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# FRUIT MATURITY INDICES AS CRITERIA FOR OPTIMIZATION OF SEED GERMINATION IN *Jatropha curcas* L.

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## ABSTRACT

**The seeds of *Jatropha curcas* were harvested from three maturity stages termed as greenish-yellow (40-45 days after anthesis, DAA), yellow (55-60 DAA) and brownish-black (65-70 DAA) at fortnightly interval from July to December to assess the effects of collection time and capsule maturity on seed germination. It was observed that seed germination varied significantly with the advancement of collection period and capsule maturity. Maximum germination was recorded in the seeds extracted from yellow capsules both under laboratory (85.8%) and nursery conditions (59.1%). Similarly, the seeds harvested during July, August and September collections showed higher germination percentage. Therefore, harvesting of fruits at yellow stage during rainy season appears better for the collection of abundant superior quality seeds.**

**Key words:** Germination, *Jatropha curcas*, maturity indices

## INTRODUCTION

Due to the limited agricultural land in India, the state and central governments have laid emphasis on the use of wastelands and other unproductive land for the cultivation of relatively hardy bio-fuel crops. In view of economic, environmental and health benefits associated with the use of biodiesel, the planners have decided to develop biofuel programme in the country and expect to replace 10% petro-diesel by biodiesel by the year 2015 (Katwal and Soni, 2003). Proper selection of fruit maturity of *Jatropha* based on colour needs to be ascertained in order to produce quality planting stocks for outplanting in field to meet the increasing demand for *Jatropha* as rehabilitation species as a source of oil.

*Jatropha curcas* L. is a highly promising plant species which can yield oil as a source of energy in the form of biodiesel owing to its short gestation period, hardy nature, high quality oil content, ease in seed collection activities, value as a medicinal plant, etc. (Ginwal *et al*., 2005). Oil contents, physicochemical properties, fatty acid composition and energy values of *J. curcas* are well documented (Pramanik, 2003; Achten *et al*., 2010). The seed production of *J. curcas* ranges from approximately 0.4 to 12 t $ha^{-1}$ $yr^{-1}$ after 5 years of growth (Achten *et al*., 2010). The seed of *Jatropha* contains 38-40% non-edible oil which is considered a potential fuel substitute of diesel

(Keith, 2000; Joshi, 2005). The seeds are orthodox and as such are dried to low moisture content (5-7%) and stored in air-tight containers. At room temperature, the seeds can retain high viability at least for one year. Seeds are borne in a fruit which is trilocular, ellipsoid capsule changing colour from green to yellow and finally turning black. Seeds, two in one cell each, are black ellipsoidal triangular-convex. The flowering of *J. curcas* depends on the location and agro-climatic conditions. In permanently humid areas flowering occurs throughout the year (Raju and Ezradanam, 2002; Punia *et al*., 2006). Fruits mature heterogeneously because of indeterminate characteristics of the plant. Seed maturity is a prime factor that decides the success of seed in further sowing. Seed maturation studies help in the fixation of optimum stage of maturity that will yield abundant seeds higher germination and vigour. The maturity stages have been found to induce changes in moisture percentage, physical and chemical properties of seed during their growth and development. Thus, there is a wide variation in physiological maturity of fruit ripening and senescence thereby requiring careful manual harvesting (Silip *et al*., 2010). Harvesters have to select only those fruits which are of right maturity stage with seeds mature enough to show enhanced germination upon sowing. Therefore, harvesting the seeds or fruit at right time is important to reduce considerable losses in quality. It is important to know the physical and chemical changes that occur during fruit/seed maturation, as these changes determine the time of collection of fruit/seed. The present study was aimed to assess the effects of collection time and capsule maturity on seed germination of *Jatropha curcas* seeds to optimize proper harvesting of abundant healthy and vigorous seeds.

## MATERIALS AND METHODS

Selective sampling was adopted for the selection of site. The fruits/capsules were collected from Baghaani range of Poanta Sahib forest division, Himachal Pradesh (India). The area is situated in Sirmour district (Himachal Pradesh) at 30° 26’ N latitude and 76° 11’ E longitude at an elevation of 320 m masl. The locality falls under sub-tropical climate with May-June as the hottest and December-January as the coldest months. On an average the annual rainfall varies from 1950-2100 mm, most of which is experienced during July-September. The annual temperature ranges between 7 and 44°C with a mean value of 23.5°C.

Five trees of *Jatropha curcas*, approximately of the same age (5-7 years), were randomly selected on the basis of their phenotypic/morphological features from a wild population. These trees were tagged and marked for the collection of fruits/capsules. Developing capsules were harvested at three maturity stages termed as greenish-yellow (40-45 days after anthesis, DAA), yellow (55-60 DAA) and brownish-black (65-70 DAA), from the selected trees (Plate 1). Capsules were picked directly from the branches throughout the height of the trees at fortnightly interval from July to December, 2007. The percentage of different coloured capsules was expressed as the percentage of the total fruit yield tree$^{-1}$.

The experiments were carried out under laboratory and nursery conditions in the Department of Silviculture and Agroforestry, Dr. Y.S. Parmar UHF, Solan (India) during the year 2007-08. The area is well drained and has silty loam soil. The viability of seeds was determined by using tetrazolium chloride test where seeds were preconditioned in water and prepared (longitudinal cut and removal of seed coat) for exposure of embryo to 2,3,5 tetrazolium chloride, which on soaking stained the viable portion of seed into pink (Bonner, 1974a). The seeds with completely stained embryos and other tissues were considered as viable. Seed moisture content (MC%), expressed on a fresh weight basis, was determined for each collection date using 3 replications of 100 g seeds dried at 103±2°C for 16 hr (ISTA, 1993) and then weighed. Moisture content was calculated as:

$$\text{Moisture content (\%)} = \frac{\text{Fresh weight} - \text{Oven dry weight}}{\text{Fresh weight}} \times 100$$

One hundred seeds in each of the three replications, harvested from different coloured capsules, were used for germination test. The seeds were placed directly on moistened blotting sheets in germination trays and kept in a germinator at 25±2°C with 8 hr photoperiod and 90-95% relative humidity. The seeds were counted as germinated when radicals emerged. The testing period was 15 days. The seeds were also sown in polybags to study various germination parameters under nursery conditions. The potting mixture comprised soil, sand and farmyard manure in 2:1:1 ratio.

The per cent germination was calculated by number of seeds in a given sample that actually germinated. The germination energy (GE) was calculated on the basis of percent total number of seed that germinated when the germination reached its peak. Germination value (GV) was calculated as the index combining speed and completeness of seed germination. Daily germination counts were recorded and calculated as per the method given by Czabator (1962).

$$GV = PV \times MDG$$

Where, PV = Peak value of germination; and MDG = Daily germination

Germination speed was worked out following the method developed by Maguire (1962).

$$\text{Speed of germination} = \Sigma (n/t)$$

Where, n = Number of seeds newly germinating at time t; and t = Number of days from sowing

The above experiments were laid out in split plot design with collection time as main plot and maturity stage as sub-plot factor. The critical differences were calculated by LSD method at 5% rejection level to see the significance of differences between different collection dates and maturity stages with respect to all the parameters.

## RESULTS AND DISCUSSION

The initial colour of the capsule/fruit of *Jatropha* was green which changed to greenish-yellow which later turned yellow and finally brownish-black. The maturation of fruits is often judged by observing the changes in their colour (Schmidt, 2000). In the present study, it was found that as the maturity stage advanced from green to brownish-black, there was gradual reduction in the moisture content. The seeds collected under $C_1$ and $C_3$ maturity stages exhibited the maximum (41.8%) and minimum (36.2%) moisture content, respectively. Similar observations have been made by Cram and Lindquist (1982) in *Fraxinus pensylvanica* seeds and in *Ulmus wallichiana* by Phartyal *et al.* (2002). The seeds extracted from yellow capsules/fruits which were harvested during July, August and September collections exhibited maximum seed viability. Seed viability varied significantly among different collections. Viability of seeds is much affected by the stage of maturity reached at the time of its collection (Bonner, 1974b), its moisture content and temperature to which it is exposed (Mathur *et al.*, 1984). The decrease in viability in the seeds obtained from brownish-black capsules might be because of the decrease in moisture content. These findings are in harmony with the findings of Bonner (1974a) and Mathur *et al.* (1984). The germinability of seeds with respect to the collection time and

**Plate 1: Capsules/fruits of *Jatropha curcas* collected at three maturity stages (top left greenish yellow capsule; top right: brownish black capsule and bottom: yellow capsule)**

**Table 1: Effect of collection time on moisture content and germinability of *Jatropha curcas***

| Collection Date | Moisture content (%) | Viability (%) | Germination (%) | | Germination energy | | Germination value | | Germination speed | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lab | Nursery | Lab | Nursery | Lab | Nursery | Lab | Nursery |
| 15th July | 40.48 | 89.98 (9.48) | 82.22 (65.40) | 68.15 | 60.33 | 38.52 (37.45) | 22.80 | 9.47 | 2.86 | 1.56 |
| 1st August | 40.60 | 90.36 (9.50) | 81.85 (65.11) | 67.41 | 58.88 | 39.63 (38.95) | 22.93 | 9.24 | 2.81 | 1.55 |
| 15th August | 40.51 | 90.01 (9.49) | 80.37 (63.91) | 66.67 | 56.67 | 41.11 (39.82) | 21.84 | 8.91 | 2.85 | 1.53 |
| 1st September | 39.60 | 90.03 (9.48) | 82.96 (66.17) | 66.60 | 58.15 | 37.41 (38.31) | 22.77 | 8.82 | 2.82 | 1.49 |
| 15th September | 39.73 | 89.24 (9.44) | 82.22 (65.40) | 64.07 | 60.37 | 37.04 (37.66) | 22.72 | 8.45 | 2.80 | 1.46 |
| 1st October | 39.41 | 89.24 (9.44) | 80.37 (64.00) | 60.00 | 58.15 | 35.19 (36.35) | 21.70 | 7.71 | 2.72 | 1.39 |
| 15th October | 39.56 | 88.09 (9.38) | 80.74 (64.23) | 55.56 | 57.40 | 34.82 (36.12) | 21.68 | 7.01 | 2.70 | 1.32 |
| 1st November | 38.80 | 87.38 (9.35) | 80.74 (64.14) | 45.93 | 55.18 | 32.59 (34.79) | 21.30 | 6.01 | 2.69 | 1.13 |
| 15th November | 37.98 | 85.56 (9.25) | 76.30 (61.01) | 39.63 | 50.74 | 28.15 (32.02) | 19.54 | 5.28 | 2.56 | 0.95 |
| 1st December | 37.40 | 81.44 (9.02) | 74.82 (60.02) | 32.22 | 48.88 | 22.96 (28.61) | 18.23 | 3.78 | 2.42 | 0.68 |
| $CD_{0.05}$ | 0.40 | 0.09 | 1.54 | 11.72 | 22.67 | 11.34 | 11.13 | 00.37 | 00.15 | 00.04 |

*****Figures in parenthesis are arc sine transformation values, except for viability where these figures are square root transformation values

capsule maturity show that the pattern of increase and decrease in values related to germination attributes were almost identical (Table 1 & 2). It means the germination parameters studied increased in the seeds extracted from the yellow capsules/fruits ($C_2$) harvested during July - September collections, which subsequently declined with further advancement of collection period till the last collection. Seed germination increased from green to yellow stage reaching maximum of 85.78%. The germination was slightly lesser in brownish-black (82.89%) stage which may be attributed to the physiological maturity of the seed at yellow stage. Kaushik (2003) reported maximum germination when fruits were harvested at yellow stage in *Jatropha*. Almost similar observations were made by Cram and Lindquist (1982) in *Fraxnus pennysylvanica.*

The seeds harvested from $C_1$ maturity stage may be physiologically immature as indicated by the high moisture content of seeds. This means, the nutrients were still flowing into the seeds from the parent trees. The decrease in germination of the seeds harvested from brownish-black capsules ($C_3$) may be due to the inter-conversion between non-reducing and reducing sugars. For germination, the reserve sugars have to be converted to soluble sugars (Krugman *et al.*, 1974). Rai *et al.* (1988) observed similar pattern of germination in *Ficus mysorences, F. bengalensis, F. religiosa,* and *F. glomerata*, with the moderately ripe brownish-yellow fruit producing more germinable seeds than unripe yellow and fully mature cherry-brown fruits. Parallel phenomenon was observed by Maithani *et al.* (1987a) in *Ficus benjamina*. According to Aldhous (1972), germinative

**Table 2: Effect of capsule maturity on moisture content and germination of *Jatropha curcas***

| Parameters | | Capsule maturity (C) | | | $CD_{0.05}$ |
|---|---|---|---|---|---|
| | | Greenish-yellow ($C_1$) | Yellow ($C_2$) | Brownish-black ($C_3$) | |
| Moisture content (%) | | 41.82 | 40.22 | 36.17 | 0.22 |
| Viability (%) | | 89.54 (9.46) | 89.57 (9.46) | 85.28 (9.23) | 0.05 |
| Germination (%) | Lab. | 72.11 (58.16) | 85.78 (67.97) | 82.89 (65.70) | 0.85 |
| | Nursery | 52.78 | 59.11 | 57.89 | 0.94 |
| Germination energy | Lab. | 50.22 | 59.11 | 60.10 | 1.46 |
| | Nursery | 29.33 (32.74) | 36.67 (37.40) | 38.22 (38.09) | 0.73 |
| Germination value | Lab. | 17.23 | 24.12 | 23.30 | 0.62 |
| | Nursery | 5.97 | 8.26 | 8.18 | 0.20 |
| Germination speed | Lab. | 2.27 | 2.99 | 2.91 | 0.08 |
| | Nursery | 1.21 | 1.36 | 1.35 | 0.02 |

*****Figures in parenthesis are arc sine transformation values, except for viability where the figures show square root transformation values; Lab = laboratory conditions

energy is a measure of the speed of germination and hence is assumed to be the measure of seed vigour as well. Germination value and germination speed exhibited increase with the advancement of maturity. Highest germination value and speed showed close association with the highest percent germination. These findings are in agreement with the observations made by Maithani *et al.* (1987b) in *Carrisa opaca*. This differential pattern of germinability might be due to the cumulative action of growth regulators in seeds harvested from three different maturity stages, variation in biochemical constituents and their interconversion in seeds of some hardwood species (Bonner, 1974a) and the impermeability of testa with the advancement of capsule maturity (Vanstone and Ronald, 1982).

**Conclusion:** The knowledge of exact stage and time of maturity of fruits is essential for collection of abundant quantity of healthy and vigorous seeds. The planting value of seed and its storability is directly related to the maturation level reached by fruit/seed at collection time. The results of present study provide useful information regarding the optimization of physiological maturity of *Jatropha curcas.* The best maturity colour of *Jatropha* for highest germination was yellow followed by brownish-black for all periods of seed collection.

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