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Hybrid seed germination in oil palm (*Elaeis guineensis*) affected by innovative dormancy breaking techniques

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ABSTRACT

Seed dormancy is considered as a major cause for low and erratic germination in oil palm (*Elaeis guineensis* Jacq.) which affects quality planting material production. To alleviate the problem, fresh hybrid seeds were subjected to seven treatments, viz. T_1-complete endocarp removal and de-operculum, T_2-chipping endocarp and de-operculum, T_3-chipping endocarp and scarification of operculum with pile rod, T_4-chipping endocarp and scarification of operculum with sand paper, T_5-chipping endocarp and needle insertion in the operculum and T_6-making crack at germ pore region of shell and T_7-dry heat method (control) with an objective to achieve uniform, speedy and maximum seed germination. Results showed that endocarp chipping combined with de-operculum resulted in the highest germination (88%) and took 3, 4 and 8 days to initiate germination, 50% germination and final germination, respectively. Dry heat method took 11 and 12 days to initiate and 50% germination, respectively resulted in only 66.6% germination even after 20 days incubation. Dry heat method also required extra heat treatment at 40° C for 60 days. It is inferred that chipping combined with de-operculum could be substituted with dry heat method at commercial seed production centres to break seed dormancy. Laboratory scale seed chipping machine is developed for chipping the endocarp of seeds. Up-gradation of lab scale machine is envisaged to scaling up germinated seed supply in a short period of time.

Key words: Chipping Machine, Germination, Oil palm hybrid, Operculum, Scarification, Seed dormancy

There are 13.5 million hectares planted with African oil palm (*Elaeis guineensis* Jacq.) in the world with a production of over 45 million tonnes of palm oil which is expected to increase substantially due to growth in demand for oil by the food industry and the use of biodiesel in Europe and other countries. Although, it is planted on only 5% of the total world vegetable oil acreage, palm oil accounts for 33% of vegetable oil and 45% of edible oil worldwide (Rajinder *et al*. 2013). Oil palm meets 30% of the world edible oil and fat requirements with lesser than seven per cent of the areas occupied by oil crops. Apart from area expansion, this perennial oil seed crop has to be replanted every 25 to 30 years. Growing demand for palm oil resulted in an unprecedented increase in global production area. Most of the current planting material is germinated seed of genetically improved varieties (Zamzuri *et al*. 2007) and seeds will continue to play major role as planting material in the next 10-15 years. Moreover, bi-clonal seed production (clonal propagation of best female *duras* and male *pisiferas* and production of seeds by adopting conventional hybridisation technique) is recommended as an alternate to clonal propagation of *tenera* by tissue culture (Corley and Tinker 2003). Hence, seed will be used for either plantation establishment or breeding trials as a propagation material (Martine *et al*. 2009). Naturally, oil palm seeds are pre-heated under sun resulting from the exothermic decomposition of the oily mesocarp by fungi and other micro organisms (Fondom *et al*. 2010). However, this natural process is very slow and few seeds only germinate. Dry heat method (heating at 40° C for 60 days and soaking in water) has been reported to have difficulties in terms of time consumption and high cost of maintenances of temperature in heating room. Another major disadvantage in dry heat treatment is differences of germination among different cultivars with similar treatment period (Fondom *et al*. 2010). There are no reports on commercial utilities of chemical methods of breaking dormancy in oil palm seed production. The operculum removal by hand (Myint *et al.* 2010b) may not be practically adopted as it is laborious and time consuming. Hence, the slow and erratic germination of seed has been realised as a practical problem due to dormancy which influences quality planting material production (Noor 2007). In the present study, experiments were conducted with an objective to find out easy to adopt, quick dormancy breaking and innovative scarification technique in oil palm seeds to get uniform planting materials.

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MATERIALS AND METHODS

The experiment was conducted using freshly processed hybrid seeds from the cross between selected *dura* mother palm and *pisifera* male palm both screened from African germplasm at Directorate of Oil Palm Research, Research Centre, Palode, Kerala state. The experimental location receives an annual rainfall of 2815 mm with a maximum, minimum temperature of 32.1° C and 22° C, respectively. It has forest laterite soil with a pH range of 5.0 to 5.5. Two hybridised bunches with uniform size, harvested from 15 years old oil palm were utilised for conducting this experiment. The mesocarp of hybridised seeds was removed by mechanical de-pulper and extracted seeds were washed with detergent to clean mesocarp remnants. Seeds were also bleached by soaking in sodium hypochlorite (4%) (NaClO) solution for 15 minutes and air dried in shade for two days by spreading on metal wire mesh trays as a single layer. The air dried seeds of one of the hybridised bunches were subjected to grading and uniform seeds alone were packed in polythene bag of 500 gauge thickness and dried in heating room at 40° C for 60 days. Seeds from above heat treatment was used as control (T_7) and compared with new scarification techniques. Seeds from another hybridised bunch after processing similar to dry heat treatment was divided into 6 groups and subjected to six treatments, viz. T_1-complete endocarp removal and de-operculum, T_2-chipping endocarp and de-operculum, T_3-chipping endocarp and scarification with pile rod, T_4-chipping endocarp and scarification with sand paper, T_5-chipping endocarp and needle insertion in operculum and T_6-making crack at germ pore region of shell using a hammer in such a way that kernel is not damaged while treating the nuts. For chipping endocarp of oil palm seeds, separate methodology was developed for easy removal of endocarp without damage to the kernel. The locally designed device was used along with electrically operated motor with cutting device for chipping the shell for the treatments (T_2-T_5). The device was named as oil palm seed chipping machine. Using the machine, a piece of shell containing germ pore is removed in such a way that kernel is not damaged. Damaged seeds if any were rejected. The technique of operculum removal was adopted as per the methodology reported by Murugesan *et al*. (2008). All the seeds were soaked in water until they attained seed moisture content of 22% before scarification.

The experimental design used was CRD with seven treatments each with three replications consisting 25 seeds per replication. The entire experimental set up was incubated in germination room at 25-28° C. Germinated seeds were counted (when radicle protrudes) daily up to six weeks. Daily germination and cumulative germination were recorded and expressed as percentage. Days to 50% germination was calculated according to the formula of Coolbear *et al*. (1984). The results were subjected to an Analysis of Variance (ANOVA) to find out significant difference among treatments and compared with heat treatment. Representative germinated seeds of all the treatments of scarification were planted in the nursery with replication as per standard procedure.

RESULTS AND DISCUSSION

Dormancy breaking treatments on seed germination

There were highly significant germination responses among different scarification techniques with a range from 18.6% to 66.6% for endocarp removal and scarification with corrugated rod (T_3) and endocarp removal and de-operculum (T_1), respectively. Maximum seed germination (88%) was recorded in the case of chipping and de-operculum treatment (T_2); the second being (66.6%) in the case of endocarp removal and de-operculum treatment (T_1) and dry heat treatment (Table 1). Germination speed and percentage has improved in seeds of *Butia capitata* when the operculum was removed and the endocarp weakened through scarification (Olveira *et al.* 2013). In all the scarification treatments, seeds started germination three days after incubation in germination room. In de-operculated oil palm seeds, embryos commenced elongation after 2-4 days at 30ºC, whereas intact seeds failed to germinate (Murugesan *et al*. 2008). Chanprasert *et al.* (2012) reported positive response from de-operculated naked (endocarp removed) seeds; but phytotoxicity effects were observed when naked seeds were treated with neonicotinoid chemical. Chipping and de-operculum (T_2) induced early germination and took less days (8 days) to reach maximum germination (Fig 1). Similar rate of germination was noticed in endocarp removal with de-operculum (T_1). However, total cumulative germination in the latter treatment reached plateau after 9th day. By that time percentage of seed germination in the chipping and de-operculum treatment (T_2) reached

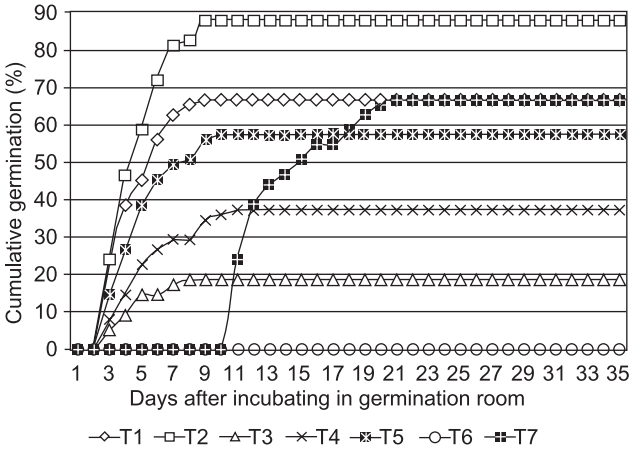

Fig 1 Cumulative germination percentage of oil palm hybrid seeds subjected to different mechanical scarification and dry heat techniques. T 1: Complete endocarp removal and de-operculum, T 2: Chipping endocarp (removing round piece of endocarp containing germ pore) and de-operculum, T 3: Chipping endocarp and scarification of operculum with pile rod, T 4: Chipping endocarp and scarification of operculum with sand paper, T 5: Chipping endocarp and needle insertion in the operculum, T: 6 Making crack at germ pore region of shell using hammer and T: 7 Dry heat method.

Table 1 Effect of innovative scarification treatments in oil palm hybrid seeds after incubating in the germination room

Treatment	Days to 50% germination	Days to maximum germination	Final germination after six weeks (%)
T 1: Complete endocarp removal and de-operculum	5	8.0	66.6
T 2: Chipping endocarp (removing round piece of endocarp containing germ pore) and de-operculum	4	8.0	88.0
T 3: Chipping endocarp and scarification of operculum with pile rod	4	6.6	18.6
T 4 : Chipping endocarp and scarification of operculum with sand paper	5	9.3	37.3
T 5 : Chipping endocarp and needle insertion in the operculum	5	9.3	57.3
T 6 : Making crack at germ pore region of shell using hammer	0	0.0	00.0
T 7: Dry heat method	12	20.0	66.6
Mean	4.90	8.8	47.8
SEd	0.36	1.12	4.99
P<0.05	0.76	2.45	10.8
CV %	8.90	15.72	12.8

maximum cumulative germination (88.0%). Seeds scarified with sand paper (T_4) needle insertion in operculum (T_5) took 9.3 days to reach maximum cumulative germination of 37.3% and 57.3%, respectively. Although, the other technique namely, scarification with corrugated rod (T_3) induced early germination (6.6%) total cumulative germination was poor (18.6%) and indicates ineffective scarification. Operculum structures including thin layer of endosperm cells provides mechanical resistance to embryo elongation in oil palm seed. The endosperm by itself could be a barrier for germination that may delay germination in seeds of *Acrocomia aculeata* (Moura *et al.* 2010). In T_1 and T_2, while removing top of operculum, the endosperm portion above embryo, which is embedded with plate like structure, is also taken out ensuring free passage of oxygen which hasten and ensure early germination. Whereas, in T_3, T_4 and T_5, endosperm barriers above the embryo is not disturbed fully and this might have resulted in lower germination percentage. Scarification of operculum with sand paper, corrugated pile rod and needle insertion in operculum of endocarp chipped seeds showed no satisfactory results in terms of rate and cumulative germination. One set of seed which received hammer crack in germpore region remained dormant even after six weeks. In this case, dormancy barriers such as plate like structure, endosperm above the embryo might not have been affected due to the treatment. Seed shell thickness and shell weight did not relate with germination (Myint *et al*. 2010a). The shell may not be involved in seed germination in spite of the fact that one of the physical barrier that is 'fibre plug' is present in the shell and cracking the shell in the germ pore region may not cause desired effect to facilitate germination. In the case of needle insertion, in spite of ensuring water entry to the embryonic axis the cumulative germination was only 57.3%. The possible reason is that germination of oil palm seeds depends on a maximum concentration of oxygen in the embryonic tissues and that seeds with high water content have water blocking in intercellular spaces which hinders the permeability of the endosperm leading to resistance of the absorption of oxygen (Green *et al*. 2013). Heat treatment (T_7) could be ranked second in terms of their total cumulative germination (66.6%) which was equivalent to endocarp removal and de-operculum (T_1). Heated seeds took 10 days to initiate germination and 21 days to reach maximum cumulative germination. Though heat treatment (T_7) was equally effective with 66.6%, it consumed extra two months and germination commenced 11 days after incubation in germination room. Moreover, variation in physical properties of seeds has been reported in oil palm hybrid seeds within single bunch (Murugesan *et al*. 2010) which may require differential thermal requirement for breaking dormancy and germination responses in the conventional method (Dry heat technique). Moreover, even after completion of 35 days in germination room, 34% seeds remained dormant in dry heat treatment. Therefore, it is certain that heat technique takes longer duration to break dormancy when compared to other techniques.

Effect of treatments on seedling growth in primary nursery

Representative germinated seeds of all the treatments of dormancy breaking except T-6 (no germinated seeds obtained) which were planted in the nursery with replication as per standard procedure showed no significant differences for seedling growth parameters taken three months after planting and all the seedlings exhibited normal growth under standard nursery management practices.

Chipping combined with de-operculum technique and seed chipping machine

Endocarp chipping combined with de-operculum resulted in the highest germination (88%) and took 3, 4 and 8 days to initiate germination, 50% germination and final germination, respectively. In seed production centres, some hybrid combinations showed embryo abnormality due to incomplete development of embryo during fruit development which resulted in abnormal germinated seeds. It has been reported by Corley and Tinker (2003) that there is relationship between percentage abnormality and germination and abnormality and seedling development. In this context, major advantage in chipping and de-operculum

method is early detection of abnormal sprouts and we can carry forward only normal and healthier ones to the nursery, whereas dry heat process takes longer duration. Since, the time to completion of germination in a given batch of seeds is very short, the production of uniform seedlings is assured. The maximum per cent of seed germination with the retention of intact endocarp, operculum removal is advantageous and germination obtained in de-operculated naked kernels (Myint *et al*. 2010b) may dehydrate quickly. Moreover, seed chipping machine reported in the present study to treat the dormant seeds will substantially reduce the involvement of labour.

It is concluded that chipping and de-operculum has induced early germination and took eight days only to reach maximum germination in oil palm fresh seeds. This technique could be substituted with dry heat method at commercial seed production centres to break seed dormancy and get uniform quality planting materials. Seed chipping device was developed at laboratory scale to successfully break seed dormancy. However, upgradation of the chipping machine is suggested to scale up germinated seed supply in a short period of time.

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