ODDÍL 11. AGRONOMIE

*§11.1 GROWING SORGHUM AS A TOOL FOR REGIONAL ECONOMIC DEVELOPMENT (***Stoliar S.**, Polissia National University, **Trembitska O.,** Polissia National University, **Zhuravel S.**, Polissia National University, **Klymenko T.**, Polissia National University)

Mass malnutrition and hunger are among the most important problems that put the global community on the brink of extinction, and to varying degrees, this applies to both economically developed and developing countries. Insufficient food supply negatively affects people's life expectancy, health, physical performance, adaptation to modern high-tech production processes, etc.

Over the past few years, Ukraine has become one of the five largest exporters of agricultural products to the EU. In the coming decades, our country may become a key player in global food security. However, the reality of microclimate change cannot be ignored. 2020 was a year of record high temperatures across Europe. Decreased precipitation is just one of the many negative effects of climate change in Ukraine. Others include soil erosion, changes in plant species composition, disruption of crop rotation cycles, and the spread of new crop and weed diseases. To address these challenges, new practical measures and technologies need to be implemented.

Climate conditions have made their own adjustments, so this year farmers are preparing more thoroughly for spring field work. Farmers are choosing more drought-resistant hybrids that are less demanding of temperature fluctuations, adjusting nitrogen fertilizer rates and sowing density, developing and planning to apply moisture-saving technologies, and paying particular attention to crop rotation.

To mitigate the risk of loss of profit, producers will reconsider the sown areas to replace sunflower, soybeans, and corn with niche crops (sorghum, chickpeas, lentils, hemp) and oilseeds (flax, safflower).

Traditionally, sunflower, wheat, and corn are grown on Ukrainian fields, as they are highly profitable, but some niche crops can bring high income and are worth paying attention to. For example, the area under seed sorghum is growing rapidly in Europe.

The global production of sorghum grain is about 70 million tons, including Africa (21.6 million tons), the United States (26.5), Asia (16.2), Mexico (6.4) and Argentina (2.5 million tons). Europe accounts for less than 1% of sorghum acreage, of which only 0.3 % is in the CIS countries (Ukraine, Kazakhstan, Central Asia and Moldova). Thus, sorghum cultivation in the world is a leader [1, 2].

According to experts, the increase in the area for growing sorghum for seeds amounted to 59 % throughout Europe. Today, our country has already risen to fourth place among the largest exporters of sorghum. It is supplied to the markets of Italy, Israel and Spain. At the same time, the export potential of Ukrainian sorghum is far from being exhausted, as its supplies do not yet cover the main consumer countries. The domestic market for this crop is just beginning to gain momentum.

Sorghum is an important fodder, industrial and food crop that is grown in a wide range of areas around the world (Fig. 1). The dynamics of sorghum production in the world has increased significantly over the past half century. It is grown in arid and semi-arid regions and areas with insufficient moisture in many countries on all continents. The crop occupies 16.6 % of arable land, which is more than 50 million hectares. Over the past 40 years, the global area under sorghum has increased by more than 50 %. In terms of gross grain harvest, it ranks third in the world among grain and fodder crops after corn and barley, and third as a food plant after wheat and rice [3].

Fig. 1. Phytocoenosis of grain sorghum, 2023

(original photo)

It should be noted that in Polissya of Ukraine, under the current conditions of agricultural development, great prospects are opening up for the cultivation of sorghum. Agricultural producers need to pay special attention to the realization of the agrobiological and production potential of the crop, its introduction, production, consumption and use.

To this end, a comprehensive study of the scientific and practical principles of productivity formation, growth and development characteristics, adaptive properties and competitiveness of plants of modern sorghum varieties and hybrids in organic and conventional production has been launched at the educational and research field of Polissia National University since 2018. Scientific research has been expanded and continued at Chaykivka PE (Zhytomyr district, Zhytomyr region) and Bel-Agro 3 LLC (Berdychiv district, Zhytomyr region).

In our opinion, a strong argument for the introduction of sorghum into the agrocenoses of Polissya is its extremely high ecological plasticity, which can be a

full-fledged alternative to other spring crops (barley, corn, sunflower, millet) under unfavorable weather conditions during the growing season.

Sorghum is a unique cereal crop, both in terms of its biological characteristics and economic attributes. Its main advantages are exceptional drought tolerance, salt tolerance, high productivity, stable yields over the years, valuable fodder qualities and universal use.

Sorghum is undemanding to soils; it can grow on light and heavy soils with high salinity, but free of weeds. In addition, having a strong root system, it can produce high grain yields when grown in monoculture, but reacts negatively to cold, wet and acidic soils [4].

Being a highly plastic crop, it provides high yields of grain and green mass in a wide range of areas and configurations. Sorghum plants in sparse crops bush intensively, forming large panicles, resulting in high grain yields. On thickened crops, the intensity of tillering is sharply weakened, the weight of grain per panicle decreases, but the yield does not decrease due to an increase in productive panicles per unit area. This reaction to changes in the size and shape of the feeding area is due to the large number of recommended sowing methods and plant density.

Grain contains 12–15 % protein, 3.4–4.4 % fat, 70–80 % MEM, 2.4–4.8 % fiber, vitamin A, and vitamin B complex fiber, provitamin carotene, B vitamins, riboflavin and tannins. Sorghum grain is even superior to barley in terms of feed quality. 100 kg of grain contains 118–130 k.u. [5].

Currently, sorghum is used in three main areas: the food industry, feed production, and bioenergy. Therefore, there is a huge interest in this crop.

The share of high-quality grain is used to produce flour, bread, cereals, extracted products, starch, alcohol, etc.

Sorghum is one of the most cost-effective crops in the green conveyor belt. Its important biological feature as a fodder crop is its ability to grow back quickly after mowing and vegetate until autumn frosts, which reduces its cost.

In modern conditions, sorghum is considered a highly competitive alternative to corn with a wide growing area and versatility in terms of use.

Sorghum has a number of advantages over corn: high yields, lower seeding rates (2–3 times) and seed costs, high environmental plasticity, the possibility of later (including post-harvest) sowing and harvesting dates, versatility of use, etc.

However, the lack of study of zonal cultivation technology is one of the limiting factors that hinders the maximum realization of the productive potential of sorghum varieties and hybrids. Therefore, one of the main tasks in solving this problem is to study and improve the technology of growing the crop in accordance with the biological characteristics of its development, which will ensure high yields of good quality grain.

Thus, the natural and climatic potential of Ukraine's Polissya region meets the biological needs of sorghum plants for cultivation in this area. Compliance with the zonal technology of crop cultivation will ensure the full realization of the productivity of varieties and hybrids and high grain yields.

Sorghum is a truly versatile crop that can be grown as a grain, fodder or sweet crop. Sorghum has been known for several millennia. India and China are considered to be the centers of its origin, from where it was introduced to other countries. In Africa, China and India, sorghum was considered a bread grain, as it was used to make flour and bake bread cakes. Today, sorghum is more widely used as a fodder crop that perfectly replaces corn, a source of bioethanol production, paper making, etc.

According to the principle of economic use, sorghum is divided into 4 groups (Fig. 2):

- ✓ grain
- ✓ sugar
- ✓ herbaceous;
- ✓ broom.

Ukrainian farmers are more likely to grow technical or grain varieties.

Criteria for selecting a grain sorghum hybrid/variety adapted to the region of cultivation

1. Early maturity – attention should be paid to soil and climate characteristics, as well as the date of sowing. To facilitate early harvesting with low moisture, it is advisable to choose early to medium-late hybrids.

2. Productivity – late hybrids have the highest yield potential. But their long growing season is not suitable for all regions. To date, early and medium-late hybrids have a fairly satisfactory yield potential and are approaching the late hybrids in this respect.

3. Resistance to panicle sterility for early crops.

4. Drought resistance, in particular for fields without irrigation.

5. Disease resistance – hybrids resistant to fungal pathogens should be selected.

Fig. 2. Grain sorghum varieties and hybrids, 2022

6. Lodging – hybrids should be selected that are resistant to lodging, as this phenomenon can cause difficulties at harvest and cause losses.

7. Panicle ejection – to facilitate harvesting, it is important to choose hybrids that have a uniform panicle ejection.

8. Tannin content – in hybrids registered in the European catalog, the tannin level does not exceed 0.3 % (this is now a mandatory rule for registering a hybrid). This is the result of more than 20 years of breeders' work. Preference should be given to these hybrids with very low tannin content, as this guarantees sorghum digestibility comparable to other cereals.

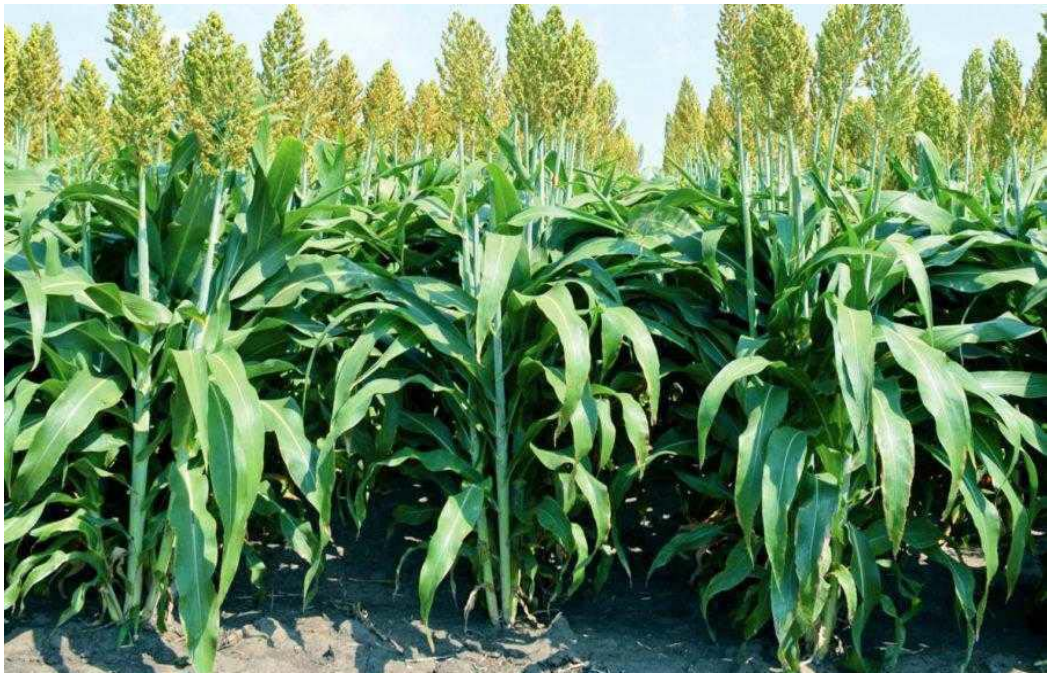
Features of grain sorghum cultivation

Developmental stages of grain sorghum

Sorghum vegetation can be divided into 3 main stages lasting approximately 30–35 days each.

The first stage is the stage of vegetative growth, which lasts from germination to the beginning of the formation of reproductive organs (panicles, grains) on the stem.

The second stage is reproductive - from the appearance of the panicle at the top of the stem to flowering**.**



The third stage – grain filling - lasts from flowering to the end of the accumulation of dry matter in the grain.

Crop rotation. Sorghum is planted in crop rotation after winter and spring crops, legumes, buckwheat, potatoes, vegetables, root crops, post-cutting and post-harvest crops. Sorghum does not significantly reduce yields when grown continuously for 4–5 years. It tolerates repeated sowing well. It can be a satisfactory predecessor to spring crops, but it is better to place it in a clean or busy fallow crop rotation after it.

Soils and their cultivation. Sorghum is undemanding to soil. It grows well on both light sandy and heavy clay soils, with common and sandy loam soils being preferred. Plants are able to withstand high concentrations of soil salts, so the crop can grow on saline soils, contributing to their desalination.

After stubble predecessors, tillage consists of post-harvest stubble peeling and 27–30 cm of autumn plowing. After corn and other late-harvested row crops, the soil is cultivated with disk tools to combat surface compaction and crush post-harvest residues, followed by deep plowing. Fields intended for sorghum are leveled in the fall. Spring pre-sowing tillage includes harrowing and pre-sowing cultivation. Cultivation is preferably combined with rolling. For pre-sowing tillage, soil herbicides Adengo, c.s., .Yukon, c.s., Premium Gold, c.s., Stream, c.e., etc. are applied.

Nutritional requirements. Sorghum has the highest nitrogen requirement, which is met by natural fertility by only 38 %, while phosphorus is met by 38% and potassium by 93 %.

High doses of nitrogen fertilizers lead to a decrease in drought resistance, a longer growing season, and damage by pathogens and pests.

On average, they are applied: $N_{90–100}P_{45–70}K_{30}$ kg/ha of fertilizer. $N_{10}P_{10–20}$ kg/ha of fertilizer and N_{30} kg of fertilizer are applied in the rows. These rates are adjusted to take into account the availability of nutrients in the soil.

Phosphorus and potash fertilizers are applied mainly for basic tillage, while nitrogen fertilizers are applied in a differentiated manner: 50 % for plowing, and the other half for pre-sowing cultivation and fertilizing. On soils where there is a threat of nitrogen leaching, it is applied in the spring for cultivation and fertilizing.

Sowing. Sorghum is sown in April-May, as the temperature during sowing should not be lower than 12 °C. The cultivation technology does not require any new specific machinery and equipment; we use the same as for corn and sunflower. The seeding depth is 2–4 cm. The soil and seedbed should be carefully prepared.

Regarding the choice of variety and sowing time. The variety should be chosen so that flowering occurs in July and ripening by October 15. The ideal time for sowing sorghum is May. If the soil temperature is above 12 °C, then sowing can be done earlier. Even in the second decade of April. In arid regions, sorghum can be sown as an intercrop, in which case early-ripening varieties are used.

The seeding rate is determined by several factors:

1. Variety: the earlier the variety, the fewer grains there will be in the panicle. However, this is fully compensated by the higher sowing density compared to later varieties.

2. Sufficient soil moisture: on dry soils, too high a sowing density leads to increased biomass formation, which increases competition between plants and accelerates the depletion of moisture reserves. In cases where irrigation is possible or the soil has significant water reserves, a higher seeding rate can increase yields.

Seeder and row spacing. The row spacing can be between 30 and 80 cm, although the optimal distance is between 40 and 60 cm. Ideally, a single grain seed drill provides the best sowing quality, but it is also possible to sow with a grain drill (if you overlap every other row). It is necessary to take into account the level of seedling losses, which ranges from 15 to 20 %, but losses can be higher under unfavorable sowing conditions (poor seed quality, cold soil).

Sowing density. Depending on the maturity group of the variety, soil type and taking into account 20 % loss of seedlings.

Protection against segetal vegetation. Sorghum is a crop that is demanding on rooting. It is very important that sorghum germinates quickly and that the seedlings are friendly, and therefore successful weed control is one of the key stages of its cultivation. Controlling cereal weeds is particularly difficult. First of all, fields with a lot of cereal weeds should be avoided, especially if they are chicken millet and alpine sorghum, for which there are no effective chemical control solutions in crop production yet.

The most numerous are: gray mousegrass (*Setaria glauca* L.) – 32.5 pcs./m^2 , common flatweed (*Echinochloa crusgalli* L.) – 21.2 pcs./m^2, white quinoa (*Chenopodium album* L.) – 7.5 pcs./m^2, common bindweed (*Amaranthus retroflexus* L.) – 12.0 pcs./m^2 , bindweed (*Polygonum convolvulus* L.) – 4.5 pcs./m^2 , common shepherd's purse (*Capsella bursa-pastoris* L.) – 3.4 pcs./m^2 , – 2.9 pcs./m^2 , etc.

Mouse gray (*Setaria glauca* L.)

Common ragwort (*Echinochloa crusgalli* L.)

White quinoa (*Chenopodium album* L.)

Common shieldwort (*Amaranthus retroflexus* L.)

Birch bittersweet (*Polygonum convolvulus* L.)

Yellow thistle (*Sonchus arvensis* L.)

Fig. 3. Dominant weeds in grain sorghum crops

The system of sorghum protection with herbicides is as follows:

Destruction of weeds after sowing in the pre-germination period.

In a situation of constant pressure from cereal and dicotyledonous weeds, pre-emergence strategies for removing segetal vegetation remain a reliable tool in terms of effectiveness. In fact, competition can begin very early, from sowing until the vegetation begins to cover the row spacing, i.e. before the 8–10 leaf stage in sorghum, when the crop can deprive the weeds that are under the leaves of light.

Early post-germination period in the 3 leaf stage.

It is very important to control cereal weeds during the germination phase and no later than the 2–3 leaf stage. This treatment is also suitable for controlling dicotyledonous weeds. Soil surface moisture at the time of treatment and in the following days is a key factor for successful weed control, particularly when using contact herbicides.

For the application of herbicides in the 3-leaf stage, sorghum has a wide range of plant protection products. Please note that only herbicides officially authorized for use in our country should be used.

Post-germination period in the phase of 3–8 leaves.

This treatment is primarily aimed at controlling dicotyledonous weeds (both annual and perennial), and which requires friendly germination of weeds starting from the sprout stage and up to the 4 leaf stage for annuals.

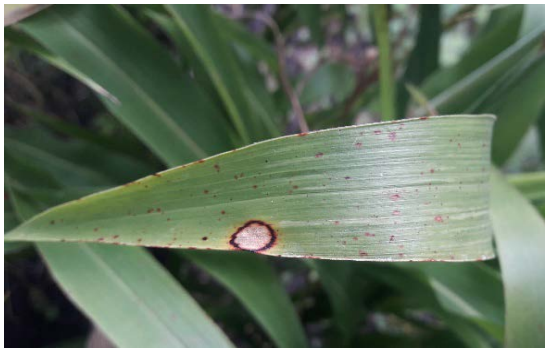
Sorghum is adapted to mechanical weed removal.

You can make a pass with a scraper harrow or a rotary hoe a few days after sowing, taking care to ensure that the sowing depth is deeper. One or more inter-row treatments (with cultivation) can be carried out at the 5–6 leaf stage of sorghum.

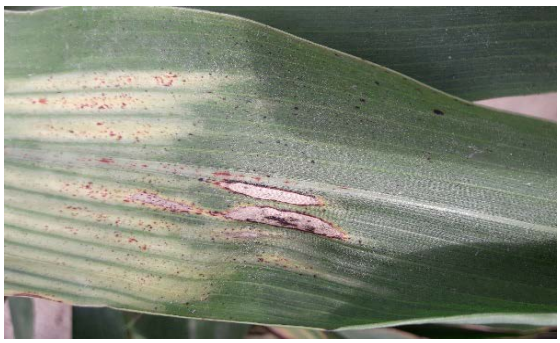
Disease protection. Pathogens constantly affect seeds and all plant organs during the sorghum growing season. Pathogens, penetrating into plants, disrupted

physiological and biochemical processes and caused their growth retardation, reduction of assimilation surface, spotting, premature drying of leaves, deterioration of root system development, plaques, rot, which led to a significant reduction in yield and deterioration of its quality.

Monitoring of the phytosanitary condition of grain sorghum agrocenoses showed that during 2018–2023, the most common pathogens were fungal etiologies: *Helminthosporium turcicum*, *Alternaria alternata*, *Magnaporthe oryzae*, fungi of the genus *Fusarium* sp., *Bipolaris* sp., *Rhizoctonia* sp., *Cercospora sorghi*, *Ascochyta sorghi* and others (Fig. 4).

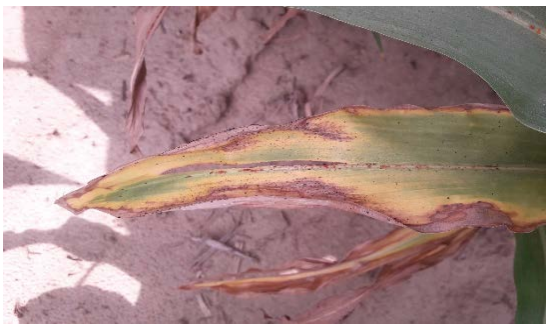


Helminthosporium turcicum



Magnaporthe oryzae

Ascochyta sorghi



Alternaria alternata

Fig. 4. Dominant leaf fungi in grain sorghum crops

It was found that the main share in the structure of crop mycoses in Polissya was made up of helminthosporium (brown spot) (38 %), common root rot (20 %)

and pyricularia (15 %). A smaller share of rhizoctonia and fusarium root rot, alternaria, cercospora and ascochitosis is 8, 5, 5, 7 and 3 %, respectively.

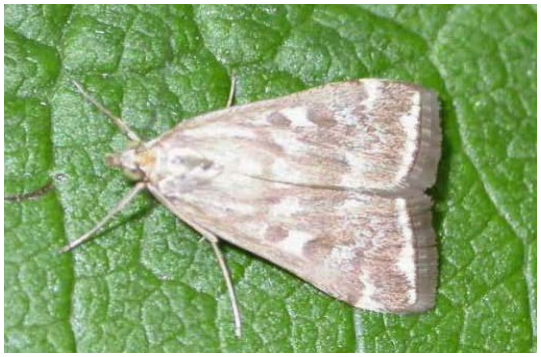
The development of diseases is mainly associated with unfavorable weather conditions.

The risk can be reduced by reducing the seeding rate and using proper irrigation during the grain filling stage, choosing varieties that are resistant to the disease.

Another important tip. Choose your seeds carefully, as disease protection is provided by fungicide treatment of the seed.

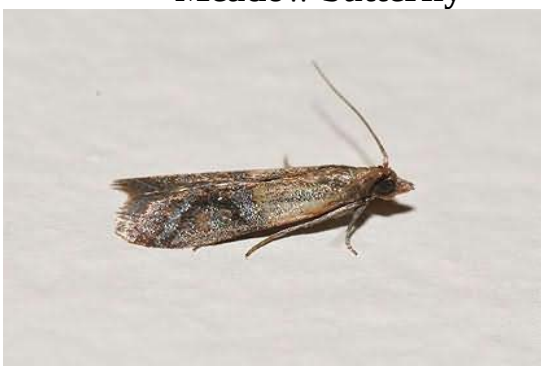
Protection against pests. Damage to sorghum phytocoenoses by pests usually does not exceed the EEI, and therefore does not require intervention. However, under favorable conditions, their development increases dramatically (Fig. 5).

Aphids



Meadow butterfly

Stem corn butterfly



Grain moth

Fig. 5. Common pests in grain sorghum crops

Sorghum is damaged by pests:

✓ ***seeds and roots*** – larvae of wireworms, grain moths - during the period of grain ripening, the butterfly lays eggs on most sorghum grains; then, after 2–2.5 months during storage under favorable temperature conditions (18–20 °C), caterpillars appear, which completely eat the contents of the grain, then an adult butterfly appears;

✓ ***leaves and leaf sheaths*** – caterpillars of the meadow butterfly and aphids; damage to plants by aphids is especially dangerous in the phase of 5–6 leaves; the plant is less susceptible to damage in the phase of intensive growth (at a height of 50 cm and above);

✓ ***stem*** – corn stem butterfly; it damages leaves and penetrates the inside of the stem, feeding on plant sap; in case of severe damage, crops look like they have been hailed or trampled by cattle.

Harvesting. If we harvest sorghum for grain, it should be remembered that it is harvested when the grain reaches the full ripeness phase (moisture content of 20–22 % or less). Harvesting is carried out by direct combining. You should not postpone the harvest date in the hope of obtaining grain with very low moisture content, as the risks of moisture recovery increase and, in addition, grain quality may deteriorate due to air humidity.

Delaying the harvest date also increases the risk of lodging. Remember that mouse-like rodents are very fond of sorghum. The threshed grain is immediately cleaned of impurities, dried if necessary (if in the open air, then with a layer of no more than 15–20 cm) and stored at a moisture content of 14 %.

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