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Effect of Seed Quality on Field Emergence and Seedling Performance of Rubber (*Hevea brasiliensis)*

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ABSTRACT

The effect of seed quality on the emergence and seedling growth performance of rubber (*Hevea brasiliensis*) was studied. Seven seed samples of various initial quality levels of the RRIM 600 clone were collected from various rubber plantations in Nakhon Si Thammarat, Phatthalung and Songkhla provinces, southern Thailand in 2012 and 2013. The seeds were tested for quality and filed sown to investigate the emergence and growth potential of seedlings using the seedling stem diameter, seedling height and leaf number at 6 mth after germination. The results showed that rubber seeds with germination of 85.50% gave a field emergence of 60.50%, whereas the lower quality seeds (50.50–72.50% germination) had field emergence levels of only 27.00–40.00%. The high quality seeds provided the best growth potential under field conditions based on the seedling stem diameter, seedling height and leaf number at 6 mth after planting with values of 1.17 cm, 118.90 cm and 13.10 leaves, respectively. A comparison among the different quality seeds revealed significant reductions in the performance of seedling characteristics such as seedling stem diameter, seedling height and leaf number, respectively. Therefore, high quality seeds with over 85% germination were recommended for rootstock production and to ensure high seedling performance under field conditions. However, using lower 70% germination rubber seeds resulted in a lower plant population by 20–30% and slower growth than from the high quality seeds.

Keywords: *Hevea brasiliensis*, rootstock, seed quality, field emergence, seedling performance

INTRODUCTION

Rubber (*Hevea brasiliensis*) seeds are normally important and are used to provide rootstock for the budding of high yielding clones (Daud *et al*., 2012). Rubber Research Institute of Thailand (2013) reported that rubber plantation and re-planted areas of Thailand in 2010 amounted to 2,931,201 and 34,228 ha, respectively; therefore budded seedlings in excess of 17,114,000 are required annually and thus a large quantity of rubber seeds is required to produce the budded rubber stumps for the new planting and re-planting program each year. The success of rootstock production mainly depends on the availability of good quality seeds to provide good quality seedlings that are vigorous, uniform and healthy as these benefit the budding process and the production of budded seedlings (Daud *et al*., 2012). However, it is often found that different seed quality affects rootstock propagation, with the various levels of quality being due to the seed behavior with regard to gradual shade and desiccation sensitivity (Chin and Roberts, 1980;

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Wongvarodom and Krisornpornsan, 2013) and the long distances the seeds are transported before planting. Therefore, mixed populations of varying seed quality are often planted into the field for rootstock production. Rodriguez and McDonald (1989) stated that poor quality seed effected slower seedling growth, plant growth and decreased crop yield. However, there was limited information on the field performance and rootstock growth of different quality rubber seeds. The objective of this study was to investigate the effect of rubber seed quality on the emergence and field performances of rootstock seedlings.

MATERIALS AND METHODS

Seed materials

Seeds of rubber clone RRIM 600 were collected in the seed-shedding season during September 2012 and February 2013 from rubber plantations in Nakhon Si Thammarat, Phatthalung and Songkhla provinces, Southern Thailand.

Seed quality determination

Moisture content

Five seeds per replicate were weighed and dried at 105°C for 24 hr. Dry seeds were weighed and the moisture content was calculated as the percentage on a wet weight basis.

Germination

Fifty seeds per replicate were germinated in moist sand in a plastic basket and placed in a plastic lath-house. Four replications were investigated. First and final counts were done at 7 and 21 d, respectively. The number of normal seedlings was averaged as the germination percentage.

Mean germination time

The seeds were germinated in a germination test. Normal seedlings were counted at 7, 14, and 21 d after germination. The mean germination time (MGT) was calculated using the formula of Ellis and Roberts (1981) in Equation 1:

$$MGT = \Sigma nd / \Sigma n \qquad (1)$$

where d is the number of days counted from the beginning of the test and n is the number of seeds which germinate on day d.

Seedling growth

Five normal seedlings per replicate from the germination test were cut above the sand-medium surface and the shoots from each replication were separately dried at 80°C for 24 hr. The dry seedling shoots were weighed and reported as grams per seedling.

Field emergence and growth of seedlings

Field experiments were conducted during 2012 and 2013 in an experimental field of the Plant Science Department, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla province. Fifty seeds per replicate were sown in 2.5 m rows with 25 cm between rows in the field. Watering was provided to maintain adequate soil moisture. Chemical fertilizer (15:15:15, N:P:K) was applied monthly at 50 g per treatment. Normal seedlings were counted at 7, 14, and 21 d after planting. The mean emergence time was also calculated. Seedling growth performances were evaluated using stem diameter (at 5 cm above soil surface) and the height and number of compound leaves were monitored monthly for 6 mth.

Statistical analysis

The experiments were arranged in a completely randomized design and means were compared using Duncan's multiple range test with the significance of results tested at $P < 0.05$ and highly significant results tested at $P < 0.01$.

RESULTS

Quality of rubber seeds from different seed lots

The seeds collected from seven plantations in 2012 and 2013 had various initial qualities as shown in Table 1. The seed moisture content of the seed lots from Nakhon Si Thammarat in 2012 and Phatthalung in 2013 varied from 17.88 to 19.97%

whereas seed lots obtained from Songkhla and Nakhon Si Thammarat in 2013 had a moisture content range from 23.29 to 25.26%. Germination of the seeds was significantly different among seed samples and varied between 50.50 and 85.50%. However, there was no significant difference in the mean germination time which ranged from 18.71 to 19.50 d. Most seeds showed little difference in the seedling shoot dry weight (0.29–0.38 g per seedling). However, the seed sample from Nakhon Si Thammarat in 2013 produced the highest seedling shoot dry weight of 0.42 g per seedling.

Effect of seed quality on field emergence and mean emergence time

Figure 1 shows the effect of the various levels of seed germination on vigor characteristics, particularly field emergence and mean emergence time. High quality seeds with a germination of 85.50 % had the highest field emergence of 60.50%, whereas the lower quality seeds with a germination of 72.50 and 50.50–63.00% had field emergence of only 40.00 and 27.00–38.00%, respectively. The mean emergence time increased as the seed quality lowered. The high, medium and

Table 1 Moisture content, germination, mean germination time and seedling shoot dry weight of RRIM 600 rubber seeds from different plantations in 2012–2013.

Year and seed source	Moisture content (%)	Germination (%)	Mean germination time (d)	Seedling shoot dry weight (g per seedling)
2012 Nakhon Si Thammarat 1	19.91[b]	54.50[d]	18.79	0.36[ab]
2012 Nakhon Si Thammarat 2	19.07[b]	56.50[cd]	19.34	0.35[ab]
2012 Nakhon Si Thammarat 3	17.88[b]	63.00[c]	19.50	0.38[ab]
2012 Nakhon Si Thammarat 4	19.97[b]	50.50[d]	19.24	0.36[ab]
2013 Phatthalung	19.77[b]	54.00[d]	18.86	0.30[b]
2013 Songkhla	23.29[a]	72.50[b]	19.35	0.29[b]
2013 Nakhon Si Thammarat	25.26[a]	85.50[a]	18.71	0.42[a]
F-test	**	*	ns	**
CV (%)	7.51	7.88	3.22	11.96

ns = not significant; * = = significant at $P < 0.05$; ** = significant at $P < 0.01$; CV = Coefficient of variation.
Means in each column with the same lowercase superscript letters are not significantly different using Duncan's multiple range test.

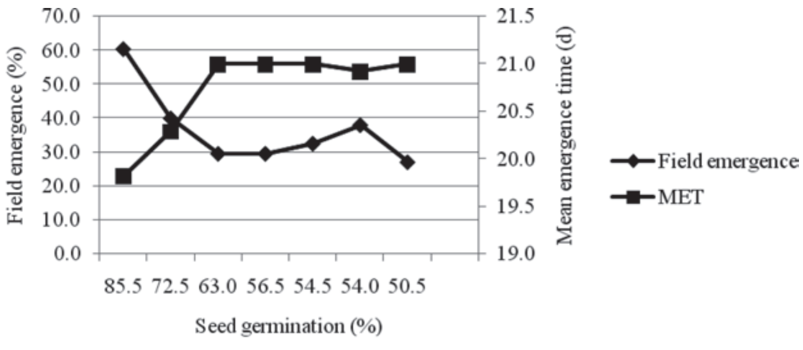

Figure 1 Field emergence and mean emergence time (MET) of different quality seeds of RRIM 600 rubber clone.

low quality seed lots had mean emergence times of 19.82, 20.29 and 20.92–21.00 d, respectively.

Effect of seed quality on field performance of rootstock seedling

The stem diameter of rubber seedlings depended on their seed quality and development times. Changes in seedling stem diameter during the 6 m after planting are shown in Figure 2. One month after planting, the seedling stem diameter ranged from 0.31 to 0.33 cm, after which, the seedling stem diameter increased in the high germination seed lots at a greater rate than for the lower germination seed lots. Significant differences in seedling stem diameter among the high, medium and low quality seeds were found 4–6 m after planting. At 4, 5 and 6 months after planting, the high germination seed lot had the highest seedling stem diameter of 0.82, 0.99 and 1.17 cm, respectively. The medium germination seed lot had seedling stem diameters of 0.76, 0.89 and 1.05 cm, respectively, while the lower quality seeds with germination ranging from 50.50 to 63.00% had seedling stem diameters of only 0.62–0.66, 0.73–0.75 and 0.82–0.88 cm, respectively.

There was also a greater seedling height and number of leaves depending on the rubber seed quality with the same ordering as for seedling stem diameter. At 6 mth after planting, the highest quality seeds with 85.50% germination had a seedling height of 118.90 cm while the medium (72.50% germination) and low quality (50.50–63.00% germination) seeds had seedling heights of 107.70 and 88.30–99.72 cm, respectively (Figure 3). The seedling leaf number for the high, medium and low quality seeds was 13.10, 12.02 and 8.36–10.60 leaves, respectively (Figure 4).

Rubber seed quality had a significant effect on the field performance of rootstock seedlings. Compared with the high quality seed lot (85.50% germination), the seedlings of the medium and low quality seed lots had a significant reduction in seedling stem diameter, seedling height and number of leaves. The reductions in seedling stem diameter of the medium and low germination seed lots were 10.26 and 12.82–29.91%, respectively (Figure 5). Seedling height and the leaf number also declined by 9.42 to 10.18–25.74% and 8.24 to 11.45–36.18%, respectively (Figure 5).

DISCUSSION

High quality plants based on seed

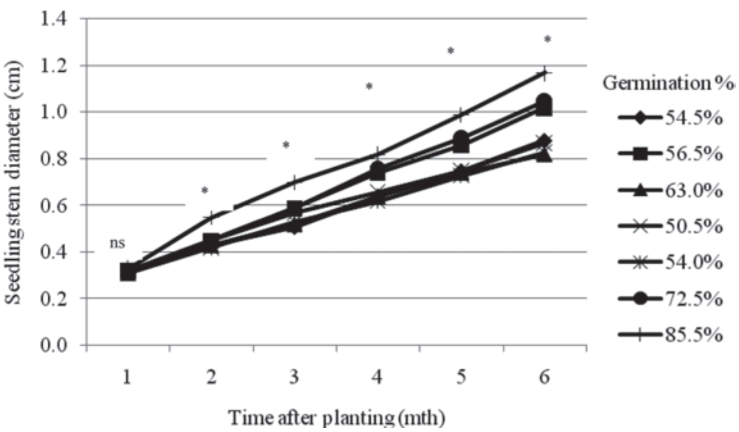

Figure 2 Seedling stem diameter for seed lots with different germination percentages of RRIM 600 rubber clone at different periods after planting (ns = not significant and * = significant at the $P < 0.05$ test level).

germination and the subsequent production of a vigorous and healthy seedling are of great interest and importance to most crop producers (Kelly and George, 1998; Finch-Savage *et al.*, 2010). Therefore, it is suggested that using high quality seeds to lead to uniform field establishment and increased production is a relevant goal for modern plant production (Miller *et al.*, 2010; Ventura *et al.*, 2012). In the current study, variation in rubber seed quality clearly influenced the field emergence and growth of seedlings. High quality seeds had a greater emergence percentage and took less time to emerge compared to the lower quality seeds (Figure 1). This might be due to there being more food reserves and metabolic activity in high quality seeds, which probably provide readily available energy for emergence and seedling growth (Du and Huang, 2008; Wongvarodom and Krisornpornsan, 2013). Therefore, high quality seeds have a rapid emergence, a rapid initial downward growth of the seedling roots and a high potential for upward shoot growth in soil of increasing impedance compared to low quality seeds (Finch-Savage *et al.*, 2010).

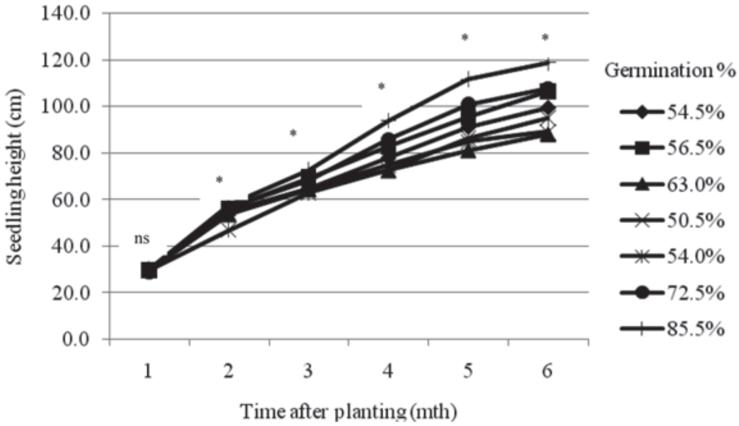

Figure 3 Seedling height for seed lots with different germination percentages of RRIM 600 rubber clone at different periods after planting (ns = not significant and * = significant at the $P < 0.05$ test level)

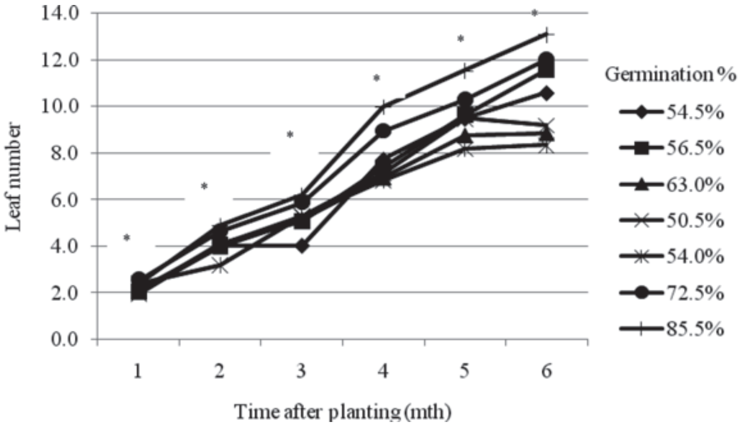

Figure 4 Leaf number for seed lots with different germination percentages of RRIM 600 rubber clone at different periods after planting (* = significant at the $P < 0.05$ test level)

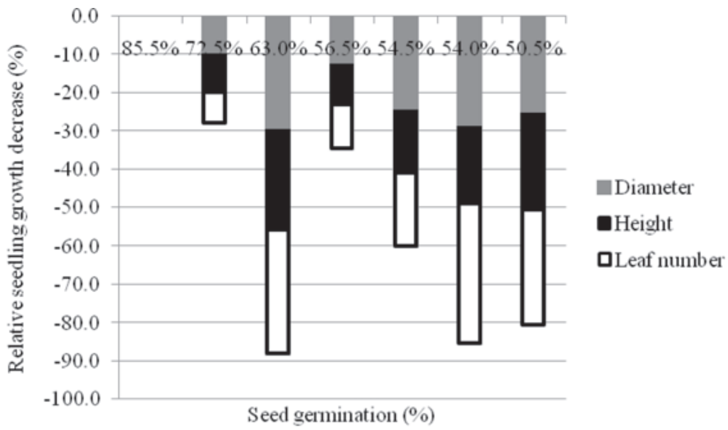

Figure 5 Relative seedling growth decrease of seedling stem diameter, height and leaf number at 6 m after planting of different quality RRIM 600 rubber seeds based on germination percentage.

The growth of rubber seedlings (stem diameter, height and number of leaves) corresponded with their seed quality. Under field conditions, medium and low quality seeds had lower seedling performance than high quality seeds. Differences in seedling field performance based on seed quality were clear at 4-6 mth after planting The reduction in seedling stem diameter, seedling height and leaf number of the two categories of 72.50 and 50.50–63.00% seed germination were 10.26, 9.42 and 8.24% for the first category and 12.82–29.91, 10.18–25.74 and 11.45–36.18% for the second grouped category, respectively, at 6 mth after planting (Figure 5). This might have been due to the lower establishment and adaptation capacity of seedlings from the low quality seeds under field conditions. Rodriguez and McDonald (1989) showed that differences in seed quality (high, medium and low) had major effects on field bean emergence, top growth and root growth and these effects persisted to seed yield. Kocsy *et al*. (2013) reported that in general, plants had adapted to weekly changes in the environment in order to achieve the appropriate growth for survival. The decreased seedling growth of low quality seeds was found also in the deteriorated seeds of citrus species (Saipari *et al*., 1998) and damaged acorns of *Quercus suber* (Branco *et al.*, 2002).

From the results, it can be recommended that planting high quality seeds should result in high quality seedlings within a reasonable time. Planting high quality seeds could also support a high seeding rate and achieve uniform and adequate population levels with fewer resources and less management leading to an increase in the efficiency of rootstock production and the budding process in rubber. Further studies are needed to investigate methods for improved rubber seedling growth in medium and low quality seeds for when there is a seed shortage during the planting season. However, an effective separation method of good quality seed from a mixed population of collected seed might be important in a planting season or year when there are abundant supplies of seed.

CONCLUSION

The results of this study emphasized the necessity of planting high quality seed to ensure high seedling performance in the seedbed to increase the efficiency and successful production of rubber rootstock. Rubber seed with high seed germination (85.50%) produced 60.50% field emergence, whereas the germination rate of lower quality seed had a lower field emergence of 40.00–27.00%. In terms of the growth performance of rootstock seedlings, the high quality seed showed the best potential growth under field conditions, particularly with regard to seedling stem diameter, seedling height and leaf number at 6 mth after planting with values of 1.17 cm, 118.90 cm and 13.10 leaves, respectively, whereas the lower quality seed had a significant reduction in seedling growth from 10.26 to 12.86–29.91%, 9.42 to 10.18–25.74% and 8.24 to 11.45–36.18% in the seedling stem diameter, seedling height and leaf number, respectively. These results indicated that using rubber seed with a germination range from 50 to 70% produced a smaller plant population by 20–30% and the resultant seedling growth was also slower than from using high quality seed.

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