

## **Effect of seed quantity on growth performance of rubber seedling plants and quality of planting material**

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### **Abstract**

*High-quality rubber seeds ensure high seedling performance and successful production of planting materials in the nursery management. An experiment was conducted at Moneragala Sub Station of RRISL in 2020 to investigate the performance of seedling plants raised from different seed quantities to determine the growth and bud-grafting success. Treatments were setup as two times of seed quantity taken and harvested in three rounds (T1-control), three times seed quantity taken and harvested in two rounds (T2), four and five times of seed quantities harvested in one round (T3 and T4). Seed beds of each treatment were arranged according to Randomized Complete Block Design (RCBD) with five replications. Germinated seeds were transferred to the rootstock nursery as soon as the tip of the radical has forced its way through the seed coat. Once the establishment was completed, the growth of seedling plants was evaluated under nursery condition. The seedling plants which were raised from four and five times of seed quantity have significantly increased stem diameter when compared with the control treatment (T1). It was also revealed that dead plant percentage of seedlings raised from control (T1) treatment was high when compared with T3 and T4 treatments. Increasing the number of fresh seeds to four to five times of the required quantity gives more opportunities to select early germinators with high vigor. Therefore, plants that were raised by T3 and T4 treatments have shown a significantly higher bud grafting success (about 80%) as compared to that of T1 and T2 treatments. The overall results revealed that a higher productivity can be achieved with one-time harvested seedlings from four to five times of required seed quantities. However, the seed availability and cost effectiveness of producing planting materials should also be considered in application of suggested method.*

**Key words:** *bud grafting, germination, growth of rootstock, seeds, seedling, stem diameter*

### **Introduction**

The rubber industry plays an important role in the economy of Sri Lanka. The current extent under rubber cultivation is 126,685 ha as per the latest statistics (Anon, 2018). In order to maintain the

present rubber extent in the country, about 3.3 per cent of rubber extent should be replanted annually (Seneviratne and Wijesekara, 2017). However, there is a great potential for the expansion of rubber plantations in

the country. The annual planting material requirement for new and replanting programs is about 2.5-3 million and plants are being produced in large scale rubber nurseries all over the country.

The annual total seed requirement of the country for establishment of rubber nurseries is around 12 million for the smooth functioning of rubber nurseries rubber nurseries. But, it has been reported that only 25% of the seeds sown in the germination bed produces vigorous root stocks (Seneviratne, 1997). Rubber seeds are collected from rubber fields with the onset of seed fall. There are two nursery seasons in the country corresponding with two seed fall seasons *viz.* January to February in the Intermediate Zone and July to August in the Wet Zone. High quality, vigorous seeds are important for seedling plant development in order to ensure fast growth, disease tolerance and high yield of the rubber tree (Rosli and Akmal, 2019). Rubber seeds are recalcitrant. The loss of viability on storage results in the production of hydrocyanic acid (HCN). Germination of the rubber seed is hypogeal and germination commences within 7 to 10 days under tropical wet climates (Priyadarshan, 2011). Young budded plants are produced by maintaining root stock nurseries for three to four months and bud grafting with authentic bud patches at the bud grafting stage as recommended by RRISL. After the bud grafting, quality planting materials with two whorls of leaf are produced within another four to five-months period. Therefore, the total nursery period for

producing young budded plants is about nine months. The quality of planting material cannot be guaranteed only by the external appearance of the plant or the size of the plant. Nursery inspection reports have shown that 20 - 30 percent of planting materials produced in the nursery are young budded plants and remaining 70-80 per cent of rootstock plants cannot be bud-grafted, within three to four months due to the poor and uneven growth. Further, nursery inspection reports have depicted that despite all the requirements, the rootstock plants are grafted continuously for whole nursery period due to poor and uneven growth of seedling plants. This condition paves way for release of only 40 - 50 per cent of the total number of plants in the nursery thus increasing the cost of production. Likewise, the production of quality planting material mainly depends on the availability of quality seeds and thereby producing quality rootstocks nurseries. High quality seeds guarantee better performance of seedlings, increase the efficiency and successful production of planting materials in the nursery. Therefore, the present study was conducted to investigate the performance of seedling plants raised from different seed quantities in order to enhance the growth, bud-grafting success and productivity of planting material production in Sri Lanka.

### **Materials and Methods**

The study area was located in Moneragala (IL1c). The experiment was carried out at a rubber nursery in an

undulated flat land in Moneragala Sub Station of RRISL in 2020. Fresh rubber seeds of clone RRIC 121 were collected at the major seed fall during February, 2020. Germination beds were prepared and seeds were sown as per the treatments given in Table 1. Seeds beds of each treatment were arranged according to Randomized Complete Block Design (RCBD) with five replications.

Germinated seeds were transplanted to polybags of rootstock nursery as soon as the tip of the radical has forced its way out through the seed coat, according to rounds given in Table 2. Germination was started on 17<sup>th</sup> day after sowing. In T1 seed block, germinated seeds were harvested every other day for three rounds as per the RRISL recommendation (Control) which is maximum four rounds. The late germinators were discarded as they did not produce vigorous plants. The rootstock nursery was established by using black polythene bags (300-gauge, size 7"x 18"). They were arranged in single rows according to randomized

complete block design (RCBD) with five replications. Each replication consisted of 80 plants per treatment.

According to Table 2, full requirement (100%) of germinated seeds were taken from T3 and T4 treatments 17<sup>th</sup> day of sowing in one round. The percentage of germinated seeds harvested from T1 and T2 treatments were 70.5% and 92.8% respectively at the first round. Accordingly, treatment structure was as follows:

T1- two times of seed quantity taken and harvested in three rounds (Control)

T2- three times of seed quantity taken and harvested in two rounds

T3- four times of seed quantity taken and harvested in one round

T4- five times of seed quantity taken and harvested in one round

Seedlings were bud grafted after reaching 6-7 mm stem diameter at 1 cm above the soil surface. Plants were bud grafted using clone RRISL 2001.

**Table 1.** *Treatments and seed quantity*

| Treatments   | Seed quantity                           | No. of seeds | Weight of seeds |
|--------------|---|--------------|-----------------|
| T1 (control) | Two times of required seedling plants   | 800          | 3.2 kg          |
| T2           | Three times of required seedling plants | 1200         | 4.6 kg          |
| T3           | Four times of required seedling plants  | 1600         | 6.3 kg          |
| T4           | Five times of required seedling plants  | 2000         | 8.2 kg          |

**Table 2.** *Percentage of germinated seeds harvested in each round*

| Treatment           | Seed quantity | Rounds | Percentage of seeds taken after each day of germination |                      |                      |
|---------------------|---------------|--------|---|----------------------|----------------------|
|                     |               |        | 17 <sup>th</sup> day                                    | 19 <sup>th</sup> day | 21 <sup>st</sup> day |
| <b>T1 (control)</b> | Two times     | 3      | 70.5  | 17.5                 | 3.8                  |
| <b>T2</b>           | Three times   | 2      | 92.8  | 7.2                  | -                    |
| <b>T3</b>           | Four times    | 1      | 100   | -                    | -                    |
| <b>T4</b>           | Five times    | 1      | 100   | -                    | -                    |

### Measurements

Growth of seedling plants was assessed by measuring the plant stem diameter (at 1cm above soil surface), diameter increment, leaf chlorophyll content, dead plant percentage, dry weight of shoots and roots and Shoot: root ratio. Plant stem diameter; dead plant percentage and leaf chlorophyll content (SPAD unit, from a chlorophyll meter) were measured at monthly intervals commencing from two months after planting. Three leaves were taken to measure chlorophyll unit by averaging all leaflets of leaf samples. Dry weights of seedling plants were taken four months after transplanting to the rootstock nursery. For this purpose, five seedlings from each treatment were uprooted at bud grafting stage and oven dried separately at 80 °C for 48 hours. In order to estimate shoot: root ratio weights of shoot and roots were separately recorded. Bud grafting success was measured after 21 days of the grafting by observing the successes bud patches.

### Statistical analysis

Statistical analysis was done by the analysis of variance followed by a mean separation procedure, using Duncan's

Multiple Range Test (DMRT), at a probability level of 0.05. SAS statistical software package – version 9.0 (SAS Inc., USA) was used to analyze data.

### Results

Plant stem diameter, diameter increment, dead plant percentage, dry matter content and bud grafting success were assessed in order to evaluate the growth performance of rubber seedling plants under nursery conditions in Moneragala District. The variation of stem diameter of seedling plants under different seeds quantities exhibited a significant variation ( $p < 0.05$ ) among treatments (Table 3). The highest stem diameter was recorded in T3 and T4 *i.e.*; four and five times of seed quantity and transferred germinated seeds in one round. Girth increment of seedling plants at four months after planting were calculated by subtracting from initial girth and recorded in Table 3. Girth increment which is referred to as the growth expansion of stem diameter showed a significant increment in T3 and T4. As shown in Table 3, the growth performance of plants that were germinated from two times of seed quantities and taken seeds in three rounds as per the current

recommendation (T1) has shown the lowest stem diameter, diameter increment and the highest dead plant percentage when compared with other treatments. There are no marked differences in chlorophyll content of leaves in all treatments. Plants which are raised from T3 and T4 seeds have shown minimum dead plant percentages and higher reachable bud-grafting percentage achieved when compared T1 and T2 seedling plants (Table 3). Dry matter contents *i.e.*; dry weights of shoot and roots, total dry matter and shoot: root ratio of different treatments

are listed in Table 4. The plants raised under T4 *i.e* five-times of required seeds have exhibited a higher total dry weight, shoot and root growth. As depicted in Table 4, total dry matter content and shoot:root ratio of plants varied among treatments.

A similar trend also observed for bud grafting success (Table 5). Plants which were raised by T4 and T3 treatments have shown significantly higher bud grafting success which is about 80% when compared with T1 and T2 treatment plants ( $\leq 70\%$ ) (Table 5).

**Table 3.** *Effect of seed quantity on dry weight of shoots and roots of rubber seedlings, four months after transplanting into poly bags*

| Treatments | Stem diameter at the initial stage (mm) | Stem diameter at the bud grafting stage (mm) | Diameter increment (mm) | Leaf chlorophyll content (SPAD value) | Dead plant %       | Budded plants % $\geq 6$ mm |
|------------|---|--|-------------------------|---------------------------------------|--------------------|-----------------------------|
| T1         | $4.4 \pm 0.05^b$                        | $5.8 \pm 0.08^b$                             | $1.4 \pm 0.05^b$        | $40.35 \pm 2.54^a$                    | 17.25 <sup>a</sup> | 47 <sup>c</sup>             |
| T2         | $4.2 \pm 0.06^b$                        | $5.7 \pm 0.08^b$                             | $1.5 \pm 0.05^{ab}$     | $40.80 \pm 1.79^a$                    | 26.00 <sup>a</sup> | 44 <sup>c</sup>             |
| T3         | $4.9 \pm 0.04^a$                        | $6.7 \pm 0.06^a$                             | $1.7 \pm 0.05^a$        | $41.38 \pm 1.83^a$                    | 1.25 <sup>b</sup>  | 71 <sup>b</sup>             |
| T4         | $5.1 \pm 0.04^a$                        | $6.9 \pm 0.06^a$                             | $1.8 \pm 0.04^a$        | $42.98 \pm 1.90^a$                    | 0.00 <sup>b</sup>  | 78 <sup>a</sup>             |

**Table 4.** *Dry matter content and Shoot:Root ratio*

| Treatment | Dry weight of shoot (g) | Dry weight of root (g) | Total dry weight | Shoot:Root Ratio |
|-----------|-------------------------|------------------------|------------------|------------------|
| T1        | $12.6 \pm 2.04$         | $4.3 \pm 0.65$         | 16.9             | 2.93:1           |
| T2        | $13.1 \pm 3.19$         | $4.8 \pm 0.97$         | 17.9             | 2.73:1           |
| T3        | $18.7 \pm 3.21$         | $6.3 \pm 1.52$         | 25.0             | 2.97:1           |
| T4        | $18.6 \pm 2.73$         | $6.9 \pm 0.77$         | 25.5             | 2.70:1           |

**Table 5.** *Bud grafting success*

| <b>Treatment</b> | <b>No. of plants grafted</b> | <b>Success plants</b> | <b>Success rate (%)</b> |
|------------------|------------------------------|-----------------------|-------------------------|
| T1               | 188                          | 128                   | 68                      |
| T2               | 176                          | 123                   | 70                      |
| T3               | 284                          | 225                   | 79                      |
| T4               | 312                          | 256                   | 82                      |

### Discussion

In nursery management, producing high-quality planting material at nursery level is a mandatory requirement. Bud grafts of seedling stocks with strong root system markedly influence on the growth of scion (Priyadarshan, 2011). The main objective of this study was to investigate the performance of seedling plants raised from different seed quantities with a view to enhance the quality and quantity of planting material production in Sri Lanka. In the current RRISL recommendation, “germinated seeds should be harvested every other day, and for a maximum of four rounds. Only *ca.* 50% of the seeds will germinate within this period and all the late germinates should be discarded as they will not grow into vigorous plants” (Seneviratne and Nakandala 2021). The results of the present experiment have shown that the growth attributes of T1 treatment have not performed well when compared with the T3 and T4 (Table 3). Increasing the quantity of fresh seeds in four to five times of required seedling plants gives more chance to harvest early germinators with high vigor. Those have shown increment of stem diameter and other growth attributes at four months after transplanting. As depicted in Table 3. Growth of T4

plants which were harvested from five times of seed quantity have shown enhanced performance on stem diameter, chlorophyll content and dead plant percentages when compared the other treatments. This might be due to the harvest of early germinators at the first instance of emergence with high metabolic activity in high-quality seeds which probably provide readily available energy for the emergence and seedling growth (Duand, 2008). The results showed that the higher the quantity of seeds sown for four and five led to harvest high-quality vigorous seeds at once, have an ability to produce evenly grown rootstock with less variation (Table 3).

The variation of dry matter content of stock plants (Table 4) revealed that there were marked difference in dry matter accumulation in T3 and T4 treatments when compared with T1 and T2. Therefore it is revealed that the plants raised by T4 and T3 seed quantities reached bud grafting stage earlier than the other two treatments (Table 5). In bud grafting also it was recorded that more than 70% of seedling plants under T3 and T4 treatments could be bud grafted at four months after transplanting whilst T1 and T2 have shown less than 45% of bud

grafting. This lead to a higher bud grafting success in T4 and T3 *i.e* more than 80% success (Table 5). Finally, cost of planting materiel production was calculated and tabulated in Table 6. In this experiment, the cost

per budded-plant was mainly determined by the number of success plants produced and cost of seed quantity used for producing young budding plants.

**Table 6.** *Cost of production of planting material*

| Treatment        | Seed quantity used (kg) | Cost of seeds used at a rate of Rs.60 per kg (Rs.) | Total cost of production (Rs.) | Number of success plant produced | Cost of production per plant (Rs.) |
|------------------|-------------------------|--|--------------------------------|----------------------------------|------------------------------------|
| T1 – two times   | 3.2 kg                  | 192.00   | 25,408.00                      | 128                              | 198.50                             |
| T2 – three times | 4.6 kg                  | 272.00   | 25,708.00                      | 123                              | 209.00                             |
| T3 – four times  | 6.3 kg                  | 378.00   | 24,890.00                      | 225                              | 110.62                             |
| T4 – five times  | 8.2 kg                  | 492.00   | 24,872.00                      | 256                              | 97.15                              |

### Conclusions

In conclusion, it is revealed that the growth performance of seedling or the stock plants raised from different seed quantities from four and five times seeds and harvested in one round significantly increased the growth attributes of seedling plants along with bud grafted plants. Results confirmed that rootstock plants which were raised by four and five times of seed quantity have resulted in a higher rate of bud-grafting success which will remarkably increase the profit of young budding nurseries. However, it is important to consider the availability of rubber seeds in a particular season and cost effectiveness of producing planting materials before selecting a suitable quantity of seed stock.

### Acknowledgements

Authors wish to thank Dr N M C Nayanakantha and Dr (Mrs) P

Seneviratne for facilitating to carry out this research at Moneragala Sub-station. Authors also wish to extend their gratitude to Dr (Mrs) W Wijesuriya, Principal Research Officer and Mr A M R W S D Ratnayake, Research Officer of the Biometry Section and Mr J K S Sankalpa, Senior Research Officer of the Agricultural Economics Unit for their assistance given in statistical and economic analysis. Assistance provided by Mr V G D Nishantha Gunaseela and Mr N V Upali, Field Officers of Moneragala Sub-station and the field staff for conducting this research is highly appreciated.

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