

Harnessing Nature's Resilience: Limonium as a Salt Tolerant Crop in Agriculture

Limonium, commonly known as statice or sea lavender, is a globally popular cut flower valued for its vibrant colours, long vase life, and ability to retain beauty when dried. In addition to its ornamental appeal, Limonium shows significant promise in addressing agricultural challenges, particularly soil salinity. As a halophytic plant, it possesses specialized salt tolerance mechanisms such as salt exclusion, ion regulation, osmolyte accumulation, and salt gland secretion. These traits make Limonium ideal for cultivation in saline and degraded soils. With India facing increasing soil degradation—6.72 million ha affected by salinity—Limonium offers a sustainable solution for reclaiming such lands. It is easy to grow, drought-tolerant, and suitable for both fresh and dried floral markets. Moreover, its adaptability and economic potential make it a valuable crop for integrated farming systems. Promoting Limonium cultivation can enhance agricultural resilience, restore soil health, and contribute to a more sustainable and ecologically balanced future.

LIMONIUM is one of the most popular cut flowers in the world, commonly known as statice or sea lavender. It is a genus of flowering plants distinguished for its attractive and enduring blooms, making it a staple in floral arrangements as a filler flower. Categorized by its leafless, sturdy stems, it supports clusters of small, papery flowers that come in a range of colours including purple, pink, white, yellow, and blue. These clusters form a dense inflorescence, giving the flower a full, textured appearance that adds both colour and structure to bouquets and arrangements.

Limonium is appreciated for its longevity; its flowers are known for retaining their shape and colour even after drying, which makes it a popular choice not only in fresh arrangements but also in dried floral designs. In addition to its use in floral arrangements, Limonium is sometimes utilized in ornamental garden settings for its hardy nature and ability to thrive in various conditions. Its drought tolerance and low maintenance requirements make it a favourite among gardeners looking for a reliable and colourful addition to their landscapes.

India, like many countries around the world, faces a pressing challenge such as soil degradation, exacerbated by factors such as water erosion and salinity. As of now, nearly 147 million ha of land in India are affected by soil degradation, with approximately 23 million ha suffering from salinity, alkalinity, or acidification. Recognizing the urgency of the situation, the Government of India has set ambitious targets to restore 26 million ha of degraded land by 2030, including areas affected by salt. Currently, about 6.74 million ha of land in India are salt-affected,

with an alarming annual increase of approximately 10%. If current trends continue, projections indicate that by 2050, nearly half of the arable land in India could be affected by salinity.

Limonium in landscapes and gardens

With an impressive array of 120 to 150 varieties, many of which are native to the Mediterranean region, Limonium holds a special place in both traditional and contemporary floral arrangements. Planting of statice is done at different times in different regions, such as August to September in plain areas and March to April in hilly areas.

It reaches a height of 90–100 cm, usually self-seeding. It is simple to cultivate, thrives in full sun on well-drained, normal soils, and, once established, can withstand drought. It produces beautiful flowers twice a year (June and November) and is nearly free of pests and diseases. The cool climate is suitable for a good yield of flowers. For good growth of plants, the day temperature should be 24°C, and the night temperature should be 16°C.

Limonium species are predominantly characterized as C_3 perennial plants, featuring basal rosettes of leaves and upright floral stems. These stems can be simple or branched, bearing abundant spikelets that contain clusters of small flowers arranged in panicles. Its versatility as a filler flower is renowned, prized for its ability to maintain the vibrant colour of its calyx even after drying, ensuring beauty for long periods. Available in a spectrum of colours including white, yellow, hot pink, light pink, and orange, Limonium offers endless creative possibilities for

floral designers using them in both fresh and dried floral compositions. Their adaptability ensures consistent supply in the global flower market. Symbolically, *Limonium* is cherished for evoking fond memories and sympathy, often gracing memorial wreaths, bouquets at reunions, and various celebrations where it symbolizes success. Besides its papery look and the decorative properties of its winged stem, it is edible and used in herbal remedies as an astringent, depurative, and decongestant.

Limonium species have greater potential for use as a horticultural crop in saline soils because the growth cycle of *Limonium* species is short (they do not need vernalization for flowering), the flower colour is varied, and it is more suitable for gardening. Given that *Limonium* species are considered to be pioneer plants for transforming saline soils, it is important to explore the use of these plants to maximize the utilization of saline lands to increase the economic and ecological value of these environments.

Limonium can be used in gardens and landscapes in the following ways

- **Borders and edging:** Plant *Limonium* along pathways or as borders to create vibrant edges.
- **Rock garden:** Use them in rock garden where their drought tolerance and vibrant flowers complement the rugged aesthetic.

- **Mass planting:** Plant en masse for striking visual impact in large spaces.
- **Mixed bed:** Combine with other salt-tolerant species to add variety and texture to the garden.
- **Cut flower garden:** Grow them specifically for fresh or dried floral arrangements to enjoy their ornamental value.

***Limonium* spp. as a tool for salinity mitigation**

Characteristics and adaptations

Limonium species, renowned for their ability to thrive in saline environments, belong to a specific category of halophytes known as recretohalophytes. These plants have evolved sophisticated mechanisms to tolerate high levels of salt in both soil and water, making them invaluable in regions with saline soils or limited freshwater resources.

- **Salt exclusion and regulation:** *Limonium* species have developed mechanisms to exclude salt from their tissues, preventing its accumulation to toxic levels. This ability helps maintain cellular integrity and function despite high salinity in the environment.
- **Ion regulation and osmotic balance:** These plants regulate ion concentrations within their cells, particularly sodium (Na^+) and chloride ions (Cl^-), which are prevalent in saline soils. By maintaining a balance of these ions and other essential nutrients, *Limonium* avoids dehydration and sustains optimal osmotic pressure.

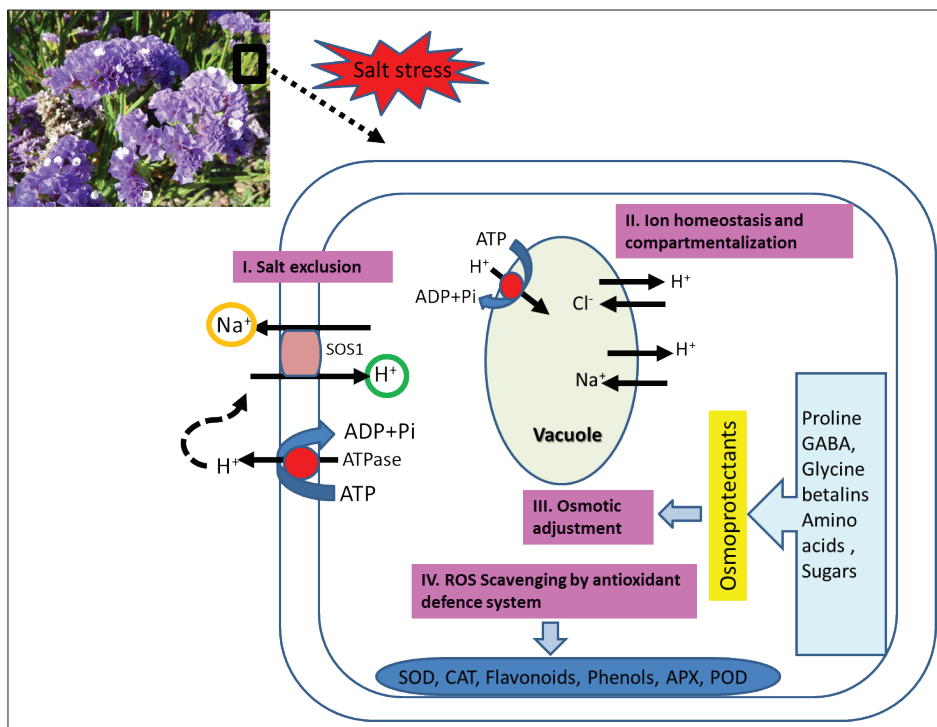
- **Role of salt glands:** Many *Limonium* species possess specialized structures called salt glands. These glands are either single cells (salt bladders) or multicellular structures sunken into the leaf epidermis. They actively secrete excess salt ions, particularly sodium and chloride, from the plant's tissues to the leaf surface. This secretion process helps regulate internal ion concentrations and reduce the harmful effects of salt accumulation.

- **Osmolytes and osmotic adjustment:** To cope with osmotic stress caused by high salinity, *Limonium* synthesizes and accumulates compatible solutes or osmolytes. These organic compounds, such as proline and glycine betaine, play crucial roles in maintaining cell turgor pressure, stabilizing proteins, scavenging reactive oxygen species (ROS), and signaling stress responses. While osmolyte synthesis is energetically costly for the plant, it is essential for adaptation to saline conditions where water availability is limited.

- **Ion sequestration in vacuoles:** Another strategy employed by *Limonium* involves the sequestration of toxic ions like Na^+ and Cl^- into vacuoles within the cells. By storing these ions away from the cytoplasm, the plant mitigates their harmful effects while maintaining cellular functions.



Two varieties of *Limonium bicolour* (a. sky light, b. silvery pink) and one variety of *Limonium sinuatum* (c. deep blue) under 250mM L^{-1} salt stress



Salt tolerance mechanisms in an ideal halophyte plant

Limonium stands as a testament to the potential of nature-inspired solutions in addressing complex agricultural challenges like soil degradation and salinity. By embracing innovative crops like Limonium, India can pave the way towards a more sustainable and resilient agricultural future. Through collaborative efforts among government bodies, research institutions, and farmers, Limonium can contribute significantly to restoring degraded lands, enhancing agricultural productivity, and securing the well-being of future generations.

Reclaiming degraded land in India

Salt-affected areas in India:

As of 2024, the total area of salt-affected land in India is 6.72 million ha, representing 2.1% of the country's total land area. This includes 2.95 million ha of saline soils and 3.77 million ha of sodic soils. The states with the largest areas of salt-affected land are Gujarat (2.23 million ha), Uttar Pradesh (1.37 million ha), Maharashtra (0.61 million ha), West Bengal (0.44 million ha), and Rajasthan (0.38 million ha). These five states together account for nearly 75% of the country's salt-affected soils.

Measures for using limonium spp. in reclaiming salt-affected lands

- **Soil Testing and Species Selection:** Assess soil salinity levels and select appropriate Limonium species that can tolerate the specific salinity of the area. Different varieties, such as *Limonium sinuatum* and *L. tetragonium*, exhibit varying degrees of salt tolerance.
- **Soil texture and structure:** Soil structure significantly influences the adsorption or desorption of chemical ions. Clayey soils, with finer textures and larger surface areas, retain more water and Na^+ ions, thereby

reducing ion toxicity and drought-related salinity stress. These soils also serve as cation exchange sites and provide essential macronutrients, promoting plant growth. In contrast, sandy soils have high infiltration rates and limited nutrient retention, which can lead to nutrient leaching during irrigation. The nutrient-holding capacity of clayey soils supports higher chlorophyll content and stomatal conductance, benefiting Limonium growth.

- **Water requirements:** Limonium requires minimal care and can thrive in well-drained soils with limited water. It produces beautiful flowers twice a year even in the absence of rainfall. Moreover, studies have reported that profit margins could be substantially increased if Limonium species are cultivated using seawater or on saline lands.

- **Soil amendments:** Combine Limonium planting with other soil improvement techniques, such as the addition of organic matter or calcium, to enhance soil structure and fertility for more effective reclamation. Calcium ions (Ca^{2+}) act as signaling molecules that improve plant growth under saline conditions by regulating aquaporin function, stomatal conductance, and transpiration. Ca^{2+} helps counter osmotic imbalance, alleviates Na^+ toxicity, and controls ion transport. It restricts Na^+ entry through non-selective cation channels and prevents K^+ loss by regulating efflux channels.
- **Integration with other crops:** Limonium can be cultivated alongside other salt-tolerant plants to increase biodiversity and enhance the ecological value of reclaimed lands. Its presence can also serve as a natural buffer for more sensitive crops in integrated farming systems.

CONCLUSION

In the pursuit of sustainable agriculture, the search for resilient crops that can thrive in challenging environments is increasingly urgent. Limonium, commonly known as sea lavender or statice, is a prime example and one of the world's top-selling cut flowers. Renowned for its remarkable tolerance to saline conditions, Limonium not only survives but thrives in soils where many other crops fail.

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