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Ecology Crop Geography of Sorghum (*Sorghum bicolor* L.)

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Sorghum (*Sorghum bicolor* L.) also called jowar in India ranked the fifth most important cereal crop on the globe and is native to Sub-Saharan Africa. It is traditionally grown for grain both as food (Africa and India) and as animal feed (developed countries like the USA, China, Australia, etc.) and stalk as animal fodder (Anonymous, 2017). Globally, during 2017-18, sorghum was cultivated on a 40.28 M ha area with a production of 57.69 MT and productivity of about 1.43 t/ha whereas in India, sorghum was grown on an area of 5.02 M ha (12.4 % of world) with a production of 4.80 MT (8.32 % of world) and productivity of about 0.96 t/ha (Anonymous, 2019). Due to its drought-adaptation capability, sorghum is preferably grown in tropical, warmer, and semi-arid regions (Patersan *et al.*, 2009). With the threat of climate change looming large on crop productivity, sorghum being a drought-hardy crop plays an important role in food, feed, and fodder security, especially in the dryland economy.

Ecological crop geography is defined as the study of crop plants about their physical environment. There is a prior need to study the ecological crop geography of the crop to maximize its potential. So, the ecological crop geography concerning sorghum has been discussed under the following heads:

1. Climate: Sorghum is one of the crops that have inherited its trait to adapt and grow in harsh climates. It grows in dry conditions, and tolerates heat, salt, and waterlogging, making it an ideal crop for semi-arid areas. It is adapted to latitude ranging from 40 ^{O}S to 45 ^{O}N of the equator. In India, the *kharif* sorghum areas extend from 9 ^{O}N to 25 ^{O}N latitudes, while the

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rabi sorghum area confines to the narrow belt of 14 ^{O}N to 21 ^{O}N (Sivakumar and Virmani, 1982). It is grown in the semi-arid tropics right from sea level to an altitude of 3000 m in variable rainfall areas. Sorghum requires warm conditions but can be grown under a wide range of soil and environmental conditions. It can tolerate moisture stress and high temperatures better than any other crop. The climatic requirements to produce sorghum are divided into temperature, photoperiodism, solar radiation, rainfall, air temperature, humidity, and CO_2 discussed below-

1.1. Temperature: Sorghum is a warm-weather crop, which requires high temperatures for good germination, growth, and development. The minimum temperature for seed germination ranges from 7^{O}C to 10^{O}C. Soil temperature of 17-18 ^{O}C has been reported highly satisfactory for sorghum seedling emergence. Higher temperatures (>35^{O}C) may result in poor emergence and seedling growth. The crop requires 26-30 ^{O}C temperature for good growth (Anonymous, 2017).

1.2. Photoperiodism: Sorghum is a short-day plant, which means that the plant requires short days (long nights) before proceeding to the reproductive stage. It thrives with 10-11 hours of sunlight a day. Photoperiods longer than 11 to 12 hours stimulate vegetative growth. The tropical varieties are usually more sensitive to photoperiod than the quick, short-season varieties. Sorghum plants are most sensitive to photoperiod during flower initiation. A shorter photoperiod results in a vegetation period of 3 weeks longer before flowering and almost 6 weeks longer before full flowering (Anonymous, 2021).

1.3 Rainfall: Sorghum is best suited for areas having an average rainfall between 450- and 650 mm. Sorghum stays dormant during extreme drought stress and recovers with rains and the yields are more stable under stress conditions.

1.4 Solar radiation: Solar radiation is the set of electromagnetic radiation emitted by the Sun**.** Visible radiation, between the wavelengths of 400 and 700 nm is the most important type as it refers to photosynthetically active radiation (PAR). Sorghum, by presenting its C_4 photosynthetic mechanism, has a high ability to capture solar radiation, significantly contributing to the response of high radiation use efficiency. Effective heat sum (above 10°C) for fast-ripening varieties is 2000-2500°C, 3000-3500°C for mid-season varieties, and over

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3500°C for slow-ripening varieties (Anonymous, 2021). Plants subjected to cuts are less efficient for utilization of solar radiation in producing dry mass due to their shorter size resulting in reduced photosynthetic rate. On the other hand, taller plants tend to have a better leaf arrangement, which intercepts solar radiation more efficiently.

1.5 Air temperatures and humidity: Sorghum blossoms most actively when air temperatures reach 16-18 ^{O}C and relative humidity reaches 60-80 %. With higher temperatures and normal humidity, sorghum blossoms more slowly and sometimes stop blossoming altogether. Lower air temperatures, precipitation the day before or at night, abundant dew, and overcast weather also delay panicle flowering (Anonymous, 2021)

1.6 CO_2: Enriched CO_2 results in delaying the boot, half bloom, and soft dough stages. Moreover, sorghum grown at elevated concentrations of CO_2 tends to record more roots and shoots than plants grown in ambient CO_2 concentration as at all soil-profile depths the root numbers and weights recorded by Chaudhuri *et al*., (1986) were higher at elevated CO_2 than at ambient CO_2

2. Soil: The various soil types *viz.*, vertisols, entisols, inceptisols, or alfisols are suitable for growing sorghum but post-rainy sorghum is largely confined to vertisols. Moreover, sorghum does best on deep fertile soils is adapted to poor soils,and can grow well on soils where many other crops would fail. It is mainly grown on low potential shallow soils with high clay content and usually grows poorly on sandy soils, except where a heavy textured sub-soil is present. Soils with a clay percentage of between 10 % and 30 % are optimal for sorghum production. It is more tolerant of alkaline salts than other grain crops and can therefore be successfully cultivated on soils with a pH between 5.5 and 8.5. Sorghum is suitable for cultivation on saline soils, as it tolerates salt concentrations of up to 0.6-0.8%. However, it does not thrive in acidic soils (Anonymous, 2017).

3. Water: Although sorghum is a drought-tolerant crop, it responds to irrigation and is well suited for limited irrigation situations. It is also known as a water-sipping crop as it uses water very efficiently.

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The sorghum's performance under deficit irrigated conditions is associated with its great ability to extract water from deep soil layers, shorter growth duration, and leaf characteristics more favorable to drought. Sorghum crop requires 425-610 mm of water for getting a higher yield (Solaimilai *et al.* 2001). Moreover, the critical stages for irrigation and getting higher yields are germination, seedling, flowering, and grain formation.

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