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Modern Techniques to Increase Sorghum Production

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ABSTRACT

Sorghum is a staple food for many people in around 30 nations in Africa and Asia's subtropical and semi-arid climates and is well-known for its ability to endure drought. Even though sorghum is grown all over the world, 90% of the land given to it is in 20 countries, with 10 of those countries accounting for 80% of the total. The production of basic food crops is negatively impacted by changes in extreme weather and climatic events, such as high temperatures, excessive rainfall and droughts, which endanger the resilience of ecosystems. Many modern approaches like post-harvest management, proper irrigation, nutrient and pest management and precision farming are all used for better yield. Increased production, lower input costs and sustainable farming are the goals of these advances. By implementing these strategies, farmers may assure food security and environmental sustainability while increasing crop quality and profitability.

Keywords: Subtropical, drought, sustainable farming, precision farming, strategies, modern techniques

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Introduction

Sorghum (*Sorghum bicolor* L.) is an annual grass having which belongs to the Poaceae family. the plant initially appeared in Northeast Africa between 8,000 and 5,000 B.C. The widest variety of farmed and wild sorghum species can be found in that area [1]. This cereal crop can tolerate cold temperatures, minor flooding and thrive in regions with heavy rainfall. A staple grain in sections of Africa, Asia, and other low-income areas, it is also used as a crop for animal feed and fodder [2]. Sorghum is commonly grown in more than 100 nations worldwide. Roughly 77% of the world's sorghum production comes from the top 10 producers which include the United States, Sudan, Mexico, Nigeria, India, Niger, Ethiopia, Australia, Mexico and China. It is a staple grain that is consumed by millions of people, especially in arid and semi-arid regions of Africa. It is the primary source of animal feed and industrial applications in developed nations like the USA, Canada and Australia. Around 59 million tons of sorghum were produced worldwide in 2018–19, of which around 64% was used for food seed industrial (FSI) and about 36% was used for feed and residuals. Furthermore, sorghum has drawn more attention recently as a valuable source of physiologically active substances that can support human health and fight against chronic diseases [3].

Due to its high concentration of health-promoting phytochemicals and gluten-free status, sorghum is given special consideration as food-grade. Primarily utilized as a food crop in underdeveloped nations, sorghum has seen significant improvements in grain productivity. The growing global population and climate change are driving up the need for food in the modern world. Because of this, sorghum is anticipated to be important in regions where other cereal crops are rarely grown because of water scarcity. Therefore, choosing genotypes that can tolerate drought for the upcoming breeding program requires an understanding of genetic diversity for drought-related phenotypes. One way to address the issues of local adaptation and local farmers' end-user requirements is to develop better sorghum varieties that are locally adapted to a specific area [4].

There are many strategies that have been considered in order to assist farmers and food producers in obtaining and cultivating sorghum cultivars that provide the highest yield with excellent crop nutritional quality. A common strategy is to breed new cereal crop varieties that can adapt to climate change. Therefore, many researchers are interested in studying sorghum's wild relatives that may have lasted for centuries in harsh climate circumstances in order to investigate and capitalize on sorghum genetic variety [2].

Sorghum has a lot of genetic variety, and many landraces have been used to breed for improved agronomic performance and disease resistance. In order to ensure quality assurance and confirm quality before moving on to subsequent evaluation stages, breeders must be prepared with the abilities they require to genotype new crosses. In addition to a number of agronomic trait enhancements, breeders also seek wider adaptability, photo and thermo-insensitivity, high sugar content and tolerance and resilience to drought, salinity and high temperatures and high biomass [5]. In order to get higher biomass sorghum output, crop production system research should focus on determining an appropriate plant count per hectare. Characterizing the planting density and spacing of profitable types is therefore essential. Regarding the seeding density, the environment and genotype affect sorghum yield. Sorghum is a viable source of bioethanol due to its unique qualities. Suitable genotypes may encourage sorghum growth traits linked to ethanol production. Greater production of biomass, grain, and bio-ethanol is the primary cause of its increased yield and greater profitability [6].

Modern Sorghum Production

High yield potential

Increased yield potential can generally be achieved by adjusting planting and harvesting times, crop cultivars and using various irrigation approaches to withstand abiotic stresses mixed cropping systems using drought and heat-resistant cultivars [7]. High yield can also be achieved by using Nitrogen. For crops, nitrogen is the most crucial nutrient since it affects every process that determines growth, yield and grain quality. With more accessible N, sorghum's grain protein content rises along with grain yield and biomass [8]. It is essential to describe the planting density and spacing of lucrative types. Acquiring more biomass from sorghum, agricultural production system research should focus on determining a sufficient number of plants per hectare. The environment and genotype affect the yield of sorghum in relation to the seeding density. The overall amount of fresh matter (biomass) obtained as the spacing decreased. Smaller spacing resulted in high biomass sorghum crop harvest. Agronomic advantages that are critical for the generation of ethanol were brought about by the sorghum crops' decreased row spacing [6].

Pest resistant varieties

Weeds are major pests of plant species that hinder crop growth, development and yield, disrupt operations, and result in significant biological and financial losses. The rise of herbicide resistance in weeds and environmental degradation make the development of sustainable weed control methods imperative. In Dryland, Sorghum bicolor produces root exudates that include the allelopathic chemical sorgoleone, which is a great illustration of a natural herbicide. Sorghum plants secrete large amounts of sorgoleone when they are young, with the root hairs containing the highest concentrations. This allelopathic agent has a significant potential for weed growth control and inhibition. It provides an auspicious platform for identifying its potential as a natural herbicide as well. Sorgoleone disrupts the intake of water and minerals, which has a direct impact on the photosynthetic system, particularly in lower plants. It also prevents electron transport in mitochondria and chloroplasts. Plant development in lab, greenhouse, and field tests is directly impacted by allelochemicals emitted from sorghum plants [9].

Drought tolerant varieties

In many semi-arid countries, drought stress continues to be the leading driver of food insecurity and yield gaps. Especially in dryland or rain-fed agro-ecologies, it has an impact on agricultural productivity and production. Most of the world's 45 million hectares of sorghum cultivation land are located in semi-arid regions of India and Africa. Crop productivity is maintained under climate change conditions by implementing appropriate soil, water and pest control techniques. Selecting commercial hybrids of sorghum which have distinct stability components, improves yield stability in a variety of conditions [7].

Drought Stress Mitigation in Sorghum

A drought is a meteorological phenomenon that is defined as a prolonged period of no rainfall that results in soil moisture depletion and a water

deficit, which lowers the water potential in plant tissues. Post-flowering (flowering to grain development) and pre-flowering (panicle differentiation to flowering) are the two separate stages of the drought response in sorghum. Plant height, panicle size, seed number, grain yield, seed set, leaf rolling, uneven leaf erectness, delayed flowering, and flower abortion are all examples of sorghum's pre-flowering drought tolerance adaptations. Stalk lodging, smaller seeds, vulnerability to charcoal rot, decreased biomass, chlorophyll loss, photosynthesis degradation, decreased seed weight, decreased grain number, decreased hundred seed weight, and early leaf and stalk senescence are all included in post-flowering drought tolerance. Regardless of the stress level, post-anthesis drought stress is thought to be more harmful to grain output because it reduces photosynthesis per unit leaf area, which can result in a 70% yield loss [4].

Plants have multiple strategies for responding to drought, which can be broadly divided into three categories: tolerance, avoidance, and escape. These methods make it possible to investigate relative yield advantage and drought adaptation in sorghum improvement. One important method for drought escape is early maturity. Before a significant moisture deficit occurs, early maturing genotypes can finish their growth cycle. In low rainfall settings, early maturing types with appropriate planting dates are favored for managing drought stress. In spite of extended drought stress, the capacity to maintain physiological activity and achieve a respectable economic yield is known as drought tolerance. Staying green is an adaptive/constructive feature for drought. Grain-filling time in sorghum is extended by this crucial agronomic characteristic, which permits persistence of photosynthetically active leaves during post-flowering drought occurrence [10].

Precision Farming in Sorghum Cultivation

Multicolor cultivation can be optimized through precision agriculture, which improves crop management and resource use efficiency. Through the use of sophisticated models, such as the Decision Support System for Agrotechnology Transfer (DSSAT), sorghum growth under various environmental conditions can be precisely simulated. To maximize yield and water use efficiency, this system aids in identifying the best irrigation techniques [11].

Sorghum farmers rely on decision support systems (DSS) to give them data-driven insights so they may make well-informed decisions. For instance, the DSSAT CERES-Sorghum module provides simulations that aid in comprehending how environmental elements and crop management techniques interact. In order to help create sustainable farming methods, this approach has been successfully utilized to predict sorghum's nutrient and water productivity. DSS can assist farmers in improving irrigation and nitrogen application schedules by simulating many scenarios, which will increase sustainability and productivity [12].

Fertilizer Implication

The cultivation of sorghum is also facing challenges due to excessive salt content in different parts of the world. When exposed to Na+, salt-tolerant sorghum varieties exhibit a sharp up-regulation of the high-affinity potassium transporter gene family, SbHKT1; 4, which improves the Na+/K+ ratio and promotes optimal plant growth. Nitrogen fertilizer is one of the most significant and commonly utilized components. The general public is concerned about the environment, while growers are financially impacted by N fertilizer decrements caused by downward movement. Forage and grain output, therefore, depend on crops with effective fertilizer and soil nitrogen utilization. By 2050, it is projected that the world's agricultural needs for N fertilizer would have grown to 250 million metric tons annually. Approximately half of the nitrogen that is provided is lost through denitrification, runoff, and downward movement because of the high dynamics of NO3 in the soil. It damages soil structure and pollutes groundwater in addition to increasing the cost of producing crops. Through the increase of greenhouse gasses such as atmospheric nitric oxide, the process damages the environment. Consequently, developing crop types with improved nitrogen uptake and utilization can aid in mitigating some of the issues related to contemporary farming. Sorghum is mostly grown in regions with poor fertility, mostly in Asia and Africa [13].

Post-Harvest Management

Poor grain post-harvest management is one of the main obstacles to increasing food and nutritional security. Even with global efforts to reduce postharvest losses, farmers in developing nations continue to suffer large losses. Abiotic conditions, rodent and insect degradation and improper storage methods can all result in postharvest losses. However, storage insect pests are responsible for the majority of postharvest losses [14].

Successful grain storage begins with proper grain moisture management. This strategy consists of a series of pre-harvest to post-harvest actions intended to reduce grain storage pests and the monetary losses brought on by their presence. Degradative organisms that impact stored cereals require varying relative humidity levels for normal development. Typically, the level for bacteria is higher than 90%, for storage molds it is higher than 70%, for storage mites it is higher than 60%, and for storage insects it is between 30% and 50%. Temperature affects relative humidity and moisture. Sorghum grain should not be stored at a moisture content of more than 130 g/kg for a year and 100–110 g/kg for five years. A moisture content level of 138 g/kg and an intergranular relative humidity of 70% are in balance in sorghum. The seeds were kept in a contemporary silo under regulated settings, which preserved their viability, inability to germinate and field emergency at the same level as freshly collected seeds [15].

Conclusion

Growing sorghum requires more than previous methods in the agriculture and changing present climate. Better seed types, precision farming, integrated nutrient management, modern irrigation and improved post-harvest practices are some modern methods that provide viable, proper and modern ways to enhance output. By using these strategies, producers or farmers can increase yields while ensuring sustainable income, effective water usage and long-term soil health. Every farmer can take tiny steps toward significant outcomes to convert sorghum into a more dependable crop for the future with the detailed information, resources and provision.

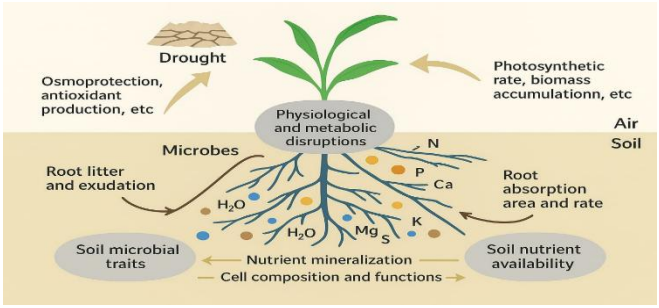

Fig. 1: Drought stress changes the physiological balance of sorghum, which eventually impacts resilience, growth and yield.

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