I J P S INTERNATIONAL JOURNAL OF PLANT SCIENCES
ISSN-0973-1547 Volume **16** | Issue 1 | January, 2021 | 19-24
DOI: 10.15740/HAS/IJPS/16.1/19-24
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RESEARCH ARTICLE

Studies on seed maturation in *Butea monosperma* (Lam.) Taub. for identification of best collection time

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SUMMARY

The purpose of this study is to determine the optimal harvest time for seeds of *Butea monosperma* as defined by fruit maturation stage. The seeds were harvested at different stages of their development and fruit and seed size, fresh and dry mass, moisture content, germination percentage, tolerance to drying were recorded. Though fresh weight of both fruits and seeds reached maximum at 58 DAA, dry weight of fruits and seeds continued to increase up to 73 DAA till the time of seed dispersal. Onset of germinability (25%) was observed at 58 DAA before the completion of dry mass accumulation. Full germinability and tolerance to low moisture content were achieved at 73 DAA at the time of seed shedding. At this stage colour of the seed turned brown that can be used as a visual indicator for time of seed collection.

Key Words : *Butea monosperma,* Seed maturation, Dry weight, Germination, Desiccation tolerance, Maturation indicator

How to cite this article : Kundu, Maitreyee and Singh, Tehsildar (2021). Studies on seed maturation in *Butea monosperma* (Lam.) Taub. for identification of best collection time. *Internat. J. Plant Sci.*, **16** (1): 19-24, **DOI: 10.15740/HAS/IJPS/16.1/19-24,** Copyright@ 2021: Hind Agri-Horticultural Society.

Article chronicle : Received : 27.09.2020; **Revised :** 05.11.2020; **Accepted :** 04.12.2020

Butea monosperma (Lam.) Taub. commonly known as 'Flame of the Forest' is a traditional Indian medicinal tree that also serves as an ornamental tree due to its vibrant red flowers. It is native to tropical and sub-tropical parts of the Indian subcontinent and Southeast Asia, across India, Bangladesh, Nepal, SriLanka, Myanmar, Laos, Cambodia, Vietnam, Malaysia, and West Indonesia.

It is a medium-sized deciduous tree, growing to 15 m (49 ft) tall. It is a slow growing tree, young trees have a growth rate of few feet per year. It is used for timber, resin, fodder, medicine, and dye. The soft and not durable wood is light, white or yellowish-brown when fresh, but often turning grayish. A red exudate is obtained from the bark, hardened into a gum known as 'Butea gum' or 'Bengal Kino'. It can be used as a dye and as

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tannin. A bright yellow to deep orange-red dye, known as butein, prepared from the flowers is used especially for dyeing silk and sometimes for cotton. A coarse fibrous material obtained from the inner bark is used for cordage, caulking the seams of boats and making paper. Young leaves are good fodder, eaten mainly by buffaloes. Leaves are sometimes used as a fuel. The wood is burnt for gunpowder charcoal. The flowers are useful in the treatment of liver disorders and seeds act as an anthelmintic. An astringent gum oozing from the cut stem has medicinal properties as a powerful astringent and is applied in cases of diarrhea. The tree is an important host for the lac insect (*Laccifer lacca*), which produces shellac. Of all the lac trees, it yields the most lac stick per hectare.

Determination of the optimal time for seed collection is an important part of plantation program of any forestry species. This time is reached when seeds attain maximum quality, *i.e.* maximum viability and vigor. The stage of development is known as physiological maturity. Delayed harvesting will not only induce aging, therefore reducing the quality of seeds, but also maximize the problems due to environmental factors such as high temperature, high humidity, rainfall, over-drying, attacks of diseases, or damage by pests, birds and animals (Copeland and McDonald, 1995).

According to Roberts (1973) orthodox seeds can tolerate desiccation at very low moisture level and their longevity increases with decreasing moisture content. Also this species passes through a maturation drying stage during its development in plant after accumulation of dry mass. At this stage, the moisture content of seed is slowly decreased. Although germinability may be attained before or after completion of dry matter accumulation, this phase may not be the right stage for achieving maximum seed quality until and unless the seeds attain desiccation tolerance (Ellis and Hong, 1994). Therefore the attainment of germinability and desiccation tolerance may be considered as the indicators for determination of earliest collection time. Though in some agriculture species, slow artificial drying was helpful in achieving desiccation tolerance earlier in maturation in comparison to rapid drying method (Kermode and Bewley, 1985), the present experiments followed only the rapid artificial drying for desiccation tolerance test.

For practical purposes, it is relevant to establish a relation between visual indicators and physiological maturity. In cultivated species such as soybean, Rubel *et al.* (1972) indicated that physiological maturity is reached when soybean seeds begin to turn yellow. Silva *et al.* (2008) observed in *Cnidosculus quercifolius* seeds that physiological maturity is reached when the fruit exocarp was coiled, but remained adhered to the endocarp.

In this study following studies had been undertaken on developing *Butea monosperma* seeds to determine the best time for seed collection: Changes in physical characters during seed development, to determine the onset of germination and to determine the achievement of desiccation tolerance.

The objective of this investigation is to characterize the physiological maturity and to assess the possibility of harvesting seeds of *Butea monosperma* before natural shedding.

MATERIAL AND METHODS

The experiments were carried out during 2018 in a natural stand of 20-25 years old plant at Jabalpur, Madhya Pradesh. Mean annual temperature in this area of the study is 32°C the average minimum of 15°C and maximum of 42°C. Rainfall is concentrated from June to September.

Leaves are shed during January-February and the leafless tree flowers abundantly which is very conspicuous in the forest. Within a month fruiting starts. At the end of the fruiting, new leaves develop, which are initially a pale bronze-tinged green. Birds are the chief pollinators. In this study during the peak period of flowering, as the flowers opened, branches were tagged with red plastic ribbon and observed weekly to verify the fruit development. From 41 days after anthesis, when the fruits were completely green, they were collected by hand at intervals until the natural dispersal of the seeds. The collected pods were packed in cotton bag and brought into the laboratory. Seeds were extracted from the pods with care and the following evaluations were conducted:

– *Fruit and seed size*: Fruits (four replicates of 10) were analysed for measurement of length and width. The seeds (four replicates of 10) were removed from the pods by hand and their length and diameter were also registered before evaluation of their physiological quality.

– *Fresh weight, dry weight and moisture content of fruit and seed*: The moisture content was determined using constant temperature oven method (ISTA, 1993). Five replication of ten fruits and seeds each was weighed in analytical balance with precision of 0.001g to obtain the fresh mass. Then they were dried in a force – draft oven regulated at the temperatures of 103 ± 2°C for 17 hours after cooling in a desiccator with silica gel and then reweighed to get the dry weight. Moisture content was estimated on fresh weight basis.

– *Pod and seed color*: Pod and seed color were recorded for 50 fruits at each harvest.

– *Germination test*: The germination test was performed by placing three replication of 50 seeds each over moist paper in petriplates at 28 ± 2°C with 16/8 light / dark photoperiod. The germination was counted daily and continued for 28 days. Seeds were considered to be germinated when the radicles grew at least 1 cm. After that, number of rotten, empty and good seeds were determined by cutting test. From this data percentage germination was calculated.

– *Desiccation tolerance test*: Seeds were extracted from the pods and were dried over silica gel as the desiccant in a desiccator. Silica was changed every day. Samples were removed from drying after varying periods ranging from 6 to 172 hours. Seed moisture content was determined after drying and germination capacity was determined after humidifying the dried seeds (in a closed container) over water for 24 h at 25°C to avoid imbibition injury during germination test.

The results were analysed by F-test (0.05) in an entirely randomized design.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Fruit and seed size:

Fruit length and width increased rapidly within few days of its formation and at 41 days after anthesis (DAA) they were 10 and 3.3 cm, respectively. After this period their growth was continued and reached maximum at 52 DAA.

Seed length and width increased sharply from 41 to 48 DAA and then slowly increased. Seed width reached maximum at 58 DAA, though small but significant change was noted in seed length till the last phase of its development in Fig. 1.

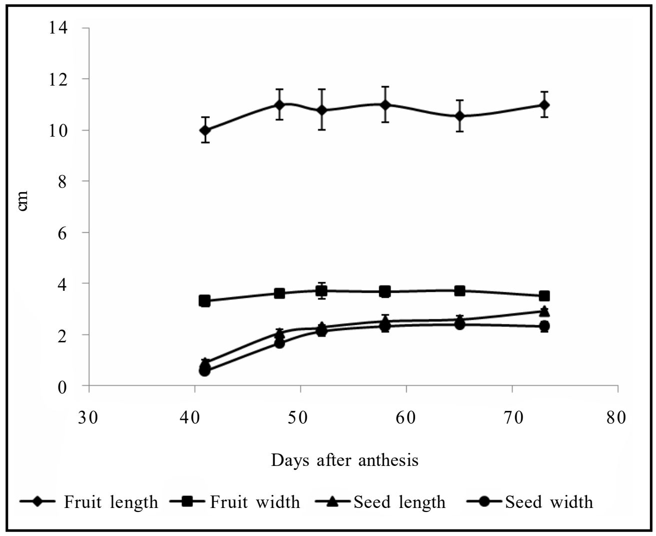

Fig. 1: Changes in mean length and width of fruit and seed at different stages of maturity of *Butea monosperma* seeds. Bars represent ± standard error

Fruit and seed weight:

Both fresh weight of fruit and seed reached maximum at 58 DAA then sharply declined up to 73 DAA, when mean of their value reached 1.64 g and 0.94g, respectively at shedding. Both fruit and seed dry weight increased steadily from initial stage of fruit formation and continued till the dispersal of seeds at 73 DAA. Maximum mean fruit and seed dry weight were 1.98g and 0.92g, respectively. Therefore seeds accumulated maximum dry mass at 73 DAA in Fig. 2.

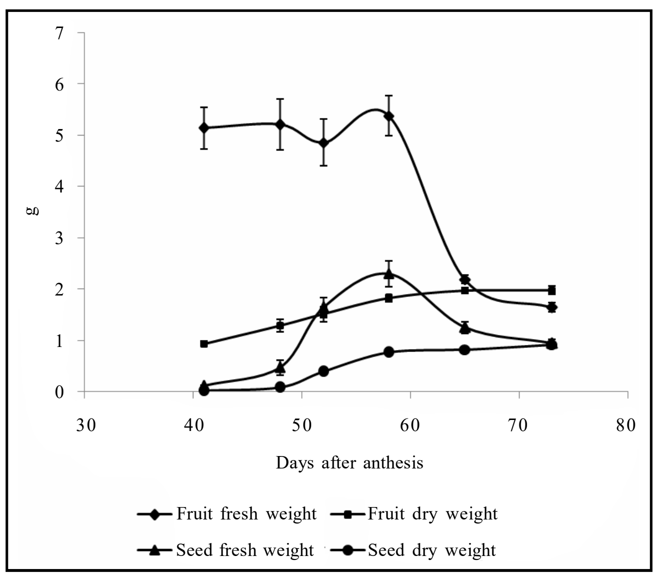

Fig. 2: Changes in mean fresh weight and dry weight of fruit and seed at different stages of maturity of *Butea monosperma* seeds. Bars represent ± standard error

Fruit and seed moisture content:

Fruit and seed moisture content was very high during the initial stage of seed development. The mean values of fruit and seed moisture content were 81.79 per cent and 85.28 per cent, respectively at 41 days anthesis. Slow reduction was observed after this period till 58 DAA, which was followed by rapid decline by the time of shedding at 73 DAA. The mean values of fruit and seed moisture content were noted as 3.74 per cent and 3.17 per cent, respectively at 73 DAA in Fig. 3.

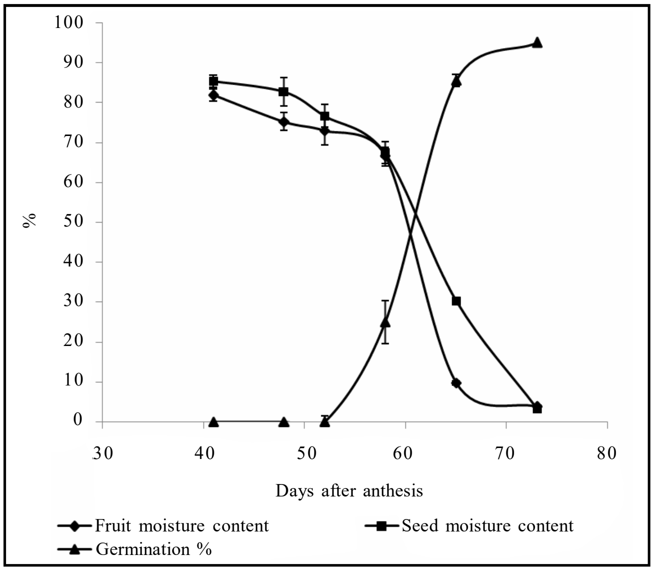

Fig. 3: Changes in mean moisture content of fruit and seed at different stages of maturity of *Butea monosperma* seeds. Bars represent ± standard error

Germination and desiccation tolerance:

Germinability of seeds was not observed within 52 DAA in fresh seeds when 42 per cent of the seeds were filled. However, drying induced 17.5 per cent germination in these seeds dried to 6.92 per cent moisture content. Onset of germinability (25%) occurred at 58 DAA in fresh seeds long before the seeds completed dry mass accumulation in their short maturation period. Drying also resulted increase in germination in seeds harvested at 58 and 65 DAA. But maximum germination and desiccation tolerance was achieved by the seeds harvested at 73 DAA. By this time the seeds accumulated maximum dry mass and minimum water content. Dispersal of seeds started at this stage of maturity.

Fruit and seed colour:

The pods did not show much change in colour from seed formation to the time of seed dispersal. In earlier stages it was greenish white. At the time of seed dispersal

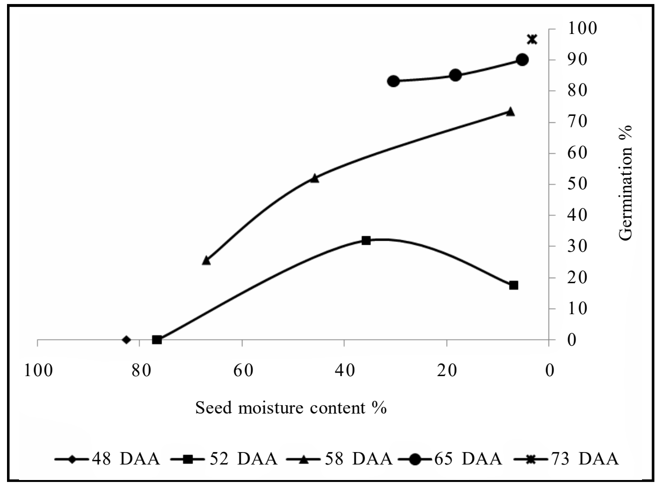

Fig. 4 : The relationship between seed moisture content and percentage germination at different developmental stages. during different stages of maturity of *Butea monosperma* seeds

it turns brownish white, which is not discernible from a distance. The seed colour comparatively show variation in color during seed maturation. The immature seeds are green. At the later stages (65 DAA) it tended to turn brownish and at the time of dispersal it was whitish brown. At this time of maturation, seed dry weight was observed maximum and seed moisture content was lowest (3.17%).

Identification of proper collection time is an important step to prepare a good nursery stock for propagation of any species. The objective of this identification is to determine the stage of development, when seeds can attain maximum quality, the stage of development known as physiological maturity. Controversies regarding this point are related to the enormous diversity of reproductive and adoptive strategies (Bewley and Black, 1985). Harrington (1972) proposed that maximum seed quality in achieved towards the end of filling period, when seed reached maximum dry weight. This hypothesis has been checked in various cultivated species such as *Grycine max* L. (Tekrony and Phillips, 1980), *Triticale hexaploid* L (Bisnnoi, 1974) and *Triticum aestivum* L. (Rasyad *et al.,* 1990). Howerver, in other species, maximum seed quality is reached sometime after attaining maximum dry weight, as has been reported by *vicia faba* L. and *Lens culinaris* Medik (Ellis *et al.¸*1987). *Hordeum valgare* L. (Pieta Filho and Ellis, 1991) and *Lycopericon esculentum* Mill (Demir and Ellis, 1992). Ellis and Pieta Filho (1992) introduced the term mass maturity to distinguish the time

Table 1 : The relationship between mean dry mass and Moisture content per cent of seed with colour of fruit and seed at different developmental stages in *Butea monosperma*

DAA	Mean dry weight of seed	Mean moisture content% of seed	Fruit color	Seed color
41	0.015	85.28	Green	Green
48	0.08	82.62	Green	Green
52	0.39	76.6	Green	Green
58	0.76	67.1	Green	Green
65	0.86	30.28	Greenish white	Brownish green
73	0.92	3.17	Whitish brown	Brown

of maximum dry weight accumulation from that of physiological maturity (when the seeds attained maximum quality during maturation).

Seeds of *Butea monosperma* can tolerate drying to 3.17 per cent moisture content and seeds disperse at low moisture content, hence may be considered as orthodox seeds (Roberts, 1973).

Fruit length and diameter reached maximum at very early stage of maturity (48 DAA). Barnett (1979) and Castellani and Aguiar (2001) reported that maximum fruit size is achieved before the seeds reached physiological maturity. Though seeds attained maximum seed width at 58 DAA, seed length increased till the time of dispersal due to increase their dry mass upto this time.

The important observation in the development of *Butea monosperma* seeds was that the dry mass accumulation continued till the time of shedding and also maximum germination was observed at later stage of maturity. Maximum seed quality which is denoted by maximum germination and desiccation tolerance was achieved at the time of mass maturity, which supports Harrington hypothesis. Though in *Butea monosperma* maturation drying stage is absent which is the characteristic feature of recalcitrant seeds. But recalcitrant seeds shed at high moisture content, whereas *Butea monosperma* seeds shed at very low moisture content (3-3.5%). Hence, drying and seed filling are simultaneous events in this species that is not so common in orthodox seeds.

The identification and characterization of the stage of maturation by visual indicator before dehiscence of the fruits is important to get the seeds of high quality. Collecting seed after natural seed dehiscence when they have been subjected to uncontrolled environmental conditions can result in seed of poor quality. As fruit size reached maximum length before the seeds attained physiological maturity, it can hardly be used as visual indicator for maturity. Regarding color of the fruit, it remained green and greenish white at 58 and 65 DAA, respectively. At the time of physiological maturity, fruit turns brownish white, not so distinguishable from early stage. But seeds turned brown at physiological maturity which can only be indicator of maturity or seed collecting time. As physiological maturity coincides the time of dispersal, care should be taken to avoid seed loss. It is, therefore, preferable to collect seeds when the colour of the seed turns brown.

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