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Climatic Suitability Analysis for Tomato Cultivation in Haryana (India)

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ABSTRACT

Suitability analysis is a prerequisite for achieving optimum utilization of the available land resources. Lack of knowledge on best combination of factors that suit production of tomato can contribute to the low production. The aim of this study was to carry out a suitability analysis for tomato vegetable crop based on climatic and physical factors of production using GIS approach. The study was carried out for Haryana state in India. Biophysical variables like climate, soil and topography were considered for suitability analysis. All data were processed in ArcGIS 10.1 and the maps were generated. Each parameter was independently analyzed for demarcating its different levels of favorable zones based on recommended criteria for tomato cultivation. Father all the zones (such as highly suitable to less or unsuitable) were clubbed in GIS by superimposing to get final suitability zones. Out of the 21 districts of Haryana, six districts such as Panchkula, Ambala, Yamunanagar, Kurukshetra, Karnal, and Gurgaon were predominantly found suitable for tomato due to good soil moisture, water availability and suitable weather, whereas it was found moderately suitable in eight districts viz. Kaithal, Jind, Panipat, Fatehabad, Hisar, Faridabad, Palwal, and Mewat. The research provided information at local level that could be used by farmers and policy makers to select regional and best cropping patterns as per suitability.

Key words: *Suitability analysis, GIS, tomato, overlay analysis*

INTRODUCTION

Tomato is globally cultivated for its fleshy fruits and known as protective food because of its special nutritive value and its wide spread production. It is the world's largest producing vegetable crop after potato and it tops the list of canned vegetables. Tomatoes are eaten directly as raw vegetable and also consumed in a variety of processed products. It is a rich source of vitamin A and C and also contains minerals like iron, phosphorous[3]. Furthermore tomato is the richest source of nutrients, dietary fibres antioxidant like lycopene and beta-carotene, the compounds that protect cells from cancer[2]. Tomato has a short generation time of about three to four months. It is well fitted in different cropping systems of cereals grains, pulses and oilseeds. Hence, it is the most widely grown vegetable crops grown worldwide under outdoor and indoor conditions.

Tomato belongs to the family Solanaceae (also known as night shade family), genus *Solanum*, sub family Solanoidaeae and tribe solaneae[7]. The cultivated tomato, *Solanum lycopersicon*, is the second most consumed vegetable worldwide and a well-studied crop species in terms of genetics, genomics, and breeding. The tomato is perennial plant but usually grown as an annual plant. It is reported that the tomato plant can reach up to 3 meter. Previously tomatoes were grown only during favourable season, but now a day's tomatoes are grown round the year. Because of its economic importance, area under cultivation is increasing every year. India contributed about 11% of world production in 2010-11. The estimated area and production of tomato in 2010-11 for India were about 865 million hectares and 16826 million tons respectively with a productivity of 19.5 ton/ha. Worldwide tomato production in 2010-11 was 150,513,813 thousand tons and with productivity of 32.8 tons/ha (www.agriexchange.apeda.gov.in).

Tomato is the second largest vegetable crop in India. The average productivity of tomato in our country is merely 158q/ha while its productivity in USA is 588q/ha, in Greece 498q/ha, in Italy 466q/ha and 465q/ha in Spain. Ten most promising states of India for tomato crop have been identified and utilized for further study on various aspects of tomato crop. Bihar State is at leading position followed by UP and Orissa in terms of area under tomato crop (www.indiaagronet.com). This significant achievement in tomato production is possible due to the development of high yielding varieties/hybrids, breeding for biotic and a biotic stresses, resistance and heterosis breeding. Bringing more area under tomato cultivation is required for growing demand.

The present study was devoted to identify best suitable area for tomato in Haryana state (India) by GIS analysis. As per Planning Commission of India, the state comes under the 'VI' agro-climatic region (Trans-Gangetic plain region). It lies within the geographical coordinates from 27º39' N to 30º55' N latitudes and 74º27' E to 77º36' E longitudes. Total geographical area is 44212 Sq.km (1.37% of country's geographical area) and 85% of it is available for agricultural use. Rest of 15% is covered for non agricultural purposes say built up, barren land or forests etc. The state has population of 25 million (2% of India's Population) as per census 2011. More than 70% of the population of Haryana is dependent on agricultural sector for their livelihood. Cereals are majorly produced in the state such as wheat, rice, cotton, oil seeds, guar, bajra and sugarcane etc. and vegetable crops like potato, tomato, carrot etc are grown over a less portion.

Suitability is a function of crop requirements and land characteristics[5]. Matching the land characteristics with the crop requirements gives the suitability. So, 'Suitability is a measure of how well the qualities of a land unit match the requirements of a particular form of land use'[1]. Emphasis had been well drawn in numerous researches over detailed analysis of suitability of each crop in a region. Land suitability analysis has to be carried out in such a way that local needs and conditions are reflected well in the final decisions[6].

MATERIAL, METHODS AND ANALYSIS

The flowchart given hereunder describes the procedure and steps followed for this research. Criteria for classification of suitability of various weather and physical parameters are explained for each one.

Flow chart (Fig.1) depicts the step by step procedure followed for this research in GIS.

Parameters for suitability analysis

Tomato is a warm season crop, requires warm and cool climate. It requires different climatic range for seed germination, seedling growth, flower and fruit set, and fruit quality. Temperature below 10^0C and above 38^0C adversely affects plant tissues thereby slow down physiological activities. It thrives well in

temperature 10^0C to 30^0C with optimum range of temperature is 21-24^{0}C [4]. The mean temperature below 16^{0}C and above 27^{0}C is not desirable. The suitable soil for growing tomatoes is sandy loam. Soil depth 15-20cm proves to be good for healthy crop. Months of July to September are best for summer tomato in Haryana state in which monsoon rainfall is received. Parameter wise suitability is discussed in following points.

a)   **Soil Topography:** The crop is grown from almost mean sea level to an altitude of 1500 m in tropical and subtropical regions. Haryana fall below the set altitude i.e. 1500 m. Hence whole state is suitable for cultivation of tomato as far as topography is concerned.

b)   **Soil Texture:** Different types of soils textures are available in the state. These types were further classified as per suitability for tomato crop as shown in Fig. 1

Highly Suitable: Sandy Loam.

Suitable soil: Sandy Loam to Clay Loam, Clay & Clay Loam, Loam & Clay Loam.

Less suitable: Clay, Sand and Silt Loam.

c)   **Rainfall Suitability:** This crop can be grown in tropical and subtropical regions, with an annual rainfall of 650-1500 mm. Very high rainfall during its growth is harmful (www.agriinfo.in). The suitable rainfall for tomato crop as reported in researches is 650-1305 mm and moderately suitable rainfall is 346.4-650 mm. Accordingly, the state was categorised in Highly and Moderately suitable zone as per these rainfall limits (Fig. 1).

d)   **Temperature Suitability:** Extreme temperature in summers in Haryana can adversely affect the tomato vegetable crop. Therefore suitability was identified on maximum and minimum temperature for every month (July to September) and final suitability map was prepared by combining all three months suitability maps.

July Temperature Suitability (Seedling Growth Period)

Maximum temperature- The **suitable maximum** temperature for July was 21-24°C

that found in northern districts i.e. Panchkula, Ambala, and the moderately suitable temperature was (maximum bearable) 32-36.5°C in west, east and south regions (Fig. 1).

Minimum temperature- The **best suitable minimum** temperature for July was 20-24°C and suitable temperature was <20 or >24°C.

Mean temperature - There is a **moderately suitable** temperature in July (24-32.5°C) in all districts of Haryana.

Union of July suitability- By superimposing the maximum, minimum and mean temperature information, **best suitable temperature** was observed in north region of Panchkula whereas; suitable temperature was in Ambala, Yamunanagar, Kurukshetra districts. Rest of the districts were under suitable temperature.

i.   August Temperature Suitability (First Fruit Set Period)

Maximum temperature - The **maximum suitable** temperature for august was 24-30°C in north region and the moderatly suitable temperature is 30-35.3°C in west, east & south regions (Fig. 1).

Minimum temperature - The **minimum best suitable** temperature was 16.3-24°C in north regions and **suitable temperature** was 24-26.6°C in west, east & south regions of state.

Mean temperature - The **best suitable mean** temperature was 24-30°C in North & South east regions and moderatly suitable temperature is 30-30.7°C in North regions.

Union of August suitability- The **best suitable** temperature was found in small region of panchkula in north. The **suitable temperature** was in the Panchkula, Ambala, Yamunanagar, Kurukshtera districts in North region.

ii.   September Temperature Suitability (Fruit Quality)

Maximum temperature - The **maximum suitable** temperature for september was 24-30°C in north region and **moderatly suitable** was 30-36°C in west, east & south regions (Fig.1).

Minimum temperature - The **highly suitable** minimum temperature was 20-24°C in mostly north region, west and east region and **less suitable** temperature was 24-25°C in Rohtak, Jhajjar & some of Sonipat regions.

Mean temperature - The **suitable mean** temperature was 20-24°C in few parts of Panchkula in north region and **moderatly suitable** tempearture was 24-30°C in all other districts.

Union of September suitability - The **best suitable** temperature was found in Ambala, Kurukshtra & few parts of Panchkula and Yamunanagar. The **suitable temperature** was over western, eastern and southern regions. But **less suitable** temperature was in Rohtak, Jhajjar and Sonipat districts.

RESULTS AND DISCUSSION

Integration of all information was done in GIS using union operator, an analytical process in which the features from two or more map layers can be combined into a single, composite layer. Union includes the data from all the included layers, meaning that overlapping and non-overlapping areas are included in a new polygon. The above detailed suitability information of July, August and September were therefore brought in GIS for preparing temperature suitability maps. Thereafter, all the maps for different weather parameters (temperature and rainfall) and soils are brought together to make a composite map to find different types of suitable area in the state for summer tomato crop. The areas which came under 'suitable' category in different maps were demarcated as highly suitable area. It means highly suitable areas had all the parameter viz. climate, soil and topography suitable for tomato cultivation. Likewise different levels of suitability were scaled depending on the number of parameters suitable for tomato crop (fig. 4).

Fig 1 demonstrates the distribution of suitable area for tomato cultivation in the state, which was dominated in north east Haryana and extended up to parts of central Haryana. Out of the 21 districts in Haryana, highly suitable zone covered Ambala and some parts of Yamunanagar and Kurukshetra districts. Five districts such as Panchkula, Yamunanagar, Kurukshetra, Karnal and Gurgaon were predominantly suitable for tomato due to good soil moisture, water availability and suitable weather. Tomato cultivation was moderately suitable in the eight districts viz. Kaithal, Jind, Panipat, Fatehabad, Hisar, Faridabad, Palwal, and Mewat. Districts viz. Bhiwani, Rohtak, Jhajjar, Rewari, Mahendragarh, and Sirsa were less suitable for tomato cultivation however, some parts in these district fall under moderately suitable.

CONCLUSIONS

Haryana state is one of major contributors in central pool of agriculture produce. Flat topography, fertile soil and facility of irrigation had resulted in intensive agricultural practice. GIS has now become a useful tool for suitability analysis in spatial sciences. Nearly, whole of the Haryana state was found suitable for tomato cultivation while level of suitability differed. North eastern parts of the state were appeared as best of tomato cultivation due to good rainfall, soil and thermal conditions throughout the summer season. Areas on western margins fall under less suitable. Some parts were even unsuitable in this area because of poor soil and arid conditions. Large portion of state covering central parts found in suitable category for summer tomato crop. Prevalent cropping pattern in Haryana state is very intensive and mainly comprised of cereals (wheat, rice). Vegetable crops share a less portion which otherwise can be a profitable option for farmers suffering from rising farming costs in cereal production. Suitability analysis can help farmers as well as policy makers in selections of other alternates in cropping practices.
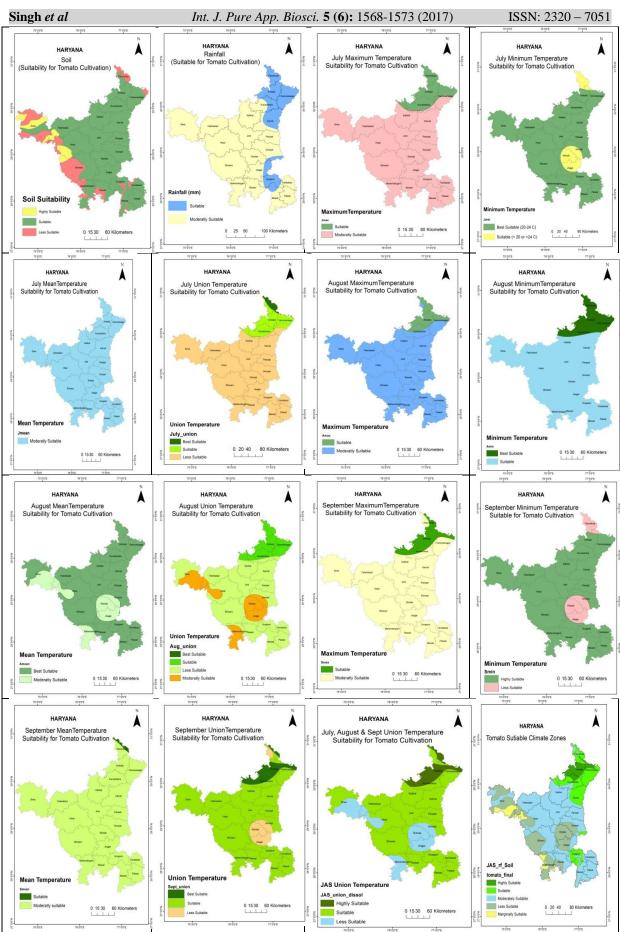
Fig 1: Maps on different themes as titled in each

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