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Effect of different stages of fruit maturity and size grading on seed quality in jatropha *(Jatropha curcas)*

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Plant oils, in addition to being a food commodity, are important as a renewable resource for both the fuel and chemical industries (Dyer and Mullen 2008). The jatropha (*Jatropha curcas* L.) is a species with great potential for biodiesel production due to the high oil content of seeds (Arruda *et al*. 2004). Interest in the cultivation of Jatropha is coming from both the public and private sectors, and a number of public companies are now involved in the cultivation of Jatropha. The major constraints in Jatropha seed production are mother plant nutrition, management of pest and diseases, irrigation and harvesting of fruits at right stage. Ideally, seed crops ought to be harvested when seed quality is at a maximum, but in most cases it is not clear when this occurs. According to Harrington (1972), seeds achieve maximum viability and vigour at physiological maturity. Harvesting of seed crop at optimum stage of physiological maturity helps to obtain the seeds with maximum germination and vigour. The knowledge of maturity stage helps the seed grower to decide when to harvest the seed crop for maintaining highest quality of seeds and plan for post harvest operations like threshing, cleaning, drying, processing and conditioning. Hence, the present study was carried out to evaluate the seed quality of Jatropha harvested at different stages of fruit maturity, to determine the right stage of harvesting to get high quality seeds and to study the effect of size grading on seed quality.

One hundred freshly opened flowers were tagged during anthesis time in 25 numbers of two year old trees and fruit set was recorded for seven weeks. Fruits of varying maturity determined based on colour were harvested in four different stages of maturity, viz. light green (Stage I), lemon yellow (Stage II), dark brown (Stage III) and dark brown with hairline crack (Stage IV). The parameters used to characterize the physiological maturity of seeds comprised morphometric determinations of capsule length and width (referring to the largest central perpendicular to the rapheal scar) in 20 capsules; moisture content obtained from 50 grams of capsules mechanically ground by oven dry method for 24 hr at 105 ± 3 °C with values expressed in percentage on a wet basis (Brasil 1992), and the test weight of 100 capsules was expressed in g. The germination test was performed based on the germination test for *Ricinus communis* recommended by the ISTA (Anon 1999) with germination expressed as percentage of normal seedlings obtained at 14 days after sowing. The test was conducted in sterilized sand substrate moistened with distilled water in amount of 60 per cent sand field capacity (Brasil 1992), using stainless trays (22.5 × 22.5 × 4 cm) under constant temperature of 25 °C with 25 seeds per replication. The vigour index was computed based on mean germination and mean seedling length in cm at 14 days after sowing (Maguire 1962). Based on the capsule length, they were graded into large, medium and small and evaluated for various seed quality parameters, viz. speed of germination (Maguire 1962), seed germination, seedling length and vigour index. The data were analysed for the F-test following the methods described by Panse and Sukhatme (1985).

Stage of fruit maturity on seed quality in jatropha

The results revealed that the fruit set was only 59 per cent and four different colour changes were noticed in the fruits during maturation, viz. light green (Stage I), lemon yellow (Stage II), dark brown (Stage III) and dark brown with hairline cracks (Stage IV). The days taken for attaining those four stages were 21, 28, 42 and 49, respectively. However, the capsule colours changed into dark and shiny black as early as in Stage I itself and remain unchanged until stage III and then turn to dark brown during Stage IV. Kaur *et al.* (2011) also observed that fruiting was visible 26.5 to 30.2 days after bud formation in Jatropha and fruit setting ranged from 37.0 to 61.6 per cent. The physical seed attributes of fruits harvested at different stages of maturity indicated that the 100-seed weight decreased with advancement of maturity. Seeds obtained from stage I registered the maximum 100-seed weight (123 g) followed by stage II (118.4 g), while stage IV registered the minimum (73.8 g). The probable reason for reduction in seed weight could be due to loss in seed moisture content as observed in

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Table 1 Effect of stage of fruit maturity on seed quality in *Jatropha curcas*

Treatment (Harvesting of fruits based colour change)	Capsule colour	100-seed weight (g)	Capsule moisture content (%)	Capsule length (cm)	Capsule width (cm)	Seed germination (%)	Seedling length (cm)	Vigour index
Stage I (Light green fruits) (21 DAA)	Shiny Black	123.0	41.3	1.97	1.05	4	19.5	78
Stage II (Lemon yellow fruits) (28 DAA)	Shiny Black	118.4	41.1	1.99	1.06	56	31.1	1742
Stage III (Dark brown fruits) (42 DAA)	Shiny Black	117.5	38.0	2.02	1.04	68	29.9	2033
Stage IV (Dark brown fruits with hairline crack) (49 DAA)	Dull, Dark brown	73.8	29.0	1.92	1.02	68	28.8	1958
Mean		108.2	37.4	1.98	1.04	49	27.3	1452.8
SEd		1.57	1.12	NS	NS	2.74	0.88	12.63
CD (P=0.05)		3.42	2.44			5.97	1.91	27.52

the present study that 41.3 per cent of moisture content recorded in stage I was reduced to 29.0 per cent at stage IV (Table 1). However, no significant differences were noticed in capsule length and width during the period of maturation.

The physiological quality attributes of capsules harvested at different fruit maturity stages expressed significant difference on seed vigour and viability. The observations on seed germination indicated that the seeds obtained from stage III on par with IV (68 per cent) excelled stage II (56 per cent) and stage I (4 per cent). Between stage III and IV, the seeds obtained from stage III was found to be superior to stage IV due to higher vigour index as contributed by the production of lengthy seedlings (Table 1). Hence, the stage III was considered as stage of physiological maturity for Jatropha and 42 days were taken for attaining the same. Similar observation was made by Sinniah *et al.* (2008) in Jatropha. According to them, the physiological maturity or the end of seed filling phase for Jatropha is around 45 DAA. Seed moisture content at physiological maturity was reduced to 39.9 per cent followed by rapid net loss in moisture to 13.0 per cent within a week. Alam *et al.* (2011) reported that continuous flowering and the incidents where flowering terminated in the middle of the flowering period were factors believed to cause the wide range of fruit ripening times recorded. Dransks *et al.* (2011) concluded that seeds of *Jatropha curcas* with germination higher than 60 per cent must be harvested from ripe fruits with fully brown colour of epicarp corresponding to the classification 7 YR 4/2 of the Munsell colour chart, or refractance values equal to or lower than 82, 70 or 65 nm in the red, green and blue scales respectively, obtained with a digital colorimeter. Fruits with epicarp presenting the aforementioned colorimetric characteristics have maximum accumulation of dry biomass, water content below 38.5 per cent, and seeds with physiological maturity. Sowmya *et al.* (2012) opined that harvesting of fruits at yellow stage (mature, 60 DAA) would be better for seed purpose in Jatropha. Kaushik (2003) also reported maximum germination, when fruits are harvested at yellow stage in Jatropha.

Size grading on seed vigour in jatropha

Significant variation due to size grades in capsules was noticed on the physical parameters observed. Among the grades, capsule length was significantly longer in larger sized capsules followed by medium and small and no significant variation was noticed in capsule breadth among the size grades. However, 100-seed weight was differed significantly due to size grades (Table 2). The results on physiological quality parameters revealed that the germination was significantly higher in larger sized seeds (45 per cent) than medium (35 per cent) and smaller seeds (35 per cent) on 10 days after sowing. The speed of germination, an important vigour component of seeds indicated that larger sized capsules had higher speed of

Table 2 Effect of size grading on seed vigour in *Jatropha curcas*

Size grades of capsules	100-seed weight (dry weight) (g)	Capsule length (cm)	Capsule breadth (cm)	Capsule L/B ratio	Speed of germination	Seed germination on 10 DAS(%)	Seedling length (cm)	Vigour index
Small	59	1.58	0.8	1.98	12.79	35	27.75	971
Medium	64	1.83	1.02	1.79	16.00	35	32.16	1126
Large	68	1.96	1.03	1.90	22.18	45	35.78	1610
Mean	64	1.79	0.96	1.89	16.99	38.33	31.90	1236
SEd	3.14	0.03	0.09	0.05	0.33	2.10	0.60	16.58
CD (P=0.05)	7.11	0.07	0.20	0.11	0.69	4.16	1.36	37.51

germination than medium and smaller capsules. Similarly, seedling length and vigour index were also prominent with larger sized capsules (Table 2). The relative higher vigour associated with the larger sized seeds could be ascribed to well matured embryo containing adequate nutrient reserves contributing to its physiological stamina or vigour residing in it (Pollock and Roos 1972) and efficient utilization of large food reserves and greater energy production, which are positively associated with seed size (McDaniel 1969).

The foregoing results revealed that the change of fruit colour from green to dark brown was considered to be the appropriate stage of physiological maturity for Jatropha which took 42 days for attaining the same after anthesis. The large seeds had excelled medium and small seeds in terms of both vigour and viability and also emphasized the significance of size grading is essential for elite seedling production in Jatropha.

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SUMMARY

The seed quality of Jatropha harvested at different stages of fruit maturity was evaluated to determine the right stage of harvesting for getting high quality seeds at Karaikal, Puducherry (UT) in the year 2011. One hundred freshly opened flowers were tagged at anthesis in 25 numbers of two year old trees. The fruit set in each tagged flower was recorded for seven weeks, consecutively. The results revealed that, only 59 per cent of the flowers set fruits and four different colour changes in fruits, viz. light green (Stage I), lemon yellow (Stage II), dark brown (Stage III) and dark brown with hairline cracks (Stage IV) were observed during maturation at 21, 28, 42 and 49 days after anthesis (DAA), respectively. Observation on seed germination indicated that the seeds obtained from stage III was on par with stage IV (68 per cent) and excelled stage I (4 per cent) and stage II (56 per cent). Between stages III and IV, the seeds obtained from stage III was found to be superior to stage IV, attributed due to higher vigour index and hence considered as the stage of physiological maturity for Jatropha. The larger sized capsules had excelled medium and smaller sized in terms of both vigour and viability and emphasized the significance of size grading for elite seedling production in Jatropha.

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