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Article

The Importance of Millet Cultivation and Aspects of Agro-Measures Related to Yield

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Abstract: This article discusses the role of millet in agriculture, its biological characteristics, and the main aspects of its cultivation technology. The impact of agrotechnical measures on yield—such as tillage, seed preparation, sowing dates, fertilization, irrigation, and pest control—is also analyzed. According to the results of the study, it was found that the correct and timely implementation of agrotechnical measures significantly increases millet yield. The article is of practical importance for agricultural specialists and farmers.

Keywords: Millet, Yield, Agrotechnology, Crop Production, Irrigation, Fertilization, Soil Fertility, Planting Dates, Pests.

Introduction

Nowadays, ensuring food security in agriculture and the widespread introduction of crop species that are adaptable to climate change and require fewer resources are urgent issues [1]. In this regard, millet is of particular importance due to its high drought tolerance, short growing season, and ability to adapt to various soil and climatic conditions. In the context of an increasing population and limited irrigated land resources, it is necessary to develop and implement effective agrotechnical measures to achieve high yields. In millet cultivation, factors such as soil cultivation, determination of optimal planting dates, fertilization systems, improvement of soil fertility, and the rational use of water resources play an important role in increasing productivity. Furthermore, the use of modern agrotechnologies can maintain soil fertility, ensure environmental sustainability, and increase the efficiency of agricultural production. Therefore, the scientific study of the importance of millet cultivation and the impact of agrotechnical measures on productivity is one of the urgent scientific and practical tasks of today [2].

Literature Review

Millet is a valuable cereal crop. Its protein content (12-14%) ranks first among cereals, and its fat content (3.5%) is second only to oat flour. It has a good taste, ripens quickly, and is rich in ash elements (especially phosphorus and magnesium), trace elements, and essential vitamins: thiamine (B1), riboflavin (B2), nicotinic acid, and folic acid. In terms of calorie content, millet groats are equal to rice and buckwheat groats (325 kcal per 100 g of grain). The ripening of cereals is 12-13%, which is twice

that of rice [3]. The grain is widely used in pig and poultry farming, increasing egg production and eggshell strength in chickens. Millet straw is equivalent in nutritional value to average-quality meadow hay: 1 kg is equivalent to 0.41 kcal units . Millet grain is used in distillation and starch production, as well as an additive to malt in beer production. The largest areas of millet crops are in India (9 million hectares, yield 0.7 t/ha), Nigeria (6.2 million hectares, 1.0 t/ha), Sudan (2.4 million hectares, 0.2 t/ha), and in Europe (the Czech Republic, Slovakia, Spain, Serbia, and Hungary). The main areas of millet cultivation in Russia are the Samara, Orenburg, Tambov, Saratov, and Kursk regions. The sown area is about 1 million hectares, with an average yield of 0.3 t/ha. In the Volga region, the Central Black Earth Zone, and the North Caucasus, millet is also grown for green fodder, hay, and silage [4].

Millet differs from other cereals in its biological properties. Common millet (*Panicum miliaceum L.*) is an annual herbaceous plant belonging to the *Poaceae* family. The root system of this crop is fibrous, penetrating to a depth of 1 m or more. It forms a bush of 3-7 stems (usually bearing 3-4 fruits). The stem (straw) is simple or branched, slightly pubescent, and 45-150 cm high. The number of nodes ranges from 2 to 10. The leaves are linear-lanceolate, pubescent or glabrous, green in various shades, 18-65 cm long, and 1-4 cm wide. The inflorescence is a panicle, with 2-flowered spikelets located at the ends of the branches (usually only the upper flower bears fruit). The fruit is a round, oval, or elongated berry of white, cream, light yellow, brown (red), or other colors. A normally developed panicle contains 600-1200 seeds; 1000 seeds weigh 4-9 g. Depending on the varietal characteristics and growing conditions, the growing season lasts 60-120 days. Common millet is self-pollinating, with a cross-pollination rate ranging from 1% to 10-20%. Flowering and seed setting last 12-18 days. Millet seeds begin to germinate on the 5th-10th day after sowing in well-warmed and moist soil [5].

Light requirements. Millet belongs to the group of short-day crops and is one of the most light-loving plants among cereals. It requires the most light during the filling period until full maturity [6]. Therefore, rows of millet should be arranged from west to east to provide more complete illumination. In such rows, plants develop better and have larger, better-grained panicles.

Temperature requirements. Millet is a heat-loving crop. The required sum of average daily temperatures for millet during the growing season is 2300°C, but the need for the sum of active temperatures largely depends on the characteristics of the variety. The average temperature for seedling germination should not be lower than 10-12°C. When the air temperature drops to minus 2-3°C, millet seedlings are seriously damaged, and at frosts of minus 4-5°C, they die. The minimum temperature at which flowering begins is 15-17°C. In general, the most favorable temperature for the growth and development of millet plants is 18-24°C. Millet has high heat tolerance, especially in the second half of the growing season [7].

Attitude to moisture. Millet is a drought-resistant plant; it tolerates soil and air drought better than other crops. Its cultivation requires one and a half times less moisture than corn, three times less than alfalfa, and two times less than other cereals. Plants use moisture sparingly, and the root system is able to absorb it from the soil to a level close to the "dead water" point. Although millet is a drought-resistant plant, it is negatively affected by a lack of moisture in the early stages of growth and development. Insufficient moisture during the emergence-tillering and tillering periods leads to the drying of the grain and a decrease in yield [8].

Materials and Methods

The Purpose of the Research To scientifically assess the effectiveness of agrotechnical measures in the cultivation of millet and to develop practical recommendations aimed at obtaining high and sustainable yields by determining their impact on productivity.

Research Objectives:

- Study the biological characteristics and agrobiological requirements of millet;
- Analyze the specific aspects of millet cultivation in various soil and climatic conditions;
- Determine the impact of tillage methods on yield;
- Justify optimal planting dates and seeding rates;

- Assess the effectiveness of the fertilization system (organic and mineral fertilizers);
- Study the impact of the irrigation regime on yield;
- Analyze the effectiveness of pest and disease control measures;
- Identify opportunities for increasing yield through the integrated use of agrotechnical measures;
- Develop practical recommendations based on the results obtained [9].

Description of the Research Area. The research work was carried out in the irrigated agricultural area of the Kashkadarya region. The climate of the region is sharply continental, with high temperatures and low precipitation in the summer months, and relatively cold weather in the winter months. The average temperature during the growing season is 25–35°C, which creates favorable conditions for the growth and development of millet crops. The soils of the experimental area are mainly of average mechanical composition, with average fertility, and a humus content of about 0.5–1.0%. The water permeability and aeration properties of the soil are satisfactory for millet cultivation. An open canal system was used as a source of irrigation water [10].

Results and Discussion

Millet Cultivation Technology. In crop rotation, millet is planted after perennial grasses, legumes, winter crops, or weed-free row crops. It is particularly effective after preceding crops from which it can be easily distinguished. It is not recommended to plant millet after or before corn, as both crops are susceptible to stem borers. Millet itself can be an excellent predecessor for many crops in crop rotation. In the middle reaches of Kashkadarya, soil preparation for millet should primarily focus on weed control, as well as moisture accumulation and retention. Depending on previous crops in the field, weed growth, and weather conditions, primary tillage for millet is carried out using a conventional, improved plowing, or semi-ploughing system. On loose, weed-free soils, especially when using herbicides, no-till methods are also possible. In this case, after harvesting the previous crop, the soil is harrowed to a depth of 6-8 cm, and in the spring, when weeds re-grow, it is cultivated once or twice. In early harvests, during wet weather and when the soil is well broken up, plowing is used to control annual weeds and volunteer crops. This is done by early conventional plowing using plows and skimmers. When weeds and volunteer crops emerge, they are controlled by one or two autumn tillages. Plowing is only suitable for flat areas [11].

Millet responds very well to the effects and residual effects of mineral and organic fertilizers. For 1 quintal of millet grain, approximately 3 kg of nitrogen, 1.4 kg of phosphorus, 3.3 kg of potassium, and 1.0 kg of calcium are consumed, along with the corresponding amount of straw. Millet responds best to nitrogen and phosphorus fertilizers. Unlike other cereals, millet does not gain excess vegetative mass when nitrogen is added but instead significantly increases grain yield. Phosphorus fertilizers have a beneficial effect on root growth at the beginning of the growing season. Millet also responds well to seed treatment with microelements (magnesium, iron, boron, manganese, zinc, copper, molybdenum, etc.) that are deficient in the soil [12].

Soil and Nutrient Requirements. Millet does not tolerate very acidic, waterlogged, or heavy soils. The recommended agrochemical parameters for soil fertility are: pH 5.5-6.5, humus content of at least 1.0%, and mobile phosphorus and potassium compounds of at least 150 mg/kg of soil. The ability of millet to produce grain yields of 40-50 t/ha even on poor soils makes it a promising crop under conditions of limited funding for agricultural intensification. With intensive millet cultivation technology, the fertilization system should fully provide the crop with mineral nutrients to achieve the planned yield and create optimal conditions for the effective use of soil and fertilizers. When developing a fertilization system, it is necessary to consider that millet consumes 2.2-3.2 kg of nitrogen, 1.2-1.5 kg of phosphorus, 2.9-3.7 kg of potassium, and 1.0-1.3 kg of calcium to produce 1 centner of grain and the corresponding amount of straw. Nutrients are supplied to millet plants throughout the growing season. In the first days of life and upon seedling emergence, excess nitrogen is not needed; the contact of primary roots with localized nitrogen fertilizer significantly inhibits them and often leads to death. The need for nitrogen nutrition increases sharply on the 30th day after emergence and lasts about 15 days. From the beginning of the booting phase to the appearance of panicles, an increase in

nitrogen supply under sufficient moisture conditions can increase grain yield by more than 2 times. In the later period, excess nitrogen leads to negative phenomena: vegetative mass development is enhanced, grain ripening is delayed, and overall yield decreases. Phosphorus nutrition is necessary for millet plants from the first days of seedling development until maturity. The need for phosphorus increases significantly in the second half of the growing season during the period of grain filling and formation. The highest potassium content in millet plants occurs during tillering. With a good content of potassium in the soil, the application of potash fertilizers does not increase its consumption by the plants [13].

In addition to drought resistance, the advantages of millet include small seeds, early ripening, a wide range of sowing dates, and long seed storage viability. Due to these traits, it is an excellent insurance crop in case of the failure of winter or early spring crops. Millet can be sown for grain from the first decade of May to mid-June, for green mass until the second decade of July, and in the southern regions until the end of July. It is important to avoid early sowing in cold weather and late sowing in dry soil. In the first case, seedlings do not germinate for a long time, and the field becomes overgrown with weeds. In the second case, seedlings are uneven and sparse, and their roots grow poorly, which sharply reduces yields.

Millet is sown in continuous rows or narrow rows using row-type seeders. When sowing grain on mineral soils with row sowing, a seeding rate of 4-5 million viable grains per hectare is preferred, which yields 35-40 kg depending on the weight of 1000 seeds; with a wide-row method, this rate is 3 million viable grains per hectare. Large, sorted seeds of Class I or II are used for sowing. To increase germination energy, the seeds are subjected to air-thermal heating for 5-7 days, spread in a thin layer, and turned frequently. Before sowing, the seeds are treated with film-forming agents (NaCMC - 0.2 kg/t or PVA - 0.5 kg/t) at a rate of 2 kg/t, along with microelements deficient in the soil, using Phenoram 70% WP, Baytan 15% WP, or Benlate 50% WP. They can also be disinfected against loose smut with a W/V formalin solution (wet method). The consumption rate of the chemical is 0.38 l/t, and the working solution is 100 l/t. The seeds are dipped in the solution, the floating fractions are removed, and the wet seeds are collected in a heap, covered with a tarpaulin, and left for 2 hours. Then they are aerated and brought to a free-flowing state. It is recommended to combine formalin treatment with germination (fermentation). After the aeration of formalin-soaked seeds, they are moistened 5-6 times with a small amount of warm water (25-30°C), ensuring they absorb at least 30% of their mass in water. Once 20-30% of the seeds have germinated, they are spread in a thin layer, dried until free-flowing, and then sown. This treatment accelerates germination and increases uniformity [14].

Millet was sown in weed-free fields using narrow-row and regular-row grain seeders such as the SZU-3.6 or SZ-3.6. In fields overgrown with weeds and in arid areas, wide-row single-row seeders (with a 45 cm row spacing using a sugar beet seeder) and two-row tape seeders (with a 45 cm spacing between tapes and a 15 cm spacing between rows using a vegetable seeder) are utilized. Wide-row and tape seeders allow for 2-3 cultivations to control weeds by cutting between rows. However, it is often more practical to clear the fields of weeds before sowing and use narrow-row or regular-row seeders. This method is cheaper, and crop loss during separate harvesting is much lower than with wide-row seeders. Under unfavorable field germination conditions, as well as during late post-harvest sowing, the seeding rate is increased by 15-25%. If the topsoil is moist, the sowing depth is 4-5 cm. When the topsoil is dry, it can be increased to 6-8 cm, and on light soils even up to 10 cm, to ensure the seeds are placed in the moist soil layer. Due to the presence of the epicotyl, millet, despite its small seeds, can withstand deep sowing well [15].

Conclusion

Care of Crops. This consists of treating the soil with mulches before germination and protecting crops from weeds, diseases, and pests. **Crop Protection.** In wide-row crops, when weeds appear, cultivation is carried out 2-3 times: the first occurs when the millet seedlings are fully formed, to a depth of 4-5 cm, and each subsequent cultivation to a depth of 2 cm. During the tillering period of the

seedlings, light hilling is recommended to improve root establishment. To control weeds, crops are sprayed with 2,4-D amine salt (1.5-2 l/ha) or its mixture Lontrel-300, 30% SL (0.3 kg/ha) against dicotyledonous weeds at the tillering stage, which allows for a more effective suppression of competitive weeds.

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