

Evaluation of soil suitability for sugarcane in the State of Punjab – a case study

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ABSTRACT

Agriculture accounts for a significant share of the country's GDP and is a major source of income for millions of rural households. Cash crops play a crucial role in enhancing farm incomes and supporting overall economic growth. Among the cash crops, sugarcane is one of the important cash crops in India. In Punjab the natural resources are diminishing due to dominant rice-wheat based cropping system. Therefore, some alternate crops are need of time. Hence the present study was conducted to study the soil resources of Punjab for assessing the soil suitability for cultivation of sugarcane. The obtained results revealed that a 44.62% area is suitable for cultivation of sugarcane followed by 39.69% area revealed moderate suitability and 1.68% area revealed marginal suitability. Considering the results of study it can be concluded that the sugarcane crop is a promising alternate land use option for the local farmers in Rajpura block of Patiala district of Punjab.

Key words: Soil-site suitability, soil resources, sugarcane, sustainable production.

INTRODUCTION

India is a predominantly agrarian nation. The economic stability and growth of the country are largely influenced by agricultural performance. India occupies the second position in the world, both in area and production, next to Brazil (DES, 2017). The Indian economy has experienced substantial transformations since the attainment of independence, particularly within the agricultural sector. Sugarcane (*Saccharum* spp.) has historically been acknowledged as a cash crop second only to textiles, possessing significant agro-industrial importance in the nation. It has emerged as one of the most promising industrial crops worldwide (Kandel *et al.*, 2018). Currently, sugarcane is cultivated across more than one hundred nations and regions, encompassing an aggregate area of approximately 26 million hectares, with an annual

yield of 1.9 billion tons of fresh sugarcane (FAO, 2021). The cultivation of sugarcane is a crucial source of income and employment in numerous countries, particularly within developing economies characterized by a substantial proportion of impoverished and unemployed populations, thereby fostering economic growth within these regions (Gopinathan, 2010). The global demand for sugar is anticipated to escalate further, concurrently confronting challenges such as diminishing arable land resources, increasing temperatures, and a highly volatile climate (Jaiswal *et al.*, 2023).

The sugar industry in India has been pivotal in driving socio-economic development in rural regions by mobilizing local resources, creating employment opportunities and augmenting farm incomes. The cultivation of sugarcane has swiftly proliferated into subtropical and even warm-tem-

perate zones (Cursi *et al.*, 2022). Sugarcane plants exhibit optimal growth at altitudes below 700 meters above sea level (Almeida *et al.*, 2019). In India, the area under sugarcane cultivation has increased by 36.30%, production by 67% and productivity by 23.14%, from 2000-01 to 2022-23. In Punjab state, the coverage of sugarcane crop has declined by about 25.62%. The sugarcane production has decreased slightly by 1.65% only whereas, the productivity has increased by 31.92%, respectively, during 2000-01 to 2022-23 (DES, 2024).

Sustainable resource management considered as one of the most prominent issues in agriculture (Nagdev *et al.*, 2024a). This situation calls for land evaluation based sustainable land use planning. Thus, the cultivation of sugarcane in Punjab has the potential to be sustainable, as it entails reduced risks, and farmers can have a reasonable expectation of returns even under adverse circumstances.

In this context, Land evaluation constitutes a fundamental component in determining the suitability of land for specific utilisation purposes (Nagdev *et al.*, 2024b; Kumar *et al.*, 2025). The evaluation process gives decision-makers information about the main obstacles and possibilities for using land for specific use types, assisting them in making the best use of available resources (Kumar *et al.*, 2021). Furthermore, the prediction of suitable land evaluation of soil suitability depends on the types of soils present in the region, in conjunction with the prevailing climatic con-

ditions, topographical characteristics and management practices. Soil and climate serve as critical environmental determinants influencing the growth and yield of sugarcane (Neswati *et al.*, 2016). Consequently, a thorough scientific assessment of soil resources is essential to identify their limitations, potentials, functionalities and suitability for varied applications (Mahapatra *et al.*, 2019). The evaluation of land suitability is also essential for the attainment of sustainable agricultural production (Patangray, 2016).

Therefore, the soil resource data base needs to be evaluated for optimal management and utilisation of land resources for sustainable production and food security (Demir, 2024). In this context, and considering the importance of the sugarcane crop, the present study assessed the land resources for the suitability of sugarcane in the Rajpura block of Patiala district in Punjab.

MATERIALS AND METHODS

Location and climatic conditions

The Rajpura block of Patiala district, Punjab is geographically located within the latitudinal coordinates of 30°24'50" to 30°39'16" N and the longitudinal coordinates of 76°25'56" to 76°49'14" E, encompassing a total land area of 283.15 km² with an elevation that fluctuates between 200 to 300 meters above the mean sea level (Figure 1). The climatic conditions of the region are classified as semi-arid and warm. The mean annual

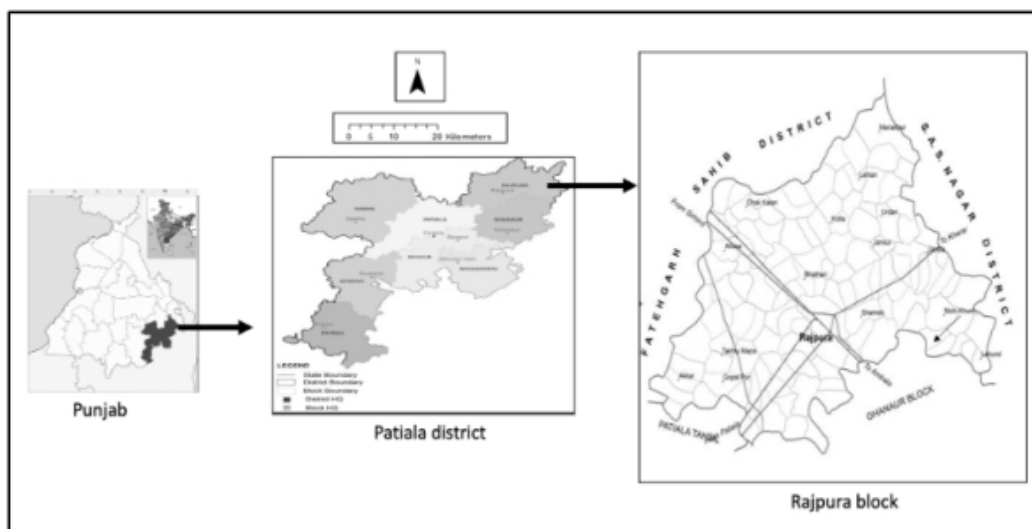


Fig. 1. Location map of Rajpura block, Patiala district, Punjab

temperature has been documented around at 23.2 °C, while the mean maximum and minimum temperatures have been recorded at 29.8°C and 16.6°C, respectively. The average annual precipitation has been noted to be approximately 758 mm.

Soil-site suitability criteria for sugarcane

The agricultural planning of a specific region is contingent upon the characteristics of its soil resources. Soil site suitability studies provide information on the choice of crops to be grown on best suited soil unit for maximizing crop production per unit land, labour and inputs. The determination of the comparative suitability of crops was accomplished through the examination of soil site characteristics in conjunction with the specific requirements of the crops, utilising established suitability criteria as referenced in prior scholarly works (Naidu *et al.*, 2006; Sys, 1985; Sehgal, 1996).

The conceptual framework of land utilisation types for land evaluation introduces a classification system based on the intended purpose of the land (FAO, 1976). This classification comprises two primary categories: S for lands deemed suitable further subcategorised into subcategories S1, S2 and S3, and N for those regarded as unsuitable which is segmented into two subcategories, specifically N1 and N2, which represent varying degrees of suitability within each classification. This classification system is imposed by various limiting factors including climate (c), topography (t), wetness (w), salinity (n), soil fertility (f) and the physical constraints of the soil (s).

Crop suitability evaluation refers to the determining of suitability of a particular type of land based on the growing conditions required for a specific crop (Karthikeyan *et al.*, 2019). The type of soil constitutes one of the biophysical characteristics that are evaluated in assessing land suitability for the cultivation of sugarcane (Spera *et al.*, 2017). Based on the land suitability criteria (Johnson, 2005), the most suitable land for sugarcane is a land with 24 to 30°C daily average temperature. It is feasible to cultivate sugarcane in various soil types, ranging from sandy loam to clay loam, provided that there is adequate water retention capacity and a pH range of 6.5-7.5, along with a sufficient supply of organic matter.

Delineation of map

The sugarcane suitability map was delineated by using remote sensing and GIS tools.

RESULTS AND DISCUSSION

Soil resources of the block

The soil resources of the block were interpreted and the soils were classified as very deep soils. The soils exhibit variability in drainage characteristics are categorised as well-drained, moderately well-drained, somewhat poorly drained and somewhat excessively drained. The soils of the block have been classified into sandy, coarse loamy, fine loamy and fine clay. These soil types are distributed across upper old alluvial plains, lower old alluvial plains & lower old alluvial plains with concave relief and recent alluvial plains. The major portion of the block is medium in organic carbon, slightly alkaline and low in available nitrogen. Cation Exchange Capacity (CEC) exhibited a range from 5 to 27 C mol (p+) kg⁻¹ (Meena *et al.*, 2024). Soil limitations encompass factors such as drainage capacity, alkalinity, salinity, sodicity, soil texture, and inadequate soil fertility.

Evaluation of soil-site suitability for sugarcane

The development and composition of sugarcane stalks are influenced by the properties and conditions of the soil (Riturang, 2013). Sugarcane thrives in deep, well-drained soils with medium fertility (DAFF, 2014). Srivastava and Rai, 2012 indicated that there was no significant difference in yield, when cultivating sugarcane in different soil types, specifically clay loam and sandy clay-loam. Soils that are saline, alkaline, or acidic are unsuitable for sugarcane cultivation, and conditions of waterlogging are detrimental to the growth of sugarcane.

Rajpura block of Patiala district reveals significant spatial variation in soil suitability for sugarcane cultivation. Sugarcane can be grown on heavily textured soils. Based on the site and soil characteristics, the soils were evaluated for their suitability for sugarcane. The data reveals that the majority of the area of the block is suitable for sugarcane crops which covers 12635 ha (44.62%) area. The areas are highly productive and capable

of supporting sugarcane, with balanced management practices such as judicious fertilizer use and proper soil conservation measures. Whereas, an area of 10,236 ha is classified as moderately suitable, achibility moderate to severe limitations such as inadequate drainage, salinity issues and slight erosion hazards. Although these areas can be cultivated successfully, they require improved management interventions, particularly efficient drainage systems, addition of organic matter, and periodic soil reclamation measures to sustain productivity and prevent degradation. A small portion of the area i.e., 476 ha (1.68%) is marginally suitable for sugarcane cultivation including limitations of soil and drainage, respectively (Figure 2 and 3). Nearly 14% of the total land area is categorized as miscellaneous, which includes non-agricultural land uses such as settlements, water bodies, roads, or other uncultivable terrains. These areas are typically unsuitable for crop production and represent permanently or currently non-suitable lands (Class N). Overall, the analysis indicates that nearly 84% of the Rajpura block has potential for agricultural use, with more than half of it being highly suitable for sugarcane cultivation. This highlights the significant potential of the region to diversify its cropping pattern and adopt sugarcane as a viable alternative crop under sustainable land management practices.

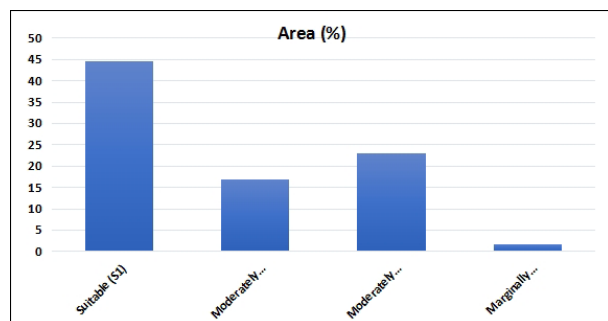


Fig. 2. Area under different suitability classes for sugarcane in Rajpura block of Patiala district, Punjab

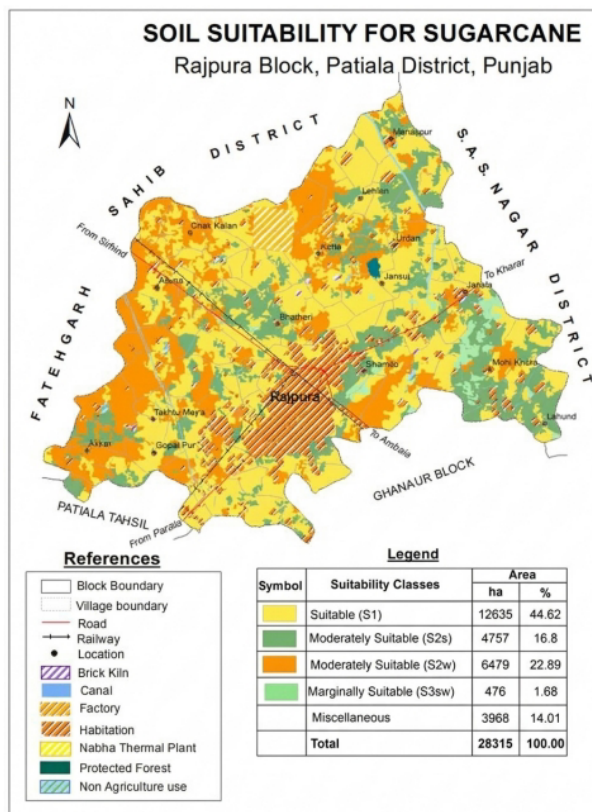


Fig. 3. Map of soil site suitability for sugarcane in Rajpura block of Patiala district, Punjab

CONCLUSION

Sugarcane crop is pivotal in contributing to economic advancement. Therefore, the suitability of sugarcane was evaluated for its sustainability in the Rajpura block of Patiala district, Punjab. The study indicates that the most of the soils in the block are suitable to moderately suitable for sugarcane cultivation despite certain limitations like drainage and low fertility. Overall, the soils are moderately fertile but with appropriate management practices, the productivity and sustainability of sugarcane can be significantly improved. Hence, it can be concluded that the sugarcane cultivation in the block could be a potential alternate land use option.

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