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Germination pattern of three *Mangifera* species

(Corak percambahan tiga spesies *Mangifera*)

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Key words: *Mangifera indica*, *M. feotida*, *M. odorata*, germination, polyembryony

Abstrak

Corak percambahan tiga spesies *Mangifera* di peringkat semaian dibincangkan. Biji benih *M. feotida* (Bacang), *M. odorata* (Kuini) dan klon *M. indica* (Mangga Telur, Tangkai Panjang dan Sala) telah disemai menegak dengan bahagian dorsalnya di dalam pasir di petak semaian. Percambahan dan kemunculan anak benih dikawal secara fizikal oleh endokarp yang berserabut. Kerintangan endokarp terhadap kemunculan anak benih menyebabkan terjadinya anak benih cacat terutamanya bagi kultivar yang ketara bersifat poliembrionik seperti Sala. Kedudukan biji benih semasa disemai mungkin dapat mengurangkan peratus kejadian anak benih cacat. Tinggi anak benih, bilangan daun dan bilangan hari daun pusaran pertama menjadi hijau berhubung kait dengan bilangan anak benih yang muncul dari setiap biji benih dan adalah bersifat spesifik bagi kultivar berkenaan.

Abstract

The germination patterns of three *Mangifera* species at the seedbed stage were described. Seeds of *M. foetida* (Bacang), *M. odorata* (Kuini) and clones of *M. indica* (Telur, Tangkai Panjang and Sala) were sown vertically with the dorsal edge in the sandy seedbed. Germination and seedling emergence appear to be regulated physically by the fibrous endocarp. The endocarp resistance to seedling emergence consequently resulted in seedling abnormalities, especially in strongly polyembryonic cultivar such as Sala. Seed position during sowing, to a certain extent, may reduce the percentage of occurrence of seedling abnormalities. Seedling height, leaf number and the number of days for the first leaf flush to become green were related to the number of seedlings produced per seed and were cultivar-specific.

Introduction

The common mango (*Mangifera indica* L.) trees are widely grown in Malaysia in commercial or mixed fruit orchards, as landscape or in home gardens (Tengku Ab. Malik 2000). Mango in Malaysia comprised many cultivars, some of which are of no commercial value but are probable source of genetic material for plant improvement. The fruits are available almost all year round but the main season is in May–June followed by October as the off-season, especially in the northern states of Malaysia.

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The main method of propagation is grafting, using a suitable variety as the seedling rootstock. Tropical mango cultivars, however, are classified as polyembryonic, which enable each seed to produce several seedlings (Litz 1997). The seedlings from each seed differ in terms of vigour, plant size or height depending on whether they are nucellar or zygotic in origin. In polyembryonic cultivars, nucellar seedlings can be identified by the uniformity in the colour of the emerging leaves that are not present in zygotic seedlings (Anon. 1990). The first seedling that emerged is not always the most viable or vigorous in growth. However, only one embryo is of zygotic in origin which then degenerates or becomes weak and stunted seedling (Litz 1997). Seedling detection, whether zygotic or nucellar, and separation at the seedbed stage is therefore crucial before transplanting into nursery polybegs to minimize the number of abnormal (crooked) seedling rootstocks or zygotic seedlings.

Some sorts of physical mechanism appear to regulate the germination and emergence processes of mangoes. Seed position during sowing may also contribute to the occurrence of higher percentage of seedling abnormality. This paper described the germination pattern or behaviour and abnormalities observed during the germination and emergence of three *Mangifera* species at the seedbed stage. Suggestions were given to minimize the development of crooked seedlings and the detection and removal of zygotic seedlings.

Materials and methods

Three *Mangifera* species, namely *M. feotida* Lour. (Bacang), *M. odorata* Griff. (Kuini) and *M. indica* clones Telur, Tangkai Panjang and Sala were collected from known tree sources in Perlis and Kedah, Malaysia. Besides Sala, the other *Mangifera* species and cultivars were of insignificant commercial value except for occasional use in fruit salad or special delicacies. Telur, however, is usually used as seedling rootstocks for propagation of commercially selected mango cultivars.

Before sowing, the skin and the flesh of 40 mature fruits of each species or cultivars were removed and the seeds were washed with clean water and air-dried for one day. The seeds were later sown at 20 cm apart, placed vertically with the dorsal end embedded 3 cm in the sandy seedbed. The seedbed was shaded with black netting and watered daily. The seedlings were randomly harvested once the shoot appeared above ground. The germination and emergence processes were recorded until the last seedling from the seed emerged. For each species and cultivar, the following observations were noted: 1) number of days to first and last seedling emergence, (2) number of seedlings produced by each seed, (3) number of leaves at the first flush, (4) number of days for the leaves of the first flush to become green, (5) seedling abnormality and (6) seedling root system.

Results and discussion

Germination and emergence

Tropical *Mangifera* species have the ability to produce more than one seedling per seed (polyembryony). The result showed that the seeds of randomly selected *Mangifera* species and cultivars produced different number of seedlings *(Table 1). Mangifera feotida* (Bacang) seeds consistently produced a single seedling while *M. odorata* (Kuini) seeds produced 1–2 seedlings *(Plate 1).* M*angifera indica* clones Telur

Table 1. Number of seedlings growing from a single seed of *Mangifera* species and cultivars at germination

Species	Number of seedlings
M. feotida (Bacang)	1
M. odorata (Kuini)	1–2 ± 0.5
M. indica cv.Telur	2–3 ± 0.5
M. indica cv. Tangkai Panjang	2–4 ± 0.8
M. indica cv. Sala	4–6 ± 0.9

Mean of ten germinating seeds of each species and cultivar (± sd)

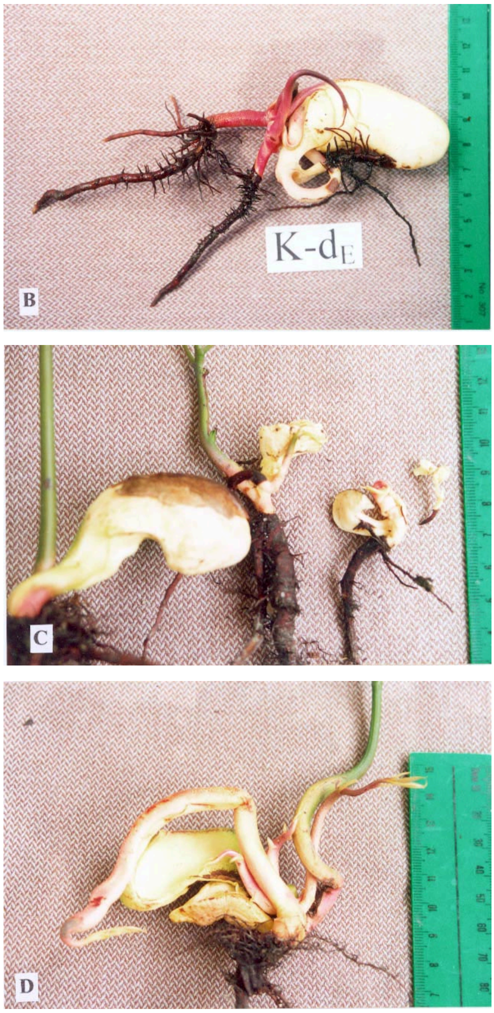

Plate 1. Number of seedlings growing from a Mangifera seed.
(A) ***M. indica*** *cv. Telur – 2,*
(B) ***M. odorata*** *(Kuini) – 2,*
(C) ***M. indica*** *cv. Tangkai Panjang – 4,*
(D) ***M. indica*** *cv. Sala – 5*

and Tangkai Panjang seeds produced between 2–4 seedlings of variable plant size. *Mangifera indica* cv. Sala, however, persistently produced between 4–6 seedlings per seed, thus exhibiting a strong polyembryonic trait compared to the other *Mangifera* species *(Plate 1).* Three to eight seedlings were usually reported to have originated from a polyembryonic seed (Litz 1997). These results indicated that the Malaysian *Mangifera* species have wide variability in germination ability, which further supported the findings that Malaysia has one of the highest species diversity (Verheij and Coronel 1992).

Occasionally, however, a single embryo is found within a polyembryonic seed (Litz 1997). *Mangifera feotida* (Bacang) exhibits this trait compared to the other species or cultivars used in this study. 'Bacang' was not considered as monoembryonic even though only one seedling was produced per seed. The cotyledons of 'Bacang' seeds were of equal sizes compared to the unequal and lobed cotyledons of the monoembryonic type (Litz 1997). However, Verheij and Coronel (1992) classified *M. feotida* (Bacang) seed as monoembryonic and *M. odorata* (Kuini) as frequently polyembryonic. The result of this work supported Litz (1997) classification that

M. feotida (Bacang) is polyembryonic because the cotyledons are of equal sizes.

Seedling number was also correlated to the period the cotyledons remain attached to the developing seedlings. In ascending order, the cotyledons of *M. feotida* (Bacang) remain attached to the seedling for the shortest time while the cotyledons of *M. indica* cv. Sala took the longest time. The cotyledons of *M. feotida* (Bacang) detached from the seedling approximately 20 days after seedling emergence while the other *Mangifera* species or cultivars took more than 50 days, which, indirectly allowing more time for the embryos to develop and emerge.

Furthermore, the ability of the cotyledons to remain functional while still being protected inside the endocarp, in turn, appears to regulate the germination and emergence processes *(Table 2)*. *Mangifera feotida* (Bacang), being dominantly single-seedling type, was clearly different compared to *M. indica* cv. Sala. The germination of *M. feotida* (Bacang) seeds took place within the range of 19–28 days compared to *M. indica* clones Sala or Tangkai Panjang that took 21–65 and 25–46 days, respectively. The mean values for the germination and emergence for these *Mangifera* species or cultivars, however, might not provide a clear indication of the actual length of time the whole processes really took place.

The differences among the means were not large, except between *M. feotida* (Bacang) and *M. indica* cv. Sala. The longer period for the germination and emergence processes were correlated to the number of seedlings each seed could produce. Competition among the developing embryos may account for the delay. *Mangifera indica* cv. Sala took 44 days for all the seedlings (4–6) to emerge compared to 11–13 days for *M. odorata* (Kuini) or *M. indica* cv. Telur to produce 2–3 seedlings *(Table 2)*. Thus, the germination and emergence period for these *Mangifera* species or cultivars were still comparatively longer than the 14–21 days reported in earlier studies conducted in Punjab and Florida (Litz 1997).

The Mangifera seed

Seed length of these *Mangifera* species and cultivars appears not related to the germination capability, polyembryony or the ability of the seed to produce more than one seedling per seed *(Table 3)*. Seed length, however, was apparently proportional to cotyledon length. In ascending order, *M. indica* clones Telur and Tangkai Panjang had similar seed length followed by *M. odorata* (Kuini), *M. feotida* (Bacang) and

Table 3. Seed length of *Mangifera* species and cultivars

Species	Length (cm)
M. feotida (Bacang)	10.3 ± 1.2
M. odorata (Kuini)	7.8 ± 0.8
M. indica cv. Telur	5.5 ± 0.5
M. indica cv. Tangkai Panjang	5.9 ± 0.6
M. indica cv. Sala	13.5 ± 1.6

Mean (± sd) of 20 seeds of each species and cultivar

Table 2. Number of days to first and last seedling emergence of *Mangifera* species and cultivars

Species	First emergence		Last emergence (after first seedling)
	Range	Mean	
M. feotida (Bacang)	19 – 28	21 ± 2.5	–
M. odorata (Kuini)	31 – 42	35 ± 3.5	11 ± 2.1
M. indica cv. Telur	19 – 32	22 ± 2.1	13 ± 2.8
M. indica cv. Tangkai Panjang	25 – 46	34 ± 4.8	21 ± 3.7
M. indica cv. Sala	21 – 65	41 ± 6.2	44 ± 5

Mean of ten germinating seeds of each species and cultivar (± sd)

M. indica cv. Sala when measured along the horizontal axis. The larger seeds of *M. indica* cv. Sala (13.5 cm) were probably to accommodate more number of embryos. However, each embryo was attached to only a portion of the total cotyledon size (*Plate 1*) and that each portion of the cotyledon that holds the embryo was of unequal size, resembling the monoembryonic seeds as described by Litz (1997). Based on these observations, *M. odorata* (Kuini) and *M. indica* clones Telur, Tangkai Panjang and Sala may be classified as monoembryonic type. On the contrary, the cotyledons of *M. feotida* (Bacang) were of equal sizes.

The persistence of the fibrous endocarp (seed coat) might be attributed for the extended germination and emergence period of the *Mangifera* seeds. The endocarp of *M. feotida* (Bacang) could be easily separated from the cotyledons 10–14 days after seedling emergence. However, for *M. indica* clones Tangkai Panjang or Sala, the endocarp could not be separated from the cotyledons even after 60 days after emergence of the first seedling. This peculiar resistance of the endocarp to physical detachment might be responsible for protecting the developing embryos. Furthermore, seedling abnormality such as crooked shoot, observed during the germination and emergence of these *Mangifera* species or cultivars might also be attributed to the persistent nature of the endocarp *(Plate 2).*

Another probable contributing factor to this malady might be the number of embryos per seed *(Table 1).* The most common type of seedling abnormality observed was twisted, crooked and broken hypocotyl or stem *(Plate 1D, Plate 2).* Consequently, *M. indica* cv. Sala was observed to exhibit the most number of deformed or abnormal seedlings compared to *M. indica* clones Tangkai Panjang and Telur, or *M. odorata* (Kuini). For *M. feotida* (Bacang), however, the L-shaped seedling was most commonly observed *(Plate 2C).* As a result, more than half of the number of seedlings produced by a polyembryonic seed may be unsuitable as potential seedling rootstocks. This apparent disadvantage of the polyembryonic trait might be overcome by some sort of mechanical or chemical manipulation to the fibrous and persistent endocarp prior to seed sowing. In addition, sowing the seeds with the concave side down has been shown, to a certain extent, can avoid the development of crooked shoots and roots (Anon. 1994).

Leaf and root

The number of leaves produced during the first leaf flush at seedling emergence stage also differed among the *Mangifera* species and cultivars *(Table 4). Mangifera feotida* (Bacang) and *M. indica* cv. Telur consistently produced four leaves per seedling *(Plate 2)* while *M. odorata* (Kuini) and *M. indica* cv. Sala produced between three to five leaves per seedling. *Mangifera indica* cv. Tangkai Panjang, however, produced the most number of leaves, usually between 5–8 leaves per seedling. Furthermore, *M. feotida* (Bacang) had larger leaves compared to the other *Mangifera* species or cultivars *(Plate 2). Mangifera indica* clones Telur and Sala, and *M. odorata* (Kuini) had comparable leaf sizes. For *M. indica* cv. Tangkai Panjang, the leaves gradually increased in size up the stem and were always erect compared to the more drooping position for the other *Mangifera* species or cultivars. In addition, immature leaf colour observed at seedling emergence was green, purplish or reddish with the reddish variant being the most common.

Seedling height measured when the first leaf flush attained green colour differed among the *Mangifera* species and cultivars *(Table 4). Mangifera feotida* (Bacang) was the tallest (28.6 cm) and *M. indica* cv. Sala was the shortest (12.8 cm) at this particular stage. The differences in height between *M. feotida* (Bacang) and *M. indica* cv. Sala seedlings might apparently be related to the greater sink-source partitioning and competition among the developing Sala

*Plate 2. Seedling abnormalities in **Mangifera** species*
*(A) **M. indica** cv. Sala – crooked stem,*
*(B) **M. indica** cv. Telur – twisted stem,*
*(C) **M. feotida** (Bacang) – L-shaped stem*

Table. 4. Number of leaves, seedling height and days for the first leaf flush to attain green colour in *Mangifera* species and cultivars

Species	Number of leaves	Seedling height (cm)	Days to green colour
M. feotida (Bacang)	4	28.6 ± 3.5	32.8 ± 2.1
M. odorata (Kuini)	3–4 (± 0.6)	22.5 ± 3.3	31.6 ± 1.5
M. indica cv. Telur	4	23.2 ± 2.6	21.3 ± 2.8
M. indica cv. Tangkai Panjang	5–8 (± 1.5)	16.8 ± 3.5	23.8 ± 2.3
M. indica cv. Sala	3–5 (± 1.2)	12.8 ± 1.8	23.6 ± 1.8

Mean of ten seeds of each species or cultivar after emergence (± sd)

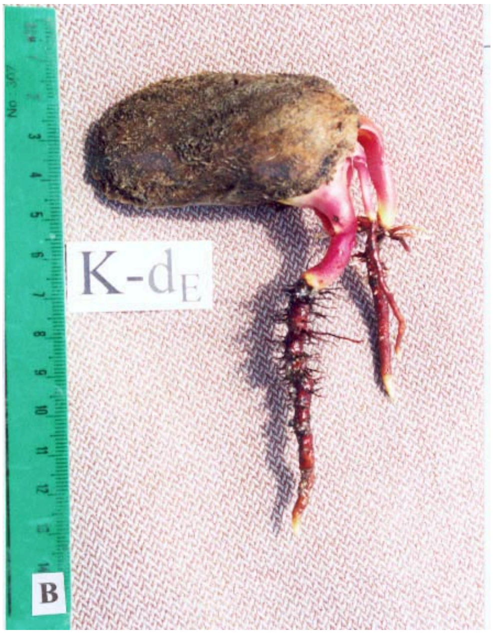

Plate 3. Early root system among ***Mangifera*** *seedlings at germination.*
(A) ***M. feotida*** *(Bacang),*
(B) ***M. odorata*** *(Kuini),*
(C) ***M. indica*** *cv. Telur and*
(D) ***M. indica*** *cv. Tangkai Panjang*

embryos *(Table 1)*. The single-seedling *M. feotida* (Bacang) has all the resources from the cotyledons compared to the 4–6 seedlings of *M. indica* cv. Sala that shared the cotyledons.

Furthermore, the apparent sink-source competition might explain the reason *M. indica* clones Sala, Telur or Tangkai Panjang, with more seedlings per seed, to attain green leaf stage earlier (24 days) compared to that of *M. feotida* (Bacang) seedlings (33 days; *Table 4*). Conversely, the longer period it took for *M. feotida* (Bacang) or *M. odorata* (Kuini) leaves to become green may indicate that these two species were slower growing compared to the *M. indica* clones (Telur, Tangkai Panjang or Sala). From *Table 4*, it can be inferred that suitable seedling height for transplanting and favourable growth rate might be the advantage for Telur to be usually selected as seedling rootstocks compared to the other *Mangifera* species and cultivars.

The early root system from the seedling appeared to function primarily as anchorage and to acquire nutrient resources from the soil. The result showed that *M. feotida* (Bacang) produced the radicle that later develops into a taproot with numerous lateral roots compared to the other *Mangifera* species (*Plate 3*). At emergence, the mean radicle length of the *Mangifera* species or cultivars was as follows: *M. feotida* (Bacang), 7.8 cm; *M. odorata* (Kuini), 7.6 cm; *M. indica* cv. Telur, 5.4 cm; *M. indica* cv. Tangkai Panjang, 4.7 cm and *M. indica* cv. Sala, 13.0 cm.

Preliminary examination of the Bacang radicle showed an estimate of more than 150 lateral roots of different length and sizes at seedling emergence stage. These lateral roots had a total length of approximately 20 cm. The other species and cultivars, however, produced several radicles corresponding to the number of germinating embryos within the seedcoat. Natural branching of the radicle at this early stage of germination was also common, as observed in *Mangifera odorata* (Kuini) and *M. indica* clones Telur and Tangkai Panjang. However, the seedling root system nutrient acquisition capacity will not be discussed in this work.

Conclusion

Based on cotyledon shape or size, *M. odorata* (Kuini) and *M. indica* clones Telur, Tangkai Panjang and Sala may be classified as monoembryonic instead of polyembryonic. Germination and emergence of these three *Mangifera* species were apparently regulated physically by the fibrous endocarp (seedcoat), which in turn determines the longevity of the cotyledons within. The longer the cotyledons remained protected by the endocarp and functional to the seedlings, the greater the chances for the seedlings to develop and emerge to the soil surface.

Consequently, the endocarp resistance to seedling emergence resulted in the development of abnormal seedling, especially in strongly polyembryonic species or cultivars such as *M. indica* cv. Sala. For *M. feotida* (Bacang) that produced only one seedling, the L-shaped seedling malady was quite commonly observed. The development of crooked shoots and roots, however, can be avoided to a certain extent by sowing the seeds with the concave side down. Mechanical or chemical manipulation to the endocarp might be practised to minimize the number of abnormal seedlings provided that precautions are taken to minimize disease occurrences during the germination process. In addition, early detection and separation of vigorous seedlings of nucellar origin might be another alternative, for example, based on the uniformity of the colour of the emerging leaves.

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