). This could be linked to the endogenous factor of the plant, in particular the high quantity of sugars contained in these cuttings.

The best position of the cuttings in the substrate for the appearance of buds in the proximal position is the vertical alignment. In fact, in a vertical alignment as well as in an oblique alignment, the cutting is not completely buried in the substrate; about 1 cm of the cutting is in contact with the light which could favor the appearance of buds at the proximal pole of these cuttings.

4.2 Rooting of Cuttings

Large diameter cuttings are more vigorous than small diameter ones. This result is in agreement with that obtained by [17] on *Acacia albida* in Burkina Faso.

The diameters of the RSC have an influence on the budding. This result is in agreement with that obtained by [13] on *Vitex doniana*. In 2016, the same author obtained similar results on *Sclerocarya birrea*. However, it is opposed to that of [18] on the Populus hybrid in which budding decreases with increasing diameter.

Indeed, the neoformation of aerial axes by RSCs suggests that the separation of root segments from their mother plants eliminated stem dominance and stimulated the expression of adventitious buds [13].

The diameter*disposition interaction has an influence on the rooting of RSC. Indeed, the emitted buds elaborate the sugars and phytohormones responsible for the formation of adventitious roots through the process of photosynthesis [15,19]. These plant growth hormones, essential for rhizogenesis, would be more important and would be better expressed in large-diameter cuttings placed in a vertical alignment.

5. CONCLUSION

It was a question for us in this work of determining the influence of the diameter of the RSC and their alignment in the substrate on the budding and the rooting of *B. costatum*. It appears from this study that *B. costatum* is a species which has a good aptitude for vegetative propagation by cuttings of the root segment. The best diameter for budding is 2.1–3.8 cm, with 62.22±1.75% budding rate. For rooting, the best diameter is 2.1–3.8 cm (28.88±1.36%). The greatest number of roots was emitted from cuttings with a diameter of 1.2-2.1cm. The alignment of the root segment cuttings in the substrate remains insignificant for the majority of the parameters evaluated. In the future work, it would be useful to evaluate the effect of genotypes on the ability of this species to bud and root.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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