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Agrotechnology and Fertilization of Proso Millet (Panicum Miliaceum L.)

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Abstract: Proso millet (Panicum miliaceum L.) is an important cereal crop valued for its drought tolerance, short vegetation period, and low input requirements, making it particularly suitable for arid and semi-arid regions. In the context of increasing climate variability and limited water resources, the cultivation of proso millet offers a sustainable alternative for enhancing food security and agricultural resilience. This article analyzes the agrotechnological practices and fertilization strategies essential for improving the growth, yield, and stability of proso millet production. Specifically, the study examines soil requirements, land preparation, sowing techniques, water management, and integrated nutrient management. Furthermore, the role of balanced mineral fertilization, including nitrogen, phosphorus, and potassium, as well as the contribution of organic fertilizers to soil fertility and microbial activity, is discussed. The findings indicate that optimized agrotechnology combined with rational fertilization significantly increases yield potential while maintaining soil health. Therefore, proso millet represents a promising crop for sustainable farming systems under changing environmental conditions.

Keywords: Proso millet; Panicum miliaceum L.; agrotechnology; fertilization; nutrient management; drought tolerance; sustainable agriculture; soil fertility.

Introduction: In recent years, increasing climatic instability, water scarcity, and soil degradation have forced agricultural systems to seek resilient and low-input crops. Under these conditions, proso millet (Panicum miliaceum L.) has emerged as an important alternative cereal crop due to its short growing season, drought tolerance, and low nutrient requirements. Moreover, proso millet plays a significant role in food security, fodder production, and sustainable farming systems. Therefore, a detailed analysis of its agrotechnology and fertilization practices is essential for improving productivity and ensuring long-term soil fertility.

Proso millet is an annual cereal crop belonging to the Poaceae family. It is characterized by a shallow but well-branched root system, erect stems, and panicle-type inflorescences. Importantly, proso millet follows the C4 photosynthetic pathway, which allows it to efficiently utilize solar radiation and water. As a result, it performs well in arid and semi-arid regions with high temperatures and limited rainfall. Furthermore, its vegetation period ranges from 60 to 90 days, making it suitable for double cropping and late sowing systems.

Generally, proso millet grows well on light and medium-textured soils, including sandy loam and loamy soils. Although it can tolerate poor and slightly saline soils, optimal growth is observed at soil pH levels between 5.5 and 7.5 [5, 301-304].

Before sowing, deep plowing is recommended in order to loosen the soil and enhance moisture retention. Subsequently, harrowing and leveling should be carried out to create a fine and uniform seedbed. In addition, proper land preparation helps reduce early weed competition, which is particularly important because proso millet seedlings grow slowly during the initial stages.

Proso millet is usually sown when the soil temperature reaches 10–12 °C, since cold conditions negatively affect germination. Sowing is commonly performed in rows spaced 45–60 cm apart, which facilitates inter-row cultivation and improves aeration. Meanwhile, seed rates typically range from 8 to 12 kg per hectare, depending on soil fertility and moisture availability.

Equally important, proso millet fits well into crop rotation systems. For instance, it is often planted after legumes, winter cereals, or early harvested crops. Consequently, such rotations improve soil structure, reduce disease pressure, and enhance nutrient availability, particularly nitrogen [3, 247-278].

Although proso millet is considered a drought-resistant crop, adequate moisture during critical growth stages significantly increases yield. In particular, germination, tillering, and panicle formation require sufficient soil moisture. Therefore, under irrigated conditions, 2–3 light irrigations may be applied. However, excessive irrigation should be avoided, as it may cause lodging and reduce grain quality. Thus, moderate and well-timed watering is crucial for optimal growth.

From a nutritional standpoint, proso millet responds positively to balanced mineral fertilization, despite its relatively low nutrient demand. Nitrogen is essential for vegetative growth and grain formation, phosphorus supports root development and early growth, while potassium enhances drought resistance and overall plant health.

In practice, recommended fertilizer rates are approximately 40–60 kg/ha nitrogen, 30–40 kg/ha phosphorus, and 20–30 kg/ha potassium. Notably, nitrogen should be applied in split doses—partly before sowing and partly during the tillering stage—to avoid excessive vegetative growth and lodging. Moreover, the use of organic fertilizers, such as farmyard manure or compost, improves soil structure and microbial activity, thereby increasing nutrient availability over time.

Weed management is a critical component of proso millet agrotechnology, especially during early growth stages. Mechanical inter-row cultivation is widely used, while chemical control may be applied when weed infestation is severe [1, 91-100].

In contrast to many cereal crops, proso millet is relatively resistant to pests and diseases. Nevertheless, fungal diseases such as smut and leaf spot may appear under humid conditions. Therefore, preventive measures, including crop rotation, resistant varieties, and certified seed use, are highly effective in minimizing crop losses.

Proso millet reaches maturity within 60–90 days, depending on cultivar and environmental conditions. Harvesting is typically carried out when grains reach full maturity and moisture content decreases to safe levels. Timely harvesting is essential, since delayed harvesting can lead to grain shattering and yield reduction. Under proper agrotechnological and fertilization management, grain yields may reach 2.0–3.0 t/ha under favorable conditions.

In the agroecological context of Karakalpakstan, where agriculture is increasingly affected by aridity, soil salinization, and limited freshwater resources, proso millet (Panicum miliaceum L.) represents a strategically important crop for sustainable development. The region is characterized by hot summers, strong evapotranspiration, and irregular irrigation water supply, which often limit the productivity of traditional cereal crops. Under such conditions, the short vegetation period of proso millet, combined with its low water requirement, allows farmers to reduce production risks and optimize land use efficiency.

Moreover, the widespread presence of saline and low-humus soils in Karakalpakstan necessitates the cultivation of crops that are tolerant to adverse soil conditions. Proso millet shows relatively high resistance to moderate salinity and can maintain stable growth on soils with reduced fertility. Nevertheless, to achieve higher and more stable yields, it is essential to implement soil-improving practices, including deep autumn plowing, surface leveling, and the application of organic amendments. In particular, the incorporation of farmyard manure or compost improves soil structure, enhances moisture retention, and stimulates microbial activity, which is especially important under saline conditions.

In addition, water management plays a crucial role in adapting proso millet cultivation to Karakalpakstan. Although the crop is drought-resistant, timely irrigation during sensitive growth stages—such as germination, tillering, and panicle formation—significantly improves yield formation. Therefore, the use of water-saving irrigation methods, including furrow irrigation with reduced norms or drip irrigation where feasible, should be encouraged. At the same time, excessive irrigation must be avoided, as it may intensify secondary salinization and negatively affect root development.

Furthermore, fertilization strategies should be adapted to the nutrient-deficient soils of the region. In Karakalpakstan, nitrogen deficiency is common, while phosphorus availability is often limited due to soil fixation. Consequently, balanced fertilization with moderate nitrogen rates and sufficient phosphorus application is essential. The use of split nitrogen application not only improves nutrient uptake efficiency but also minimizes losses under irrigated conditions. Additionally, micronutrient fertilization, particularly with zinc and iron, may be beneficial in calcareous and saline soils, where micronutrient deficiencies frequently occur.

Finally, from an agro-economic and environmental perspective, expanding proso millet cultivation in Karakalpakstan contributes to crop diversification and reduces dependence on water-intensive crops. Its integration into crop rotation systems with legumes and fodder crops helps improve soil fertility and break pest and disease cycles. Thus, the adaptation of proso millet agrotechnology to local soil, climatic, and water conditions can play a significant role in enhancing agricultural sustainability, improving farmers' resilience to climate stress, and ensuring rational use of land and water resources in Karakalpakstan.

Conclusion

In conclusion, proso millet (Panicum miliaceum L.) is a highly adaptable and resource-efficient crop that holds great potential for sustainable agriculture, particularly in arid and semi-arid regions. Through appropriate land preparation, optimal sowing practices, balanced fertilization, and efficient water management, its productivity can be significantly enhanced. Moreover, its low input requirements and short growing season make proso millet an ideal component of climate-resilient farming systems. Therefore, expanding its cultivation and improving its agrotechnology will contribute to food security, environmental sustainability, and agricultural diversification.

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