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Growth Performance of Oil Palm Seeds of Different Vigor in Pre-Nursery

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ABSTRACT

Seeds are products due to combination of parental genetic materials and hence, are different from one another, especially with outcrossing species, for example oil palm. Despite controlled pollination to produce desired hybrid of Tenera, oil palm seeds can still be greatly different in vigor expressed as the speed of seed germination. In this study, seeds of two different vigor, namely those germinated fast within three to five days (vigorous seeds) and those that took more than 14 days to germinate (seeds of low vigor), were studied for their seedling growth performance and culling rate in pre-nursery. The experiment was conducted at Tun Razak Agricultural Research Centre, Felda Agricultural Services Sdn. Bhd., Jengka, Pahang. For each type of seeds, 300 germinated seeds grown in six 50-cell plug trays in peat moss as the growth media using semifloat system were randomly selected as test materials. This experiment was based on a Completely Randomized Design (CRD) with six replicates. The results obtained showed that there was generally no significant difference in plant height, leaf number, length of foliage and relative chlorophyll content between seedlings raised from seeds of the two different qualities throughout the pre-nursery period of three months. However, vigorous seeds developed into seedlings with significant better growth performance in terms of width of foliage and stem diameter and had relatively lower culling rate as compared to those grown from seeds that took more than 14 days to germinate. Therefore, the use of vigorous seeds is beneficial in production of oil palm planting materials but seeds with low vigor were still useful in providing cheaper planting stock to planters.
Keywords: *seedling; plug tray; peat moss; semifloat; culling*

1. Introduction

Oil palm, with its scientific name of *Elaies guineensis*, is solely propagated by seeds as it does not produce offshoots like some of its relatives. It has been planted in the tropical commercial plantations with Tenera hybrid (DxP), which is produced by crossing Dura (D) and Pisifera (P), for the past decades. High quality seeds have always been the concern in raising planting materials of oil palm (Mohd Khairil *et al*., 2014a). Seed vigor of oil palm, defined as properties that enable rapid, uniform and normal germination and development of seedling under a wide range of conditions, has been said to be important in ensuring rapid plant growth after field planting, and also probably the ultimate capability and quality of fruiting. Lower production of oil palm due to lower quality of seedlings has been recognized in oil palm plantations. Hence, seedlings with marked low quality, appear less superior and eventually become abnormal trees in the field, have to be culled to ensure only high-quality seedlings are planted out to maximize return from plantations.

The quality of seedlings can be determined by a few factors, for example by using vigorous seeds that germinate fast followed by development of healthy seedlings under optimal nursery practices to provide superior planting materials (AOSA, 2002; Szemruch *et al*., 2015). Seeds that spend prolonged periods to germinate can be attributed to genetic factors (McDaniel, 1973; Kneebone, 1976; Akinyosoye *et al*., 2015). Such lower quality seeds may develop into seedlings with stunted growth or other genetic disorders. In addition, good oil palm nursery management is also important to produce high quality seedlings with lower culling rate. This can ensure that only uniform, normal and healthy seedlings are transferred to the field.

Two-stage oil palm nurseries are the important type in supplying planting materials of oil palm in Malaysia. In pre-nursery as the first stage of nursery, germinated seeds of oil palm are mostly raised in plug trays as semifloat system to save space, labour, media and costs (Wong *et al*., 2013). The pre-nursery is usually three to four months and the seedlings will then be transferred to big polybags spaced

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accordingly in the main nurseries before they are eventually planted out in the field. As the starting point, seed quality has been the concern to reduce wastage of resources. Delayed seed germination has been associated with low vigor and quality and eventually affects seedling growth and field performance. Current commercial nurseries in Malaysia have, hence, demanded supply of vigorous seeds that germinate within less than a week as assurance to high quality seedlings with rapid and uniform growth performance. Such vigorous seeds are commonly supplied to planters or growers with a license. These seeds are very costly. However, less vigorous seeds that germinate only after two weeks from sowing are not discarded but also saved and raised for smallholders as there are claims that many of these seedlings also perform well up to field planting. This study was, hence, aimed to evaluate the differences in mortality, growth performance and culling rate in pre-nursery between vigorous oil palm seeds that germinate within three to five days and the less vigorous seeds that germinate after prolonged period of more than two weeks. This study is hoped to be beneficial to oil palm industries in providing superior and best quality seedlings originated from vigorous seeds while those from the less vigorous seeds are still useful, especially for the smallholders that opt for cheaper planting materials.

2. Material and Method

2.1. Experimental Site

This experiment was conducted in the plant house in pre-nursery of Tun Razak Agricultural Research Centre, Felda Agricultural Services Sdn. Bhd., Jengka, Pahang, Malaysia (N 3°53’4.56”, E 102°31’38.27”). It has estimated terrain elevation of 77 m above sea level. In the plant house, planting of the oil palm seeds for the first four months using plug trays as semifloat system was carried out before transplanting to main nursery. The plant house was warm and humid with an average temperature of 27 - 32 °C and relative humidity of above 70%. It occupied an area of 0.5 hectare and can accommodate approximately 422,400 seeds at one time.

2.2. Test Material

The test materials were Tenera (DxP) oil palm seeds germinated within three to five days (vigorous seeds) and those that took more than 14 days to germinate (less vigorous seeds). The growth performance of the seedlings developed from these two types of seeds was compared in this experiment. Total number of seeds involved in this study was 600 germinated seeds, being 300 vigorous seeds and 300 less vigorous seeds.

2.3. Experimental Procedure

Germinated seeds were raised in peat moss as media in 50-cell high impact polystyrene plug trays measuring 28.2 x 54.5 x 11.3 cm (BX Trays, Humibox). Plug tray application is an alternative to smaller polybag planting in oil palm pre-nursery to reduce cost as the plug trays can be used repeatedly, at least for a few cycles (Wong *et al*., 2013).

Vigorous and less vigorous seeds were planted in the plug trays in the plant house on August 20th, 2015. Prior to planting, planting media of peat moss was filled into the plug trays and water was sprayed onto the media several times using a conventional knapsack sprayer to moisten the media for at least one day. Then, planting of the germinated seeds into peat moss was carried out at a depth between 1.5 to 2.0 cm, with plumule placed upright and radicle placed facing downwards. Correct planting of germinated seeds was emphasized to avoid the development of twisted seedlings.

After planting, germinated seeds were first grown with only water in the water trays of semifloat system until one-leaf stage seedlings. Growth of the seedlings was then enhanced with liquid fertilizer (Felda Liquid Fertilizer, FLF) at recommended rate in the water trays. FLF contains macronutrients of nitrogen (N), phosphorus (P), potassium (K) and magnesium (Mg) at 6:1.2:3.8:0.2. It is a stable fertilizer to be diluted to EC of approximately 0.5-0.7 mS for oil palm pre-nursery.

2.4. Data Collection

Data on growth of the seedlings were recorded monthly for three months. Mortality rate and vegetative growth of the seedlings in terms of height, number of foliage, length, width and relative chlorophyll content of foliage and stem diameter were monitored for this purpose. Mortality rate was scored with all the 50 seedlings per replicate (a plug tray) and all six replicates were taken into account for this parameter. For measurement of vegetative growth performance of the seedlings as affected by seed quality, nine seedlings were randomly sampled from each tray of 50 seedlings (replicate) and tagged.

Plant height was referred to the longest distance between the root collar of the seedling and the highest point of shoot tip in its own form. The latest mature foliage was used for measurement of length, width and relative chlorophyll content of foliage. Foliage length was the longest distance of foliage from its base near the stem to its tip. Foliage width was the longest width from the left to the right across the central of the foliage. The relative chlorophyll content meter, SPAD-502, was used in collecting data on relative chlorophyll content of foliage. Stem diameter, on the other hand, was the diameter of the trunk measured perpendicular to the axis of the trunk using a digital vernier caliper.

Culling rate and observation on abnormal seedlings were recorded at the end of three months. The culled pre-nursery seedlings included those with narrow/grass foliage, twisted foliage, rolled foliage, crinkled foliage, as well as chimaera and collante seedlings.

2.5. Experimental Design and Statistical Analysis

The experiment above was based on a Completely Randomized Design with six replicates. Each replicate was a 50-cell plug tray selected at random from the 50 plug trays for each type of seed quality. There were, hence, 50 seeds in each replicate. Descriptive analysis and two-sample T-test were carried out to determine the difference in the growth of seedlings raised from vigorous and less vigorous seeds. Statistical Package for the Social Sciences version 23 was used for statistical analysis in this study.

3. Results

Mortality of vigorous and less vigorous seeds in pre-nursery was rather similar, being 3% and 3.33%, respectively (Figure 1). Less vigorous seeds had slightly higher mortality count than vigorous seeds in the first month but overall, the mortality rates of both types of seeds were at acceptable level.

In terms of vegetative growth performance, seedlings developed from both vigorous and less vigorous seeds did not show significant difference (P>0.05) in height and number of foliage throughout the study period of three months. The seedlings were taller than 20 cm and had four foliage by the end of the study period. Oil palm seedling generally produces 1 to 1½ foliage monthly until the seedling is six month-old (Corley & Tinker, 2003). After radicle emergence, two bladeless plumule sheaths are first produced before green foliage emerges. When the first foliage expands, photosynthesis will start and the seedling begins to gain size and weight rapidly, and it also changes in shape. Similarly, the length of the mature foliage did not differ between seedlings raised from seeds of different vigor (P>0.05). It was 18-20 cm. Such growth achievement was satisfactory for pre-nursery seedlings (Corley & Tinker, 2003).

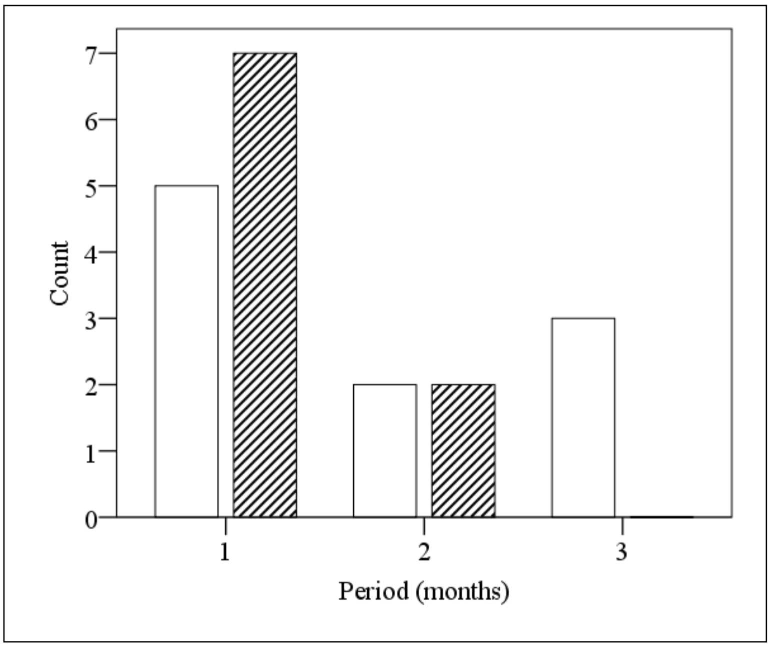

Figure 1. Mortality Count of Seedlings; n=300 for Each Type of Seeds; Blank Bars represent Vigorous Seeds; Bars with Slant Lines represent Less Vigorous Seeds

However, seedlings developed from seeds that took more than 14 days to germinate generally had significantly narrower foliage (P<0.05) as compared to those raised from fast germinating seeds (Figure

2). In spite of having significant difference in width of foliage, there was no significant difference (P>0.05) in foliage relative chlorophyll content between seedlings developed from these two types of seeds throughout the study period of three months. Mean relative chlorophyll contents of foliage at one, two and three months were 34.31±6.93, 36.47±8.53 and 39.98±9.91, respectively.

The stem diameter of the seedlings was not significantly different (P>0.05) in the first two months but those developed from seeds germinated after 14 days were significantly more inferior than those grown from vigorous seeds in terms of stem diameter at three months after planting (Figure 3). Some smaller stems with seedlings developed from less vigorous seeds showed development of swollen bulbs at this stage of three months after planting where the undesirable adventitious roots can then emerge from them (Corley & Tinker, 2003).

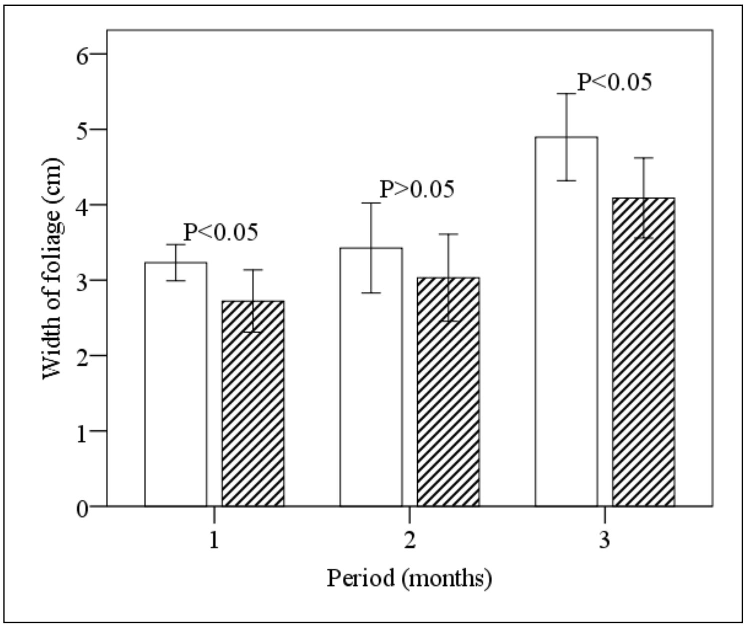

Figure 2. Mean Width of Foliage; I indicates 95% Confidence Interval for Mean; Blank Bars represent Vigorous Seeds; Bars with Slant Lines represent Less Vigorous Seeds

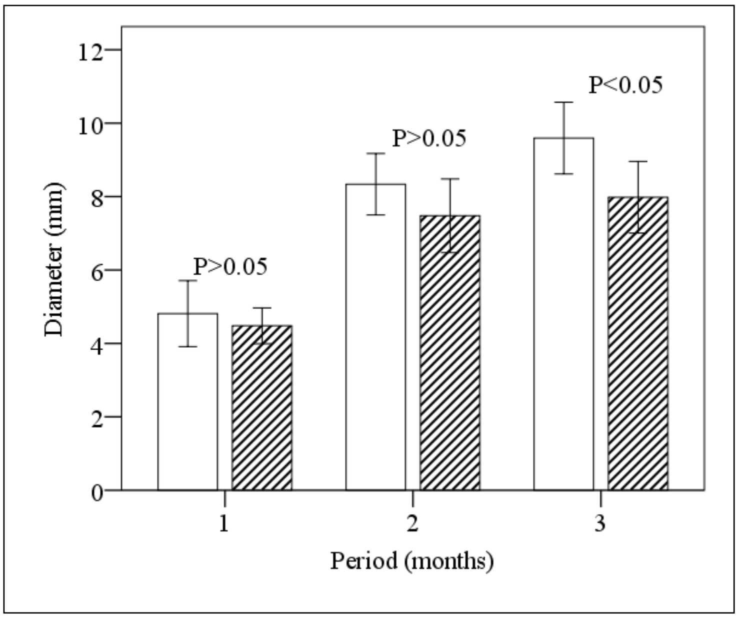

Figure 3. Mean Stem Diameter; I indicates 95% Confidence Interval for Mean; Blank Bars represent Vigorous Seeds; Bars with Slant Lines represent Less Vigorous Seeds

Figure 4 shows the culling counts of the seedlings developed from seeds of different qualities. Higher culling count was recorded with those developed from seeds of lower vigor at three months after planting. There was a total of 17 culled seedlings (n=300) with the less vigorous seeds. The highest count of culled seedlings from the less vigorous seeds was those with narrow foliage (9 seedlings), followed by stunted, crinkled leaved and chimaera seedlings. However, vigorous seeds had much lower culling rate, i.e. only 8 (n=300), or 2.67%, as compared to seeds that took more than 14 days to germinate with 5.67% culling rate. Figure 5 shows oil palm seedlings identified as abnormal seedlings in this study.

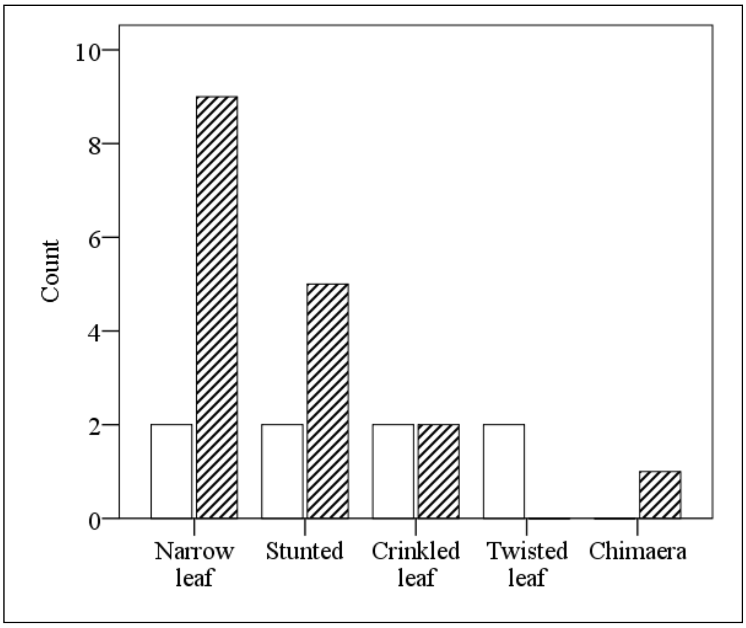

Figure 4. Types of Culled Seedlings; n=300 for Each Type of Seeds; Blank Bars represent Vigorous Seeds; Bars with Slant Lines represent Less Vigorous Seeds

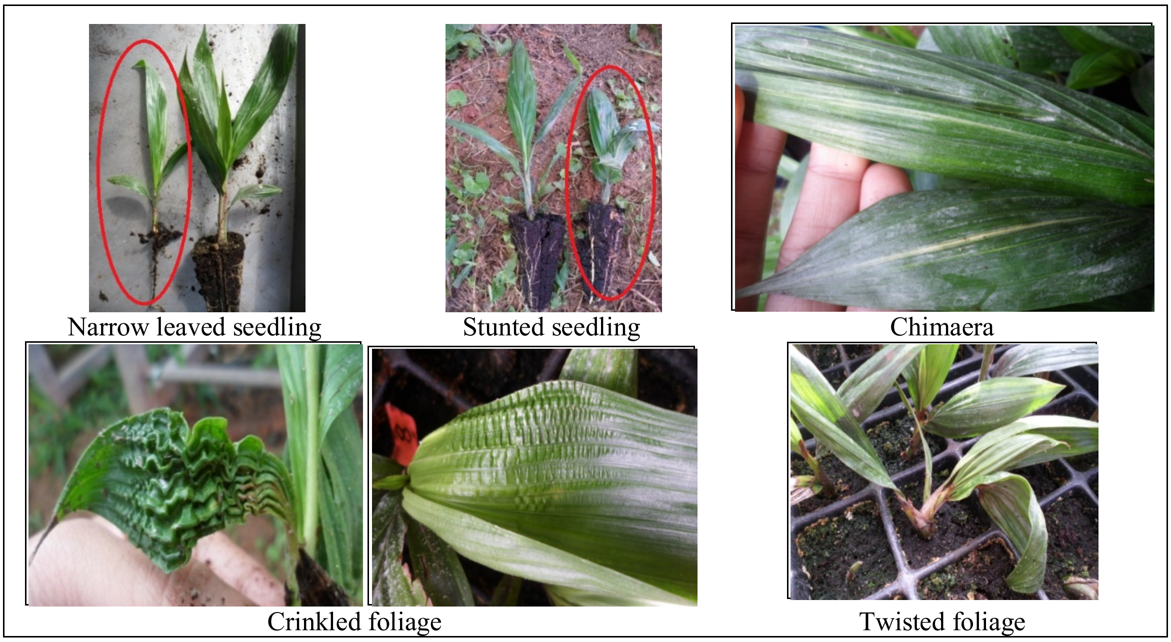

Figure 5. Abnormal Seedlings in Pre-nursery

4. Discussion

In this study, quality of oil palm seeds seemed to affect the growth of foliage and stem, despite the similar quantity of nutrients and water were supplied to each seedling in plug trays at pre-nursery.

According to Tan *et al.* (2014), the difference of seedling growth was frequently attributed to fertilizer and nutrient inputs. Growth of oil palm seedling was also influenced by other environmental factors of sunlight, carbon dioxide concentration, temperature and water availability (Valencia-Diaz & Montana, 2005; Syed Salim *et al.,* 2011; Shibghatallah *et al.,* 2013; Mohd Khairil *et al.*, 2014b; 2014c). However, such differences among the seedlings were eliminated in the current study as all seedlings raised from seeds of different vigor were nursed within the same plant house. Genetic make up of seeds, hence, served as the major determinant of the seed vigor, and eventually the growth and quality of the seedlings in this oil palm planting material production procedure.

Seed is a mature ovule of flowering plant resulted from mixing of parental genetic materials after cross over of chromosomes during meiosis followed by random combination of gametes during fertilization. Such processes can be natural or carried out by breeders to benefit the agricultural and plantation sectors (Mathews & Chong, 2007; Mathews *et al.,* 2008). The offspring produced are hence, different from one another, enhancing ecology adaptability of the plant species and creation of superior hybrids (Dickson, 1980; Kueneman, 1983; Nakonechnaya *et al*., 2013). In addition, the maturity of seeds may even vary within developing fruits; not all seeds develop at the same rate or to the same extent as their fruits, affecting seed germinability and vigor, and ultimately seedling growth, development and normality (El-Kassaby & Edwards, 1998; Diggle *et al*., 2010).

Seed vigor can be revealed through a stress test, for example the accelerated aging test (Delouche & Baskin, 1973; Baskin, 1977; AOSA, 1983; ISTA, 2011). Modeling of seed germination and vigor against seed deterioration treatments has been reported as early as 1960 by Delouche and Caldwell. A lot of subsequent work on seed membrane integrity and leakage, alteration of metabolites within cells and eventually theories on their relationships with fitness of the seeds for sowing has followed (Roberts, 1973; Ellis *et al*., 1990; 1991; Vieira *et al*., 1994; Egli *et al*., 2005; Samaraha & Alqudaha, 2011; Hasan *et al*., 2013; Sharma *et al*., 2013; Szemruch *et al*., 2015). Such models are also of benefits for field performance and yield in many years down the line.

In oil palm pre-nursery, germinated seeds obtained from suppliers were always subjected to quality and quantity inspection before planting in plug trays. Damaged seeds, seeds infected by diseases like brown germ were first recorded and isolated. In standard practice, extra seeds were planted as spare seedlings to replace inferior seedlings that could only be detected later during culling in providing sufficient planting materials to the main nursery and eventually to the field. The current study demonstrated that high vigor oil palm seeds that germinated rapidly within three to five days were advantageous in ensuring high quality planting materials and deserved high prices in the market. Nevertheless, abnormal seedlings could also be minimized with lower vigor seeds that had prolonged germination of after two weeks with good nursery management. Such seeds of lower vigour are much cheaper and affordable by smallholders while high percentages of normal seedlings and low culling rates are still achievable with these seeds with good nursery practices.

Disorders found in oil palm seedlings can be attributed to certain factors, mainly genetic disorders that result in abnormal growth of the seedlings, when optimal husbandry practices are offered to all types of seeds and seedlings. Besides genetic factor, invisible pests and excessive pesticide application can also bring about abnormal seedlings. All seedlings with abnormal characteristics, damage and disease infection must be culled (Mohd Khairil *et al.,* 2014a). In order to obtain superior and high quality seedlings, there is generally no limit set in culling percentage (Mohd Rafi & Esnan, 2009). However, the culling rate of a good nursery is usually below 20%. According to Gillbanks (2003), when the seeds were of low quality or improper nursery management was carried out, the culling rate of oil palm seedlings could exceed 35%. The low culling rate of less than 10% in the current study, despite lower vigor of seeds in terms of germination after two weeks, could have to be greatly denoted by good nursery management while unavoidable genetic factor of the seeds was left to express as differences in the speed of germination and subsequent growth of the seedlings. Culling at pre-nursery contributed to higher efficiency in removing the abnormal seedlings and this can then save resources in the main nursery.

5. Conclusion

Vigorous oil palm seeds that germinated within three to five days were more superior as compared to seeds that germinated after 14 days. Long period germinated seeds, also described as seeds of lower vigor, brought about narrower foliage and smaller stems, and had higher percentage of culled seedlings by the end of three months in pre-nursery. Nonetheless, low culling rates of below 10% could still be accomplished with such lower vigor seeds with good nursery management, providing much cheaper planting materials as benefits to the smallholders.

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