**Fruit chromaticity: A maturity index in *Tinospora cordifolia***

Rekha R Warrier*, B Gurudev Singh, R Sivalingam, R Anandalakshmi, V Sivakumar

Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore, Tamil Nadu, India

*Corresponding author:
Rekha R Warrier, Ph.D.
Institute of Forest Genetics and Tree Breeding (IFGTB),
Forest Campus, R.S.Puram, P.B No. 1061,
Coimbatore, Tamil Nadu, India.
Email: rekha@ifcfr.org

**Abstract**

Germination response of seeds of *Tinospora cordifolia* as influenced by different stages of fruit ripening based on pericarp colour was studied under nursery conditions at the Institute of Forest Genetics and Tree Breeding, Coimbatore. Maximum germination of 57.5% was observed in red fruits (ripe) followed by yellow 27.5% (partially ripe) and green 17.5% (unripe) fruits. Measurements on fruit and seed parameters also followed similar trend. However, the moisture contents and the seed weight followed a reverse trend relative to germination evincing these parameters as indicators of seed development and maturation.

**Keywords**: *Tinospora cordifolia*, fruit, development, germination.

**INTRODUCTION**

An important quality property for harvest of seeds is the maturity status. The optimal time to harvest is when a large amount of viable, germinable seeds can be collected. Premature collection of fruits yields seeds of poor quality while delayed collection results in very few seeds. Seeds which are immature or not fully mature are recognized as of lower quality than mature seeds. Maturity indices vary according to fruit type and species. The most commonly used indices of fruit or seed maturity are based on physical characteristics. Change of fruit color is widely used as a maturity index on both dry and fleshy fruits. The most common color changes are from a “vegetative green” to a shade of brown in dry fruits or to a bright or blue-black color in fleshy fruits (Willan, 1985).

Fruit colors are commonly considered to increase the conspicuousness of a ripe fruit crop and/or attract the birds that eat fruits and disperse the enclosed seeds (van der Pijl 1982).

*Tinospora cordifolia* (Willd.) Miers ex Hook. f.

& Thoms, a medicinal plant of the family Menispermaceae, is used in ayurvedic medicines to improve the immune system and the body resistance against infections (Verma and Sharma, 2003). The Task Force on Conservation and Sustainable Use of Medicinal Plants identified the species as one of the most commercially exploited plants in pharmaceuticals. The estimated annual demand of this species used in preparation of crude herbal drugs in the Indian system of medicines is 10,000 tonnes (Gurudev Singh and Warrier, 2004).

Aqueous extract of stem and root of the plant has been used therapeutically because of immunomodulation property as well as antimalarial and antileprotic activities (Singh et.al., 2003). The aqueous extract contains a number of chemical constituents—alkaloids, steroids, glycosides, polysaccharides, etc. Significant antioxidant properties have been observed in the polysaccharide immunomodulator obtained from *T. cordifolia* against peroxynitrite and photosensitization induced damage (Singh, 2005).

The plant is sometimes cultivated as ornamental plant. *Tinospora cordifolia* flowers twice a year during January-February and June-July, both will set fruits. *Tinospora cordifolia* regenerates through seed in the natural conditions. For artificial regeneration, information on the exact stage and time of maturity of fruits is essential.
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**Table 1:** Fruit and seed characteristics of *Tinospora cordifolia*

<table>
<thead>
<tr>
<th>#</th>
<th>Pericarp colour</th>
<th>Maturity stages</th>
<th>Fruit size (mm)</th>
<th>100 fruits weight (g)</th>
<th>100 seeds weight (g)</th>
<th>Seed size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Green colour</td>
<td>Unripened</td>
<td>8 x 9</td>
<td>38 – 39</td>
<td>8 – 9</td>
<td>6.5 x 5</td>
</tr>
<tr>
<td>2.</td>
<td>Yellow colour</td>
<td>Partially ripened</td>
<td>8 x 9</td>
<td>39 – 42</td>
<td>8 – 9</td>
<td>6.5 x 5</td>
</tr>
<tr>
<td>3.</td>
<td>Red colour</td>
<td>Fully ripened</td>
<td>9 x 10</td>
<td>44 - 45</td>
<td>7.5 – 8.5</td>
<td>8 x 6</td>
</tr>
</tbody>
</table>

Table 2: Effect of different maturity stages of seeds on germination percent in *Tinospora cordifolia*

<table>
<thead>
<tr>
<th>#</th>
<th>Pericarp colour</th>
<th>Moisture content %</th>
<th>Germination percentage (in Weeks)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Green</td>
<td>31.28</td>
<td>5</td>
<td>12.5</td>
<td>15</td>
<td>17.5&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Yellow</td>
<td>33.83</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>20</td>
<td>27.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Red</td>
<td>25.71</td>
<td>20</td>
<td>30</td>
<td>35</td>
<td>40</td>
<td>57.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

which greatly influences the germination of seeds. In the present study, the pericarp colour has been considered as an index for fixing the right time for the harvest of the seeds of *Tinospora cordifolia* to obtain maximum germinable seeds.

**MATERIALS AND METHODS**

**Plant Material**

*Tinospora cordifolia* fruits were collected from Forest Campus, Coimbatore, Tamil Nadu (N 11° 00´ & E 77° 00´). The fruits were collected from heavily fruiting branches (Fig. 1) and were subjected to sorting.

**Fruit sorting**

Based on the colour of the pericarp, the fruits were categorized into 3 groups namely red, yellow and green (Fig. 2). They were designated as mature- red, partially mature – yellow and immature-green.

**Seed extraction and processing**

The fruits were depulped by manual maceration in water. The extracted seeds were thoroughly washed further under running water to completely remove any pulp adhering to the surface. The seeds were shade dried for a day to remove the surface moisture. The processed seeds were tested for moisture content on fresh weight basis by low constant temperature oven method. The seeds were dried at 103 °C for 16 hours and expressed as % (ISTA, 1999). Moisture content was studied in 4 replications of 10 seeds.

**Germination tests**

Germination percentage was obtained by sowing 25 seeds in 4 replications. The seeds were sown in sand medium in the nursery at 25±2 °C temperature and 95±2 % relative humidity. After 30 days of sowing the normal seedlings were counted and the germination (%) expressed in whole number (ISTA, 1993). The experiment was laid out in a Completely Randomised Design (CRD). Daily count was taken. No pretreatment was given to the seeds.

Germination Value (Czabator, 1962) was calculated based on Daily germination speed (Final DGS x Peak DGS). Germination rate (GR) (T50, number of days to reach 50% of maximum germination) and uniformity (T75 - T25, number of days between 25% and 75% of maximum germination) were also calculated.

**Statistical analysis**

Percentage germination was computed for each trial as proportion of germinated seeds to the total number of seeds sown per replicate. One-Way ANOVA was used to test the main effects of maturity. Means that exhibited significant differences were compared by Duncan’s Multiple Range test (α = 0.05).

**RESULTS AND DISCUSSION**

Details on fruiting and flowering phenology were recorded. Flowering starts in the first week of January following leaf bud break. Pollination is mainly by insects. The species is self pollinated. The flowers are held together in an inflorescence. Following pollination, the sepals and petals are shed, and the ovary develops into...
Physiological maturity is morphologically reflected in a distinct colour change of the fruits and seeds during different maturity indices are presented in Table 1. The weight of fruits, seeds and size of the pericarp ranging from dark green to greenish yellow to orange to bright red during the process of maturity of fruits. In the present study, three distinct stages of maturity were collected i.e. at the seventh, eighth and ninth weeks after anthesis to fix the optimum period for harvest maturity. The weight of fruits, seeds and moisture content of the seeds during different maturity indices are presented in Table 1.

Figure 1: High fruiting branch of *Tinospora*
Figure 2: Unripe fruits of *Tinospora*
Figure 3: Partially ripened fruits of *Tinospora*
Figure 4: Ripened fruits of *Tinospora*

fleshy fruits between 6–9 weeks following anthesis. Beyond nine weeks, the fruits are shed off. There is a variation in the colour of the pericarp ranging from dark green to greenish yellow to orange to bright red during the process of maturity of fruits. In the present study, three distinct stages of maturity were collected i.e. at the seventh, eighth and ninth weeks after anthesis to fix the optimum period for harvest maturity. The weight of fruits, seeds and size of the fruits and seeds and moisture content of the seeds during different maturity indices are presented in Table 1.

Physiological maturity is morphologically reflected in a distinct colour change of the fruits from green turning yellow and to red, which could be used as a ripening index. The fruits mature 6-8 weeks after anthesis, which is the optimum time for collection. The results indicate a gradual increase in fruit weight which could be attributed to accumulation of metabolites in the fruits during the process of ripening. The process of accumulation of metabolites in fruits during ripening, mainly in the form of sugars has been well documented, especially in cases where seed dispersal is brought about by animals and birds feeding on the fruits (Willson et al. 1989).

Change of colour has been designated as one of the practical maturity indices for fleshy fruits. Colour changes are usually from the green of the immature fruit to various conspicuous shades (Schimdt, 2000) of red or black, brown and sometimes blue, purple, pink, or white. Common patterns observed in different species are changes from green to yellow to brown (*Quercus alba* L.); green to canary yellow in *Ficus benjamina* L. (Maithani et al., 1987), and green through greenish yellow to black (*Gmelina arborea* Roxb.) (Samidha Pandey et al., 2002); from green to red to purple or black (*Syzigium cuminii*); from green to yellow to purple (*Gleditsia triacanthos*). The stages, green, yellow and red, in *Tinospora cordifolia* hence indicate the state of development of fruits until maturity.

However, the trend in seeds varied. Seeds from red fruits showed a decrease in seed weight and
moisture content when compared to the other developmental stages. A reduction in the moisture content of the seeds during the process of maturation suggests the seeds’ ability to prolong viability by built-in desiccation mechanisms within the seeds which is indicative of orthodox type of storage behaviour. Orthodox seeds are able to withstand desiccation up to 5% and can be stored under this condition for longer periods of time (Berjak and Pammenter, 2008).

Germination data presented in Table 2 indicates that germination was more or less negligible during first week in seeds from yellow and green fruits, but seeds from red fruits showed 20% germination. In second week, germination was initiated in the other stages also. After 5 weeks, highest germination (57.5%) was recorded in for seeds extracted from red fruits followed by yellow (27%) and green (17.5%).

**Figure 5:** Effect of different maturity stages of seeds on germination characteristics of *Tinospora cordifolia*

GP - Germination Percent; PV - Peak Value of Germination; GV - Germination Value; Final DGS - Final Daily germination speed; GR - Germination rate

Fig. 5 depicts variations in germination characteristics in seeds collected from fruits at different maturity stages. All the characteristics namely GV, PV, DGS, Final DGS and uniformity were higher for seeds from red fruits. However germination rate was higher for seeds from green and yellow fruits. Another interesting observation was that the seeds from these two maturity stages had the same rate of uniformity and germination rates.

This is important as the information gives us an indication of whether germination occurred during the first or last part of the test period. This gains significance especially under field conditions where rapid germination is obviously an advantage for seedling establishment.

In this study, a lower germination rate for the seeds from red fruits indicates that germination has occurred rapidly which is supported by values presented in Table 2. Seeds from ripe fruits showed 20 per cent germination in the first week following sowing wherein almost 40 percent of germination was complete. This is also an expression of seed vigor as it is anticipated that high vigor seeds germinate faster than low vigor seeds.

In order to have seeds of good viability and vigour it is necessary that, fruits are collected when they are fully ripe and before they are dispersed or eaten away by predators. In addition, if the exact time of collection of fruits is fixed, processing of seeds in bulk quantities would be economical in terms of time and money. For this, maturity – indices, such as change in size, shape, weight, and colour of the fruit have been extensively used. Results of colour variation of fruits during maturation was reported in cocoa where yellow ripe and over ripe pods provided higher proportion of quality seed (Premalatha and Mohanakumaran, 1989). Bharathi *et al.*, (1996) reported such observation in neem drupes. Similarly early and higher germination of seeds from redberries in coffee compared to green or maroon berries were reported by Shao *et al.* (1998) while the change of fruit colour to yellow red in *Coffea arabica* and maroon red in Robusta as the indicator for seed maturity and harvest was reported by Srinivasan and Anilkumar (2000). Highest recovery of quality seeds in cocoa was fixed by using pod maturity attributes as indicator of seed quality (Vanitha *et al.*, 2005).

From the above study it is inferred in *Tinospora cordifolia*, the red colour pericarp (fully ripened) seeds give better germination percentage than yellow colour pericarp (partially ripened) seeds and green colour pericarp (unripened) seeds. The range of fruit weight (44-45 g), fruit size (9x10 mm), and the seed moisture content (25%) coincided with maximum germination and appear to be reliable indicators of seed maturation in *Tinospora cordifolia* complementing the pericarp colour as the major indicator.
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References


