AGREEN

CROSS-BORDER ALLIANCE FOR CLIMATE-SMART AND GREEN AGRICULTURE IN THE BLACK SEA BASIN

Subsidy Contract No. BSB 1135

CROP MODEL

GROWING OKRA IN ORGANIC AGRICULTURE SYSTEM: GREENHOUSE GROWING VS. GROWING UNDER FIELD CONDITIONS

Common borders. Common solutions.

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GROWING OKRA IN ORGANIC AGRICULTURE SYSTEM: GREENHOUSE GROWING VS. GROWING UNDER FIELD CONDITIONS

Climate-smart crop models, adapted to the environmental, social and economic conditions in the BSB region

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Contents

A. Choice of crop and method of experiment implementation

Okra is among the most ancient cultural vegetable plants, that has been grown on the territory of Egypt 2000 years B.C. Presumably, the crop has been introduced in Bulgaria from Asia Minor, and its production is nowadays traditional for the country, though it is limited exclusively and only to private gardens. The large-scale production of okra for the market is rather limited and is concentrated only in the southern regions. On the territory of Dobrudzha, the growing of okra as an industrial crop has no traditions.

One of the main reasons for this is the lack of irrigation systems and the comparatively dry climate in comparison to the other regions. At the same time, the conditions of North Bulgaria are characterized by lower temperatures until considerably later in spring (the beginning of May), which is also a limiting factor for the distribution of the crop due to its high requirements for temperature.

Nevertheless, okra is widespread in backyards and gardens all over the country, including Dobrudzha region, as a vegetable plant of secondary importance. Usually 10 to 20 plants are grown, which are sufficient to meet the demands of a single household. A tendency is observed, however, of using okra of non-local origin to prepare home-made preserves and for food in restaurants and catering establishments. This is an opportunity to develop a local market for this crop, provided that it can be successfully grown in industrial fields on the territory of Dobrudzha.

The climatic conditions in Dobrudzha determine comparatively late dates for growing of okra. On the one hand, this limits the possibility to offer the product in the market earlier. On the other, the rather hot weather at the end of the summer further shortens the fruiting period of the crop. Therefore, greenhouse growing of okra is a possible approach, which can simultaneously allow earlier sowing and a longer period of fruiting.

Regardless of this, a conventional greenhouse production can hardly be considered regenerative and crop-friendly agriculture. Such production requires considerable resources for fertilizers, pesticides and fuel. Therefore, an agricultural system is needed, which will significantly reduce the use of chemical products for plant protection and fertilization, and be at the same time soil and environment friendly. Since the main priorities of the European Union are the use of increasingly less synthetic pesticides and fertilizers, the adoption of an organic system of agriculture in the greenhouse production of okra can be an efficient and environmentally friendly process, which will in parallel contribute to the necessary diversification of the vegetable products in the region of Dobrudzha at optimal utilization of the resources for production.

B. Objectives and tasks of the experiment

The main objective of the experiment is to provide high-quality plant raw material produced through an organic method that will meet the demands of the local markets and ensure short chains at high level of productivity. At the same time, it is necessary to determine if okra as a crop can be grown effectively under conditions of greenhouse organic production. The primary target of such a research is diversification of the vegetable production at high efficiency.

The following tasks ensue from the original objectives laid out:

- To find out if the organic greenhouse production can be efficiently applied to the growing of okra under the conditions of Dobrudzha;

- To investigate if the greenhouse production can ensure earlier and longer period of produce in comparison to the conventional growing of the crop;

- To determine if the soil largely maintains its physical and chemical properties in accordance with the priorities of regenerative and conservation agriculture;

- To study if okra maintains its productivity potential under organic greenhouse production;

- To find out if it is cost-effective to grow okra by the organic method in a greenhouse in comparison to the conventional cultivation of the crop in a greenhouse and in field.

C. Material and methods

C1. Technology for growing of okra

I. Greenhouse growing

1. Pre-sowing preparation of soil

The preparation of the soil is highly significant for the proper growing of okra. Since the crop develops deep roots, it is important to provide to the plants sufficient depth for penetration of the roots. Okra requires very good soil tillage, regardless of the way of its growing. This is related to its extremely tender seedlings, which, in order to penetrate the soil on their way upwards, need loose, light and well-structured soil. Therefore, it is necessary to perform high-quality soil tillage, which involves the following activities, regardless of the previous crop:

1.1. Stages of soil tillage

1.1.1. Deep plowing or other soil layer inverting tillage

Deep plowing is the first, primary and mandatory tillage of soil. It is usually done at depth 30-40 cm and its main purpose is the plant residues from the previous crops, the weed vegetation and some applied organic or synthetic fertilizers to remain at the bottom of the furrow. From a phytosanitary point of view, the weed seeds, the phytopathogens and a part of the pests, which overwinter in the upper soil horizons, are buried to deeper layers, which considerably favors the development of the crop.

On the other hand, deep plowing incorporates the applied fertilizers to a depth, where they become accessible to the okra roots in the process of its development. Deep plowing is performed with a common plow attached to a tractor of different power depending on the area, the depth of tillage and the type of plow.

The tractor should be very powerful, since the greater depth of this tillage requires higher power from the energy machine. Since it is not possible to do deep plowing under greenhouse conditions, if enough manual labor and time are available, it is possible to replace deep plowing with inverting of the soil layer by digging with a spade. This method is equally efficient, although it requires considerable labor input and is at the same time rather time-consuming. Furthermore, it may not give the depth of tillage suitable for growing of the crop. It may also not ensure the even tillage, which the tractor, to which a good plow is attached, provides.

1.1.2. Cultivating

Cultivating is the next stage of soil tillage. Usually single, double or more cultivatings are undertaken on a preliminary plowed area to achieve well-structured soil for the proper growing of okra. This type of tillage is not preferable under greenhouse conditions because the cultivators usually have greater working width, and the possibility for maneuvering under such conditions is limited. Besides that, the greenhouses are often occupied all the year round by a certain part of the crop rotation and therefore it is sometimes impossible to carry out efficient soil tillage of the spot where it is needed. Nevertheless, there are small-sized cultivators, which can, if the greenhouses is large enough, perform this type of tillage, too. It is usually done with a cultivator attached to a tractor of different power.

There is a variety of cultivators, depending on both their construction characteristics and the type, size and purpose of their working parts. Usually, the cultivators for pre-sowing tillage consist of one or two rows of working parts with arrow-shaped double-edged surface. Cultivating is often combined with simultaneous harrowing to ensure finer tillage of the soil. The depth of cultivating depends largely on the condition of the soil and the condition of the deep plowing, but is most often within 8-10 cm.

1.1.3. Harrowing

Harrowing is an additional way of pre-sowing tillage of vegetable crops, such as okra. This tillage should be applied independently only on light soils free from weeds, not wet and if the amounts of plant residues are small. It is performed with tine harrow attached to a tractor. This tillage is rather shallow and is of secondary importance, primarily used to level the surface after cultivating which has not been uniform, or is applied simultaneously with the cultivating.

Harrowing is not mandatory. Under greenhouse conditions, this type of soil tillage is almost unnecessary if good cultivating or rototilling have been performed. Nevertheless, harrowing can be undertaken, with the aim to better level the soil surface, even manually, with the so called light harrows, if there are enough available agricultural workers and time, and if fast soil tillage and sowing of this crop are not required. The use of light harrows further facilitates sowing, and if there are plant residues, helps to remove them.

1.1.4. Rototilling

Rototilling is a pre-sowing tillage applicable to small areas and is particularly important under greenhouse conditions. Although this tillage requires significant resources in the form of time and labor, it ensures the best soil conditions for growing of okra.

Rototilling is carried out by a horizontal-axis or vertical-axis active rototiller. Thus, fine, well-structured soil tillage is provided, which is especially suitable for sowing. It is undertaken at depth from 10 to 30 cm depending on the parameters of the rototiller. This tillage is appropriate after any type of previous crop, including tillage of plowed areas with perennial forage and grass species such as alfalfa and ryegrass. It is exceptionally suitable for small experimental plots that are to be cultivated and leveled to ensure uniformity of the soil surface and incorporation of different fertilizers and chopping of available plant residues.

A significant disadvantage of this tillage is the excessive soil dispersion and the formation of a high percent of the small-sized soil units. In heavier soils, this is a prerequisite for formation of soil crust, which is extremely undesirable, especially when sowing okra directly from seeds, because the dry soil crust makes the emergence of the crop difficult.

1.1.5. Soil tillage system for implementation of the experiment

When choosing the pre-sowing tillage for this experiment, significant were the current status of the soil and the available plant residues. The high amount of plant residues, especially from later previous crops, require undertaking of quality deep plowing at higher depth. Since under greenhouse conditions the soil is often dry and compact due to treading by the workers in the greenhouse, the performance of quality deep plowing requires a considerably more powerful energy machine and a plow with a smaller number of plow bodies. For a standard-sized greenhouse of 100-200 m^2, a tractor of 150 h.p. equipped with a plow with maximum three plow bodies is sufficient. Under greenhouse conditions, a rollover plow is not necessary.

If the amount of moisture in soil is high, usually in terrains where new greenhouses are constructed, in greenhouses left uncovered during the winter, or in greenhouses with excessive moisture after solarisation and over-irrigation, plowing should be undertaken when the amount of soil moisture is such, that when squeezing a handful of soil, a mud ball should not be formed, but rather be broken loose. If the soil moisture is high and predominantly weed vegetation is available, deep plowing may be impeded significantly due to the accumulation and sticking of wet soil and plant residues to the working parts of the plow. The working parts must be cleaned in this case, since if there is soil accumulated and stuck on them, the efficiency of the soil layer inversion will be considerably reduced.

A significant element of the soil tillage technology is ensuring equal depth on the entire area of the experimental greenhouse plot. This is done by measuring the depth at minimum 10 locations of the cultivated area by a vertically positioned poker. The depth is determined, when the poker stops sinking without any further pressure on it. Measurement is done with a ruler or other measuring tool from the tip of the poker to the place where the soil surface is.

Since plowing is impossible to repeat, the depth has to be determined at the beginning of the tillage and has to be monitored at certain distances so that it can be maintained the same on the entire experimental area.

After overwintering, the plowed area should be rototilled at the place where the experiment is to be carried out. In this case, the tillage is done at depth no more than 10-12 cm.

After rototilling, light harrowing may be undertaken to make a better bed for the seeds, although it is not mandatory. If there were weeds in the previous vegetative growth season, it is advisable to let the weeds grow and develop to a certain degree after the first rototilling. Immediately before sowing of okra, a second rototilling is to be performed to destroy the emerging weeds and prepare an appropriate bed for germination and emergence of the okra seeds.

1.2. Resources for pre-sowing soil tillage

1.2.1. Energy machines

- A 150 h.p. tractor, to which a common plow with up to three plow bodies can be attached. A smaller tractor is necessary under greenhouse conditions, which can fit the size of the construction.

1.2.2. Attached equipment

- A plow able to perform tillage to depth of 35 cm, with up to 3 angular adjustable bodies allowing better inverting of the soil layer.

1.2.3. Labor resources

- To perform primary tillage of soil, one agricultural mechanic is needed, who has the necessary qualifications and skills to manage a tractor with the respective equipment. He should be able to regulate both the depth and the angle of attack of the plow to ensure even plowing.

1.3. Dates of primary soil tillage

The dates of primary soil tillage are related to the proper structuring of soil during the winter period and providing appropriate basis for the spring soil tillage for sowing. In this respect, the timing of the deep plowing or the respective adequate tillage with inverting of the upper soil layer are especially important.

1.3.1. Early dates

The early dates are usually related to the undertaking of deep plowing immediately after harvesting of the previous crop or if there is no previous crop – at the end of summer. When the previous crops are late ones (sunflower, maize, sorghum, beet, cotton), early tillage is not optional. A serious disadvantage of the early dates is the weed infestation of the plowed areas, which causes subsequent difficulties to the pre-sowing tillage.

1.3.2. Optimal dates

These are usually within September – October or after harvesting of the medium-late and late previous crops. This period is the most favorable for undertaking plowing because the danger of weed infestation is low and the pathogens and pests have moved entirely to the plant residues or to soil. This allows their incorporation at the respective depth thus considerably improving the phytosanitary condition of the soil.

Under greenhouse conditions, the weather has little effect, except if the greenhouse is not covered during the winter period or in places where the greenhouse is to be constructed.

1.3.3. Late dates

The late dates under greenhouse conditions have the same significance as the optimal, but if they are too late, the soil will be frozen and the quality of tillage will be different. In greenhouses not covered during the winter, the meteorological conditions (available snow or defrosted soil) are a further hindrance to the soil tillage.

1.4. Dates for pre-sowing soil tillage

The pre-sowing dates are rather significant for the quality sowing of okra. The proper performance of the sowing is related to the previously ensured well-leveled, structured, weeds-free soil with good available moisture reserves. Therefore, the timing of the pre-sowing soil tillage is especially important.

1.4.1. Early dates

The early dates are usually during February-March and are definitely not desirable from various points of view. Firstly, if rototilling and sowing are too far apart in time, the soil can possibly subside and get too compact, especially if it is simultaneously irrigated. Subsequently, when the soil dries out, especially in soils with higher content of clay, a thick crust is formed, which would require additional tillage prior to sowing.

On the other hand, the early dates of rototilling allow weed infestation of the sowing area due to the optimal conditions for growing of the weed seed; a follow-up rototilling will entirely remove this weed vegetation.

1.4.2. Optimal dates

The optimal dates for pre-sowing tillage when growing okra are usually during April – May. When growing okra under greenhouse conditions, however, these dates may be earlier since the soil temperature in April is already high enough, there is no danger of frosts in the greenhouse, and the air humidity and temperature allow the growing of the crop. The optimal dates for rototilling in this case are at least one week prior to sowing. This is due to the necessity the soil to subside sufficiently after rototilling; furthermore, if the soil moisture is higher at the time of sowing (which requires considerable manual labor, especially with stratified seeds on small areas), significant compaction of the soil layer is possible, which would deteriorate the physical properties of the upper layer of the soil.

1.4.3. Late dates

The late dates almost coincide with the optimal dates for undertaking pre-sowing tillage. They are related to tillage immediately before sowing. Such practices are to be avoided due to the reasons described above.

1.5. Resources necessary for primary soil tillage

1.5.1. Energy machines

- A 100 h.p. tractor, to which an active rototiller can be attached. A smaller tractor is necessary under greenhouse conditions, which can fit the size of the construction.

- A rototiller of up to 10 h.p. to perform tillage of smaller plots in the greenhouse when necessary, which are not accessible for the tractor.

1.2.2. Attached equipment

- An active rototiller with width no less than 1.5 m.

1.2.3. Labor resources

- To perform pre-sowing tillage of soil, one agricultural mechanic is needed, who has the necessary qualifications and skills to manage a tractor with the respective equipment. He should be able to attach the rototiller to the tractor and regulate the depth of tillage.

2. Primary fertilization

2.1. Within an organic agriculture system

Within the system of organic agriculture, the major requirement to both the primary fertilization and the further fertilization of the crop is the entire exclusion of synthetic and mineral fertilizers, which are chemical industry products. In this relation, the applied primary fertilization should be carried out, when necessary, with organic products only. Since this experiment is not subject to certification, specific products will not be considered from the point of view of the national and European legislation. All good agricultural practices providing organic production with regard to fertilization should be, however, followed.

One of the best well-known products of organic origin is the manure from Californian red worm, the so-called lombricompost. Its advantages are that it is an entirely organic product, which gives a very good structure to the soil and simultaneously ensures sufficient nitrogen and organic matter for the plant to grow and develop properly. The okra is highly responsive to soils rich in organic substance, which are well-structured. Therefore, the lombricompost is a product that can be used for this purpose without any issues.

A serious disadvantage of its usage, however, is that it cannot be applied with a mechanized equipment, particularly under greenhouse conditions. Therefore, the fertilizer has to be incorporated manually.

The application of lombricompost as a part of the primary fertilization should be immediately before the final pre-sowing tillage of soil. The fertilizer should be well mixed with soil to have effect on its structure, and the roots of the plant to be able to have contact with the organic matter down the soil profile. The necessary amount is 100-500 l/da, depending on the specificity of the soil.

2.2. Under conventional growing

Okra is a crop, which is highly responsive to nitrogen fertilization. However, the nitrogen fertilization of the crop should be balanced, in accordance with the amount of phosphorus and potassium in the soil. Therefore, it is necessary to apply combined fertilizers, which contain all three elements. They should be incorporated prior to deep plowing, since the direct fertilization of okra with phosphorus and potassium fertilizers can lead to improper plant development.

Another possible variant is the separate incorporation of the three elements in the form of different applications. In this case, triple superphosphate is a good source of phosphorus, and potassium chloride – of potassium.

First of all, however, a thorough soil analysis is to be performed to determine if the incorporation of these two elements is indeed necessary, because it is possible that their amount in soil is sufficient. At the same time, it is important to determine if a certain type of fertilizer was applied to the previous crop, because due to a previous reserve-forming fertilization, the necessary amounts of the two elements may already be present in soil.

The type of previous crop and the available plant residues are also significant for the nitrogen fertilization. The occurrence of heavy weed infestation and numerous plant residues containing lignin and cellulose require higher nitrogen norms since a part of the nitrogen is utilized for decomposition of the organic matter of the plant residues. If there was no previous crop, or the previous crop was a perennial leguminous one (alfalfa), the nitrogen fertilization as a primary treatment should be reduced because such crops form sufficient nitrogen reserves in soil.

If nitrogen, phosphorus and potassium fertilization are needed, the fertilizer norms are to be determined after performing analysis of the soil, because their unjustified incorporation may affect the proper development of the plants. If there is such a need, mainly granulated fertilizers are used, which are spread on the soil surface. Since the working area in a greenhouse is limited, the fertilizers may be spread manually, but such an operation requires enough skilled and experienced workers; the fertilizers could also be applied by a manual tool with a preliminary regulated fertilizer norm.

3. Sowing

The sowing of okra is in practice a rather precise process, because, in contrast to most vegetable and field crops, the seeds of okra are hard to emerge, have high requirements, and the sprouts are extremely tender, which is why okra prefers soils rich in organic matter, that are well structured. Therefore, there is a considerable number of peculiarities that should be observed.

3.1. Ways of sowing

The sowing of okra is carried out according to two methods: directly, or by preceding stratification of the seeds. The direct sowing is done in rows, and the distance between the rows and between the plants under greenhouse conditions should be according to the applied method of irrigation. For optimal production, the row interspacing should be 70 cm, and the distance between the plants should be 20 cm. This allows the okra plants to branch unrestricted thus ensuring optimal yield. The sowing depth for okra is 5-8 cm depending on the tillage depth and the structural condition of the soil.

There is no difference in the sowing requirements under organic and conventional growing of the crop. If drip irrigation is used, the seeds should be sown at previously marked spots. After sowing, the area is irrigated to ensure sufficient moisture for germination of the young plants. Due to the fact, that okra has considerably hard germination, 2-3 seeds should be sown at each allocated spot. After emergence, the extra plants are picked up, and if there are spots without emerging plants, the picked-up seedlings are replanted there.

The sowing of stratified seeds strongly contributes to the growing of uniform and healthy plants. The inter-row spacing and the spacing between the plants are the same, as well as the depth of sowing.

Stratification is carried out in 40 cm high wooden boxes. The seeds are mixed with sand at ratio 1:4. The sand should be with larger grains and have good drainage capacity. Sand with even lager grains than the one used for mixing with the seeds is placed at the bottom of the wooden box. Then the mixture of finer sand and seeds is added, and clean sand is placed on the top. The box is watered, avoiding excessive moisturizing. The wooden boxes are kept at the greenhouse where the seeds are to be later sown. Optimal moisture should be maintained, they should be neither too dry, nor excessively watered, for 2-3 days or until sprouting of seeds.

When sprouts emerge, the seeds are carefully taken out and the sand is carefully removed avoiding possible damage on the small sprouts. The germinating seeds are sown entirely manually in spots preliminary allocated according to the system for drip irrigation. Immediately after sowing the seeds are watered, especially if the soil is dry, in order to avoid damage of the sprouts and to ensure optimal environment for the development of the young plants. All sterile seeds are removed prior to sowing.

3.2. Sowing dates

The sowing dates are determined by the high requirements of okra to temperature and light and dark regime. Under greenhouse conditions, the soil temperatures becomes optimal for emergence of okra as early as the end of March and the beginning of April. On the other hand, the light and dark regime at that time still does not allow sowing since okra is a plant of the short day. In this respect, the following sowing dates can be envisaged under greenhouse conditions:

3.2.1. Early dates

The early dates are from mid-April to the beginning of May. Under greenhouse conditions, the temperature is suitable for germination of the plants and there is practically no danger of frosts. In ventilated greenhouses, the mean diurnal temperature should be monitored, and in the evening and night hours in particular, the greenhouse should be closed to prevent cooling.

3.2.2. Optimal dates

These dates are from the beginning to the middle of May. They are actually most suitable for growing okra in Bulgaria, because the young plants suffer less from the later heat waves at the end of the summer. There are no significant regulations for the temperature regime of the greenhouse, though the temperatures should not exceed the biological maximum of the crop. Too high temperatures in combination with high humidity allow the occurrence of powdery mildew.

3.2.3. Late dates

The late dates are after mid-May. Under greenhouse conditions, this is too late, because the soil temperature increases too much, especially during the daytime. The plants will develop later and possibly suffer from late summer heat waves. Furthermore, if the air temperatures and humidity are too high and there are long periods of sunshine, the plants become more susceptible to powdery mildew and aphid attacks.

3.3. Sowing depth

The depth of sowing depends primarily on the irrigation options, on the type of irrigation and the pre-sowing tillage of soil. If there is available irrigation, there is practically no serious risk of drying of the upper soil layer thus endangering the plants; therefore, the seeds can be sown at lower depth.

When using drip irrigation, however, sowing should be deeper, so that drops do not fall directly on the internode from the root to the stem, which is a rather sensitive zone, that can become an entrance point for attacks by sclerotinia root rot. Sowing deeper than 8 cm is not recommendable in okra, because the germs are extremely tender and may not sprout properly. Furthermore, if the sowing is deep, the germ elongation becomes a prerequisite for susceptibility of the plant to pathogens and pests.

3.4. Resources necessary for sowing

3.4.1. Energy machines

- Energy machines are not needed for greenhouse sowing.

3.4.2. Attached equipment

- A planter or other attachable equipment are not necessary for greenhouse sowing.

3.4.3. Labor resources

- Considerable labor resources are needed, since the process of sowing this crop in a greenhouse is entirely manual. At least three agricultural workers are needed to work in a 100 m^2 greenhouse. The workers have to be qualified for growing of okra, for stratification of seeds and for working with drip irrigation systems.

3.5. Compaction

Compaction is recommendable after sowing of okra when performed on a cultivated area to ensure optimal contact of the seeds with the soil. If, however, the pre-sowing soil tillage was rototilling and if drip irrigation is used for sowing, compaction is not needed. The soil after rototilling is much more loose and if compacted, would become too dense. On the other hand, compaction is actually impossible if there is a drip irrigation system installed in the greenhouse, because the seeds are close to the hose down the soil profile. Even if there is a possibility for manual compaction, this operation is unnecessary.

4. Cares during the vegetative growth

Okra is a comparatively undemanding crop with regard to cares during the vegetative growth of the plants. The main requirements are related to avoidance of weed infestation, proper and timely irrigation and providing sufficient nutrients in soil. In this respect, there are certain differences depending on the used system of agriculture.

4.1. Under organic agriculture system

4.1.1. Fertilization during vegetation

The fertilization during vegetation under conditions of organic agriculture, similar to primary fertilization, should be done exclusively with organic products, not allowing incorporation of synthetic and mineral fertilizers. Okra is responsive to nitrogen fertilization during its vegetative growth and therefore it is possible to incorporate organic fertilizers with high nitrogen content. Most of the organic nitrogen fertilizers, however, should be applied with the primary fertilization – compost or manure. The nitrogen fertilization within a system of organic production is possible again with lombricompost or well-rotted manure.

Nevertheless, such types of nutrition are to be undertaken very carefully and only if necessary, since manure in particular may cause improper plant development. Nitrogen fertilization during the vegetative growth can be corrected with foliar bio products as well. It should be emphasized that under conditions of organic production, nitrogen fertilziation should be provided with the primary fertilization prior to deep plowing rather than during the vegetative growth of plants.

4.1.2. Plant protection

The same rules apply for plant protection under a system of organic production as for the use of fertilizers: only organic products are to be applied. No synthetic pesticides for plant protection are allowed, with the exception of mineral sulfur and Bordeaux mixture. In this respect, the efficient plant protection is related not to treatment with chemicals but rather to the observance of good plant protection practices when growing the crop.

The control of weed infestation in okra, particularly under greenhouse conditions, is carried out by manual hoeing or by a power tiller. In practice, since okra is grown under irrigation conditions, all late spring weeds, and the perennial rootstock and rhizomatous weeds are a serious challenge to the growing of the crop. Especially dangerous are field bindweed, creeping thistle, birthwort, blackberry and Johnson grass among the perennial weeds, and white goosefoot, galynsoga, the amaranth species, common knotgrass and duckweed among the annual weeds. They develop extremely fast under high temperatures and humidity, form abundant biomass and if not controlled, may be heavy competition for the okra plants. In this respect, the frequent weeding and hoeing are highly efficient for their control.

When applying lombricompost or manure, particularly as a variant of fertilization during vegetation and for soil structuring, it is important the two types of fertilizers to be free from weed seeds. At the same time, when performing all operations related to soil tillage, the equipment should be cleaned, because the soil, which may stick to the surface of the equipment is a potential source of weed seeds or parts of rootstocks or rhizomes, which can easily be carried to the greenhouse.

A significant stage of the plant protection process is following the dynamics and distribution of the pests. When growing okra, as early as the emergence and at the initial phases of the plants development, highly important are the omnivorous pests – mole cricket, crickets, wireworms, cutworms (caterpillars of the Noctuidae species), and white worms (larvae of common cockchafer, April beetle and some similar species). Their management is extremely difficult and mainly control of the weed vegetation, which allows these pests to develop, is required, as well and proper and timely primary tillage of soil.

Important pests are also the aphids and cicadae, which besides the damages they inflict by sucking sap from stems and leaves, also transfer viral and phytoplasma diseases. Their control is difficult without chemical plant protection. Treatment with bio insecticides based on pyrethrum and azadirachtin is possible, and also the use of sticky traps (on small areas) and sowing of coulisse plants.

Among the pathogens on okra, most important are powdery mildew and sclerotinia.

Powdery mildew is a particularly harmful pathogen under greenhouse conditions due to the combination of temperature and humidity most favorable for optimal development of the pathogen. Application of sulfur is also an option, although it should be done prior to the fruiting of the crop.

Concerning sclerotinia, the occurrence of sclerotia in certain plants, especially in the previous crop, should be monitored. The good phytosanitary condition of the soil is the primary means for control of this pathogen. Among the methods for control under greenhouse conditions, especially efficient is the method of solarisation. After harvesting of the crop, the soil is watered abundantly, then it is covered with polyethylene, and the greenhouse is closed. It is desirable to undertake solarisation in the months with highest air temperatures and most intensive sunshine.

4.1.3. Irrigation

The irrigation of okra under conditions of organic production should be carried out according to the biological specificity of the crop, the temperature regime of the greenhouse and the used method of irrigation. Highly efficient is the method of drip irrigation since this is one of the ways to save considerable amounts of water. For the installation, special hoses are necessary, which are attached to the main water pipe, connected to the water source. Taps are fitted to the water pipe, which allow certain hoses to be switched on/off the irrigation system. The distance between the hoses is in accordance with the agro technology requirements to the crop (70 cm), and the hoses themselves have drippers every 20 cm. Each hose ends with a stopper, which does not allow the water to escape. The water pipe can be connected to a water source – a reservoir mounted to at least 1 m height to create sufficient pressure for proper and even irrigation.

The reservoir should have capacity allowing at least one watering of the area planned for sowing with okra. It should be painted in a dark color to warm up the water for irrigation to a higher temperature. The irrigation water should be free from any added products (chlorine, lime, fertilizers). Irrigation is done usually in the evening to avoid stressing the plants after high daily temperatures.

4.2. Under conventional growing

4.2.1. Fertilization during vegetation

Since okra is responsive to nitrogen fertilization, the fertilization during vegetation under greenhouse conditions may be done with granulated products, particularly carbamide-containing ones, because the leaf mass of okra is extremely susceptible to solutions with high concentration. When applying such fertilizers, considerable leaf blights are possible, which can reduce the active photosynthetic surface of the plants and cause improper development.

The ammonium nitrate should be applied in several treatments, the total amount of the nitrogen norm depending on the chemical composition of soil. Under greenhouse conditions, the incorporation of the fertilizer should be carried out by qualified workers, who will ensure even distribution of the fertilizer manually, or with the help of a tool for fertilizer application able to regulate the fertilizer norm. The maximum amount of ammonium nitrate to be introduced is 40 kg/da, which has to be applied in at least two treatments – prior to flowering to ensure optimal growth and induce fast fruiting, and after the first picking to elongate as much as possible the duration of fruiting of this crop.

4.2.2. Plant protection

The problems occurring during the growing of okra by the organic method do not differ from the growing under conventional cultivation. The only difference is in the possibility to control the pathogens, pests and weeds by plant protection products. In this respect, much more efficient is the control of aphids, cicadae and powdery mildew, since certain pesticides allow short quarantines and treatment even during fruiting.

Chemical control of weeds is not recommended, except in cases of infestation with cereal weeds, because the products for broadleaf weeds may cause improper plant development.

4.2.3. Irrigation

Irrigation under conventional growing of okra does not significantly differ from irrigation under organic production. The only difference is that by irrigation different products may be introduced, especially such with rich microelements composition.

5. Picking

Picking of okra begins with the formation of the first fruits on the plants. Under greenhouse conditions, this is from mid-June to the beginning of July, depending on the exact time of sowing and the cultivars used. Picking begins when the first fruits reach length of 4-6 cm. Initially the fruits are picked every day, and later the frequency slows down. Picking is entirely manual, by cutting the fruits, not by plucking them off in order not to damage a branch or the entire plant.

Fruits bigger than the above length should not be left on the plant, because they accumulate large amount of fiber and lose their quality, and also due to the fact that the old fruit sets hinder the growth of new ones and do not allow the formation of new flowers. If properly exploited, the okra crop can give fruits for more than two months.

II. Growing under field conditions

1. Pre-sowing soil preparation

The soil preparation under field and under greenhouse conditions are equally important. Under field conditions, the soil tillage system is similar, although some specificity is observed:

1.1. Stages of soil preparation

1.1.1. Deep plowing or other tillage with inverting of the layer

The way of soil tillage is the same, but under field conditions a considerably more powerful tractor with a larger plow can be used, since there are no restrictions to size. It is also important to monitor the meteorological situation and to coordinate deep plowing according to the rainfalls and the condition of the soil.

Deep plowing should not be undertaken in wet soil because this will lead to low-quality tillage; the tractor and the plow can also be damaged.

1.1.2. Cultivating

Cultivating is a process preferable to rototilling under field conditions, especially as a first tillage after plowing. It does not significantly differ from cultivating in a greenhouse, except that larger tractor and cultivator can be used, with greater working width. For sowing of okra, however, cultivating cannot be independent, especially of heavy soils; it should be combined with rototilling, or a compactor with specialized working parts should be used, allowing the so-called garden-type tillage of soil.

1.1.3. Harrowing

Harrowing under field conditions is combined with cultivating, and when using a compactor, it is not applied as a tillage.

1.1.4. Rototilling

Rototilling, as a part of the pre-sowing preparation of soil for okra does not differ significantly from the soil preparation under greenhouse production. The only difference is that it should take into account the meteorological conditions.

1.1.6. Soil tillage system for implementation of the experiment

When choosing the pre-sowing tillage for this experiment, significant were the current status of the soil and the available plant residues. The high amount of plant residues, especially from later previous crops, require undertaking of quality deep plowing at higher depth.

If the soil is treaded and compact, the performance of quality deep plowing requires a considerably more powerful energy machine and a plow with a smaller number of plow bodies.

For the scale of this experiment, a tractor of 150 h.p. equipped with a plow with maximum three plow bodies is sufficient.

If the amount of moisture in soil is high, usually after heavy rainfalls, plowing should be undertaken when the amount of soil moisture is such, that when squeezing a handful of soil, a mud ball should not be formed, but rather remain loose.

The cleaning of the working parts of the plow and ensuring equal depth of plowing in the field are identical to the operations carried out under greenhouse conditions.

After overwintering, the plowed area should be rototilled at the place where the experiment is to be carried out.

1.2. Resources for pre-sowing soil tillage

1.2.1. Energy machines

- A 150 h.p. tractor, to which a common plow with up to three plow bodies can be attached.

1.2.2. Attached equipment

- A plow able to perform tillage to depth of 35 cm, with up to 3 angular adjustable bodies allowing better inverting of the soil layer.

1.2.3. Labor resources

- To perform primary tillage of soil, one agricultural mechanic is needed, who has the necessary qualifications and skills to manage a tractor with the respective equipment. He should be able to regulate both the depth and the angle of attack of the plow to ensure even plowing.

1.3. Dates for primary soil tillage

The dates for primary soil tillage do not differ from the dates under conditions of greenhouse growing.

1.4. Dates for pre-sowing soil tillage

The dates for pre-sowing soil tillage do not differ significantly from those under greenhouse conditions. It should be borne in mind, that due to the later sowing of okra under field conditions, the dates should be according to this specificity.

1.5. Resources for pre-sowing soil tillage

1.5.1. Energy machines

- A 100 h.p. tractor, to which an operational rototiller can be attached.

1.5.2. Attached equipment

- An active rototiller with width no less than 1.5 m.

1.5.3. Labor resources

- To perform pre-sowing tillage of soil, one agricultural mechanic is needed, who has the necessary qualifications and skills to manage a tractor with the respective equipment. He should be able to attach the rototiller to the tractor and to regulate the depth of tillage.

2. Primary fertilization

2.1. Within the system of organic agriculture

The norm and dates of primary fertilization do not differ from primary fertilization under greenhouse conditions. Under field conditions, however, the incorporation of both lombricompost and manure may be mechanized, using a manure spreader trailer for larger areas that are to be fertilized. On smaller areas, however, the spreading of manure is done by the method applied in greenhouse.

2.2. Under conventional growing

The norm and dates under this method also do not differ from primary fertilization under greenhouse conditions. In this case, too, similar to organic production, the mineral fertilizers for larger areas, if granulated, may be spread by a conventional spreader attached to a tractor. In smaller crops, the fertilizer spreading is manual or through a hand tool for fertilizer application.

3. Sowing

3.1. Ways of sowing

Besides the manual way used for growing okra in a greenhouse, sowing under field conditions is possible by a seed drill for row crops. In this case, the requirements for both inter-row spacing and spacing between the plants will be observed. On smaller areas, however, mechanized sowing will not be efficient. Mechanized sowing cannot be used with stratified seeds. If drip irrigation is applied, mechanized sowing has to ensure straight rows and extremely precise sowing at certain distance. In this case, a planter for precise dotted-pattern sowing is needed, which is a rather expensive equipment that will be cost-ineffective on small areas.

3.2. Sowing dates

The sowing dates are determined by the high requirements of okra to temperature and light-dark regime. Under field conditions, the soil temperatures becomes optimal as late as the beginning of May. In this respect, the following sowing dates can be planned:

3.2.1. Early dates

The early dates are mid-April to the beginning of May. Under field conditions, the temperature is suitable for emergence of the plants, but there is a considerable risk of frosts in this period.

3.2.2. Optimal dates

These dates are from the beginning to mid-May. In practice, this is the most suitable period for sowing of okra on the territory of Bulgaria, because the young plants suffer less from the later heats at the end of the summer. The danger of frosts is no longer present and okra develops comparatively fast after emergence.

3.2.3. Late dates

The late dates are from the middle to the end of May. Under field conditions, this is not too late, but the actual possibility for longer fruiting of the plants is reduced, because the air temperatures at the end of the summer are too high during the day. The plants will develop later and may suffer from the late summer heats.

3.3. Depth of sowing

The sowing depth under field conditions does not differ from the depth under greenhouse conditions. In mechanized sowing, however, the depth is more even, as compared to manual sowing.

3.4. Resources necessary for sowing

3.4.1. Energy machines

- On larger areas, a 100 h.p. tractor is needed, to which a seed drill for row crops can be attached. The tractor should have a power take-off shaft.

3.4.2. Attached equipment

- For mechanized sowing, a planter for row crops with working width up to 6 rows with 0.7 m interspacing is needed.

3.4.3. Labor resources

- Considerable resources are needed, since the process of sowing may be entirely manual, although carried out under field conditions. At least three agricultural workers are needed to work on a 100 m^2 plot. The workers have to be qualified for growing of okra, for stratification of seeds and for working with drip irrigation system.

- For mechanized sowing, one agricultural mechanic is needed, who has the necessary qualification and skills to manage a tractor with the respective equipment. He should be able to regulate both the depth and the sowing norm.

- If the mechanic is not able to load the planter, one more worker is needed to help with the loading. He should also monitor the amount of seeds in the seed drill.

3.5. Compaction

Compaction is recommendable for sowing of okra when undertaken on cultivated area to ensure optimal contact of the seeds with the soil. After rototilling as a pre-sowing tillage and when using drip irrigation, however, compaction is not necessary. After mechanized sowing, and if there is no drip irrigation system already installed, it is advisable to carry out compaction with lighter compactors immediately after the sowing.

4. Cares during the vegetative growth of plants

4.1. Within organic agriculture system

4.1.1. Fertilization during vegetation

The procedure is not different from the one used under greenhouse growing of okra.

4.1.2. Plant protection

The plant protection does not differ from the growing of okra in a greenhouse.

4.1.3. Irrigation

The only difference comes from the possibility to install drip irrigation system after the emergence of the plants.

4.2. By the conventional method

4.2.1. Fertilization during vegetation

Fertilization during vegetation does not differ from the one under greenhouse growing; the only exception is the possibility for mechanized application of granulated fertilizers on large areas.

4.2.2. Plant protection

Plant protection does not differ from the one under greenhouse growing; the only exception is the possibility for mechanized application of the plant protection products on large areas.

4.2.3. Irrigation

The only difference comes from the possibility to install drip irrigation system after the emergence of the plants.

5. Harvesting

Harvesting does not differ from the operation applied in greenhouse, but it starts later due to the later sowing of the crop.

C2. Choice of cultivars

The old landrace Lyaskovska bamya was chosen for this experiment. It is characterized by very good productivity under local (predominantly garden) conditions and very good quality of the plant production. This cultivar has not been tested under greenhouse conditions, nor within organic production system on the territory of Dobrudzha region.

D. Measured parameters

D1. Parameters of soil

Determining the physical and chemical properties of the soil: They are determined by standard methodologies in specialized laboratories. For this purpose, a soil sample is taken, which is to be provided to the respective laboratory. At least 5 samples are taken from each variant from the 0-20 cm profile. The following parameters are determined:

-Fraction composition – sand, clay, organic substances;

-Water resistance of the structural soil units;

-Content of total, ammonium and nitrate nitrogen;

-Content of potassium;

-Content of phosphorus.

The established values of the above parameters allow adequate primary fertilization and fertilization during vegetation.

D2. Parameters of plants

Physiological parameters

- Chlorophyll content. The content of chlorophyll gives valuable information about the current status of the occurrence of photosynthesis in the plants. From this point of view, its monitoring is important for determining if the intensity of the photosynthetic process was different in the two variants. The reading is done with the help of a chlorophyll-meter directly on the leaf area.

The measuring is undertaken during the phenophases of budding, flowering and active fruiting. Thirty random plants are selected from each variant. The measurement is performed on three random leaves from each plant. One reading is done on each leaf. Each reading is filled in a standard Table (Appendix 1).

- Leaf area and leaf area index. The leaf area and leaf area index are another parameter, which gives a realistic picture about the plant’s ability to form its photosynthetic apparatus.

The measurement is done according to a standard method - the length and width of the leaf are multiplied and then a correction is made with a coefficient described in the literary sources.

The data on the length and width of the leaf are filled in a preliminary prepared standard model (Appendix 2). All leaves of 30 random plants from each variant are measured.

The Leaf Area Index (*LAI)* is:

$$LAI = \frac{GLA}{A}$$

, where
GLA is the leaf area of the plants per unit area;
A is crop area.

Based on the preliminary determined number of plants per unit area, the leaf area index is determined through multiplying the mean value of parameter LA obtained from the measurements by the determined mean number of plant per unit area.
The leaf area is determined in three stages – flowering, beginning of fruiting, active fruiting. Thus, it is possible to determine the intensity of biomass accumulation in the leaves and the effective photosynthetic area in the four variants of growing.

-Temperature of the leaf area – it is measured with an infrared thermometer during the periods critical for the growing of the crop: budding, flowering, beginning of fruiting. In each of the stages, the measurement is direct. Thirty permanent spots in the experimental area are allocated for each of the variant of the experiment. Five measurements are made at each spot. A phenophase is considered commenced when 75% of the plants have entered into it.

Each measurement is filled in a standard Table (Appendix 3).

Morpho-physiological parameters

- Plant height. Plant height is an important indicator for accumulation of biomass in the process of growth and development. The measurement is done on 30 random plants from each of the variants. The plant height is the length of the stem from the soil surface to the vegetative shoot apex. To properly determine plant height, the plants should be in upright position when taking the measurement.

The reading is done with the help of a plank preliminary marked with gradings, zero marking corresponding to the surface of the soil and the actual length corresponding to the marking at the vegetative apex.

Each reading is filled in a standard Table (Appendix 4).

- Flowering and fruiting. The duration of flowering and fruiting are important plant characteristics allowing to determine in the separate variants of the greenhouse and field experiments which of the systems ensures highest duration of fruiting.

The two parameters are measured as number of days from the beginning to the end of each phase. The beginning of flowering is when the first flower on the plant opens, and the end is the closing of the last formed flower. The beginning of fruiting is when the first formed fruit is ripe for picking, and the end is the picking of the last fruit, which is mature.

The reading is done on 30 random plants from each variant. The results are filled in a standard Table (Appendix 4).

- Number of fruits per plant. This parameter gives an idea about the productivity potential of the plant. It is determined on 30 random plants from each variant, counting all fruits picked during the fruiting period, which are well-formed, without damages by pathogens and pests.

The results for each plant are filled in a standard Table (Appendix 4).

- Number of flowers (ratio of number of set flowers to number of formed fruits). The parameter gives an idea about the fertility of the plant. It is determined on 30 plants from each variant, counting all flowers formed and open during the flowering phase, which are well-formed and not damaged by pathogens and pests.

The results for each plant are filled in a standard Table (Appendix 4). Fertility is calculated by referring the number of formed fruits to the number of flowers.

- Weight of fruit. These data allow determining the effect of the system of growing on the productivity potential of the plants. It is measured on 30 plants, weighing the fruits picked from each plant.

The results for each plant are filled in a standard Table (Appendix 5).

- Yield. The yield is determined on the entire quantity of fruits picked from each variant. The obtained quantity is divided by the area of the experiment. Separately, all fruits from 30 random plant are weighed, and then the obtained value is multiplied by the number of plants per unit area. Thus, the optimal yield from each variant is calculated.

The results for each plant are filled in a standard Table (Appendix 5).

APPENDIXES

APPENDIX 1. Table for registering the parameter chlorophyll content over phenophases

PROTOCOLE

№………… Date…………

Variant: □ Greenhouse □ Field □ Organic □ Conventional

	Budding			Flowering			Active fruiting		
Leaf	1	2	3	1	2	3	1	2	3
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
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22									
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25									
26									
27									
28									
29									
30									

Responsible person ……………………………………………

APPENDIX 2. Table for registering leaf parameters for calculation of leaf area

PROTOCOLE
№………… Date…………

Variant: □ Greenhouse □ Field □ Organic □ Conventional
Plant №…

Leaf	Leaf 1		Leaf 2		Leaf N	
	L	W	L	W	L	W
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Responsible person …………………………………………

APPENDIX 3. Table for registering leaf area temperature

PROTOCOLE

№………… Date…………

Variant: □ Greenhouse □ Field □ Organic □ Conventional

Location	Budding					Flowering					Beginning of fruiting				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1															
2															
3															
4															
5															
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27															
28															
29															
30															

Responsible person ……………………………………………

Appendix 4. Table for registering some parameters of the tested variants

PROTOCOLE

№………… Date…………

Variant: □ Greenhouse □ Field □ Organic □ Conventional

№	Plant height	Beginning of flowering	End of flowering	Beginning of fruiting	End of fruiting	Number of flowers per plant	Number of fruits per plant
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							

Responsible person ……………………………………………

APPENDIX 5. Table for registering fruit weight and yield in the tested variants

PROTOCOLE

№………… Date…………

Variant: □ Greenhouse □ Field □ Organic □ Conventional

№ of fruit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant N
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
Yield							

Responsible person ……………………………………………

The editor of the material: Dobrudzha Agrarian and Business School (DABS)

Address: Bulgaria, 9300 Dobrich, 3 Bulgaria str.

Phone: +359 58 655 626

E-mail: dabs.projects@gmail.com

Website: www.dabu-edu.org

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