

## Using Spectral Vegetation Indices to Study the Growth of *Opuntia ficus-indica* and Identify Suitable Production Sites in the Southwestern Region of Saudi Arabia

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### ABSTRACT

This study was conducted to investigate the growth of two *Opuntia ficus-indica* varieties (var. *inermis* and var. *Mill*) in eleven geographical sites in the southwestern region of Saudi Arabia. Selected spectral vegetation indices (VIs) were used to identify suitable production sites for each variety. The results showed significant variations between the studied sites for both varieties. The best growth performance of the *inermis* variety was at Thaqeef Canal site, as evidenced by the highest values of

the Normalised Difference Water Index (NDWI, 0.477), Normalised Difference Vegetation Index (NDVI, 0.553) and the Green Normalised Difference Vegetation Index (GNDVI, 0.392), and the second highest value of the Soil Adjusted Vegetation Index (SAVI, 0.392) compared to other sites. While the moderate growth performance of the var. *Mill* was at the Bani Saad site compared to other sites, as indicated by the values of NDVI (0.575), SAVI (0.428), and GNDVI (0.408). A land suitability analysis focusing on site-variety interactions was conducted using the Analytical Hierarchy Process (AHP). The results indicated that Thaqeef Canal and Al-Shifa were the most suitable sites for the growth of both

### ARTICLE INFO

#### Article history:

Received: 28 June 2025

Accepted: 16 March 2026

Published: 17 April 2026

DOI: <https://doi.org/10.47836/pjtas.49.2.08>

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*Opuntia ficus-indica* varieties. Other sites considered highly suitable for growing the variety *inermis* include Al-hada, Wadi Muharrm and Sayyadah. While Baqran Village, Al-Thumalah farm, and Al-Thumalah were considered highly suitable for growing the variety of *Mill*. The results of this study provide a good basis for future studies aimed at improving agricultural practices and decision-making related to the production of *Opuntia ficus-indica* in the southwestern region of Saudi Arabia.

*Keywords:* Arid regions, cactus plants, land suitability, spectral reflectance, vegetation indices

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## INTRODUCTION

Saudi Arabia is characterised by its arid environment and limited water resources, with about 80-90% of the water supply coming from groundwater, which is rapidly depleting and requires proper management (Al-Salamah et al., 2011). As these conditions have exacerbated the problem of desertification and increased sand encroachment on agricultural lands, many challenges have arisen that have led to a shift in plant species in terms of their presence or absence in habitats. The southwestern region of Saudi Arabia encompasses a wide and diverse range of plant species and populations across various ecological niches. Productivity in this region can be enhanced by growing adaptable crops such as prickly pear, an excellent plant for soil conservation and regeneration in arid and semi-arid environments (Al-Aklabi et al., 2016; Osman et al., 2024).

Cactus crops are gaining increasing interest worldwide. In particular, cactus pear (*Opuntia ficus-indica*) can grow on lands where other crops fail due to its unique properties, which provide the ability to withstand harsh conditions, and thus can be used to restore degraded lands (Kumar et al., 2018). Cactus pear has proven its potential as a versatile and sustainable crop in arid and semi-arid regions due to its high-water use efficiency and tolerance to dry conditions (Slot & Fort, 2024). Also, Shoukat et al. (2023) reported that cactus pear is highly valued worldwide for its effective uses in medicine, cosmetics, human nutrition, livestock feed, wastewater treatment, fuel production, and sustainable and environmentally friendly building materials, in addition to its versatility and high environmental adaptability. The phenological, physiological, and structural adaptations enable *Opuntia ficus indica* to maintain reasonable productivity levels in dry rangeland conditions and even under extreme water scarcity (Hassa et al., 2020). In addition, Naorem et al. (2024) noted that the ability of cactus pear to grow in arid environments and poor soils makes it ideal for combating desertification and soil erosion, and it can also be used as livestock feed. Furthermore, its nutritional properties, including antioxidant and antidiabetic effects, enhance its value as a food source. The same has been stated by Sipango et al. (2022) that due to its adaptability to harsh conditions of less fertile soils, high temperatures, and low rainfall, the prickly pear cactus is drought-resistant and well adapted to high temperatures in arid regions, especially on low-profile soils.