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ECOLOGICAL CONDITIONS AND PRACTICAL APPROACHES TO THE FORMATION OF A RANGE OF AGROCENOSIS CROPS

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INTRODUCTION

Modern climatic transformations are forcing agricultural producers to increasingly revise the concepts and practical approaches to the formation of a range of agrocenoses capable of providing stable and economically profitable yields in increasingly harsh conditions in terms of hydrothermal coefficient.

In the current conditions of agricultural production in Ukraine, the prospect of realising the agrobiological and production potential of sorghum crops, their introduction, production, consumption and use is of utmost importance. Among the botanical species that make up this group of crops, a special place should be given to grain sorghum, which, under conditions of a hard hydrothermal coefficient, the progressive decrease of which is becoming more and more typical for the South and South-East of Ukraine, is able to form sustainable and economically feasible grain yields with quality indicators that allow its multi-vector use. Recently, the crop has been increasingly associated not so much with food or fodder use, but with a significant source of raw materials for bioethanol production.

However, in our opinion, the most important argument for more intensive involvement of this crop in the agrocenoses of the Southern Steppe has been its extremely high ecological plasticity, which could be a full-fledged alternative to other spring crops (barley, corn, sunflower and even millet) in unfavorable agricultural seasons with a hydrothermal coefficient.

Therefore, we see the lack of proven zonal technologies for its cultivation, which do not fully contribute to the realization of the yield potential of new varieties and hybrids of the crop, and incomplete compliance of the cultivation agrotechnics with their biological characteristics, as the only constraint to increasing grain sorghum production volumes. We believe that an effective lever to influence this problem is to improve the elements of crop agro technology in order to bring them in line with the biological characteristics of a particular variety or hybrid, which will allow for maximum use of its productive potential.

In order to comprehensively and objectively solve the problems of scientific research, the following methods have been used in the work: historical – for the purpose of retrospective generalization of the practice of

growing crops in Ukraine and abroad, developments of domestic and foreign authors in the issue of scientific substantiation and practical support of grain sorghum cultivation technologies; field short-term two- and three-factor experiment – to determine the yield, provide biometric observations and related studies; laboratory – in order to establish the qualitative parameters of sorghum grain, analysis of individual accompanying data; design – in case of establishing true criteria for seeding standards and doses of the growth-regulating drug, assessing the economic and bioenergy efficiency of the studied technology elements.

1. Use of varietal plant resources as a basis for economic and social development of the country's agricultural sector

One of the key criteria for obtaining high yields of grain sorghum, subject to strict and timely implementation of the regulations of technological schemes, has been the selection of varieties and hybrids with high yield potential and increased adaptability to adverse abiotic factors of the growing zone. The cultivation of zoned hybrids has led to the maximum realization of their genetic productivity potential. The most important factor of modern technology for growing and obtaining high yields of sorghum grain is the use of high-quality seed material for sowing, which allows to increase the productivity of a hectare of crop rotation area by 40-60%[1].

Varietal resources are one of the main priorities of the state. They are the product of the intellectual activity of a large part of society – geneticists, breeders, physiologists, biochemists and biophysicists, immunologists and mathematicians, economists, ecologists and variety testers. The use of varietal plant resources is one of the most important parts of agriculture, the basis for economic and social development. The most efficient and cost-effective is the widespread introduction of new varieties and hybrids with a genetically determined level of adaptation to the conditions of the soil and climatic zones where they are grown[2].

New varieties, regardless of the purpose of their use, must be suitable for intensive cultivation technologies, ensure high economic efficiency of grain and other products production, be adapted to a certain level of farming, and be resistant to various biotic and abiotic stress factors. It is the variety that plays a decisive role in the use of its plants for certain purposes. Particular

[1] Bezruchko O. I., Dzhulai N. P. (2012) Popovnennia rynku sortiv roslyn Ukrainy: sorho zvychaine (dvokolorove) (Sorghum bicolor (L.) Moench.) [Replenishment of the market of plant varieties of Ukraine: common sorghum (bicolor) (Sorghum bicolor (L.) Moench.)]. *Variety research and protection of rights to plant varieties. Scientific and practical journal*, no. 3(17), pp. 45–51. Kyiv: Ukrainian Institute of Plant Variety Expertise. (in Ukrainian)

[2] Yalansky O. V., Samoilenko A. T., Fedorenko E. M. et al. (2014) Nasinnia sorhovykh kultur [Seeds of sorghum crops]. *Agribusiness today*, no. 4, pp. 32–41. (in Ukrainian)

importance is attached to the development of varieties with different maturity periods to introduce them into production in different agro-climatic zones of Ukraine.

Selection of varieties for real growing conditions is an important condition for obtaining high yields. Given the weather and climatic conditions of Ukraine, breeders at research institutions have developed varieties of common bicolor sorghum with high plasticity, i.e. varieties capable of producing satisfactory and stable yields not only in favorable years but also in years of moderate and severe drought[3].

For example, the State Register of Plant Varieties Suitable for Distribution in Ukraine for 2023 includes 98 varieties of common bicolor sorghum[4].

As a result of breeding, sorghum varieties and some varieties of grain sorghum suitable for food use have been created. Sugar sorghum varieties Dovista and Troisty selected by the Institute of Grain Farming provide a green mass yield of 400-450 c/ha in the Steppe, with 24-26 feed units per centner, and juice sugar content of these varieties is 18-20%, and in some samples up to 25%. These varieties are recommended for the production of high-quality silage and can also be used as a raw material for bioethanol production. This direction has been very relevant and promising today[5].

The main requirements for crops used in bioenergy are low production costs and a stable raw material base. All types of sorghum are suitable for bioenergy use, as they are able to accumulate large amounts of soluble carbohydrates in the stem sap and produce high biomass yields.

In order to obtain high and stable yields in a particular zone, it is important to sow varieties of common bicolor sorghum that have been recommended for that particular zone using varietal cultivation technology. It is under these conditions that the genetic potential of the variety can be fully realized. According to the recommendations for soil and climatic zones, they are arranged as follows: Steppe – 24 varieties, Forest-Steppe – 14 varieties.

Producers of this crop have offered a wide range of varieties with a significant biological potential in terms of productivity. The quality characteristics of new varieties of common bicolor sorghum have also

[3] Kurylo V. L. et al. (2012) Produktyvnist sortiv ta hibrydiv sorho tsukrovoho zalezhno vid rivnia udobrennia [Productivity of varieties and hybrids of sugar sorghum depending on the level of fertilisation]. *All-Ukrainian scientific and production journal*, no. 5 (89), pp. 11–13. Kyiv: CJSC "Atopol". (in Ukrainian)

[4] Derzhavnyi reiestr sortiv roslyn prydatnykh dlia poshyrennia v Ukraini [State Register of Plant Varieties Suitable for Distribution in Ukraine]. Available at: https://minagro.gov.ua/file-storage/reyestr-sortiv-roslin

[5] Yalanskyi O. V., Ostapenko S. M., Sereda V. I. (2013) Perspektyvy vprovadzhennia vysokoproduktyvnykh hibrydiv tsukrovoho sorho u bioenerhetyku [Prospects for the introduction of high-yielding hybrids of sugar sorghum in bioenergy]. *Scientific Proceedings of the Institute of Bioenergy Crops and Sugar Beet NAAS*, no. 19, pp. 124–127. (in Ukrainian)

improved significantly. Only with information about the potential productivity, adaptability and stability of a variety, its ability to respond to improved growing conditions, can a variety be used effectively under different energy consumption conditions.

The main criteria for selecting varieties are their plasticity, length of the growing season, degree of cold resistance, intensity, resistance and tolerance to pests and extreme environmental factors.

The State Register of Plant Varieties Suitable for Distribution in Ukraine contains a full list of such varieties for each soil and climatic zone. In the context of market relations, it is important to teach producers how to use the available genetic potential rationally.

The use of varietal plant resources is one of the most important links in agriculture, the basis for economic and social development of the state. The most efficient and cost-effective is the widespread introduction of new varieties and hybrids with a genetically determined level of adaptation to the conditions of the soil and climatic zones where they are grown. At this time, extensive comprehensive research on varietal crops in Ukraine has been carried out by the Institute of Steppe Agriculture of the National Academy of Agrarian Sciences of Ukraine in Dnipro, and the Breeding and Genetic and Agricultural Institutes in Odesa. The high-yielding varieties and hybrids they have developed over many years of research work are bringing sorghum to a new stage of production.

According to the Ministry of Agrarian Policy of Ukraine, certified seed producers annually produce a significant amount of elite and reproductive sorghum seeds. However, due to significant fluctuations in grain prices for these crops, there is an unstable dynamics of sown areas and, accordingly, unstable production of sorghum seeds.

In order to obtain a high sorghum yield, in addition to paying attention to the agro-technological aspects of the technology, special attention should be paid to the selection of hybrids and varieties that can yield an additional 0.5-0.8 t/ha of grain. Preference should be given to zoned sorghum varieties and hybrids of domestic breeding, which are more adapted to specific soil and climatic conditions and have high resistance to drought, lodging and disease. On farms with large areas of cultivation, it is more expedient to grow 2-3 hybrids or varieties that have different biological properties and different responses to key environmental factors.

2. Technological aspects for sustainable and environmentally friendly production of organic products

The technology for growing sorghum is almost the same for all forms. In the crop rotation, sorghum has sown after winter wheat, legumes, corn for

grain and silage. After harvesting the predecessor, stubble is peeled and autumn plowing is carried out. Full mineral nutrition N45-60 P45-60K45-60 is applied for plowing. In the pre-sowing period, two cultivations are carried out to destroy weed seedlings.

A characteristic feature of sorghum has been the slow growth of plants at the beginning of the growing season (30-40 days from germination). At this time, the root system is intensively formed. Therefore, there are increased requirements for the choice of predecessor, soil cultivation, crop care and weed control. For this reason, grain sorghum should be preceded by crops that leave fields free of weeds. Sorghum has placed in the crop rotation after winter and spring cereals, corn, and legumes. You can not sow sorghum after millet and Sudanese grass, and also undesirable – after sunflower. According to the Institute of agriculture of the Steppe zone NAAS, when applying fertilizers and herbicides, sorghum can be grown in permanent crops without a significant decrease in yield[6].

According to the Institute of Climate-Smart Agriculture of the National Academy of Agrarian Sciences of Ukraine, sorghum under irrigation is a good precursor for all spring cereals, and its early maturing varieties are good for winter cereals. As a precursor, sorghum is not inferior to corn, and after low-growing early-ripening varieties, subject to the recommended technology, the yield of winter wheat on dark chestnut soils is at the level of MVD corn.

It should be noted that in the overall system of agricultural production, the selection of predecessors is important, as they affect the moisture reserves in the soil, the degree of nutrient supply, weediness of crops and, ultimately, crop productivity. The issue of rational placement of sorghum in crop rotation is often controversial. In the steppe zone of Ukraine, the best predecessors of sorghum are peas, winter crops, barley, and when growing it for green feed and silage, sunflower. Here, with a high culture of farming, it is quite acceptable to grow sorghum for a long time on a permanent plot without reducing its productivity.

The experience of farms that grew grain sorghum on large areas of 1000 hectares and more (LLC «Sheshirnya», Shyrokivskyi district of the Dnipropetrovsk region, LLC «Prodexim Ltd» of the Kherson region) shows that high yields of sorghum (from 5 t/ha) can be grown even after sunflower, or as a monoculture, if new technologies have been applied.

The system of basic tillage for sorghum does not differ for all areas of use and is determined by the soil and climatic conditions of cultivation and biological characteristics of the crop. The main regions of sorghum cultivation

[6] Dremliuk G. K., Hamadiy V. L. (2011) Bahatohranna kultura / [Multifaceted culture]. *Nasinnytstvo*, no. 4 (100), pp. 14–21. Kyiv: Breeding and Genetic Institute, Ukrainian Institute of Plant Variety Expertise, Kolobig Publishing House. (in Ukrainian)

are areas of insufficient moisture, so maximizing the accumulation and preservation of moisture during tillage is one of the most important conditions for obtaining high sorghum yields.

Soil cultivation for sorghum, when placing after winter or spring spiked crops, begins with stubble peeling with disk stubble harrowers, which is carried out after harvesting the predecessor, to a depth of 7-8 cm. In the presence of a significant number of perennial weeds during the period of their rosettes appearance, a second peeling is carried out to a depth of 10-12 cm. 10-15 days after peeling, plowing should be carried out to a depth of 25-27 cm. In the case of using herbicides (Roundup or its analogues), the second peeling is replaced by herbicide treatment (Roundup, 4-5 l/ha) with a working fluid consumption of 250-300 l/ha. In this case, plowing to the same depth is started 15-20 days after herbicide application. Such soil preparation ensures the destruction of root and sprout weeds – up to 85-100%, and annual weeds that appeared at the time of herbicide treatment – up to 100%[7].

In order to ensure and accumulate reserves of productive moisture in the soil, autumn plowing should be leveled (chisel tillage) in the fall. Unleveled winter plowing loses a significant amount of moisture both in the fall and winter and in the spring before the soil becomes physically ripe. Such a field has significantly less moisture in the 0-10 cm soil layer than a field that has been leveled since autumn, and spring rains, if they fall before sowing, do not replenish the total moisture reserves, but only restore the moisture of the upper, dried-out soil layer.

[7] Boyko M. O. (2016) Vplyv hustoty posivu ta strokiv sivby na produktyvnist hibrydiv sorho zernovoho v umovakh Pivdnia Ukrainy [Influence of sowing density and sowing time on the productivity of grain sorghum hybrids in the conditions of the South of Ukraine]. *Bulletin of Agrarian Science of the Black Sea Region*, no. 3 (91), pp. 96–104. (in Ukrainian); Boyko M. O. (2017) Formuvannia asymiliatsiinoho aparatu hibrydiv sorho zernovoho v zalezhnosti vid strokiv sivby ta hustoty posiviv [Formation of the assimilation apparatus of grain sorghum hybrids depending on the sowing time and sowing density]. *Tavriyskyi naukovyi vestnyk: Scientific journa*l, no. 97, pp. 18–22. Kherson: Hrin D. S. (in Ukrainian); Boyko M. O. (2016). Obgruntuvannya ahrotekhnichnykh pryyomiv vyroshchuvannya sorho zernovoho v umovakh Pivdnya Ukrayiny [Substantiation of agrotechnical methods of growing grain sorghum in the South of Ukraine]. *Scientific Bulletin of the National University of Life and Environmental Sciences of Ukraine. Series: Agronomy*, no. 235, pp. 33–39. (in Ukrainian); Boyko M. (2017) Ahrobiolohichne obgruntuvannia elementiv tekhnolohii vyroshchuvannia hibrydiv sorho zernovoho v Pivdennomu Stepu Ukrainy [Agro-biological substantiation of the elements of grain sorghum production technology in the Southern Steppe of Ukraine]: thesis. … candidate of agricultural sciences: 06.01.09 "Plant growing". State Higher Educational Institution "Kherson State Agrarian University". Kherson, p. 230. (in Ukrainian); Boyko M. (2016) Vplyv hustoty posiviv ta strokiv sivby na strukturu vrozhaiu hibrydiv sorho zernovoho [Influence of sowing density and sowing dates on the yield structure of grain sorghum hybrids]. Scientific journal *"Plant and soil science"*, no. 235, pp. 33–39. (in Ukrainian)

Harrowing on heavy loamy soils is carried out in 2 traces, on light sandy soils – in 1 trace. If the field has not been leveled in the fall, then in the spring on heavy soils it is necessary to carry out chisel cultivation to a depth of 10-12 cm. Further tillage depends on weather conditions. If the field is free of weeds, one pre-sowing cultivation to a depth of 5-6 cm is sufficient. In the case of significant weed infestation, 2 cultivations have been carried out: the first to a depth of 10-12 cm, and the second (pre-sowing) to a depth of 5-6 cm. In the spring, pre-sowing tillage includes early spring moisture closure with heavy tooth harrows in 1-2 traces across or diagonally to the plowing.

In years with insufficient moisture, an effective agricultural measure is to roll the soil with ring-spur rollers after the first cultivation, which helps to increase the temperature and moisture content of the topsoil, intensify weed germination, which is then destroyed by pre-sowing cultivation. In general, as practice shows, it is better to prepare the soil for sowing sorghum in the same way as for vegetable crops and with the same tools. The main thing is to destroy weeds in order to preserve moisture at the depth of sowing seeds.

A scientifically based choice of sowing dates for sorghum depends on soil and climatic conditions, soil condition, soil moisture, biological characteristics of varieties and hybrids, purpose of sowing and specific growing conditions. For sowing, it is necessary to use seeds that are well formed, even in size and weight. Sorghum seeds begin to germinate at a temperature of 8°C. At the same time, the period from sowing to germination lasts up to 30-35 days, resulting in reduced field germination, and seedlings appear unevenly and sparsely. Optimal conditions for seed germination occur when the temperature in the soil at a depth of 10 cm is 12-15°C. Under such conditions, seedlings appear 8-10 days after sowing[8].

With the application of soil herbicides and seed inlay, medium- and late-ripening varieties and hybrids can be sown 5-7 days earlier than the optimal time. Early-ripening varieties make better use of soil moisture reserves and thermal resources of the zone to form high productivity when sowing their seeds from May 5-10 to May 20-25. The optimal seeding depth when sowing in the third decade of April – first decade of May is 4-5 cm, and when sowing on May 20-25 and there is no moisture in the sowing layer of soil, it can be deepened to 6-7 cm.

To obtain a well-ripened grain before frost, sowing grain sorghum is necessary in optimal terms. Filmy varieties, which have tannin in the grain

[8] Domaratsky E. O., Bazaliy V. V., Boyko M. O., Pichura V. I. (2018) Ahrobiolohichne obgruntuvannia vyroshchuvannia zernovykh kultur v zoni Stepu za umov klimatychnykh zmin [Agribiological substantiation of growing grain crops in the Steppe zone under conditions of climate change]: monograph. Kherson: ALDI-PLUS, p. 334. (in Ukrainian)

coat, are better able to withstand unfavorable conditions during germination, so they can be sown three days earlier than naked varieties.

One of the most important techniques of sorghum farming is the correct sowing depth, which depends on the soil's mechanical composition, moisture, temperature, sorghum varieties and types, weight of 1000 seeds, germination energy and other factors. When sowing, seeds should be placed on a firm, moist seedbed and at the most optimal depth, which contributes to the relatively rapid emergence of friendly seedlings and provides the right conditions for obtaining high grain yields and green mass.

In conditions of insufficient moisture, the method of sowing sorghum, the number of plants per unit area and their uniformity are of great importance. Important plant functions such as mineral nutrition, transpiration, photosynthetic activity, water consumption, etc. are closely related to sowing methods and plant density. In addition, these factors have had a diverse impact on the microclimate in crops, biological processes in the soil, as well as the spread of diseases, pests, weeds and the degree of their harmfulness.

By changing the size and shape of the feeding area of sorghum plants, such processes as tillering intensity, uniformity and speed of grain ripening can be regulated. The most common method of sowing sorghum in the southern regions of Ukraine is wide-row sowing with a row spacing of 70 cm. In the beet growing area, where the necessary equipment for sowing and caring for crops is available, it is more expedient to sow grain sorghum (especially undersized) with a row spacing of 45 cm. This method provides a yield increase of 0.4-0.5 t/ha. The optimal sowing density has determined depending on the specific soil and climatic conditions, morphobiological characteristics of sorghum varieties and hybrids, and the intended use of the product.

The optimum planting density for the Ukrainian Steppe zone for grain sorghum is 140-160 thousand germinating seeds per hectare. In the southern and eastern parts of the Steppe and especially in the anomalous weather and climate conditions of the Trans-Dniester region, the planting density of sorghum crops is somewhat different. For grain sorghum, it ranges from 60-100 thousand germinating seeds/ha, and in particularly favorable years, it can reach 140 thousand germinating seeds/ha.

For sowing sorghum, the company uses SPCH-6M, SPCH-8M, SUPN-8, UPS-8, beetroot, vegetable and the latest models of foreign-made implements. Despite the condition of the seeds, insurance premiums of up to 60-65% are always added during sowing.

Proper and timely crop care is one of the conditions for high yields. Due to their slow growth in the initial period of development, sorghum plants are largely suppressed by weeds in the first 30-40 days of the growing season.

Therefore, one of the first agronomic practices is to harrow the crops 4-5 days before emergence, when sorghum sprouts are still 3-4 cm deep from the soil surface and weed seedlings (70-80%) are easily destroyed by the teeth of harrows. Depending on the soil condition and the size of the sprouts, harrows should be light or medium with a pressure of 0.6-0.9 kg per harrow tooth.

If heavy rain falls after sowing and a soil crust forms, which is detrimental to the emergence of simultaneous sprouts, it must be destroyed with harrows. When the sorghum sprouts are less than 1 cm from the soil surface, the crust has broken by rolling with ring rollers or cultivating the crops with a rotary hoe.

Due to the fact that weeds do not appear simultaneously, it is advisable to harrow crops even after sorghum germination. It is carried out 1-2 times, depending on the weediness and density of the crops: the first time when the sorghum plants have 3-4 leaves, the second time when they have 6-7 leaves. Harrowing across the crops is carried out in the afternoon, when the plants partially lose their turgor and are less damaged by tillage tools. The machine speed is no more than 4-5 km/h. Quite effective harrowing with mesh and light harrows, which reduce damage to sorghum plants and well destroy weeds[9].

As a result of harrowing, even if all the requirements of this agricultural measure have been met, some sorghum plants are damaged: during the first harrowing by an average of 19-20%, during the second – by 5-7%. Thus, with 2 harrowing operations, the plant density decreases by 25-30%. This must be taken into account when setting the seeding rate, which is increased against the optimal rate by this amount. Especially high crop sparseness is observed when the speed of the machine increases. Thus, at a speed of 6.5-7.5 km/h, the number of damaged plants has increased to 37-44%. When harrowing with heavy harrows, weeds are destroyed more efficiently, but twice as many sorghum plants are damaged. It should be noted that harrowing is most effective when carried out during the period when weeds are in the sprouting ("white thread") phase. Being late with this agrotechnical measure has led to a sharp decrease in its effectiveness.

Inter-row cultivation is carried out to destroy weeds as they appear, as well as to loosen the soil. To increase work productivity and reduce sprinkling of plants with soil, it has been advisable to use special shields that are installed next to the working bodies. The number of inter-row cultivations depends on the presence of weeds in the crops. The last cultivation is carried out with hilling, which contributes to the formation of aerial roots, which not only

[9] Makukh Y. P., Ivashchenko O. O., Sham I. V. et al. (2013) Kontroliuvannia zaburianenosti posiviv sorho tsukrovoho [Controlling the weediness of sugar sorghum crops]. *Scientific Proceedings of IBKiTSB*, no. 18, pp. 93–95. (in Ukrainian)

counteract lodging but also provide additional nutrition. This measure also contributes to the destruction of weeds in the rows.

Along with agronomic measures, chemicals such as herbicides are also effective for weed control in sorghum crops. Their use in combination with agronomic practices ensures the destruction of a significant number of weeds, helps to increase yields and reduce additional costs of growing sorghum. Primextra Gold 720 SS hp has been used as a soil herbicide at a dose of up to 2.5-3.5 litres/ha.

For vegetative plants, the herbicides of the 2,4-D group Amine salt, Dialen, Agritox water-soluble 50%, Pik 75WS water-soluble granules, and Ladok new are highly effective for the destruction of dicotyledonous weeds. The optimal consumption rate of amine salt 2,4-D is 0.9-1.7 l/ha, Dialen – 0.8-1.2 l/ha, Agritox – 0.7-1.7 l/ha, Pik – 15-20 g/ha, Ladok new – 2.5-3.0 l/ha. Crops should be treated with these herbicides, except for the last one, in the phase of 3 to 5 leaves of sorghum. In later phases (6-10 leaves), the use of herbicides has a detrimental effect on sorghum plants. It is advisable to apply Laddok New at the 2-3 leaf stage of weeds, regardless of the developmental stage of sorghum plants. Herbicides have been applied using rod sprayers OP-2000, OPSh-2000, MZU-320, etc.

The modern technology of obtaining high and sustainable yields is impossible without the use of fertilizers, which account for up to 35-40% of the yield increase. Sorghum takes 23-25 kg of nitrogen, 9-10 kg of phosphorus and 28-30 kg of potassium from the soil to form one tone of grain and the corresponding amount of leaf mass. With a grain yield of 5-6 tones per hectare, sorghum consumes 140-160 kg of nitrogen, 50-60 kg of phosphorus and 150-180 kg of potassium per hectare. Most soils in sorghum-growing regions can provide only half of the required nutrients, so the rest must be replenished with fertilizers[10].

The amount of fertilizer required to achieve the planned yield is calculated based on agrochemical soil analysis for each specific field. On average, for the southern steppe of Ukraine, the fertilizer dose has been N60-90P60. It is most advisable to apply the entire specified dose in autumn for plowing (except for fields on slopes up to 5-8°). If no fertilizer has been applied in autumn, it should be applied in spring for cultivation, sowing and top dressing. It should be remembered that spring application of mineral fertilizers is less effective due to the rapid drying of the topsoil and the inability of the plant root system to use them.

It has been established that nitrogen and phosphorus fertilizers applied to the side and deeper than the seed have a positive effect on germination,

[10] Lutsko G., Karanda T. (2013) Sorho – vidpovid ekstremalnii posusi [Sorghum – the answer to extreme drought]. *Proposal*, no. 1, pp. 44–46. (in Ukrainian)

increasing field germination by 10-12%. Full doses of mineral fertilizers have a particularly positive effect on the field germination of seeds when applied to a depth of 8-10 cm before sowing. In this case, they increase the activity of the catalase enzyme, acting as a stimulant of growth processes in seeds[11].

Sorghum is very sensitive to organic fertilizers especially in combination with mineral fertilizers. As studies have shown, when applying 10-20 tons of manure in autumn for plowing, as well as N10R10 (placing them deeper and on the side of the seeds) in the spring when sowing, the increase in the yield of sorghum grain was 0.4 t/ha, and in some years up to 1 t/ha. In general, fertilizers not only increase yields, but also improve the quality of products (increases the content of protein, fat, grain in the feed mass, as well as dry matter and feed units).

Sorghum plants are slightly damaged by pests. Only cereal aphids, wireworms and gnawing scoops cause significant damage. The most widespread and harmful in southern Ukraine is the cereal leaf aphid, which causes great damage to sorghum crops: the ripening period is extended, the number of non-green spikelets in the panicle increases, and grain shrivelling occurs. Preventive aphid control measures include all agronomic practices that increase plant growth, while extermination measures include the destruction of cereal carrion and cereal weeds in autumn, stubble peeling, and deep plowing. In the event of massive aphid infestation, especially in the early stages of plant development, crops are sprayed with BI-58 new, 40% concentrate, at a rate of 0.7-1.0 l/ha.

The biological method has been quite effective (releasing a seven-spotted ladybug on crops at the rate of 20-30 thousand individuals per hectare). One larva of a ladybug eats about 200 aphid larvae per day. The development of varieties and hybrids resistant to this pest is of great importance in the fight against aphids. This is the most effective way to do so, and it is both economically and environmentally sound.

Wireworms and false wireworms eat the germs of sown sorghum seeds, gnaw the roots of young plants and damage the tillering nodes. If there is a large number of wireworms and false wireworms in the soil, both agronomic and chemical control measures should be applied. Agrotechnical measures include crop rotation, autumn plowing, and tillage between rows, especially during the period when the wireworm larvae turn into pupae. To control

[11] Samoilenko A., Samoilenko V. (2011) Sorhovi kultury v stabilizatsii vyrobnytstva kormiv [Sorghum crops in the stabilisation of fodder production]. *Proposal*, no. 2, pp. 39–40. (in Ukrainian)

larvae, seeds have treated with seed treatment agents: Cosmos 500, flowable concentrate, 500 g/l, Cruiser 350 FS flowable concentrate, 6 l/t[12].

Gnawing scoops damage the root system of plants. The damaged plants dry up or lean to the ground and can continue to grow by means of single roots. Fallen plants no longer rise. The caterpillars of the scoop moth also damage the leaves and stems of young plants. According to the Genichesk Experimental Station, on average over 2 years, the damage to grain sorghum crops by these pests has been 4.7-41.7%, depending on the variety, and to sugar sorghum – 13.3-36.7%. To prevent damage to plants by gnawing scoops, it is necessary to keep the crops free of weeds. If caterpillars of the moths appear on the crops, which at the beginning of their development settle and feed on weeds around the clock, they can be destroyed by spraying with approved insecticides.

Many researchers have reported on sorghum's resistance to fungal diseases. However, cereal, sugar and broom varieties, as well as sorghum hybrids, are often affected by the most common disease in the Ukrainian Steppe, the smut. Volatile smut affects sorghum, corn, and occasionally Sudanese grass. Instead of a normal panicle, affected plants develop a mass of spores, which are initially covered with a greyish shell, then it cracks and the spores fly away.

Hard (grain) smut affects only the ovaries of sorghum flowers. The films and other parts of the panicle remain unaffected. The affected grain looks like elongated dirty grey sacs that are easily crushed and instead of endosperm we have a black mass – smut spores[13].

Among the preventive measures to combat smut sorghum diseases, it is recommended, first of all, to harvest seeds of soot not affected by spores, as well as to grow varieties and hybrids of sorghum resistant to this disease; of agro technical – of great importance: proper observance of crop rotation, deep plowing of post-harvest residues, fertilization, sowing with high-quality seeds, avoiding mixing the harvest of healthy grain with grain affected by this disease; of extermination measures – the most important is the disinfection of seeds before sowing with chemicals. For this purpose, seeds are etched with a suspension of Vitavax 200, water-suspension concentrate (5 l/t of water + 2 l/t of the drug), Maxim 0.25 FS, since (8 l/t of water + 1 l/t of the drug).

The time and methods of harvesting sorghum are determined by its purpose (for grain, silage, green fodder) and the availability of harvesting

[12] Hamandiy V. L., Dremliuk G. K. (2012) Hospodarstvam Pivdnia chas rozshyriuvaty posivy sorho [It is time for southern farms to expand sorghum sowing]. *The Ukrainian Farmer*, no. 2, pp. 12–13. (in Ukrainian)

[13] Maslak O. (2012) Rynok sorho v Ukraini i sviti [Sorghum market in Ukraine and the world]. *Agribusiness today*, no. 11, pp. 14–18. (in Ukrainian)

machines on the farm. Grain sorghum is harvested when the grain moisture content was no more than 20%. An effective measure to reduce grain moisture has been desiccation of crops (performed in the waxy phase – full grain ripeness, but no later than 4-6 days before harvesting, and does not affect sorghum yields). As a desiccant, we use Reglon Super 150 WS, 4 l/ha. Desiccation of sorghum crops in the waxy ripeness phase with Reglon reduces the moisture content in the grain by 8.4-10.8%, and at the beginning of full ripeness – by 5.5-7.1%.

When the grain reaches full ripeness, physiological and biochemical processes associated with post-harvest ripening continue. Sorghum seed harvesting should begin at a grain moisture content of 24-26%, which corresponds to the maximum accumulation of dry matter.

During direct harvesting, the grain moisture content is kept at 18.9%, and in some years even at 19.7-21.8%. After harvesting, to prevent grain spoilage, it is necessary to clean it from the remains of the leaf-stem mass and, if necessary, dry it to a moisture content of 13% using tower and drum dryers. In order to significantly reduce the use of expensive energy sources and, accordingly, reduce the cost of production, technological equipment capable of operating on solid fuels, which can be crop residues, should be used[14].

The main components of the technology for growing stable and economically viable grain sorghum yields are consistent and strict implementation of all components of scientifically sound agricultural technologies, adherence to modern progressive measures and techniques, and high-quality and timely execution of technological processes.

CONCLUSION

Over the past few agricultural seasons, farmers have learnt the hard way that spring barley and corn production in the southern regions of Ukraine is highly risky. Unfavorable hydrothermal coefficient values, which are typical for the growing seasons of an increasing number of years, do not contribute to sustainable yields of early spring wedge crops, and in the case of late spring crops, grain sorghum is seen as a virtually unalterable option to get economic benefits from arable hectares. The crop, which has no analogues among the crop species typical for the agrocenoses of the Ukrainian South due to its unique characteristics such as drought and heat resistance, salt tolerance and

[14] Hunchak T. I. (2014) Osoblyvosti vyroshchuvannia sorho tsukrovoho v yakosti syrovyny dlia vyrobnytstva biopalyva v umovakh Pivdenno-Zakhidnoho Lisostepu Ukrainy [Features of growing sugar sorghum as a raw material for biofuel production in the conditions of the South-Western Forest-Steppe of Ukraine]. *Scientific Proceedings of the Institute of Bioenergy Crops and Sugar Beet NAAS*, no. 21, pp. 240–244. (in Ukrainian)

high yield potential, should take a prominent place in the gross harvest of the risky farming zone.

SUMMARY

The formation of a spectrum of crops in agrocenoses and management of environmental conditions in agriculture is an important task for ensuring sustainable development and conservation of natural resources. The study highlights the main aspects of environmental conditions and practical approaches to the formation of a crop spectrum in agrocenoses of modern agribusiness. Adaptive technologies for the production of drought-tolerant crops contribute to the conservation of natural biodiversity, maintenance of ecosystem services, reduction of negative environmental impact, and improvement of soil and product quality. The proposed approaches are aimed at creating sustainable agro-ecosystems that ensure food security, preserve soil fertility and minimize the negative impact of agricultural activities on the environment.

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