Studies on Seed quality and germination parameters using different treatments in Butea monosperma

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ABSTRACT

Butea monosperma (Lam.) Taub (Fabaceae) is a medium-sized tree of the Indian sub-continent. It is an important species that yields several non-timber forest products, such as a water-soluble dye, lac resin, fodder and leaves for platters. The plant has beautiful flowers adorning leafless canopies during early summer and is aptly described as ‘the flame of the forest’. Seeds from different locations in Rajasthan were analyzed for seed quality as well as germination potentials with different treatments. GA3 was found to increase seed germination in compare to other. A detailed work with review work on its reproductive biology is presented in the present study.

Keywords: Reproductive biology; Germination; Pollination; Medicinal uses; Conservation; Traditional knowledge; Cultivation; Floral morphology.

1. Introduction

Butea monosperma (Lam.) Kountze belongs to family Fabaceae and commonly known as “Flame of Forest”. In English it is also known as Bastard teak. Plant is known by different languages in hindi as Dhak, Tesu, in Sanskrit as Kimsuka, Rakta-puspaka, in Bengali as Palash, in oidia as Porasu, in gujrat as Kasudo, in Urdu as Dhak, Plaspaka, in Kannada as Muttag, Muttala, in Malayalam as Plasu, Camata, in Marathi as palas, in Punjabi as Palas, Dhak, Tesu, in tamil as Parasu, Paras and in telugu as Moduga, hettu etc. (Patil et. al., 2006; Kirtikar, K.R. & Basu, 1935).

Butea monosperma is a medium sized tree of Indian subcontinent. It can grow up to 50 feet high. It has cluster of flower. Its leaves shade down as the flowers develop in the month of January to March. It is deciduous tree with crooked trunk and irregular branches. It can attain height of 8m and diameter up to 40 cm when it matures at the age of about 50 years. Its wood is greenish white in colour, soft and weighs about 14-15 kg per cubic foot (Boutelje, 1980). Its bark is ash colour. Its leaves fall off by December and reappear during spring. When the tree is leafless it bears flaming orange to red-coloured flower. Flowers start appearing in February and stay on nearly upto the end of April (Cowen, 1984). Fruit of Palas is a flat legume. Seeds are flat 25 to 40 mm long 15 to 25 mm wide and 1.5 to 2 mm thick seed coat is reddish brown in colour (Boutelje, 1980; Huxley, 1996). Its flowers yield an orange dye, used as an insecticide. Leaves are essential for various religious rituals in Hindu homes as plate and cups. It is a sacred tree. Its dry stem pieces are used for making sacred fire. In different areas these are used for wrapping tobacco to make biddies. Leaves are further used to pack parcel materials. Its seeds are used in Ayurvedic and Unani medicine for treating different disorders. Its flowers are offered in place of blood in sacrifices and rituals to Goddess Kali (Ambasta, 1994).

B. monosperma bears flowers in which the nectaris concealed within the keel and require a special foraging effort by the vector. Thus a specialized relationship between the structural organization of the flower and the pollinator is implicated. In a study on reproductive biology of Butea Monosperma I which phonology, floral biology, pollinations &breeding systems were also studied in protected area of New Deli. Results indicate that species
though regular lying flowered but all trees do not flower every year. Study show 7 species of birds frequently visited tree but only one species people sunbird (*Nectarinia asiatica*) in the effective pollinator. Its flowers are also pollinated by three striped squirrel (*Funambulis tristiatus*). These two pollinators forage. The nuclei from the open side of the seed (legitimate path) during which pollen grains are deposited on their body parts. After the first visit of a sunbird/squirrel, Virgin flowers showed pollen load on the stigma and developed into fruits. *Butea monosperma* shows a week from of self incompatibility. In study fruit set following manual self pollination (5.25 percent) was copperplate with open pollination (approx 5 percent) but was significantly lower than manual cross pollination (22.51 This indicating that there in a high degree of geitonogamous pollination in this species which) May lead to a weakening of self incompatibility high degree of geitonogamous pollination in this species, which may lead to a weakening of self incompatibility as a means of reproductive assurance.

Several factors may be responsible for the low fruit self in *Butea monosperma* under open pollination. Limitations of compatible pollen is tone factor however in manual cross pollination fruit set was only increased from 23to 32 percent indicator that there are additional constraints for fruit set which have to be studied.

*Butea monosperma* variety monosperma: - *Butea monosperma* (Lam) Tack variety lutea *B. Monosperma*. Lute posses' charismatic ivory – White (albino) flower buds and yellow flowers. It is latter than well known var monosperma which has elegant arrange- scarlet raceme inflorescence. *B. monosperma* var. lutea is endemic to Deccan plateau of India. It has very has populations i.e. equaled or less than 100 plants only across the plateau. It is reported from Aurangabad in Maharashtra.

Jiljella block of sirisila forest of Kalimnagar, Peddagutta of Nizamabad and Kummarigudem and Mallakaphy of Warangal district of Andhra Pradesh. It is not mentions in flou of A. P. and also not included in IUCN red dist also. It is very rare and declared as globally endangered medicinal plant by conservation Assessment Management planning workshop for medicinal plant of Andhra Pradesh. Presently due to destructive harvesting of plant for medicinal was, for firewood & other reason- is under threat of extinction (Jadhav, S.N. et al., 2001; Nayar M.P. et al., 1987; Ready C.S. et. al., 2001).

The plant (*B. monosperma* var. lutea) is much demand in folk medicine. Stem back extract with jeera powder used for leucorhoea, Jaundice and skin disease. The decoction of stem back is said to be given as tonic to women after child birth. Chemical analysis shows presence of flavonoids, chalcones, linolic acid and unsaturated acids (Thirupathaiah A. 2007).

1.1. Traditional uses of *Butea monosperma* var. *mono spure*

Its flowers used as antioxidant, anticonvulsant, antistress, memory and behavior stimulant, dietetic, antileptotic, anti-inflammatory, antiulcer, astringent and antihepatotoxic. Flower is also used to treat enlarged spleen, menstrual disturbances, burning sensation and eye diseases. Leaves cue traditionally used as anti inflammatori, antitumor, diuretic, ant diabetic, antimicrobial, anthelmintic, appetizer, carminative, astringent and aphrodisiac.

It stem back is used as aphrodisiac, anti dysentery, antiuken, antitumor, anti microbial, antifungal, antipyretic, blood purifier and anti-asthmatic. It is also used is bleeding hemorrhoid disorder, liver disorder, gonorrhea, hound, warm infections, scorpion sting, cold & cough etc. (Kirtikar & Basu, 1935; Kala 2004).
Its root is used in night blindness, elephantiasis, and impotency and in snake bite. It also causes temporary sterility in women and is applied in sprue, piles, ulcers, tumors and dropsy.

Seeds are used in stomatitis, corneal apacititis, ring worm, leucorrhoea, senticsoal throat, excessive perspiration and diarrhea (Kirtikar & Basu 1935).

The plant is being used by tribal people for their medicinal properties. The mucilaginous bark is boiled and the juice squeezed out and applied to rheumatic swellings. Decoction of the bark is externally applied to treat inflammation of lymph glands, common fever and ringworm and scabies. Decoction of the leaves is used to regulate fat metabolism, treat ringworm eczema and coetaneous diseases. Stem bark acts as an anti-inflammatory agent specifically for eyes. Bark and leaf paste the plants are applied externally on the white patches or leucoderma. Bark boiled in coconut oil with that Pongamia glabra Vent and garlic and is applied externally to eczema. For treatment of herpes simplex infection, bark paste applied over the affected pat until it disappears. Bark cut in the sharp of a coin tied on left arm below the shoulder for treatment of malaria, patient advised not to use cow’s milk curd and sour foodstuffs. It is also used for treating intestinal cancer. Leaf bud mixed with lime juice and applied externally to affected area for treatment of hair loss by infection and treatment of herpes infection. A handful of bark and leaves ground with 15 pepper seeds, one bulb of garlic in rice washed water. Half litter of plant extract given to cattle, daily once for 1-2 days for treatment of cold and cough and bark ground with weakness (. Seeds used topically on ringworm and dried fruit used in poly urea and urinary disorders.

1.2. Cultivation

The plant is commonly cultivated by the transplantation of nursery-raised seedlings. In the nursery, seedlings are raised by sowing seeds in lines about 12-20 cm apart. Transplantation is done when the seedlings are 10 cm in length at spacing of 22.5 x 22.5 cm. The seedlings are kept in the transplant beds for two years and then planted in the season of monsoon. Fresh seeds are also sown directly at the rate of 2 seeds per stake on the lines of 3 m apart. Continuous watering is required in both cases.

1.3. Study Objectives

As Butea monosperma is very useful plant for livelihood and afforestation purpose the objective behind this study was to identify the better seed sources and treatment for getting good germination and subsequently producing quality seedlings.

2. Review of literature

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 environment factors such 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 seed can tolerate desiccation at very low moisture level 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.

Leaves are shed during January-February and the leafless tree flowers abundantly which 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 pollinations. In pale 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 analyzed 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 evaluation of their physiological quality.

2.1. 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 0.001 g to obtain the fresh mass. Then they were dried in a force-draft oven regulated at the temperature of 103±2ºC for then reweighed to get the dry weight. Moisture content was estimated on fresh weight basis.

- Pods and seed color: Pods 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±2ºC 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, numbers 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 pod and were dried over silica gel day. Samples were removed from drying after varying periods ranging from 6 to 172 hours. Seeds moisture content was determined after humidifying the dried seeds (in a closed container) over water for 24 h at 25ºC to avoid imbibition injury germination test.

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 reached maximum dry weight. This hypothesis has been checked in various cultivated species such as *Glycine max* L. *Triticale hexaploid* L (Bisnnoi, 1974) and *Triticum aestivam* L. (Rasyad et al., 1990). However, in other species, maximum seed quality is reached sometime after attaining maximum dry weight, as has been reported by *Vivia faba* L. and lens (Pieta Filho and Ellis, 1991) and *Lycopercon esculentum* Mill (Demir and ellis, 1992). Ellis Pieta Filho (1992) introduced the term mass maturity to distinguish the time 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 and seeds disperse at low moisture content, hence may be considered as orthodox seeds (Roberts, 1973).

The important observation in the development of *Butea monosperma* seeds was that 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. Through 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 environment conditions can result in seed poor quality. As fruit size reached maximum length before the seeds attained physiological 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 seeds loss. It is, therefore, preferable to collect seeds when the colour of the seed turns brown.

### 3. Material and Methods

Seeds from different localities were collected from seed trees and after cleaning and drying were store for further testing. Seeds of *Butea monosperma* were collected and after proper cleaning and drying they were stored for further analysis. Seed length, width and thickness were recorded for 100 seeds of each seed lot. The seed germination tests were performed in seed germination Laboratory of Silviculture and Forest Management, ICFRE-Arid Forest Research Institute, Jodhpur. With the help of seed counter machine seeds per kilogram were calculated. Laboratory test on the germination response of seeds to pre-germination treatments of Hot water, GA\(_3\) (500 and 1000 ppm) and IBA GA\(_3\) (500 and 1000 ppm) compared to untreated seeds (control).

Soaking Hundred seeds in hot water for 15 min. Twenty seeds were also soaked in GA\(_3\) (500 and 1000 ppm) and IBA GA\(_3\) (500 and 1000 ppm) for 6 hours. All the pre- treated and untreated seeds were rinsed thoroughly in
distilled water and were placed in germination tray. The experiment was carried out at room temperature in the laboratory. Seeds were considered germinated upon plumule emergence. The number of seeds that germinated was recorded while the percentage seed germination was calculated.

Following procedure was made for different parameters determinations-

3.1. Formulas for various calculations

A) **GP (Germination percentage)** = (Total number of seeds germinated/total number of seeds tested) × 100

Final Germination Percentage (FGP %) = Final no. of seeds germinated in a seed lot × 100

The higher the FGP value, the greater the germination of a seed population (Scott et al., 1984).

B) **MGT (Mean germination time)** = total (daily germination) × 1 days /total seed sowing

Mean Germination Time (MGT day) =Σf ·x/Σf

f=Seeds germinated on day x

The lower the MGT, the faster a population of seeds has germinated (Orchard, 1977).

- First Day of Germination (FDG) day =Day on which the first germination event occurred

Lower FDG values indicate a faster initiation of germination (Kader, 1998).

- Last Day of Germination (LDG) day =Day on which the last germination event occurred

Lower LDG values indicate a faster ending of germination (Kader, 1998).

- Germination Rate Index (GRI) (%/day) =G1/1 + G2/2 + · · · + Gx/x

G1=Germination percentage × 100 at the first day after sowing, G2=Germination percentage × 100 at the second day after sowing

C) **AVG MGT (Average Mean germination time)** =Total MGT/Total number of days.

D) **GV (Germination Value)** = (Total MGT/total germination) × (GP%/10).

4. Reproductive Biology of Butea monosperma (Fabaceae)

The reproductive biology of flowering plants is important for determining barriers to seed and fruit set, for conservation, and for understanding pollination and breeding systems that regulate the genetic structure of populations. Detailed studies on reproductive biology of Indian plant species, especially trees, are limited. Out of nearly 2500 tree species reported from India, 180 are leguminous (Dr. M. Sanjappa, Director, Botanical Survey of India, pers. comm.) being predominantly pollinated by bees. There are very few species that are pollinated by birds.

According to a survey on ornithophilous species in India, 93 are regularly visited by 58 species of birds (Subramanya and Radhamani, 1993). Over 80 % of these plant species are frequented by more than one species of bird and, similarly, over 80 % of the bird species visit more than one plant species. Thus, a generalized relationship exists between plant species and bird pollinators (Subramanya and Radhamani, 1993; Waser et al., 1996). In the majority of ornithophilous species, no attempts have been made to establish the obligate necessity of birds for
pollination and to distinguish pollinators from floral visitors. More intensive studies are needed on Indian species for a better understanding of bird-pollination systems.

*Butea monosperma* (Lam.) Taub (Fabaceae) is a medium-sized tree of the Indian sub-continent. It is an important species that yields several non-timber forest products, such as a water-soluble dye, lac resin, fodder and leaves for platters (Anon., 1988). The plant has beautiful flowers adorning leafless canopies during early summer and is aptly described as ‘the flame of the forest’. The flower colour has been variously described as scarlet, red and orange-red (Anon., 1983, 1988, 1994) but, according to the Royal Horticultural Society colour chart (Anon., 1946) is most accurately termed Indian-orange. Although rare, yellow and white flowering trees have also been reported (Sanjappa, 1987). Except for a report by Ali (1932) based on observations that several bird species visit the flowers, there have been no systematic studies on the reproductive biology of *B. monosperma* implicating bird pollination.

The tree is largely propagated by seeds. Fruit set is very low and each fruit bears only one seed (hence the specific epithet monosperma).

In recent years, there has been a discussion on generalization vs. specialization in pollination systems (Waser et al., 1996; Johnson and Steiner, 2000). In *B. monosperma*, as many as 12 bird species have been reported to visit flowers (Subramanya and Radhamani, 1993). These features fit into the generalized relationship between flowers and bird pollinators. However, unlike many of the species pollinated by passerine birds in which flowers are open-type and have unprotected nectar, *B. monosperma* bears flowers in which the nectar is concealed within the keel and requires a special foraging effort by the vector. Thus, a specialized relationship between the structural organization of the flower and the pollinator is implicated.

The flowers of *B. monosperma* show many features, such as a bright reddish-orange colour, abundant nectar protected by the keel, and diurnal anthesis, characteristic of bird pollination (Faegri and van der Pijl, 1979). Present studies on pollination biology have revealed an unusual pollination guild in *B. monosperma*. As indicated by floral morphology, flowers are frequented by as many as seven bird species belonging to six families. Of these, only one species, *Nectarinia asiatica*, forages from the legitimate position and brings about effective pollination. All other bird species pierce their bills through the calyx to reach the nectar. As they do not come into direct contact with the anthers and the stigma, they have no role in pollination.

Although honeybees were seen around flowers, they were observed to forage the nectar only from the holes made in the calyx by non-pollinating birds. The flowers are too large, and the stigma and anthers remain out of reach, for the bees to bring about pollination. As suggested by Johnson and Steiner (2000), the results of the present study show clearly that the large number of pollinating species frequenting a plant species is not a satisfactory method to measure the degree of specialization; the active pollinators comprise only a very small fraction of the total number of visitors. The findings reported here have established that *B. monosperma* demonstrates a specialized bird-pollination syndrome (Johnson and Steiner, 2000).

Sunbirds constitute one of the most important groups of bird pollinators and are reported to frequent up to 58 species of flowering plants in India (Subramanya and Radhamani, 1993). Interestingly, an analysis of the ratio of beak length to body size of all visitors to B. monosperma flowers showed that sunbirds had a much higher ratio
(0·210) compared with all other visitors (0·125–0·074) (Subramanya and Radhamani, 1993). Elongated, gently decurved beaks seem to facilitate sunbirds to harvest the deep-seated nectar from flowers in a large number of plant species.

Squirrels foraged from the legitimate position, the stigma and anthers come into contact with their snouts and heads. Furthermore, after the first visit by purple sunbirds or squirrels, pollen was deposited on the stigmas of visited flowers, which subsequently developed into fruits. These results were comparable to those obtained by open-pollination, confirming that these two foragers are indeed the pollinators. Nectar is their reward. Nectar production is confined to the period during which the stigma is receptive. Visits by both purple sunbirds and squirrels were correlated with the availability of nectar.

No unique morphological features that would facilitate squirrel pollination were identified in B. monosperma flowers. However, many features of ornithophily, such as large, robust flowers (that could withstand the foraging activity of squirrels), abundant nectar, anthers and stigma positions, and diurnal opening of the flowers, are ideal for squirrel foraging and pollination. Squirrels are generally territorial and restrict their movement to one or a few neighboring trees. Their intensive search for food could have led them to explore a vast number of very conspicuous flowers which opportunistically would have brought them into contact with nectar. Due to easy floral access and the availability of abundant nectar, visits would have stabilized without requiring any change in floral features. Thus, flowers of B. monosperma conform to the classical bird pollination syndrome but are flexible enough to accommodate opportunistic pollinators belonging to an entirely different group of animals (Johnson and Steiner, 2000). Pollination by squirrels has been reported in Grevillea robusta (McCann, 1933) and in Ganua sp. (Yumoto et al., 1996), although these taxa do not show any special features for squirrel pollination. In Ganua, the flowers are open and it is suggested that the fleshy perianth with attached stamens serves as a reward for the squirrels.

The pollination system in B. monosperma involving birds and squirrels is an unusual pollination guild. In another papilionoid legume, Erythrina sp. (Bruneau, 1997), there are two modes of pollination, one by hummingbirds and the other by passerine birds. These pollination modes essentially require structural changes in the flower’s morphology. In hummingbird-pollinated Erythrina sp. the standard petal is conduplicately folded to form a pseudo-tube, whereas in passerine-pollinated flowers the standard petal is open so that nectar is visible and accessible. However, in Erythrina crista-galli, Galetto et al., (2000) noticed that, in addition to the birds, bees also pollinated the flowers, indicating an intermediate step from entomophily (typical of the tribe Phaseoleae) to ornithophily (typical of Erythrina). In B. monosperma, two different groups of vectors are able to act as effective pollinators without any change being necessary in the floral features. Bird- (ornithophily) and squirrel-pollination (therophily) in this species is thus an atypical pollinator guild in the tribe Phaseoleae.

4.1. Butea monosperma seed germination and other parameters studies

Seeds of Butea monosperma were collected and after proper cleaning and drying they were stored for further analysis. Seed length, width and thickness were recorded for 100 seeds of each seed lot. Mean length was 21.33 mm in Nahargarh Biological park area, Jaipur while it was highest as 36.62 mm in Manoharpura, Shahpura, Jaipur seed
lot mean width was lowest as 17.46mm in Nahargarh Biological park area, Jaipur while it was highest as 25.93mm in Manoharpura, Shahpura, Jaipur Seed lot. Mean thickness was minimum in Nahargarh biological park area Jaipur as 0.82 mm while it was maximum as 2.43 mm in loharai-dham, Udaipurwati, Jhunjhunu.

Under laboratory conditions germination percentage was recorded with hot water treatment, GA$_3$500 ppm, GA$_3$1000 ppm, as well as in control treatment. Under control treatment it was in range of 20 percent in both Shahpura, Jaipur and Lohargarh, Udaipurwati seed lot while it was highest as 80 percent in 3 seed lot viz. (Shahpura, Jaipur, Loharai-dham, Udaipurwati, Jhunjhunu and in Nahargarh biological park area, Jaipur) while it was highest as 80 percent in Munder van khand Shahabad seed lot.

In GA$_3$500 ppm treated seed lot germination percentage was 20 percent in Munder van khand, Shahabad and Nahargarh biological park area, Jaipur while it was 80 percent in Manoharpura, Shahpura, Jaipur seed lot. With GA$_3$1000 ppm minimum germination was reported as 20 percent in Nahargarh biological park area, Jaipur while it was 80 percent in both Munder van-khand, Shahabad and in Loharai-dham, Udaipurwati, Jhunjhunu seed lot.

Overall germination was in the lowest 20 percent in 8 seed lots
1. Control & hot water treated seed lot of Shahpura, Jaipur.
2. Hot water treated seed lot of lohargari-Dham, Udaipurwati, Jhunjhunu.
3. GA3 500 ppm seed lot of Munder van Khand, Shahbad.
4. Hot water, GA3 500 ppm & GA$_3$ 1000 ppm treated seed lot of Nahargarh Biological park, Jaipur.
5. Control treated seed lot of lohargari, Udaipurwati, Jhunjhunu.

While it was 80 percent in 5 seed lot (1. GA$_3$ 1000 ppm treated seed lot of lohargai- dham, Udaipurwati, Jhunjhunu. 2. GA$_3$ 500 ppm treated seed lot of Manoharpura, Shahpura, Jaipur. 3. Control & hot water treated seed lot of Munder van Khand, Shahabad. 4 GA$_3$ 1000 ppm treated seed lot of Munder van Khand, Shahabad)

Total MGT value was 18.4 in Control treated seed lot of shahpura, Jaipur while it was 192.40 in both control and hot water treated seed lot of Munder van Khand, Shahabad.

Total GV value was lowest as 80.92 in GA$_3$ 500 ppm treated seed lot of Munder van khand, Shahabad while it was highest as 8115.2 in two seed lots viz. GA$_3$ 500 ppm seed lot of Munder van khand, Shahabad and in GA$_3$ 1000 ppm treated seed lot of Lohargarh, Udaipurwati, and Jhunjhunu.

Average MGT value was lowest 1.23 in control treated seed lot of Shahpura, Jaipur while it was highest as 8.75 in control and hot water treated seed lot of Munder van khand, Shahabad.

Average GV value was minimum as 19.65 in control treated and maximum as 2969.6 in GA$_3$ 1000 ppm treated seed lot of Lohargarh, Udaipurwati, and Jhunjhunu.

5. Conclusion

The present study revealed that there is wide variation in seed size and germination percentage with reference to different treatments. However GA$_3$ is found to substantially increase germination percentage. Various parameters
viz. Average MGT value, Average GV value of different seedlots was calculated. The variation may be due to different edaphic, environmental factors as well as due to genetic makeup of seed lots.

6. Future Recommendations

A detailed study with reference to its reproductive biology need to be studied to better understand the mechanism. To produce quality seedlings various parameters should be studied thoroughly. Similarly to increase germination and field performance various treatments and edaphic factors, microclimate were also needed attention.

Declarations

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Competing Interests Statement

The authors have declared that no potential competing financial, professional or personal interests exist.

Consent for publication

All authors contributed to the manuscript and consented to the publication of this research work.

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References


[27] McCann, C. (1933). The flying fox (P. giganteus) and the palm squirrel (F. tristiatus) as agents of pollinization in (Grevillea robusta A. Cunn.) the silky oak. Journal of Bombay Natural History Society, 36: 761–764.


Table 1. Effect of Seed Size on Germination in Butea monosperma

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Location</th>
<th>GPS</th>
<th>Date of Collection</th>
<th>Seed Analysis</th>
<th>Germination Percentage</th>
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<td>05-05-2023</td>
<td>Mean Length (mm)</td>
<td>Mean Width (mm)</td>
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<td>1</td>
<td>Shahpura, Jaipur</td>
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<td>23.25</td>
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Table 2. *Butea monosperma* with Germination Value and Mean Germination Time

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(a) Butea monosperma tree  
(b) Butea monosperma in flowering  
(c) Butea monosperma Tree and lab work photos