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Flowering Annuals Suitable for Problem Soils

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A B S T R A C T

This review article discusses the suitability of flowering annuals for problem soils. Problem soils, such as those with poor drainage, high acidity, or low fertility, can pose challenges for growing plants. However, with careful selection, many annuals can thrive in these conditions and provide vibrant and long-lasting blooms. The article explores the characteristics of problem soils and identifies a range of flowering annuals that are particularly well-suited for these environments. These include hardy varieties such as zinnias, marigolds, and cosmos, as well as more delicate species like impatiens and pansies. The article also provides tips for preparing problem soils for planting, including testing and amending soil as necessary. With this information, gardeners can create colorful and successful gardens even in challenging conditions.

Introduction

Evaluation of flowering annuals suitable for sodic soil has become an important area of research due to the potential for these plants to provide environmental and economic benefits. Sodic soils are characterized by high levels of sodium, which can negatively impact plant growth and productivity. However, certain flowering annuals have shown promise in adapting to and thriving in these conditions.

In recent years, a number of studies have been conducted to evaluate the performance of flowering annuals in sodic soils. For example, a study published in the Journal of Arid Environments in 2019 examined the growth and biomass accumulation of several species of flowering annuals, including marigold, sunflower, and zinnia, in a sodic soil environment. The study found that these species were able to adapt to the sodic conditions and displayed good growth and biomass accumulation, indicating their potential suitability for sodic soil environments.

Another study published in the Journal of Soil Science and Plant Nutrition in 2020 evaluated the impact of different soil amendments, including gypsum and compost, on the growth and nutrient uptake of several species of flowering annuals in sodic soil. The study found that the use of gypsum and compost significantly improved the growth and nutrient uptake of the flowering annuals in sodic soil, suggesting that soil amendments may be an effective strategy for improving plant performance in these conditions.

Overall, the evaluation of flowering annuals suitable for sodic soil is a promising area of research that has the potential to provide solutions for managing and utilizing these problem soils. However, more research is needed to fully understand the mechanisms by which certain flowering annuals are able to adapt to sodic conditions and to develop effective management strategies for utilizing these plants in sodic soil environments.

What is sodic soil?

Soils with an exchangeable sodium percentage (ESP) greater than 15 are classified as sodic soils Excess exchangeable sodium has an adverse effect on the physical and nutritional properties of the soil, with a consequent reduction in crop growth, significantly or entirely.

What are sodic soils?

Sodicity refers to the high concentration of sodium ions in the soil in comparison to other cations. When sodium salts are washed through the soil, some of the sodium ions adhere to clay particles, replacing other cations. Soil structure is affected by the amount of sodium present, and soils are typically classified as sodic when this concentration impacts their structure.

The pH of sodic soil is above 8.5 while saline-sodic soil is between 7 and 8.5 while the pH of sodic soil exceeds 8.5.

Application of gypsum help to improve water and root infiltration in sodic soils. For gypsum, 1 cmol weighs 0.86 g. Therefore, to replace all the sodium in 1 kg of soil containing 10 cmolc/kg of exchangeable sodium would require the addition of 8.6 g of gypsum. The other name for sodic soil is alkali soil.

Among the Indian states the highest sodic soil occurs in Gujarat and West Bengalt (72%) of coastal saline soils. The largest area under sodic soils (35.6%) occurs in the state of Gujarat.

Why are sodic soils bad for plant growth?

Saline soils contain high concentrations of soluble salts. The existence of soluble salts in the root zone can impede the plant's ability to extract water from the soil. While sodic soils have excessive amounts of sodium, saline-sodic soils contain high levels of sodium and other soluble salts.

The present population of India is 1110million and the annual food grain production has been to the tune of 205 million tonnes. India's population is expected to cross 1400 million by 2025 A.D. With this scenario in mind, on average, the country has to raise the annual food production by 5million tonnes from the existing 205 million tonnes to reach the food grain requirement of 261.5 to 267 million tons by 2020-2021 (Chand, 2007). In order to cope with the food grain requirements of the increasing population, agricultural production has to be stepped up substantially. This can be done either by multiple cropping on the existing cultivated lands or by bringing the additional land area under cultivation. The possibility to increase the food grain production to the required extent by these two ways is very much limited in India. The only feasible alternative is to increase the cultivated land area by bringing the wastelands and problem soils under cultivation.

The problems of soil sodicity, salinity, and of poor quality water are likely to increase in the near future due to planned expansion in irrigated areas and intensive use of natural resources to meet food, fodder, fibre, and timber requirement of the burgeoning human and livestock populations. The tentative estimate indicates that the salt-affected soils will constitute a nearly 13 m ha area in the country by 2025. Out of this, Tamil Nadu State alone has 0.43 million ha of salt- affected soils. The reclamation and utilization of thirteen million hectares of salt-affected soils can lead to additional production of 50 - 60 million tonnes of food grain every year. As a result of the technologies generated by the CSSRI, Karnal over the years, more than 1.3 million ha salt-affected soils have been reclaimed. The reclaimed area provides more than 8 million tonnes of more food grains (Anon., 2007).

Annual plants complete their life cycle in a single growing season and die, while perennial plants regrow each spring. Perennials usually have a shorter blooming period than annuals, so gardeners frequently combine both types of plants in their gardens.

Flowering annuals

Annual, any plant that completes its life cycle in a single growing season. The term is usually applied to herbaceous flowering plants in which the dormant seed is the only part of an annual that survives from one growing season to the next.

Annuals that prefer a higher pH (over 7, alkaline) include geraniums (Pelargonium), celosia and marigolds. Annuals that like acid soil (pH lower than 7) are petunias (shown), and pansies.

What are annual flower crops?

Annuals are typically herbaceous flowering plants in which only the dormant seed survives from one growing season to the next. Examples of annuals that prefer a higher pH include geraniums (Pelargonium), celosia, and marigolds, while annuals that thrive in acid soil include petunias, pansies, and bacopa.

Annual flower crops complete their life cycle within a year, from germination to fruiting and dying off. Plants from the grass family, such as mustard, watermelon, corn, lettuce, and wheat, are often annuals.

Perennials, on the other hand, live for more than two years and require little maintenance once established. Marigolds are a popular annual flower that can be grown easily from seeds or transplants and will produce an abundance of bright blossoms in the right conditions.

A true annual completes its life cycle in a single growing season and blooms for an extended period, usually throughout the summer. Some plants that are used as annuals in gardens are actually herbaceous perennials that bloom in their first season but cannot survive winter.

Here are some popular flowering plants:

Marigold: A low-maintenance flower that is easy to care for.

Geranium: A hardy plant that comes in a variety of colors and can thrive in many conditions.

Vinca: A drought-resistant flower that can bloom all season long.

Zinnia: A colorful and long-lasting flower that attracts butterflies and hummingbirds.

Impatiens: A shade-loving flower that comes in many colors and can add a pop of color to a darker area of the garden.

Cornflower: A tall, slender plant with blue, pink, or white flowers that can add a delicate touch to any garden.

Begonia: A flower that can thrive in both sun and shade, and comes in a wide range of colors and shapes.

Petunia: A versatile flower that can be grown in pots, baskets, or in the ground, and comes in a wide range of colors and patterns.

If you're looking for popular annual flowers, you can try petunias, marigolds, zinnias, and impatiens. However, if you're looking for more unique bedding plants, consider spider flower (cleome), gazania, vinca, and lisianthus. Examples of true annuals include corn, wheat, rice, lettuce, peas, watermelon, beans, zinnia, and marigold. Annual crops include maize, rice, sorghum, soybeans, guinea corn, cowpea, sweet potato, cotton, tomato, and yam. Flowers can be categorized into annuals, perennials, and biennials. Annual flowers, such as sunflowers, germinate, grow, flower, produce seeds, and die all in one year.

In contrast, perennial flowers like hydrangeas live and flower for multiple years. Roses are one of the most popular flowers worldwide, with over 100 species primarily native to North America. They are perennials and are prized for their various colors and beautiful scent. The blooms of roses range from small and compact to large and lush. Most sunflowers are annuals. They germinate in late spring, bloom during the summer, and die back at the first frost of fall. If you want to extend their bloom time, plant your sunflowers every few weeks.

Zinnias are a smart gardener's best friend due to their quick growth and ease of care. As annuals, they go from seed to flower to seed in a single year. On the other hand, perennials like dahlias come back every spring, while annuals complete their life cycle in one growing season. Annuals are often used in gardens for their constancy in blooming, making them a popular choice for decorative containers and flowerbeds. Annuals can be classified into rainy season, cool season or winter, and warm weather annuals. True annuals complete their life cycle in one year by germinating, flowering, setting seed, and dying. Some examples of true annuals are cosmos, marigolds, and sunflowers.

Annual crops include popular garden vegetables such as beans, peppers, potatoes, and tomatoes. Annuals can be selected for different gardening purposes, such as bedding, fragrant flowers, cut flowers, loose flowers, hanging baskets, rock gardens, screening, pots, and dry flowers.

There are three primary types of flowers: annuals, perennials, and biennials, and a fourth type that behaves like a hybrid of annuals and perennials. In addition, there are two other categories of flowers: shrub flowers and tree flowers.

Dahlias are native to the mountains of northern Mexico. They are hardy, or perennial, in tropical and warm climates, springing up from the ground each spring. Generally, dahlias are perennial in Zones 8 and above. In Zones 7 and below, dahlia's fleshy roots—called tubers—are killed by cold temperatures.

Different crops have varying levels of tolerance to sodicity and water logging. Wheat is considered to be moderately tolerant and can yield good crops even at ESP values of 30% if the growing conditions are appropriate. On the other hand, lentil and chickpea yields are significantly reduced when grown in soils with ESP values as low as 10%.

What are sodic soils treated with?

Gypsum is often used to amend sodic soils and mitigate the negative effects of high-sodium irrigation water due to its availability, low cost, and solubility. Its addition can induce changes in permeability by increasing EC and cation exchange effects. Similarly, cow manure is a prevalent organic acidic amendment that can enhance soil physical properties and boost soluble calcium, which is essential for the reclamation of sodic and saline-sodic soils.

Sodicity can have several detrimental effects on soil health and productivity. Firstly, it limits water flow by excess sodium in the soil, which reduces leaching and causes salt accumulation over time, ultimately leading to the development of saline subsoils. Secondly, sodicity can cause soil particles to disperse on the surface, leading to crusting and sealing that impedes water infiltration.

Thirdly, the dispersion of soil particles can occur in the subsoil, accelerating erosion and leading to the appearance of gullies and tunnels. Lastly, sodicity destroys soil aggregation, resulting in dense, cloddy, and structureless soils.

These negative effects of sodicity can significantly impair soil fertility and productivity, leading to reduced crop yields and economic losses for farmers.

Therefore, it is crucial to adopt effective soil management practices to mitigate the negative impacts of sodicity on soil health and productivity.

Farmers can use soil amendments and irrigation management techniques to mitigate sodicity and improve soil structure and fertility, ultimately leading to increased crop yields and profitability

"Sodicity can be identified through various signs such as stunted growth of crops or vegetation, inadequate water infiltration, surface crusting, compact or firm subsoil, subsoil exhibiting prismatic or columnar structure, slimy texture when wetting and working up soil, pH levels exceeding 8.5, murky water in puddles, and limited depth of root growth.".

Sodicity and salinity

Salinity is often confused with sodicity because both are associated with sodium—a naturally occurring element in Queensland soils.

Saline soils can often be sodic, but these soils will not show indicators of sodicity. The salts in the soil prevent dispersion of soil particles. Therefore soil sodicity cannot be determined by the level of sodium in the soil alone.

The salinity levels also have to be measured. If this salt level falls below the requirement for soil stability even a small amount of sodium can produce adverse effects. A combination of high sodium levels and low salt will produce extremely poor physical conditions in soils.

Mechanisms

Sodium is an essential nutrient for plant growth and development, but high levels of sodium in the soil can be toxic to plants, leading to decreased yields and even plant death. To survive in high-sodium environments, plants have developed various mechanisms of sodium tolerance that allow them to maintain normal growth and development despite elevated sodium levels.

One of the most important mechanisms of sodium tolerance in plants is the regulation of sodium uptake and transport. Sodium uptake by plant roots is regulated by various transporters, including high-affinity transporters that can take up sodium at low concentrations and low-affinity transporters that are activated when sodium levels in the soil are high. These transporters are regulated by various signaling pathways, including calcium signaling and protein phosphorylation.

Once inside the plant, sodium is transported to various parts of the plant, including the leaves, where it can be toxic to photosynthesis. To prevent sodium toxicity, plants have developed various mechanisms to compartmentalize sodium in the vacuole, where it can be safely stored and detoxified. These mechanisms include the activity of proton pumps, which generate an electrochemical gradient that allows sodium to be actively transported into the vacuole.

Plants also produce various osmolytes, such as proline and glycine betaine, in response to high-sodium environments. These osmolytes can help to maintain turgor pressure in the cells and protect the plant from the osmotic stress caused by high sodium levels. In addition, plants can also modify the composition of their cell walls, increasing the proportion of neutral polysaccharides, which can help to bind and sequester sodium ions.

Table.1 Trees and Crops Suited for Problem Soils

Soils	Tree sp.	Crops
Saline soils	*Casuarina , Prosopis juliflora, Acacia nilotica, Terminalia arjuna, Butea monosperma, Eucalyptus, Achressapota* and *Glyricidia*	Paddy, Ragi, Sunflower, Sorghum, Green manure.
Alkaline soils	*Sesbania. Dalbergia, Prosopis, Albizzia, Neem, Pongamia, Glyricidia.*	Rice, Cotton, Millets, Medicgo, Berseem, and Sugar cane
Acid soils	*Eucalyptus, Teriticornis, Mango, Guava* and *Anilotica sp.,*	Paddy, Wheat, Sorghum, Cotton, Vegetables and Sugarcane
Water Logged Soils	*Terminalia arjuna, jamun,* bamboo	Vetiver
Calcareous soils	*Acacia Leucopholea, Swietenia sp. Tamarind,*	Paddy, Sorghum, Sugar cane and Castor
Gravel soils	*Acacia planifrons, A.lebbeck and Dalbergia sp.*	Sorghum, Castor and other millets

Table.2 Tolerance of Crops to Salinity and Sodicity

Saline Soils			**Sodic Soils**		
Tolerant	Semi - tolerant	Sensitive	Tolerant	Semi - tolerant	Sensitive
Barley **Sugar beet** **Rape** **Cotton**	Pomegranate Wheat Rice Sorghum Maize Sunflower Potato	Citrus Gram Peas Groundnut Lentil Cowpea	Rice Sugar beet Paragrass Sugarcane Cotton Millets	Wheat Barley Oats Peas Maize Gram	Groundnut Cowpea Lentil

Finally, plants can also respond to high-sodium environments by altering their gene expression patterns, resulting in the production of various stress-responsive proteins, such as chaperones, proteases, and antioxidant enzymes. These proteins can help to protect the plant from oxidative stress and protein denaturation caused by high sodium levels.

In conclusion, plants have evolved various mechanisms of sodium tolerance that allow them to survive in high-sodium environments. These mechanisms include the regulation of sodium uptake and transport, compartmentalization of sodium in the vacuole, production of osmolytes, modification of cell wall composition, and alteration of gene expression patterns.

Understanding these mechanisms can help to develop crops that are more tolerant to high-sodium environments, which can be particularly important in areas with saline soils or irrigated with high-sodium waters. Plants have evolved various mechanisms to tolerate and regulate the uptake and transport of sodium (Na^+) ions to maintain optimal growth and productivity under saline conditions. Salinity is a major abiotic stress that affects plant growth and productivity worldwide.

High levels of Na+ ions in soil can disrupt the ionic balance of plants, causing toxicity and nutrient deficiencies. Therefore, understanding the mechanisms of sodium tolerance in plants is critical for developing salt-tolerant crops to ensure food security in the face of increasing soil salinization.

One of the most important mechanisms of sodium tolerance in plants is the ability to exclude Na+ ions from the root to reduce its accumulation in the shoot. This is achieved through the activity of plasma membrane transporters such as the high-affinity K+ transporter (HKT) and the sodium-proton antiporter (SOS1) that regulate Na+ uptake and efflux in plant roots. These transporters are regulated by various stress-responsive signaling pathways such as the abscisic acid (ABA) and Ca2+ signaling pathways.

Another mechanism of sodium tolerance is the sequestration of Na+ ions in the vacuole. The tonoplast-localized Na+/H+ exchanger (NHX) plays a crucial role in sequestering Na+ ions into the vacuole to maintain cytosolic Na+ homeostasis.

Moreover, the synthesis and accumulation of compatible solutes such as proline and glycine betaine can also help plants to maintain osmotic balance under saline conditions.

Furthermore, sodium tolerance in plants is also linked to the maintenance of cellular redox homeostasis. Salinity stress can cause oxidative stress in plants by generating reactive oxygen species (ROS). The antioxidant system comprising enzymes such as superoxide dismutase (SOD), catalase (CAT), and peroxidases (POD) can scavenge ROS to maintain cellular redox homeostasis.
In addition, recent studies have shown that epigenetic mechanisms such as DNA methylation, histone modifications, and small RNA-mediated gene regulation can also contribute to sodium tolerance in plants.

These mechanisms play a critical role in regulating the expression of stress-responsive genes and modulating the signaling pathways involved in sodium tolerance.

In conclusion, understanding the mechanisms of sodium tolerance in plants is critical for developing salt-tolerant crops to ensure food security in the face of increasing soil salinization.

The complex interplay between the transporters, signaling pathways, compatible solutes, and the antioxidant system, as well as the emerging role of epigenetic mechanisms, highlights the need for multidisciplinary approaches to unravel the mechanisms of sodium tolerance in plants.

Management of sodicity

The use of gypsum to increase the salt content is used to manage sodic soils. By raising the level of salts in the soil, helps to suppress dispersion. There is no defined rate to apply gypsum to ameliorate a sodic soil. This has largely to do with landscape, climate and specific soil type. The application of gypsum to improve soil salinity is a common practice to manage sodic soils (Qadir *et al.,* 2014). Increasing the salt content through gypsum application can help suppress soil dispersion (Rengasamy, 2006).

However, there is no single defined rate for gypsum application to effectively improve sodic soils. The required amount of gypsum depends on various factors such as soil type, climate, and landscape (Fanning and Fanning, 1989). It is important to consider the individual soil's chemical properties and physical characteristics to determine the optimal rate of gypsum application for sodic soil reclamation.

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