



Plant Archives

Journal homepage: <http://www.plantarchives.org>DOI Url : <https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.2.071>

INVESTIGATION AND EVALUATION OF WIND-MEDIATED PRIMARY SEED DISPERSAL MECHANISMS IN SELECTED ANGIOSPERMS

Santosh Bala

Department of Botany, Multani Mal Modi College (Affiliated to Punjabi University, Patiala), Patiala - 147 001, Punjab, India.

*E-mail : santosh_gamo@rediffmail.com; ORCID ID : <https://orcid.org/0009-0004-8897-4789>

(Date of Receiving-01-06-2025; Date of Acceptance-10-08-2025)

ABSTRACT

In ecological evolution, knowledge of seed form and seed dispersal mechanisms is crucial. This study is to investigate plants that have primary seed dispersal mediated by wind and assess the different morphological characteristics responsible for this dispersal in a few farmed Angiosperms. Eleven seed and fruit samples taken from cultivated plants in the Chandigarh and Patiala (Punjab) areas are the subject of the current study. It was discovered that fruit and seeds have unique coverings and appendages, such as modified wings, hairs, or some light-weighted, delicate papery structures, which help disperse seeds and fruits by carrying them to far-off locations via wind currents and flows. This process is known as anemochory.

Key words : Seed dispersal mechanism, Wind, Seed/ fruit morphology, Winged seeds.

Introduction

According to Baker (1974), a species' reproductive potential, number, habitat range, area occupied, and ability to carry on the genetic line can all be used to gauge its evolution. Tree layers made up of pioneer species are frequently where wind-dispersed seeds can be discovered (Bansal and Sen, 1981). According to Willson *et al.* (1990) and Nathan *et al.* (2011), wind-mediated seed dispersal is the most significant and thoroughly researched dispersal method. According to Schurr *et al.* (2005) and Zhu *et al.* (2019), there are two types of seed dispersal that are defined in the literature: primary dispersal, which involves the movement of seeds via the air, and secondary dispersal, which involves subsequent movement of seeds across the ground before the seed becomes caught.

The dispersal environment and dispersal features are key factors in wind dispersal. The horizontal wind speed, vertical uplift and turbulence are important characteristics of the dispersal wind environment. Nathan *et al.* (2011) talked about the morphological characteristics of seeds and fruits that carry seeds, including the existence of hairs, wings, small size and an adaptable structural framework that makes it easier for the seeds to travel

through the air. Plant species use morphological and anatomical adaptations as part of their dispersal processes. Some plants may undergo informed dispersal, in which dispersal-related features are altered based on environmental conditions, according to Seale and Nakayama (2020). To make it easier for plants to spread by biotic or environmental carriers, their dispersal units have evolved from basic to more sophisticated structures. According to Takenberg *et al.* (2003), the presence of membranous wings or fluffy seed hairs significantly boosts the likelihood of wind distribution.

In order to disperse seeds to farther-off locations, tree species mostly adopted the wind dispersal mechanism and displayed distinctive morphological adaptations. In order to better understand these characteristics and the main mechanism of dispersal, I conducted this study on eleven angiospermic plants: *Albizia lebbek* (L.) Benth, *Calotropis procera* Aiton, *Chukrasia tabularis* A. Juss., *Jacaranda mimosifolia* D. Don, *Koelreuteria elegans* Subsp. *formosana*, *Lagerstroemia indica* L., *Moringa oleifera* Lam., *Nerium indicum* L., *Oroxylon indicum* (L.) Benth. ex Kurz, *Sterculia alata* Roxb.

Materials and Methods

Study area : Samples of dried seeds and fruit were gathered from the Chandigarh region (30.7333° N, 76.7794° E) and Patiala, Punjab (30.3398° N, 76.3869° E). The years 2021–2024 were used for the explorations.

Sample collection : At the time of their spread, the fruit and seed samples were gathered in 2021–2024 and stored in the herbarium of the Department of Botany at Multani Mal Modi College in Patiala.

Identification : The India Biodiversity Portal, the CABI digital library, and the Database of Plants of the Indian Subcontinent were used to identify the samples.

Evaluation : In the laboratory, additional morphological analysis of seed and fruit characteristics was conducted, encompassing general measurements of plant sample size, type, weight, color, quantity, and image. Fruit dehiscence and splitting mechanisms were also documented to show how the seeds were released.

Results and Discussion

In order to investigate the methods of primary seed dispersal mediated by wind, eleven Angiosperms were explored and analyzed. A table compiles numerous findings about the properties of seeds.

Albizia lebbek (L.) Benth.

Nearly every region of India has it as a roadside tree (India Biodiversity Portal, 2016) and it is also grown in gardens as a shade tree (Gupta, 1993). It is frequently seen in Chandigarh as a roadside tree (Kohli *et al.*, 1998). *A. lebbek* is a deciduous tree that grows to a height of 30 meters. It produces indehiscent fruit pods that contain 5–12 seeds each. The huge (15–30 × 2.5–5.0 cm) elongated, thin pods are pale yellow in hue (Fig. 1). According to Lowry *et al.* (1994), seeds are naturally dispersed across long distances via intact indehiscent pods. Fruits are papery pods that are easily carried away by wind due to the pericarp's expansion.

Calotropis procera Ation

Usually found in wastelands, it produces fruit and flowers all year round in India (Little *et al.*, 1974). The 4.5-meter-tall shrub has recurved follicular fruits that encase brown, flattened, 5-cm seeds with silky hairs (Fig. 2). These smooth hairs serve as wings on seeds. Hairs that cover the entire or partial surface of seeds aid in their wind-borne dissemination. According to Francis (2002), light breezes carry seeds several hundred yards.

Chukrasia tabularis A. Juss.

Growing to a height of 25 meters, it is cultivated as an avenue tree. The gray to brown, subglobose, woody,

5-valved capsules measure around 4.5 × 3.6–4 cm and contain a large number of seeds (Fig. 3). The seeds are about 3–3.5 × 0.5 mm and are flat and oval. The seeds are lightweight and contained in woody, valved, dehiscent capsules that split open to reveal flat, membrane-winged seeds.

Jacaranda mimosifolia D. Don

The plant commonly referred to as Jacaranda belongs to the Bignoniaceae family. The deciduous tree *J. mimosifolia* is grown as an ornamental tree and can reach a height of 20 meters. Fruits are 3.3–5.7 cm long, disc-shaped capsules that are flattened and have two valves (Fig. 4a, b). Its seeds have a brown membrane integument, a hyaline wing, and a cordiform-orbicular morphology (Fig. 4c). A thin membrane that functions as a wing and generally encircles the seed body (PIER, 2014) and allows for long-distance wind dispersal is advantageous for colonization (Gogosz *et al.*, 2015). The seeds are most suited for wind dissemination since they are born in dehiscent pods, which are lightweight and have feathery, circular wings.

Koelreuteria elegans Subsp. *formosana*

Fruits with papery, three-valved capsules up to 50 mm long are produced in drooping clusters by a medium-sized deciduous tree that is 5–12 m tall (Fig. 5). Black seeds are affixed to the valve's lower surface. The pink papery capsule breaks into three pieces, as the wind blows the seeds away.

Lagerstroemia indica L.

In many tropical and subtropical regions of the world, this lovely little tree has become naturalized. The dry, brown, spherical, woody capsular fruits of small trees up to 7m tall are 1–1.3×0.7–1.1cm in size, often 6-valved, and have a persistent calyx (Fig. 6). The seeds are about 8 mm in size. When capsules dehisce lengthwise, several winged, light, flat seeds are released.

Moringa oleifera Lam.

Known by most as Moringa, this plant originated in North India's sub-Himalayan regions and was brought to all tropical and subtropical areas (Qutani *et al.*, 2023). Moringa, a member of the Moringaceae family, is extremely important in medicine. 10 m tall *Moringa oleifera* trees produce hanging, three-sided, brown, 16–18 inch long capsular fruits. Fig. 7 shows that the seeds are dark brown, spherical, and 2 cm in size. They have three white, papery expanded parts that serve as wings and aid in wind dispersal. When the fruit ripens, the seeds are released when it ruptures or splits open longitudinally.

Table 1 : General information on 11 presently studied taxa, family, plant habit and habitat, common name, fruiting time, morphological features and adaptation of fruit and seed responsible for wind dispersal.

S. no.	Name of Taxon	Family	Plant habit and habitat	Common name	Fruiting time	Morphological features of fruit and seed	Morphological adaptation of Dispersing part
1.	<i>Albizia lebbek</i> (L.) Benth.	Fabaceae	Tree, growing Roadside, Chandigarh	Siris	June	Fruits are Papery Pods with expansion of pericarp	Flat winged fruit (Light weight and easily floats in air)
2.	<i>Calotropis procera</i> Aiton	Asclepiadaceae	Shrub, Cultivated in botanical garden, Patiala	Indian milkweed	November-February	Hairy seeds enclosed in follicular fruit	Silky hairs attached to seeds act as wings
3.	<i>Chukrasia tabularis</i> A. Juss.	Meliaceae	Tree, growing as avenue tree, Chandigarh	Indian mahogany	March-May	Seeds are winged & light weighted enclosed in 5-valved dry dehiscent woody capsules split open to release seeds	Flat seeds with membranous wings
4.	<i>Jacaranda mimosifolia</i> D. Don	Bignoniaceae	Tree, Cultivated as ornamental, Patiala	Jacaranda	April- May	Disc shaped flattened 2-valved capsule	Flat winged seed brown membranous integument
5.	<i>Koeleruteria elegans</i> Subsp. <i>formosana</i>	Sapindaceae	Tree, growing as avenue tree, Chandigarh	Flamegold rain tree	August	3-valved Capsular fruit carry seeds in pairs on lower surface of each valve	Pink Papery capsule splits into 3 parts & seeds are blown away by wind
6.	<i>Lagerstroemia indica</i> L.	Lythraceae	Small Tree, growing in garden, Patiala	Grape myrtle	October	Woody dry 6-valved Capsular fruit with small winged seeds	Flat, papery winged seed
7.	<i>Moringa oleifera</i> Lam.	Moringaceae	Tree, growing in garden, Patiala	Moringa, Drumstick tree	March-April	Long, slender 3-sided capsular fruit splits open longitudinally from sides; Seeds have two expanded wings at opposite sides	Dark brown 3-angled seed with papery wings
8.	<i>Nerium indicum</i> L.	Apocyanaceae	Evergreen Shrub, growing in garden, Patiala	Oleander	January-March	Fruit comprises of two ventrally fused follicles dehisces marginally; seeds with silky hairs	Downy seeds (hairs in tuft at end of elongated seed)
9.	<i>Oroxylon indicum</i> (L.) Benth. ex Kurz	Bignoniaceae	Tree, Growing Roadside, Chandigarh	Oroxylum	March	Large sword like flat 2-valved capsular fruit	Seeds flat, papery wings
10.	<i>Sonchus oleraceus</i> L.	Asteraceae	Herb, growing in garden, Patiala	Sow Thistle	September	Single seeded dry indehiscent achene fruit; Sepal modified into hairy (Winged) structure- pappus	Seeds small, light weight, with fine hairy pappus easily flows in wind
11.	<i>Sterculia alata</i> Roxb.(Syn.= <i>Pterygota alata</i> (Roxb.) R.Br.	Malvaceae	Tree, growing as avenue tree, Chandigarh	Buddha coconut	April-May	Dry dehiscent woody Follicle brown colored fruit split along one side	Large woody, oblong 40 winged seeds per fruit

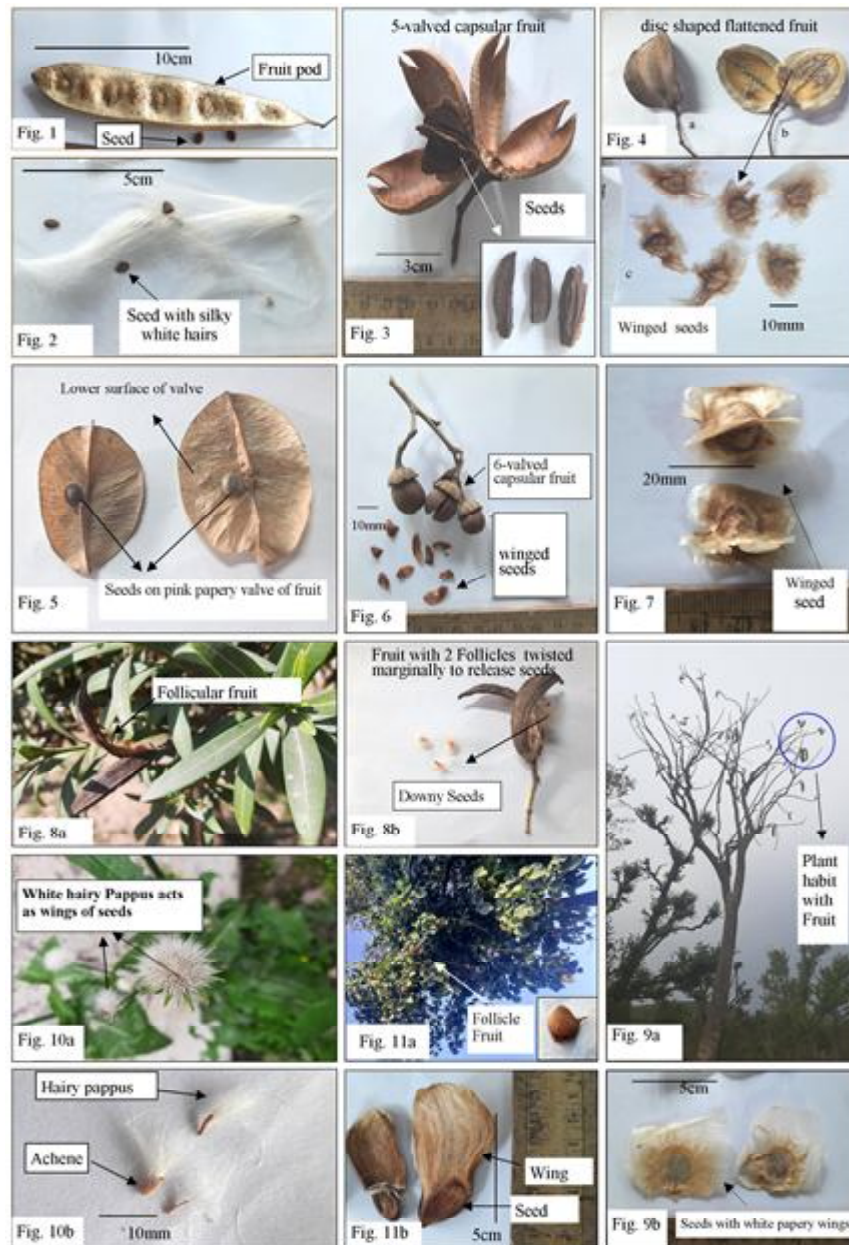


Fig. 1 : Fruit of *Calotropis procera* Aiton **Fig 2.** Hairy seeds of *Chukrasia tabularis* A. Juss. **Fig 3.** Woody capsular fruit and flat seeds of *Jacaranda mimosifolia* D. Don **Fig 4a.** Capsular fruit b. split fruit c. winged seeds of *Jacaranda mimosifolia* D. Don **Fig 5.** Split capsular fruit with seed of *Koelreuteria elegans* Subsp. *formosana* **Fig 6.** Capsular fruit and winged seeds of *Lagerstroemia indica* L. **Fig 7.** Seeds with papery wings of *Moringa oleifera* Lam. **Fig 8.** Follicular fruit and hairy seeds of *Nerium indicum* L. **Fig 9a.** Plant body with capsular fruit **b.** Papery winged seeds of *Oroxylon indicum* (L.) Benth. ex Kurz **Fig 10a.** Plant bearing achene fruits **b.** Seeds with hairy pappus of *Sonchus oleraceus* L. **Fig 11a.** Plant body with woody follicular fruits **b.** large winged seeds of *Sterculia alata* Roxb.

Nerium indicum L.

Apocynaceae is a family of evergreen shrubs that are grown as attractive plants in Indian gardens. Fruits range in length from 4 to 6 inches and are cylindrical (Fig. 8). To release its hairy seeds, the fruit's small follicle opens. The seeds are about 7 mm in size and have a hairy tuft to aid in dissemination.

Oroxylon indicum (L.) Benth. ex Kurz

In tropical and subtropical regions, *Oroxylon indicum*, a medium-sized tree that is a member of the Bignoniaceae family, thrives alongside roadsides. Fig. 9 shows the woody, long, sword-like fruits with two-valved capsules that contain kidney-shaped, yellowish spherical seeds encased in a light-brown papery wing. For airborne dissemination, the seeds' papery wings provide buoyancy.

It is known that seeds that weigh more have spread farther (Bhuyan *et al.*, 2000).

***Sonchus oleraceus* L.**

Asteraceae is a family of annual herbs that grows to a height of about one meter. Cypsela fruit is achene, a single-seeded indehiscent variety (Fig. 10). Brown, 2.5-3.75 x 0.7-1 mm, oblanceolate achenes are joined at the top end by white, cottony pappus that is 10 mm long. Hutchinson *et al.* (1984) attribute the achenes' extensive distribution to tall scapes and lightweight achenes with dense filamentous pappi characteristics of *S. oleraceus*.

***Sterculia alata* Roxb.**

This deciduous tree, which belongs to the Malvaceae family, is commonly referred to as Buddha Coconut. It may reach a height of 20 to 25 meters and is grown as an avenue tree. Large, woody fruits with 3-5 follicles that are obliquely spherical and 10–12 cm long are produced (Fig. 11). The seeds are compressed, oblong, brown, winged, and 5-7.5 cm long, with 40 seeds per follicle.

Bansal and Sen (1981) explained anemochory, a unique wind-driven seed-dispersal process in plants. Pappus, wings and plumed seeds are examples of modified features seen in wind-dispersed seed plants. Currently seen in *Sonchus oleraceus*, the 'pappus' are hair-like alterations of the persisting calyx. This is the distinctive quality of Asteraceae family members. Pappus protects the achenes (fruits) when they are encased in the involucre and aids in their dissemination once they are released from the inflorescence when they are mature. The achene floats in the air thanks to the pappus's parachute-like ability to carry it. According to Seale and Nakayama (2020), the Apocynaceae family has separately evolved structures similar to the pappus in the Asteraceae family. Typically, the pappus has about 100 tiny hairs composed of dead, hollow cells (Cummins *et al.*, 2018).

Many plant seeds have thin, flat membranous wings as appendages so they can glide during wind dissemination. The winged structures in *Albizzia lebbek* (L.) Benth, *Chukrasia tabularis* A. Juss. and *Jacaranda mimosifolia* are considered in this study. D. Don, *Oroxylon indicum* (L.) Benth. ex Kurz, *Lagerstroemia indica* L., *Moringa oleifera* Lam., *Koelreuteria elegans* Subsp. *formosana* and *Sterculia alata* Roxb. Partially or completely covered hairs on the seed body are characteristics of comose or plumed seeds. The plant *Calotropis procera* yields two pedicellated follicles. By rupturing the ventral and dorsal sutures, the follicle progressively opens up to reveal seeds in a saucer shape. Silky white hairs adorn the mature, dried seeds, which

are separated by wind currents that carry them great distances. A case similar to this was documented in *Nerium indicum*.

Conclusion

More research in this area is required given the significance of seed dispersal mechanisms for a species' evolutionary success. In-depth research on these plants is necessary to have a better understanding of the secondary mechanism of wind-borne seed dissemination.

Acknowledgments

The author is thankful to Multani Mal Modi College, Patiala (India) for providing necessary time and place for completion of this research article. Author is also thankful for providing financial support for this research work under DBT Star college scheme by DBT, Ministry of Science and Technology, Govt. of India.

Disclosure statement

The author undertakes that there is no conflict of interests regarding the publication of this article.

References

- Baker, H.G. (1974). The evolution of weeds. Annual Review of Ecology, Evolution and Systematics. *Annual Reviews*, 5, 1-24. <https://doi.org/10.1146/annurev.es.05.110174.000245>
- Bansal, R.P. and Sen D.N. (1981). Dispersal strategies in plants of the Indian Desert. *J. Arid Environ.*, 4(1), 3-14.
- Bhuyan, P., Khan M.L. and Shankar U. (2000). Trade-off Between Dispersal Efficiency and Seedling Fitness in *Oroxylum indicum*, A Wind-Dispersed, Tropical Tree. *Int. J. Ecol. Environ. Sci.*, 26, 67-73.
- Cummins, C., Seale M., Macente A., Certini D., Mastropaolo E., Viola I.M. and Nakayama N. (2018). A separated vortex ring underlies the flight of the dandelion. *Nature*, 562, 414-418.
- Francis, J.K. (2002). *Calotropis procera* (Ait.) Ait. In: *Wildland shrubs of the United States and its territories: thamnisc descriptions*. Francis, J.K. (ed.) USDA Forest Service General Technical Report, IITF-WB-1. <http://www.fs.fed.us/global/iitf/Calotropis%20procera.pdf>.
- Gogosz, A.M., Boerger M.R.T., Cosmo N.L. and Nogueira A.C. (2015). Morfologia de diásporos e plântulas de espécies arbóreas da floresta com araucária, no sul do Brasil. *Floresta*, 45(4), 819-832.
- Gupta, R.K. (1993). Multipurpose trees for agroforestry and wasteland utilisation. *International Science Publisher*, xv, 562. <https://doi.org/10.2307/3235789>
- Hutchinson, I., Colosi J. and Lewin R.A. (1984). The biology of Canadian weeds. 63. *Sonchus asper* (L.) Hill and *S. oleraceus* L. *Canadian J. Plant Sci.*, 64, 731-744.
- India Biodiversity Portal (2016). *Online Portal of India Biodiversity*. <http://indiabiodiversity.org/species/list>

- Kohli, R.K., Singh H.E. and Batish D.R. (1998). An Inventory of Multipurpose Avenue Trees of Urban Chandigarh, India. *Integrated tool Proceedings*, 697-704.
- Little, E.L. Jr., Woodbury R.O. and Wadsworth F.H. (1974). *Trees of Puerto Rico and the Virgin Islands*, Vol. 2. Ag. Handbook 449. Washington, DC, USA: USDA.
- Lowry, J.B., Prinsen J.H. and Burrows D.M. (1994). *Albizia lebbbeck* - a promising forage tree for semiarid regions. *Forage tree legumes in tropical agriculture*, 75-83.
- Nathan, R., Katul G.G., Bohrer G., Bohrer G., Kuparinen A., Soons M.B., Thompson S.E., Trakhtenbrot A. and Horn H.S. (2011). Mechanistic models of seed dispersal by wind. *Theoretical Ecology*, **4**, 113–132.
- Outani, B.A., Adamou H, Mahamadou A. and Delmas P. (2023). Moringa (*Moringa oleifera* Lam): a Review on its Importance Worldwide. *East Afr. Scholars J. Agricult. Life Sci.*, **6(7)**, 112-120.
- PIER (2014). *Pacific Islands Ecosystems at Risk*. Honolulu, USA: HEAR, University of Hawaii. <http://www.hear.org/pier/index.html>
- Schurr, F.M., Bond W.J., Midgley G.F. and Higgins S.I. (2005). A mechanistic model for secondary seed dispersal by wind and its experimental validation. *J. Ecol.*, **93**, 1017–1028.
- Seale, M. and Nakayama N. (2020). From passive to informed: mechanical mechanisms of seed dispersal. *New Phytologist*, **225**, 653–658. doi: 10.1111/nph.16110
- Tackenberg, O., Poschlod P. and Bonn S. (2003). Assessment of wind dispersal potential in plant species. *Ecological Monographs*, **73**, 191–205.
- Willson, M.F., Rice B.L. and Westoby M. (1990). Seed dispersal spectra: A comparison of temperate plant communities. *J. Vegetation Sci.*, **1**, 547–562.
- Zhu, J., Liu M., Xin Z., Liu Z.M. and Schurr F.M. (2019). A trade-off between primary and secondary seed dispersal by wind. *Plant Ecology*, **220**, 541–552. <https://doi.org/10.1007/s11258-019-00934-z>.