

SHORT COMMUNICATION

**PRODUCTIVITY IMPROVEMENT OF SEED PLANTS OF MANGOSTEEN
(*Garcinia mangostana* L.) THROUGH PROVISION OF AN ADDITIONAL
ROOT SYSTEM**

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INTRODUCTION

Mangosteen (*Garcinia mangostana* L.) is one of the high demanding fruits in Sri Lanka. However, it is limited to a few small scale plantings of the moist region in the low and mid country due to that the crop needs specific ecological requirements and cultural practices for its survival. In addition, the inherent characteristic of having a slow growth habit has become the major drawback for the wider distribution of this delicious fruit crop. When propagated by seeds, it takes about 8-15 years to reach the bearing stage. This factor makes the crop a low priority one among the growers. The slow growth rate is mainly due to the weak root system of the crop that reduces the intake of moisture and nutrients (Poerwanto, 2002).

In order to strengthen the root system in mangosteen and thereby shorten the unproductive vegetative phase, a series of studies has been conducted in the past. Development of conventional propagation techniques on single root stock has been introduced as one of the potential remedies. The productivity of grafts was found to be low (Pamplona and Gracia, 2001; Poerwanto, 2002; Dassanayaka and Perera 2006; Thantirige *et al.*, 2009). Similarly, introduction of root stocks of related genera, to mangosteen grafts was found to be unsuccessful (Cox, 1988; Coronel, 1986; Poerwanto *et al.*, 1995). Consequently, introduction of an additional stock plant in wedge grafting of mangosteen was successful with a high rate of productivity (Poerwanto, 2002; Thantirige and Karunaratna, 2004). The canopy development of double-root stocked mangosteen grafts was improved and thereby the productivity has been compared to single-root stocked grafts (Thantirige *et al.*, 2009). Attempts were also made to study the applicability of adoption double root system technique for seed plants, which is helpful for establishment of medium and large scale cultivations. The present study was carried out with the objective of reducing the time taken for fruiting and thereby increasing productivity of seed plants of mangosteen.

MATERIALS AND METHODS

The experiments were conducted at the Fruit Crop Research and Development Centre (FRDC) at Horana, Sri Lanka during September 2006 to May 2012.

Experiment I. Success of inarching of seed plants of mangosteen

The experiment was conducted to test the impact of the time duration that the plants are kept in shade after inarching. Two time durations namely, 45 and 60 days after inarching, were evaluated in a Complete Randomized Design (CRD) with three replicates along with 30 inarched plants per treatment. Seedlings of 2 different sizes of growth in 20 x 30 cm pots were considered for the study. The stem height and girth of two sets of plants varied from 30-45 cm and 1.5-3.0 cm, respectively. In inarching, the top portion of the small sized seed plants was cut off at 15-20 cm and grafted with the large seed plant making a 3-4 cm long slant cut. The inarched union was wrapped and left in 100 % shade. Fifteen inarched plants of each replicate were taken out after shading treatments and transferred to 70 % shade at a net house. Percentage success of inarch was recorded at three months after inarching.

Experiment II. Growth and yield performances of inarched seed plants vs normal seed plants of mangosteen

Six months after inarching, the inarched seedlings along with ordinary seedlings were established in the field at the spacing of 8 x 8 m. The experiment was done in a Randomized Complete Block Design (RCBD) having 2 blocks with 8 plants per treatment in September 2006, to evaluate the growth, development and fruiting of inarched seed plants compared to normal seed plants of mangosteen. The cultural practices recommended by the Department of Agriculture (DOA), Sri Lanka were adopted for the maintenance of the plants. The height of the branching was observed. The trunk height and number of lateral shoot pairs developed were recorded at six-month intervals commencing at three months after the establishment. At the fruit set, in addition to above data, the trunk diameter was also measured. Data on time taken for fruit initiation, number of trees producing fruits, and number of fruits produced was measured. The data were subjected to t-test ($p=0.05$). The Chi-square test ($p=0.05$) was used for the non-parametric data.

RESULTS AND DISCUSSION

Success rate of inarching

No significant differences ($p>0.05$) were observed in the success rate of inarching between 45 and 60 days, in which plants were kept in 100 % shade (Table 1). Therefore, the lesser time period (45 days) is acceptable for healing the inarch union. The seedling inarching is a simple technique that can be accomplished easily, and it does not need the facility of having a mist propagator for the inarch. Poerwanto (2002) provided a nurse stock plant to mangosteen, which is called the approach grafting technique. In approach grafting, a nurse stock plant with the top portion intact was inarched into a mangosteen seed plant and after inarch showed success, the top portion of the nurse plant was removed. This technique of grafting was used in the present experiment with a slightly modification were the upper portion of added plant was cut off at the time of inarching.

Table 1. Success of inarch take of seedlings of mangosteen at two different durations

<i>Duration in 100% shade(days)</i>	<i>Number of Plants inarched</i>	<i>Inarch take</i>	<i>% of success</i>
45	45	44	97.98
60	45	43	95.56

Vegetative growth and fruiting parameters of double-root stocked seed plants vs normal seed plants

A similar increase in the trunk height was shown in both the single-rooted and double-rooted seed plants from the establishment up to the 3rd year. From the 4th year onwards up to the 5th year, the single-rooted plants had a higher plant height over that of double-rooted plants (Figure 1).

Table 2 shows that the percentage trunk height increased in the inarched seed plants compared to normal seed plants. A sharp increase in the trunk growth from the first year to the second year from planting was observed irrespective of the single- or double-rooted seed plants. No significant difference ($p>0.05$) in trunk growth increment was shown up to the 3rd year. In the 4th year, a significant variation ($p<0.05$) in the increase of trunk height was observed, indicating that mangosteen requires a longer time period to show the effects of the added root system. With the onset of fruiting at 5.4 years after planting, the double-rooted plants had a significantly lower stem height increment ($p<0.05$; Table 2) and a lower stem height (Figure 1) than those of non-fruiting single-rooted seedlings. This

suggests that more assimilates may have been utilized for fruit formation rather than vegetative growth and development of the tree trunk.

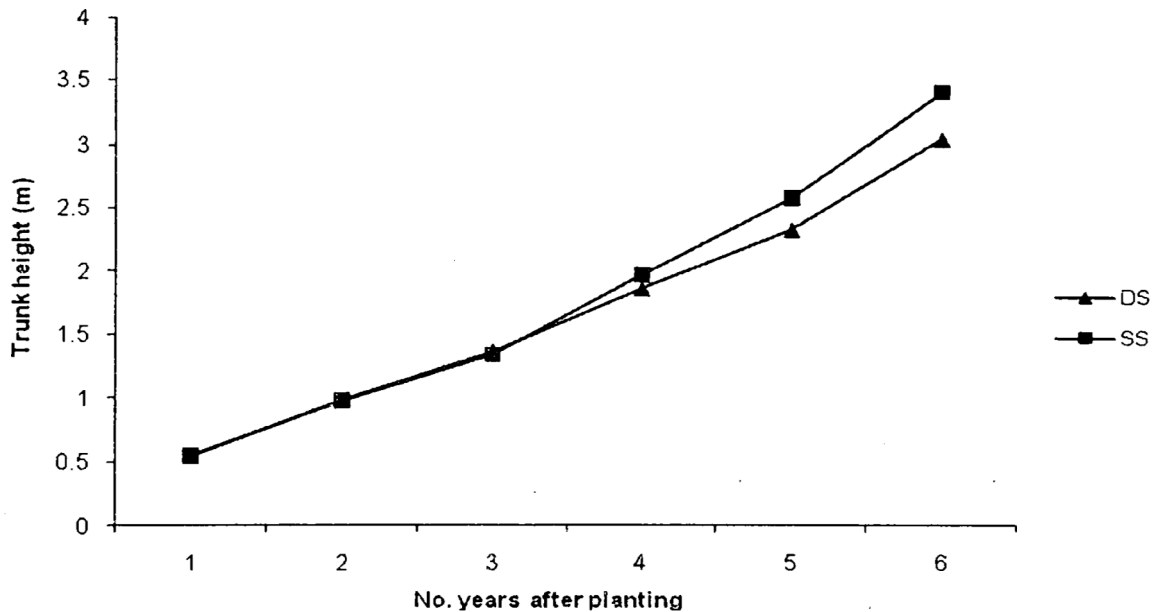


Figure 1. Trunk height of double-rooted (DS) and single-rooted (SS) seed plants of mangosteen from planting to fruit set

Table 2. The percentage increase in trunk height of two types of plants in vegetative phase

Type of Plant	Height Increase %			
	Years after planting			
	2 nd	3 rd	4 th	5 th
Double-rooted seed plants	62.89±13.5	41.90±6.69	74.39±10.11	22.84±5.51
Normal seed plants	77.23±19.47	31.76±2.24	44.08±4.49	54.57±8.26
P value	0.23 ns	0.24 ns	0.005*	0.003*

* Significant at $p=0.05$; ns – non-significant

Research carried out in Australia ([http://www.at.gov.au/d/primary industry](http://www.at.gov.au/d/primary%20industry)) indicated that in the 5th year, the single un-grafted mangosteen trees had higher trunk height over the double-root stocked un-grafted trees, which confirms the findings of the present experiment. In contrast, Poerwanto (2002) reported that double-root stocked seedlings grown in 25 x 35 cm pots significantly enhanced the stem height at six months after approached grafting than those of single-rooted seedlings. This may be due to the increased absorption by two root systems of double-rooted plants in the limited soil content available in pots. Thereafter, no observations on this study were available.

During the two initial years, branching habit of the two types of plants was similar. However, from the 3rd year onwards up to fruiting, the double-rooted plants showed a gradual increase in the number of laterals developed compared to the ordinary seed plant. At the fruit set, the double-rooted plants produced a higher number of primary branches (17) than the normal seedlings (12.5) (Figure 2). This suggests that the provision of an additional root system has an impact on the lateral shoot development than that of trunk elongation. It has been reported that the juvenile period of mangosteen lasts for about 16 pairs of lateral development and the 1st bearing takes place thereafter (Nakasone and Paull, 1998). As such, similarities in observations made on the branching pattern in relation to fruit initiation as mentioned by previous workers confirm the findings of the present study.

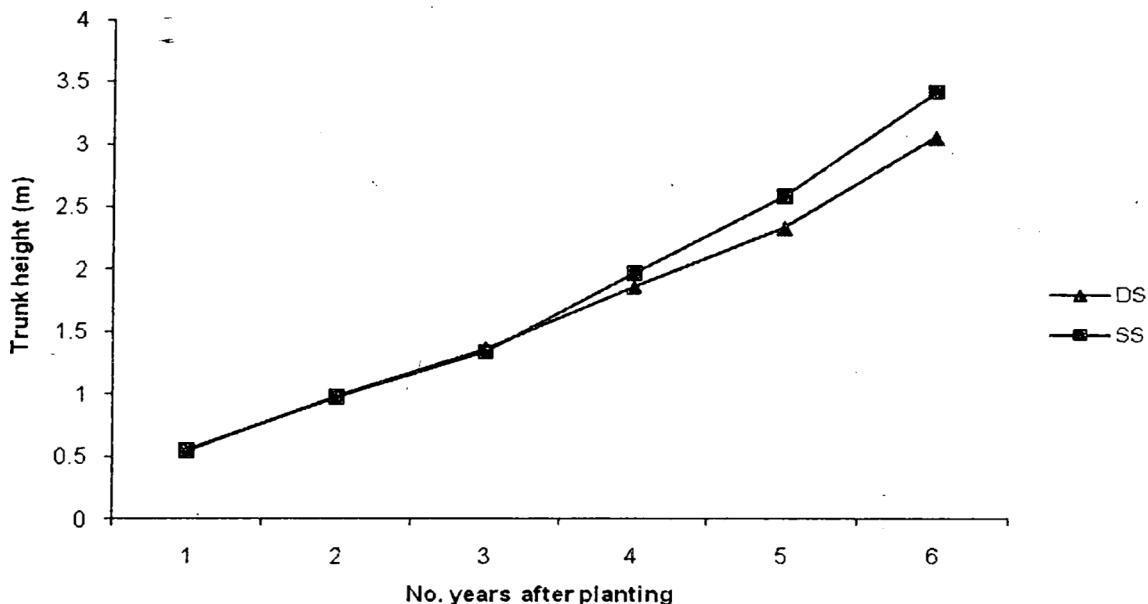


Figure 2. Lateral branch development in double-rooted (DS) seed plants and normal seed plants (SS) of mangosteen during vegetative phase

At the fruit set, seed plants with additional root system have shown a significantly lower rate of trunk growth compared to the single-rooted plants (Table 2), resulting in a significantly lower stem height to that of single-rooted. No significant variation ($p > 0.05$) was observed in either the trunk perimeter or height of the branching point between the two different types of plant. There were a higher number of well-expanded lateral branches in the double-rooted plants, which in turn contributed to fruiting (Table 3).

Table 3. Growth parameters at fruit set and fruiting ability of two types of mangosteen plants

<i>Type of plant</i>	<i>Branching height (cm)</i>	<i>Trunk height (m)</i>	<i>Lateral pairs developed</i>	<i>Trunk perimeter (cm)</i>	<i>% No of fruited plants</i>	<i>Average time taken to fruit initiation from planting (years)</i>	<i>Average No of fruits produced per plant</i>
Double-rooted seed plant	49.33±5.48	3.05±0.18 ^a	17±0.02	21.41±1.82	88	5.4	11.8±6.46
Normal seed plant	50.17±3.60	3.41±0.27 ^b	12.5±0.02	20.01±1.96	-	-	-
Probability				0.41			

Effect of double rooted mangosteen seed plants on fruiting performances

Eighty three per cent of seed plants with added root system initiated flowers and set fruits at the age of 5.4 years after planting, producing a mean fruit yield of 12 fruits tree⁻¹. Even though, studies have been conducted on double-rooted mangosteen seed plants by Poerwanto (2002), no information on fruiting ability was reported.

Experiments carried out in Australia (<http://www.at.gov.au/d/primary> industry) shows that by the 5th year, flowering had not occurred in double-rooted seed plants of mangosteen, whereas no fruits have been formed in ordinary seed plants in the present experiment. It has been reported that the normal seed plants had taken seven years to come into bearing giving a mean yield of 4 fruits tree⁻¹. Similar observations were made by Cruz (2001) and Poerwanto (2002) who reported that the initial bearing takes place in 7-20 years and 8-15 years, respectively, after plant establishment. Thus, in comparison of such findings on seed plants, the present study reveals that the double-rooted plants enhanced early fruiting and produced a relatively acceptable number of fruits. Positive growth and performances of double-rooted seed plants as suggested by Poerwanto *et al.* (1995) are due to enhanced intake of moisture and mineral nutrients and there by increased growth hormone production. Therefore, the technology of using double-rooted seed plants could help promoting early fruiting and enhance productivity of mangosteen.

CONCLUSIONS

The methodology adopted for providing an additional root system for seed plants of mangosteen was inarching. Inarched plants kept in 100 % shade for 45 days showed 98 % success rate. The double-rooted seed plants of mangosteen set

fruits at the age of 5.4 years after field planting. A mean initial yield of 12 fruits tree⁻¹ was recorded from the double-rooted trees, when compared to normal seed plants, which had taken 7-20 years to come into fruiting giving an initial yield of 4 fruits plant⁻¹. Therefore, use of the double-rooted seed plants of mangosteen has shown to be a promising technology in promoting early fruiting and productivity.

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