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Black Sea CROSS BORDER COOPERATION

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

Subsidy Contract No. BSB 1135

CROP MODEL

GROWING OF **TRITICALE**

BY THE NO-TILL METHOD VS. CONVENTIONAL GROWING

Common borders. Common solutions.

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GROWING OF TRITICALE BY THE NO-TILL METHOD VS. CONVENTIONAL GROWING

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

Under constantly changing climate and locally specific meteorological conditions, the proper choice of a crop that would express resistant nature in a variety of locations is of key importance for optimal productivity and economic efficiency. At the same time, the ever-growing population increases the demand for high-quality food and forage resources.

In this respect, one way of achieving highly efficient production is to grow crops, which, on the one hand, have various applications as resources, and are, on the other hand, resistant to a wide range of stress factors and need comparatively low input of energy, plant protection products and fertilizers. One such plant that can completely meet these requirements is triticale.

Triticale is the first cereal crop that is entirely the product of human activity. Although the initial idea was to develop a hybrid between wheat and rye, at the contemporary stage of the crop development, triticale can be described as a separate biological species possessing traits entirely different from its initial parental forms. The modern hexaploid triticale cultivars are characterized by exceptionally high productivity of grain, which can reach over 1200 kg/da. Such figures are significantly higher than the yield from common winter wheat and come close to the yields obtained from maize. Since these yields are obtained with considerably lower input than in wheat and maize, this is an indication of the high production efficiency of triticale as a cultivated plant. However, triticale is of limited production in modern agriculture. This crop is not traditional neither for Bulgaria nor for Dobrudzha region in spite of its good food and forage properties. Triticale remains a crop neglected by the farmers and the processors of raw materials since the consumer demands are low and its marketing as a grain resource is underdeveloped.

A significant trait of triticale is its high applicability for diversification of the traditional production of cereals. Various pastry products can be made from triticale, including high-quality bread in spite of the lower gluten quantity. Furthermore, triticale has considerably higher amounts of fibers, protein, and easily digestible carbohydrates and arabinoxylans, which make it a better dietetic food than wheat, maize or oat. At the same time, due to the lower content of gluten, the triticale products are suitable food for children and teenagers. High-quality beer can also be made from triticale because malt with very good brewing properties is obtained from the grain of triticale. Since this grain is also rich in carbohydrates, it is suitable for the production of different types of beverages.

The biomass obtained from triticale is characterized by high content of lignin and cellulose, especially at the later stages of the crop development and therefore it can be efficiently used for production of biogas and lignocellulosic bio alcohol. Simultaneously, at the earlier stages of development, high-quality silage and haylage is obtained, which possess high nutrition value for different types of animals. These characteristic, together with the high fodder value of grain, make triticale an indispensable part of the forage crop rotations, especially in the cattle farms. Triticale is digested by the animals much better than rye, although the crop concedes to oat in this respect.

One of the most important practical aspects of the crop is that it can be grown under variable environments. Triticale is characterized by resistance to unfavorable conditions of the environment, which is considerably higher than that of the wheat types and barley, and the crop can be efficiently cultivated on almost all soil types. The contemporary cultivars possess high cold resistance, some of them are more cold-resistant even than rye. This makes triticale suitable for growing in basin areas, and low- and highland mountain regions, where the winter conditions do not allow growing wheat. On the other hand, triticale is more adaptable to dry conditions in comparison to wheat, rye and barley. This is due to its well-developed roots allowing the uptake of moisture and nutrients from the deeper soil layers. Triticale tolerates also high levels of soil acidity, which is toxic to the other cereal plants. In practice, this crop can be grown on almost all soil types, with the exception of the high salinity ones.

Triticale is a crop, which needs less resources in the form of fertilizers and plant protection products. Due to its well-developed roots, it can assimilate nutrients more efficiently. In parallel, it does not need much fertilization because the high fertilization norms lead to excessive development of the leaf mass, the plant becomes susceptible to various diseases and the danger of lodging becomes greater. These unfavorable phenomena strongly reduce its productive potential.

On the other hand, triticale suffers from a comparatively low number of pathogens and pests and competes to a lesser degree with the weeds. Among the pathogens, most important are yellow rust and the different types of Fusarium blight; most important among the pests are the cereal ground beetle and the cereal leaf beetle but only under certain conditions. Among the weeds, most important for this crop are field bindweed and creeping thistle, as well as wild oat, white goosefoot and royal knight’s spur. Nevertheless, the adequate plant protection management allows considerably less treatments with plant protection chemicals.

All of the above characteristics make this crop quite a good choice for the implementation of different forms of smart, environmentally friendly or regenerative agriculture. On the one hand, the lower input of fertilizers and plant protection products means reduced use of agricultural machines and equipment in the triticale fields, which would considerably decrease the carbon footprint of the crop. On the other hand, triticale produces a large amount of biomass indicating that carbon is to a high degree accumulated in it. Using proper agricultural practices, this carbon can be effectively restored in soil in the form of organic matter.

One of the methods allowing the fast restoration in soil of the organic matter from the grown triticale is No-till. This is a method of not using tillage for soil cultivation. Such a technology allows maintaining a comparatively good level of productivity, strongly reducing almost all types of input – fuel, fertilizers, plant protection chemicals, deprecation of equipment and labor.

However, the method has certain disadvantages: significant decrease of the phytosanitary status of the crop in the field, which requires very good plant protection management, over-compaction of the soil and disturbance of its water-air regime, and impossibility to provide optimal nutrition regime for the plants. Such disadvantages are an obstacle to the wide usage of this method for growing of agricultural plants. Nevertheless, its adherents are many.

In triticale, a scientifically based technology for growing the crop by the No-till method, which would take into account the soil and climatic peculiarities of Bulgaria, and Dobrudzha region in particular, has not been developed yet. This poses a great number of questions as to whether the combination of triticale with No-till is suitable, what would be the input of resources, whether this type of production is efficient enough in comparison to the conventional growing, whether the structure of the soil and its physical and chemical properties will be preserved, and whether triticale will respond adequately to such conditions. Finding answers to all these questions justifies the testing of the crop with the aim to determine if the combination of these two resource-saving practices (growing of triticale and No-till) can be applied simultaneously under the soil and climate of Dobrudzha region.

B. Objectives and tasks of the experiment

The main objective of the experiment is to provide high-quality plant raw material with high dietetic and nutrition properties at high level of productivity. At the same time, it is necessary to determine whether triticale can be efficiently grown under conditions of No-till. The main target of such an experiment is diversification of the production of the grain raw materials at high level of efficiency.

The following tasks derive from the above objective:

- To determine whether No-till can be successfully used in growing of triticale under the conditions of Dobrudzha;

- To investigate if No-till is more efficient in comparison to the conventional growing of the crop;

- To find out if the soil maintains most of its physical and chemical properties, which are in accordance with the priorities of regenerative and conservation agriculture.

- To investigate whether triticale maintains its productivity potential under the No-till method;

- To determine if it is cost-effective to grow triticale by the No-till method in comparison to the conventional growing of the crop.

C. Materials and methods

C1. Technology for growing of triticale

I. Growing by the No-till method

1. Preparation of the terrain for sowing

A significant element in the growing of triticale by the No-till method is the proper preparation of the terrain where the crop will be planted. In contrast to the conventional growing, the preparation for sowing does not involve any type of soil tillage since the method is based on the complete exclusion of any operations that involve inverting or loosening of the soil layer. In this case, the preparation of the field consists in management of the plant residues, monitoring the presence of weeds and determining the soil characteristics: density, available soil flora and fauna. These are necessary stages allowing, on the one hand, to specify the exact time for sowing, and on the other – to choose the appropriate working parts of the planter, its weight, etc.

1.1. Plant residues

The different types of plant residues can strongly affect the quality of sowing triticale, especially their density, even distribution on the soil surface and the available moisture in them. Therefore, prior to sowing, a decision has to be made, depending on their specificity, whether they are to be removed from the field or further chopped, cut or compacted with a roller-compactor. If the available plant residues do not allow quality sowing or significantly impede the work of the planter, they should be removed from the field.

The type of plant residue and its moisture content are especially important when deciding when and how to undertake sowing. The plant residues should be either entirely dry or entirely fresh, because under these conditions they are easy to cut by the working parts of the planter. The moist plant residues are considerably more resilient, especially the residues from some weeds, and can cause serious difficulties during sowing.

1.2.1. Plant residues from technical crops

1.2.1.1. Sunflower – most often in the form of stems and heads. They do not significantly impede sowing since they become dry after harvesting and are comparatively easy to break.

1.2.1.2. Beet – completely unsuitable previous crop for the No-till method. The cultivation of beet requires its extraction from soil, which, in itself, is loosening of the soil layer. However, in sowing after this previous crop there will be comparatively little plant residues – mainly stems, leaves and root pieces, which could not hinder the normal operation of the planter.

1.2.1.3. Cotton – after harvesting, whole cotton plants are left in the field, which are rather resilient before drying. Since they could hinder the normal operation of the planter, it is necessary before the planter enters the field, the plants to be either preliminary cut or chopped using different tools, or fell them to the ground using roller-compactor.

1.2.2. Plant residues from cereals

1.2.2.1. Wheat, barley, triticale, rye, oat – their plant residues are most often in the form of stubble or uncut straw, which could not impede the operation of the planter since they are comparatively easy to cut with the disks, even when moist.

1.2.2.2. Maize, sorghum, millet – stems, cobs, wide leaves, panicles, roots, they all leave considerable amounts of residue on the soil surface, which can impede the normal operation of the planter. It is necessary to preliminary chop the plant residues or fell them to the ground by compaction. The harder cobs and the lower stems are more likely to hinder the planter, especially in humid weather. The leaves and upper stems are considerably easier to cut with the planter disks.

1.2.2.3. Rice – stubble and on rare occasions straw; in the rice fields, the wet soil is a serious problem, which, in combination with the straw, can considerably hinder the operation of the planter. A serious problem is also the moist rice straw because it is considerably more resilient than that of the other cereals.

1.2.3. Plant residues from legumes

1.2.3.1. Bean – plant parts, which are not a serious problem for sowing.

1.2.3.2. Soy bean – stems, which are rather easy to chop and break, especially when well ripe.

1.2.4. Plant residues from perennial forage crops

1.2.4.1. Alfalfa, bird's foot trefoil, sainfoin – these crops leave small amounts of plant residue, especially after the last mowing during the vegetative growth. The plants form little biomass, which remains lush until the sowing date for triticale. Therefore, these crops do not leave significant plant residues that could impede the planter's operation.

1.2.4.2. Rye grass species, cat grass, couch grass: similar to legumes, but with extremely strong roots.

1.2.5. Plant residues from essential oil plants

1.2.5.1. Lavender – For proper sowing by the No-till method, the lavender crop should be chopped or mowed down and removed from the field, because the plant residues are hard and extremely resilient when moist. They can considerably affect normal sowing

1.2.5.2. Damask rose – the plant residues should be well chopped, without large pieces, because the branches are rather hard and the disks of the planter, no matter how heavy it is, cannot easily go through these plant residues.

1.2.6. Predominant weed vegetation – weeds form a specific cover on the soil surface. Depending on the type of weeds and their density, the sowing may be rather difficult. The large weeds are a particular problem, because they leave large biomass, and their stems are very resilient: white goosefoot, rough cocklebur, the amaranth species, abutilon, royal knight's spur. A significant problem are also the stems of field bindweed and blackberry when not completely dry.

1.2. Compaction of soil

One of the most serious issues in using the No-till method is the extreme compaction of soil. It deteriorates the proper water-air regime of the plants; it also makes sowing rather difficult. The over-compacted soil, particularly under insufficient moisture, becomes too dense. In soils with heavy clay mechanic composition, this is a particular problem because the dry soil is very hard and the planter's disks are subjected to excessive friction, which quickly wears the working parts of the equipment; on the other hand, the planter is not able to ensure optimal depth and cover the seeds with sufficient soil.

Therefore, in soils genetically predisposed to compaction, it is recommendable to plant as a predecessor a crop or a pre-crop, which has ameliorative properties through its root system. In this respect, a very good predecessor for triticale in such soils are the technical crops with large root volume: sunflower, maize and legumes, which, do not contribute to soil compaction; furthermore, they facilitate the formation of nitrogen reserves in soil. The excessive compaction of soil is a solvable problem if the plant residues are well chopped and spread on the soil surface.

The compaction of the soil is significant for the sowing date of triticale. In the densely compacted soils with low moisture content, sowing should begin when the soil moisture is sufficiently high for the working parts of the planter to ensure optimal sowing depth. On the other hand, the wet soils can also delay sowing because soil units or plant residues or both may stick to the working parts of the planter.

The testing of soil compaction is done by a special tool called penetrometer. It allows determining whether the soil is suitable for normal operation of the planter. The measurement of soil compaction should be done immediately prior to sowing, together with the measurement of soil moisture. In soils with very high compaction and low moisture, sowing should be undertaken when the moisture content increases sufficiently. At low soil compaction and low moisture and high compaction and high moisture, sowing can begin immediately after each measurement. If the compaction is low and moisture is high, it is necessary to wait for the soil to dry, because soil units and plant residues may stick to the planter's working parts.

1.3. Flora and fauna in soil

Soil flora and fauna are highly significant for the proper implementation of the No-till technology. First comes soil micro flora: bacteria, actinomycetes, fungi, yeasts, algae. Then come the representatives of the fauna: different types of worms, myriapoda, larvae of beetles and moths (the so called wireworms, false wireworms, white worms and cutworms). The presence of worms is an indicator of the balance in soil with regard to nutrients and physical properties. The higher the amount of these species in soil, the better the soil's condition is.

In triticale, special attention should be paid to the presence of the larvae and adults of the cereal ground beetle. This is one of the pests with strong damaging effect on the crop. The larvae gnaw and chew the young seedlings and if their density is high, they can destroy large parts of the crop. One of the methods for their control is soil tillage. Since in our method of growing there is no tillage, the pest's density should be monitored constantly, especially immediately prior to sowing. On areas attacked by the cereal ground beetle, triticale should not be sown. Areas with high infestation of some couch grass types should also be avoided because the cereal ground beetle prefers this plant. In this respect, good predecessors are the perennial legumes, the technical crops and the annual legumes.

Another serious danger in this agricultural system are the pathogens of fusarium head blight, basal rot and snow mold – all of them fungi of genus Fusarium. Their development is facilitated by the presence of plant residues, high soil moisture and higher temperatures during the winter period. Therefore, it is especially important to monitor, as far as possible, the occurrence of these pathogens, and also to avoid sowing of triticale, when possible, after previous crop any of the cereals. On areas with extremely high concentration of the pathogens, the seeds should be preliminary treated with suitable fungicides. Very good predecessors for control of various types of fusarium head blight are the technical crops, especially sunflower, the annual and the perennial legumes.

2. Primary fertilization

The primary fertilization, when growing a crop by the No-till method, considerably differs from the fertilization under the conventional technology (see II.2.). A significant difference between the two methods is that when using No-till, it is not possible the preliminary applied fertilizer, mineral or organic, to be incorporated by tillage at a suitable depth. This is particularly valid for phosphorus and potassium fertilizers, which cannot be in practice introduced in soil by spreading on the surface because they will remain there, since they are considerably less mobile than nitrogen. Therefore, the only possibility for phosphorus and potassium storage or primary fertilization is to introduce the fertilizers by a planter together with the sowing itself.

In this case, some peculiarities of such type of fertilization are worth mentioning. The fertilization norms should be considerably lower because the high concentrations (especially of the potassium salts) are not favorable for the proper development of the young plants when in close proximity to the roots. The necessary amount should be introduced in one dose, because there will be no other opportunity for additional application of these elements. The introduction should be timed precisely by soil analysis and if there is no need, this fertilization can be omitted. When using the No-till method, a large amount of plant residues remain in soil, which contain high quantities of phosphorus and potassium; under the effect of the soil microflora, they are gradually mineralized and are released in the soil uptake complex. However, this process is rather slow and therefore additional amounts of these elements are needed.

Concerning nitrogen fertilization, it can be performed during sowing, and also by spreading the fertilizer on the soil surface. However, the precise amount of nitrogen fertilizers that are to be incorporated when growing the crop by the No-till method should be in accordance with the analysis of the sowing area carried out. Since a large amount of plant residues are left in soil and on the soil surface, a great part of the soil nitrogen is used for mineralization of the organic matter. Therefore, nitrogen fertilization should be increased to provide the necessary amounts for the proper development of the plants. This is particularly valid for plant residues, which contain high amounts of cellulose and lignin.

Similar to the conventional technology, the spreading of the nitrogen fertilizers can be done with a standard spreader attached to a tractor. In the No-till method, however, the tractor used for introduction of nitrogen should not be too heavy to avoid additional excessive compaction of the soil. The timing for application of the nitrogen fertilizers depends largely on the pre-winter development of the plants. In triticale, high nitrogen fertilizer norms should not be used in principle, especially in the pre-winter period, because, regardless of the fact that the plants are better developed, their overgrowth before the low winter temperatures can cause greater frost damages in comparison to the less developed plants. One of the most efficient methods for introduction of the necessary amounts of nitrogen, phosphorus and potassium is the use of a variety of combined products, which have different proportions of the three elements. Such products, due to the presence of phosphorus and potassium, should be applied again during the sowing. Therefore, the dates for primary fertilization completely coincide with the sowing dates.

When using the No-till method in crops like triticale, due to the fact that nitrogen fertilization is a specific element of the technology of its growing, the previous crop is of primary importance for the sowing. On the one hand, there is a requirement to increase the fertilizer norm if there are large amounts of plant residue; on the other hand, there is the possibility that the previous crop fixed considerable amounts of nitrogen in soil. Therefore, autumnal fertilization with nitrogen should not be used when sowing triticale after annual (bean, lentil, peas) or perennial leguminous predecessors (alfalfa, bird's foot trefoil, sainfoin). The excessive nitrogen not only in the pre-winter period, but also during the entire vegetative growth of the plants has a negative effect on the crop's productivity. This is due to the stimulation of the greater part of the vegetative development of the plants at the expense of the generative development (formation of grains and grain filling).

3. Sowing

The actual sowing under the No-till method is the most important process with regard to the goals of agricultural production. It relates to the fact that during sowing the seed bed preparation, the primary fertilization and the actual sowing are carried out simultaneously. Therefore, quality sowing should be done according to a precise methodology in accordance with a number of requirements: meteorological conditions, biological specificity of the plant, quality of the sowing material, condition of the soil and available plant residues, biological background of the crop to be grown.

The meteorological requirements prior to sowing by the No-till method differ to some extent from the requirements for conventional sowing. While in conventional agriculture it is desirable to perform sowing at the exact moment when the soil is with specific moisture and the soil surface is dry, in the No-till method it is necessary the soil to be not entirely dry, because, due to its compaction, it is not possible to perform sowing at sufficient depth in dry and compact soil. Nevertheless, soil should not be wet, because, in this case, the plant residues on the surface could not be chopped by the discs of the planter; they will sink under the weight of the machine and will form unsuitable bed for the seeds. In this respect, it is important the moisture content of the plant residues to be comparatively low, which makes them considerably more brittle. Therefore, sowing at high humidity, especially in foggy weather, should be avoided. Since the working parts of the planter for No-till cultivation are much more complex than the working parts of the conventional planter, and sharp disks are heavily relied on to cut the plant residues, any sticking of soil units to the working parts leads to lower quality of sowing. In this respect, sowing at rainfall or immediately after rainfall is not recommended.

The biological peculiarities of triticale are another important element, which determine the specificity of sowing. Since triticale is a winter cereal crop, they determine the specific sowing dates, depth of sowing and the sowing norm.

The quality of the sowing material is also significant. The sowing material should be certified in one of the categories according to the national legislation (pre-basic, basic or certified seeds of first or second propagation). They should, respectively, possess economic value, germinating capacity and purity as stated in the legislation.

The soil condition is one of the peculiarities, by which No-till agriculture differs from the conventional with regard to the requirements for quality sowing of triticale. In No-till, important are the amount of plant residues, their moisture content, moisture in soil and its density, while in the conventional technology for growing of triticale tillage is significant; in this case the surface layer of the soil is not important as long as the above factors allow the formation of a good bed for the seeds and their covering with soil.

The biological background, by its nature, is a totality of all weed species, pathogens and pests, which are economically important for the development of the crop plants and occur or may occur on the territory where the crop is grown. In the cereals, and especially the crops grown by the No-till method, most significant are yellow rust and the cereal ground beetle.

Yellow rust has the ability to survive in the plant residues; therefore, their proper management is highly important for the distribution of the disease. The cereal ground beetle respectively multiplies on territories with compacted soils, available cereal weed vegetation and high amounts of plant residues.

Among the weeds, more important are black bindweed, field bindweed and creeping thistle. However, the greater compaction of the soil allows such weeds as stinking pepperweed, couch-grass and birthworth to propagate on a large scale. Their occurrence on the terrain where triticale is to be grown, cannot hinder sowing, but it is of primary importance to provide detailed information, because this would allow adequate plant protection later on. When using the No-till technology, the extremely high amount of plant residue is by itself a prerequisite for the occurrence of a biological background of both weeds and pathogens and pests. The cultivation without inverting of the plow layer is the reason for the accumulation of a large amount of infection with economically important diseases and pests and therefore under this technology plant protection should be carried out on a much higher level.

3.1. Ways of sowing

The sowing by the No-till method is carried out only with the help of a special No-till planter, or by a standard planter for whole-area cereal crops, to which additional equipment is attached. An obligatory condition for the good sowing of triticale is the planter to have disks, which are sharp enough to cut the plant residues, and are heavy enough to provide pressure for the working parts so that optimal depth of sowing is ensured. Since the sowing is done with a planter, the way of sowing can be described as standard row whole-area crop seeding.

3.2. Sowing dates

The sowing dates for triticale by the No-till method differ from the conventional ones. This relates not to the timing of the dates, but rather to their significance for the triticale crops. The differences are due to the fact, that in this method of sowing there is no preparation of the soil and the actual sowing does not depend on preceding activities (with the exception of removing the plant residues when necessary).

3.2.1. Early dates

The early sowing dates of triticale on the territory of Dobrudzha start from the end of September. Usually this period is not suitable for sowing not only because the month of September is dryer than the rest of the periods when sowing is possible, but also because the plants, which emerge earlier, are prone to significant overgrowth, and can also be attacked by a number of pathogens and pests. The availability, on the other hand, of higher amounts of moisture in soil, due to its higher density and its more difficult drying, allows the emergence of weeds. Although in this method there is no possibility to control the weeds through pre-sowing tillage, at the earlier sowing dates triticale and the weeds develop in parallel, which is a considerable obstacle to the proper development of the crop. At the same time, if the soil is rather dry in this period, it is impossible the planter to operate normally in compacted and dry soil since it cannot ensure the necessary depth of sowing.

3.2.2. Optimal dates

On the territory of Dobrudzha, this period encompasses October and the beginning of November. This time is most suitable for sowing mainly from a biological point of view. This is related to the possibility triticale to develop sufficiently in the pre-winter period, the plants to harden well and over-winter optimally. During this period, the soil contains optimal amounts of moisture, the weeds emerging due to lower temperatures enter dormancy, and the plant residues from the previous crop are already entirely dry. Considering that plant protection against weeds was carried out at the beginning of September, by this time the fields are comparatively clean and actually provide the best conditions for sowing.

3.2.3. Late dates

The late dates for the region of Dobrudzha start a little after the beginning of November and can last up to the beginning of December. In practice, these sowing dates by the No-till method are risky, because the soil is often with higher moisture content, the plant residues, especially in the early hours of the day, are considerably more moist and resilient and the planters have difficulties performing normal operation. Sowing by this method in this period is a compromise, especially in fields, where the predecessor was a crop leaving large amounts of hard plant residues such as sunflower and maize. In contrast, with crops such as bean, soy bean, the perennial legumes and cereal grasses, sowing is considerably easier due to the small amount of plant residues or the fresh perennial plants. Nevertheless, the soil moisture should not be too high to allow efficient coverage of the seeds at optimal depth.

3.2.4. Exceptional dates;

Exceptional can be considered the dates after the beginning of December until mid-February. Within these dates, sowing is still possible, even on experimental areas, but it is related to serious compromises with productivity and plant development. Such dates are acceptable in cases of emergency; the need to sow triticale after the late sowing dates is usually dependent on meteorological extremes not allowing to undertake sowing within earlier dates. Cultivars, which are sown too late, especially if characterized by a certain sensitivity to the photoperiod, may not begin heading and the crops may be completely compromised. Typically of such late dates, the sowing norm is higher to compensate for possible percent of plants which will not manage to head, and for possible freezing of some of them.

3.2.5. Spring sowing dates

Spring sowing dates are acceptable in two cases. The first one is if alternative or spring type of triticale is to be sown. The second one is if the spring sowing is performed not later than the end of February for the winter types of triticale. In this case, there is a high risk, if temperatures are not low, the crop not to develop properly and a great part of the emerging plants not to begin heading at all. Such variants of sowing are an extreme compromise and should be applied only under exceptional circumstances.

3.3. Depth of sowing

The depth of sowing triticale by the No-till method is a significant problem largely dependent on the type of planter, the degree of soil compaction and the type of plant residue spread on the field. Regardless of these factors, the depth the planter should provide is 5-8 cm, which is optimal for the crop. This depth is necessary due to the biological peculiarities of the crop (cf.II.3.3.).

3.4. Resources for sowing

3.4.1. Energy machines

-A 100 h.p. tractor, to which No-till trailed or mounted seed drill for sowing of a whole area crop can be attached. The tractor should have a power take-off shaft, allowing the attachment of a planter with a pneumatic system.

3.4.2. Attached equipment

- No-till planter for sowing of a whole-area crop with working width 3-3.6 m.

3.4.3. Labor resources

- To perform 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 agricultural worker is needed to help with the loading. He should also monitor the amount of seeds in the planter.

3.5. Compaction

Compaction is an important process, which ensures optimal contact of the seeds with the soil under conventional growing of triticale. Under No-till sowing, however, compaction has a rather different function, which is more related to providing optimal operational conditions for the planter. It is optionally possible to attach special compactors to the front-end loader of the tractor (if it has one), or another possibility is the field to be compacted prior to the work of the planter. This allows leveling of the sowing surface, and the plant residue forming a specific cover on soil thus preventing high evaporation. However, this operation is not obligatory, provided that the available plant residue allows normal operation of the No-till planter.

4. Cares during the vegetative growth of plants

The cares during the vegetative growth of plants do not significantly differ from that of conventional growing (cf. II.4.). One of the differences is related to the amount of ammonium nitrate to be introduced at the spring fertilization of the crop. Since a large amount of plant residues are left using this method, in order to provide sufficient nitrogen in soil, it is necessary to increase the norm depending on the quantity of the residues. The greater their amount, the higher the norm should be, because the nitrogen is necessary for their mineralization.

Also, phytosanitary monitoring is obligatory to avoid the possible occurrence and distribution of the cereal ground beetle.

It is necessary to carry out plant protection exclusively directed to the dangerous perennial rootstock weeds due to the possibility of their propagation and distribution on wide areas in the crop.

5. Harvesting

Harvesting also does not differ from the conventional one in triticale. It is possible instead of a common header for harvesting of whole-area cereal crops, to equip the harvester with a stripper-header specialized for harvesting of No-till crops.

II. Conventional growing (referential experiment)

1. Soil preparation prior to sowing

In the conventional growing of triticale, one of the most important stages prior to sowing is the proper, timely, and quality tillage of soil. This relates to the fact that for optimal and timely development and obtaining of optimal yield under this way of growing, the timely tillage is of primary importance. There are numerous cases when, due to improper, untimely or low-quality pre-sowing cultivation, the crops are entirely compromised, and the crop productivity is drastically reduced. In this respect, there are a number of requirements to be fulfilled for precise conventional growing of triticale. The choice of suitable soil tillage before sowing of triticale in the implementation of this experiment depends on multiple factors, which require detailed knowledge on different options.

1.1. Types of soil tillage applicable to conventional growing of triticale

Soil tillage is largely dependent on the type of previous crop, the condition of soil and the weather typical for the location of the experiment. In this respect a series of activities are to be undertaken to provide optimal conditions for sowing and subsequent development of the plants. The following types of soil tillage are possible:

1.1.1. Disking

Disking is one of the most widespread methods for pre-sowing tillage of soil applicable to the conventional way of sowing of triticale. It is usually suitable after previous crops, which remain in the field until late: sunflower, maize, sugar beet, cotton, bean, soy bean, sorghum, millet, etc. It is possible to perform disking also in fields with whole-area crops of predecessors such as wheat, barley, oat or triticale, but in this case there is a real danger the plant residues to remain on the surface thus allowing the propagation of pathogens or biological contamination of the crops.

Disking is done with disk harrows attached to tractors of different power depending on the working width of the machine. Usually, the greater the working width of the disk harrows, the more powerful the tractor should be. The tillage when using disk harrows is usually comparatively shallow: 10-15 cm. This depth is sufficient to provide suitable bed for the seeds and ensure the proper placement and development of the roots of triticale.

It should be emphasized that deeper tillage of soil is not desirable since germination may be considerably delayed, and the long process of emergence is usually endangered by pathogen attacks on the young seedlings or by various type of damage caused by insect pests. On the other hand, soil tillage, which is too shallow, does not form a good bed for the seeds, the placement of the plants is too shallow and the roots do not develop properly. This may cause different damages during the winter period such as freezing and elongation.

1.1.2. Shallow pre-sowing plowing

Pre-sowing plowing is a suitable soil tillage before the sowing of triticale on comparatively rare occasions, usually after predecessors, which are difficult to process, in which disking may not give the necessary results. Pre-sowing plowing is not an independent pre-sowing tillage and is usually accompanied by cultivating, harrowing, cutting or disking. In such previous crops as perennial legumes and cereals (alfalfa, bird's foot trefoil, sainfoin, ryegrass species, cat grass, etc.), and also after permanent essential oil crops, shallow plowing is a preferable practice.

This tillage is usually done at depth 20-25 cm, the main purpose being the plant residues from the above predecessors to remain at the bottom of the furrow, where their subsequent rooting and emergence become impossible. It is done by a common plow attached to a tractor of different power. The tractor need not be very powerful because the lower depth of this tillage in comparison to deep plowing requires less power from the energy machine. This tillage may be applied after the same crop or a whole-area predecessor of another cereal crop. Thus, the plant residues from these crops are buried to a certain depth, which allows the proper development of triticale.

1.1.3. Cultivating

Cultivating is a rare pre-sowing tillage for triticale. It can be usually applied on areas, which were left on fallow and which are comparatively clean from weeds. Cultivating is also possible in areas with shallow pre-sowing plowing, but in this case the working parts of the machine may unearth the buried plant residues and considerably impede the operation of the planter. In areas with higher moisture, when the work of the disc harrow as a tillage tool is hindered and it cannot perform quality disking of the areas, multiple cultivating is possible but only as a compromise alternative of pre-sowing tillage.

This type of tillage is more suitable for spring crops to be sown on areas after deep plowing. It is performed by a cultivator attached to a tractor of different power. There is a variety of cultivators available, with regard to both their construction and to the type, size and purpose of the working parts. Usually, the cultivators for pre-sowing tillage consist of one or two rows of working parts with arrow-shaped and double-edged surface. Cultivating is often combined with simultaneous harrowing to ensure finer soil tillage. The depth of cultivating depends primarily on the soil condition, the previous crop and the meteorological conditions, but is most often within 8-10 cm.

1.1.4. Harrowing

Harrowing is a rare type of pre-sowing soil tillage in the winter cereals such as triticale. Harrowing should be used independently only in light soils, free from weeds, which are not wet and if the amount of the plant residues is small. It is done with tines attached to a tractor. This tillage is rather shallow and is more of a secondary function to level the surface after non-uniform disking; it is used simultaneously with the cultivating.

1.1.5. Rototilling

Rototilling is a pre-sowing tillage applied on small areas; it is not significant for production, since it is rather energy-consuming, slow and requires a lot of resources such as fuel, time and labor. It is done with a horizontal-axis or vertical-axis rototiller. Thus fine, well-structured soil tillage is ensured, which is highly suitable for sowing. It can be done at depth from 10 to 30 cm depending on the working parameters of the rototiller. It is suitable for all types of previous crops, including secondary tillage of plowed areas with perennial fodder and grass species such as alfalfa and the ryegrass species. It is also highly convenient for tillage of small experimental plots, which should be cultivated and leveled to provide uniformity of the soil surface, to mix different fertilizers and chop the available plant residues.

1.1.6. Choosing a method of the experiment

When deciding on the type of pre-sowing tillage for this experiment, the current condition of soil and the available plant residues are highly important. The high amounts of plant residues, especially at the later sowing dates, make disking the only alternative of quality pre-sowing tillage.

On the other hand, before undertaking disking, the meteorological conditions and the soil moisture should be monitored. In case the soil moisture content is high, especially if the amount of plant residues is also high or the weed vegetation is predominant, disking may be rather difficult due to sticking of wet soil particles and plant residues to the working parts of the disk harrow. Cleaning of the working parts in this case is obligatory, since the sticking and layering of soil does not allow the disk harrow to perform uniform tillage. A significant element of the technology of this tillage is to ensure equal depth on the entire area of the experimental field. This is done by measuring the tillage depth at minimum 10 locations of the tilled area by a vertically inserted poker. The depth is determined when the poker stops sinking without pushing it any further. The measurement is done by a ruler or another measuring tool from the tip of the poker to the place at the level of the soil surface.

If the tillage is uneven, it is recommendable to repeat it for levelling. A second tillage is needed also if the weed vegetation cannot be removed and the plant restudies cannot be chopped. The tillage is always to be undertaken diagonally to the sowing of the previous crop so that the plant residues and the weed vegetation can be efficiently chopped and incorporated.

If it is not possible to undertake disking on time, rototilling is optional at the location of the experiment. In this case, the depth of tillage should not exceed 10-12 cm. After rototilling, harrowing with light harrows may be applied to form a more suitable bed for the seeds, but this operation is not mandatory. It should be emphasized that sowing in the rototilled area runs the risk of elongation or freezing of the plants due the large volume and loosening of the soil. Rototilling is performed across the rows of the previous crop for maximal chopping of the plant residues and the weed vegetation.

1.2. Plant residues from the previous crop

The available plant residues can strongly affect the quality tillage of soil prior to sowing. Therefore, before the tillage, a decision has to be made, depending on their specificity, whether they are to be removed from the field or chopped and incorporated during the tillage itself. If the plant residues available after tillage do not allow quality sowing or significantly impede the work of the planter, they should be removed from the field.

1.2.1. Plant residues from technical crops

1.2.1.1. Sunflower – most often in the form of stems and heads. They do not significantly impede tillage and sowing.

1.2.1.2. Beet – available leaves, cut-off scrapes, roots, leaf stalks and beet bodies. If fresh green parts remain in the soil until tillage, they may obstruct the operation of the disk harrow under humid conditions.

1.2.1.3. Cotton – after harvesting, whole cotton plants remain in the field, which should be preliminary removed or chopped.

1.2.2. Plant residues from cereals

1.2.2.1. Wheat, barley, triticale, rye, oat – their plant residues are most often in the form of stubble or uncut straw, which could considerably impede the tillage since they are scattered on the field.

1.2.2.2. Maize, sorghum, millet – stems, cobs, wide leaves, panicles, roots, they all leave considerable amounts of residue on the soil surface, which in most cases requires secondary processing.

1.2.2.3. Rice – stubble and on rare occasions straw; in the rice fields, the wet soil is a serious problem, which, in combination with the straw, can considerably hinder disking and rototilling.

1.2.3. Plant residues from legumes

1.2.3.1. Bean – plant parts, which are not a serious problem for tillage.

1.2.3.2. Soy bean – stems, which are rather easy to chop.

1.2.4. Plant residues from perennial forage crops

1.2.4.1. Alfalfa, bird's foot trefoil, sainfoin – roots, stems, leaves, which are lush and require mandatory plowing before the final pre-sowing tillage.

1.2.4.2. Ryegrass species, cat grass, couch grass: similar to legumes, but with extremely strong roots.

1.2.5. Plant residues from perennial essential oil plants

1.2.5.1. Lavender – stems and roots in small amounts after uprooting of the crops.

1.2.5.2. Damask rose – stems, leaves and roots that must be removed.

1.2.6. Predominant weed vegetation – weeds form a specific cover on the soil surface. Depending on the type of weeds and their density, soil tillage may be rather difficult.

1.3. Dates of pre-sowing tillage

The dates for undertaking this tillage have direct effect on the sowing dates. Therefore, it is very important to predict exactly the time of undertaking soil tillage. The dates of pre-sowing tillage depend on the amount of plant residue, the degree of weed infestation and the dates of fertilizer incorporation.

1.3.1. Early dates.

The early pre-sowing tillage is justifiable only if early sowing is to be carried out. Otherwise, the early tillage runs the risk of secondary weed infestation on the one hand, and on the other – of crust formation due to rainfalls, that would impede sowing. Too early soil tillage requires subsequent secondary tillage thus increasing the resources necessary for fuel. The early soil tillage dates are recommendable only in cases of heavy weed infestation, which is impossible to eliminate with a single tillage and this tillage is necessary to undertake considerably earlier to sowing.

The early dates of tillage may be from mid-August to mid-September.

1.3.2. Optimal dates

The optimal dates of pre-sowing tillage of triticale are usually from mid-September to the end of October, the exact timing being strictly dependent on the meteorological conditions. It is recommendable to perform the tillage once or twice to provide optimal quality of the soil units thus allowing uniform and quality sowing.

1.3.3. Late dates

The late dates of tillage are after mid-October. Usually such tillage is needed after heavy rainfalls in October, which do not allow tillage within the optimal dates. Another possible obstacle is the formation of soil crust after the last tillage following intensive rainfalls, which, with some types of planters, does not allow optimal sowing depth. Therefore, late soil tillage is necessary.

1.3.4. Exceptional dates

The exceptional dates are usually after mid-November and are related to certain circumstances, which impede normal sowing of triticale. Soil tillage can be actually performed by the end of February, provided that there are necessary conditions of the environment, but such sowing is rather risky both with regard to productivity and to the possibility of proper development of the crop during the vegetative growth of the plants.

1.3.5. Spring dates

If there are sufficiently low temperatures that would allow vernalization of triticale, the crop may be sown very early in spring as well. Similar to the exceptional sowing dates, in spring sowing too, there is a considerable risk for productivity. Disking also may be performed early in spring, provided that the weather allows it. It should be emphasized that in most cases the soil after the winter period is characterized by higher moisture content, which would hinder the performance of proper tillage. Therefore, the spring sowing of winter triticale cultivars should be done only in exceptional cases.

1.4. Resources needed for pre-sowing tillage of soil

To carry out the part of the experiment related to sowing of triticale to be grown conventionally, the following materials and labor resources are needed for pre-sowing tillage of soil:

1.4.1. Energy machines

- A tractor with power up to 100 h.p., to which a disc harrow with working width 3.2 m can be attached. The tractor should also have a power take-off shaft allowing the attachment of an active rototiller when necessary.

1.4.2. Attachable equipment

-Disk harrow with working width 3.2 m.

-Active rototiller with working width not less than 1.5 m.

1.*4.3. Labor resources*

- To undertake preliminary soil tillage, an agricultural mechanic is needed, who has the necessary qualification and skills to drive a tractor with the respective farming equipment. He should know how to regulate both the depth and the angle of attack of the disk harrow, and also how to attach and work with the active rototiller.

1.5. Tillage dates

The tillage dates chosen for this experiment are comparatively late, which means careful assessment of the meteorological conditions and taking into consideration the specific soil status immediately prior to the beginning of tillage.

2. Primary fertilization

Fertilization is an important part of the experimental work. This is so because the cultivars selected for growing, were developed against a sufficient background of nutrition elements in the soil and in case of their lack, a certain response of productivity is possible. The primary fertilization as an integral part of the technological process of triticale growing can often be combined with the primary tillage of the field after the previous crop or immediately before undertaking pre-sowing tillage. Nevertheless, it is essential to properly choose the product to be applied.

2.1. Types of fertilizers applied with the primary tillage and fertilizer norms

A standard stage of the technological process under conventional growing of triticale is the application of phosphorus and potassium fertilizers in autumn with the aim to perform not only primary fertilization of the crop but also to carry out fertilizing for maintenance of the mineral reserves in soil. This is related to the accumulation of the two elements of the soil uptake complex and their gradual subsequent release not only during the current vegetative growth of the crop, but also in the next vegetative cycle of the crops in the crop rotation. From this point of view, suitable for this experiment are potassium chloride, which has the task to ensure potassium reserves in soil, and also triple superphosphate, which will ensure the phosphorus necessary for the plants.

There is a considerable number of commercial fertilizer products, which could be incorporated at this stage of the technological processes under the conventional growing of triticale. In spite of that, however, the amount of the applied fertilizer should be in accordance with several major requirements.

First, soil analysis should be carried out to determine to what extent the soil has reserves of the above two elements. It is also necessary to determine the available amount of total ammonium and nitrate nitrogen, which will indicate if nutrition with this element is needed at the stage of pre-sowing soil preparation. It should be borne in mind that the plant residues in the process of their decomposition consume considerable amounts of the nitrogen in soil; therefore, their presence, especially heavy plant and weed residues with high content of lignin and cellulose, decreases the content of nitrogen in soil. Therefore, their presence is an indication for increasing the nitrogen norms even at the stage of pre-sowing preparation. An exceptionally favorable practice is the incorporation of combined fertilizers, which contain, besides phosphorus and potassium, a certain amount of nitrogen as well. It is a common practice to use products for autumn fertilization, which have an equal proportion of the separate elements to the total content in the fertilizer product.

It is essential at this stage, however, the nitrogen norm to be in accordance with the specificity of the growth and development of triticale as a cultivated plant. The high nitrogen norms lead to faster overgrowth of triticale in the winter period, which makes it more susceptible to low temperatures. Therefore, the application of nitrogen in the pre-winter period, either with the pre-sowing soil treatment or subsequently, should be undertaken only if there is a justifiable need of this fertilization based on soil analyses.

2.2. Dates of fertilization

The dates of fertilization with nitrogen and potassium fertilizers almost entirely coincide with the dates of pre-sowing soil tillage. It is recommendable, when using combined fertilizers, which contain phosphorus and potassium, to apply them immediately before soil tillage so that the fertilizer be absorbed in soil but not remain on the surface. When applying separately nitrogen fertilizers, or in combination with phosphorus and potassium, this is an obligatory requirement. The independent fertilization with nitrogen aimed at pre-winter fertilization of triticale should be limited, except if the soils are very poor. In this case, it should be undertaken after the plants have formed at least one additional tiller.

2.3. Ways of applying the fertilizer

The application of fertilizers prior to soil tillage, especially if they are granulated, has to be done with a standard spreader attached to a tractor. Since the primary pre-sowing tillage is disking of the field (or rototilling), other methods of fertilizer incorporation (immediately before sowing, fertilizer incorporation by planter) are not recommended. This relates to the fact that triticale is sown as a whole-area crop and it is desirable to spread the fertilizer norm as good as possible on the soil surface, and subsequently distribute it well down the soil profile through the soil tillage. The incorporation of nitrogen fertilizers by a planter during the sowing is not desirable, especially at the late sowing dates, because the dissolving of the nitrogen fertilizer decreases the soil temperature, and the higher salt concentration close to the young seedlings is a significant stress that can impede their development.

3. Sowing

Performing quality sowing is practically the most important activity for achieving the original objectives of agricultural production. Therefore, the quality sowing should be carried out according to a precise methodology in accordance with a number of requirements – meteorological conditions, biological specificity of the plant, quality of the planting material, condition of the soil, biological background for growing of the crop.

The meteorological conditions are a rather complex whole comprising of meteorological elements, which are important for the quality sowing. Firstly, sowing should be undertaken in a period without rainfalls. Sowing during rain or snowfall should be avoided at all cost due to the following considerations: As a result from the rainfalls the soil becomes wet, subsequently aggregates of soil or soil mixed with plant residues are formed, which stick to the working parts of the planter. With certain types of planters, the seeds may be aggregated in such type of a complex whole leading to uneven crop with empty rows. The working parts of the planter may be blocked and spots or entire areas in the field may remain without planted seeds. Furthermore, the planter drop tubes may by blocked with unsown seeds thus causing losses of planting material, which may remain spread on the surface of the soil.

Due to the above reasons, sowing should be undertaken in a sunny day, the air temperature and the wind speed should be appropriate to keep the soil surface comparatively dry even if dew or frost occur. Another highly important aspect is the avoidance of sowing in low visibility due to fog. On the one hand, this low visibility disturbs the proper sowing trajectory (except for precise sowing navigated by geo location); it also does not allow uniformity of the sowing, and can lead to rather large areas with double sowing, or to areas without any sowing at all. On the other hand, the available fog is accompanied by high humidity, which causes condensation on the planter and the working parts. Soil may stick to the working parts leading to the technical difficulties described above, and if moisture comes in contact with the seeds, they may stick to metal surfaces.

The biological peculiarities of triticale are another important aspect determining the specificity of sowing. Since triticale is a winter cereal crop, they determine the specific dates, depth and norm of sowing.

The quality of the sowing material is also significant. The sowing material should be certified in one of the categories according to the national legislation (pre-basic, basic or certified seeds of first or second propagation). They should, respectively, possess economic value, germinating capacity and purity as stated in the legislation.

The condition of the soil is probably one of the most important peculiarities for performing quality sowing of triticale. The primary soil tillage should have provided depth of at least 10-12 cm, a suitable bed for the seeds, and soil units of predominant size up to 3 cm. The too large soil units do not allow good contact of the seeds with the soil, and cause premature perishing of the young seedlings because the roots fall in large air pockets and cannot feed the young plant. Vice versa, the too small soil units, especially in the heavier soils and at high content of soil moisture cause over-compaction of the crop, and hence lead to reduced intensity of transpiration of the young plants and their hindered subsequent development.

In this respect, the soil moisture during sowing should be optimal – the soil should be neither too dry, nor wet. At the same time, the soil moisture should be evenly distributed. The too dry soil causes excessively long dormancy of the seeds and possible attacks by pathogens and pests. Therefore sowing at very low soil moisture should be avoided. On the other hand, uneven moisture on the surface should also be avoided because the seeds will germinate faster in the moist spots and the plants there will develop before those planted in dry spots.

The biological background is often underestimated as a specific feature of a given region or field of growing. It is the totality of all weed species, pathogens and pests, which occur or have occurred there and are economically important for the development of the cultivated plant to be sown. In this respect, triticale is characterized as comparatively undemanding to the biological background, because a comparatively small number of weeds, pathogens and pests relate to its development.

It should be noted, that among the pests pointed out, most important are the yellow rust, the Sunn pest and the cereal leaf beetle. Among the weeds, more important are the black bindweed, the field bindweed and the creeping thistle. Their presence on the terrain where triticale will be grown is not an obstacle for the sowing, but it is highly important to provide detailed information for their occurrence because it will allow further adequate plant protection.

3.1. Ways of sowing

In this experiment, the way of sowing is one of the factors, which distinguish the two models. In this respect, the only way of sowing that can be applied with the aim to obtain adequate information from the model is the standard sowing in rows. In extreme situations, broadcast seeding is acceptable but it will give inaccurate data, although the further development of the plants will be similar.

3.2. Sowing dates

The sowing dates are important from a biological point of view, because in all cereal plants, including triticale, the differences in the timing of sowing influence productivity. In this respect, several possible variants of sowing of triticale can be considered, although some of them are applicable only in extreme situations, when the above requirements to the implementation of sowing cannot be adequately met.

3.2.1. Early dates

The early dates of sowing are between mid-September and the end of the same month, particularly for the triticale cultivars distributed in Bulgaria. Earlier sowing is not recommendable due to several reasons. Usually, on the territory of Dobrudzha this period is comparatively dry and therefore the soil is also over-dried in spite of the applied tillage. On the other hand, tillage under such conditions is often the reason for the formation of dry and wet spots in the field, which is definitely unacceptable, especially when carrying out a referential experiment. From a biological point of view, when sufficient moisture is available, the triticale plants sown within these dates would develop too early, under certain conditions they could also over-grow and suffer different types of damage under the winter conditions. At the same time, the earlier sowing facilitates autumn weed infestation and increases the population of pest flies and aphids. The early crops also turn into reservoirs of yellow rust, which causes considerable problems in the susceptible varieties in late spring, especially if the air temperatures are high.

3.2.2. Optimal dates

For the territory of Dobrudzha, this period encompasses October and the beginning of November. This time is the most suitable for undertaking sowing, primarily from a biological point of view. It gives the opportunity triticale to develop sufficiently in the pre-winter period, the plants to harden well and have optimal over-wintering. It should be emphasized that we should not wait for the maximum combination of all the optimal conditions mentioned above; however, it is important that the soil and the weather allow normal operation of the planter.

3.2.3. Late dates

The late dates for Dobrudzha region are several days after the beginning of November up to the beginning of December. These dates are nevertheless acceptable from the point of view of favorable meteorological conditions and ensuring of soil tillage, which is good enough for sowing. The major issue with the late dates is the lower tillering of the plants in the pre-winter period, which implies higher sowing norms to provide a certain number of germinating seeds per m^2. On the other hand, the later dates do not allow the pathogens, pests and weeds to develop until the pre-winter period thus facilitating the phytosanitary condition of the crop.

3.2.4. Exceptional dates

Exceptional can be considered the dates after the beginning of December to mid-February. Within these dates, sowing can still be undertaken, even on experimental areas, but it is related to a serious compromise with the productivity and the possibility for development of the plants. Such dates are acceptable if it is actually impossible to sow triticale within the late sowing dates and are usually related to specific meteorological conditions not allowing timely soil tillage. The cultivars, which are sown too late, especially if characterized by a certain susceptibility to the photoperiod, may not start heading thus entirely compromising the crop. In these dates, the sowing norm is typically much higher to compensate for a certain percent of plants that could not start heading and those that could freeze.

3.2.5. Spring dates

Spring sowing dates are acceptable in two cases. The first one is if alternative or spring type of triticale is to be sown. The second one is if the spring sowing is performed not later than the end of February for the winter types of triticale. In this case, there is a high risk, if temperatures are not low, the crop not to develop properly and a great part of the emerging plants not to begin heading at all. Such variants of sowing are an extreme compromise and should be applied only under exceptional circumstances.

3.3. Depth of sowing

The depth of sowing in triticale is an important element from the crop's agro technology, which should not be underestimated. Most planters are adapted for sowing at depth 5-8 cm, which is standard for the crop. However, the depth of sowing is highly dependent on the quality of the soil tillage that has been carried out. There are certain requirements to the sowing depth. At shallow placing of the seeds, the emergence, provided that the other conditions for growth and development are available, is comparatively faster in comparison to the seeds planted deeper. In this case, however, the roots are formed at lower depth and subsequently the plant may suffer from the lower temperatures during the winter period and later from probable droughts during the vegetative growth.

Furthermore, the surface soil layer dries faster and therefore the seeds with shallower placement can emerge more quickly, and then the seedlings may perish if their roots cannot reach soil with sufficient moisture. On the other hand, too deep sowing is not preferable, too. The plants will be with slow emergence. This exposes the young seedlings to risks of damage by pathogens and pests. Additionally, if the seeds are placed deeper in soil, the plants may be cut from the roots as a result from freeze-thaw stress.

3.4. Resources for sowing

3.4.1. Energy machines

-A 100 h.p. tractor, to which No-till trailed or mounted seed drill for sowing of a whole-area crop can be attached. The tractor should have a power take-off shaft, allowing the aggregation of a planter with a pneumatic system.

3.4.2. Attached equipment

- Planter for sowing of a whole-area crop with working width 3-3.6 m.

- Cambridge type compactors or other-type compactors, which are not smooth.

3.4.3. Labor resources

- To perform 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, another agricultural worker should be available to help with the loading. He should also monitor the amount of seeds in the planter.

3.5. Compaction

Compaction is the final operation from the sowing process of the whole-area crops and is especially important for those crops, which are with small-sized seeds. Triticale belongs to the group of the so-called small-grain cereals and therefore compaction is one of the recommendable processes for ensuring maximum contact of the seeds with the soil. Compaction may be omitted but in such case, processes of plant elongation may be observed during the winter period. On the other hand, compaction ensures more uniform emergence and better distribution and density of the plants in the crop.

There are also cases in which compaction is not a recommendable post-sowing operation. After rainfall immediately after sowing, soil units and seeds may stick to the rollers due to the soil moisture thus leading to spots on the soil surface, which are not seeded. Compaction of heavy and clay soils is also not recommendable, as well as of wet soils, because the normal air regime of the soil is disturbed.

4. Cares during the vegetative growth of the plants

4.1. Spring fertilization

The spring fertilization of triticale is carried out according to the condition of the crops, the previous crop, and the amount, type and timing of the primary fertilization. Usually, triticale is fertilized with nitrogen fertilizer in spring and the introduction of the entire norm with a single treatment is a common practice. This is an improper practice, regardless of the low norms used for triticale. It will be more appropriate to divide the fertilizer norm at least in two treatments that are to be applied 20 days apart from each other. Thus, the applied form of nitrogen will be assimilated easier not only by the plants but also by the soil, and it will not stress the plant organism. The recommendable norm for fertilization is 3-5 kg/da a.m. nitrogen, which is equal to 10-18 kg/da ammonium nitrate. Triticale assimilates well this type of fertilizer and it is not necessary to resort to other forms.

However, some farmers prefer carbamide, or a combination of carbamide and ammonium nitrate in a liquid form. For this experiment, fertilization with such products is not necessary, because they are comparatively rarely used on triticale and their application has additional specificity. Carbamide should be applied up to the moment when the air temperature is low enough, which leaves a very short time slot. Carbamide application in warmer weather is not desirable because a great part of the active matter is lost under the effect of higher temperature. In this case ammonium nitrate is more suitable, because the time slot is not that short (its application may be in accordance with the so-called Nitrates Directive), and it can also be used in a referential experiment.

Ammonium nitrate (usually granulated) is applied by a standard spreader in the norm indicated above. The dates for application are on the one hand defined in Council Directive 91/676/EEC: not to introduce nitrogen fertilizers from 1st November to 31st January in field crops. This ultimately defines February 1st as the initial date for spring fertilization of triticale. Nevertheless, it is recommended to undertake fertilization when vegetative growth has started, i.e. the plants should not be in dormancy to assimilate nitrogen more efficiently. Furthermore, nutrition should be carried out under specific meteorological conditions.

Firstly, the weather should not be windy. This is related to the specificity of fertilizer spreading. Fertilization in windy weather causes uneven spreading of the nitrogen fertilizer on the field and considerable differences in certain areas of the crop. Also, fertilization on snow-covered or frozen soil is to be avoided. Although this is a common practice, it is extremely improper, because when the soil defrosts or the snow thaws, the spread fertilizer is distributed rather unevenly in the field. Fertilization at high soil moisture content is not desirable, too, because on the one hand the proper operation of the energy machines is impeded and on the other deep trucks from the machine's wheels are formed, which subsequently are over-compacted and filled with rain water; all these are factors which hinder the proper development of the plants.

Due to the above reasons, fertilization should be undertaken in calm, sunny weather when the soil is sufficiently but not entirely dry, because the soil moisture helps to dissolve the fertilizes. There are highly favorable conditions for this type of activity immediately before rainfall. This, however, is not always easy to predict precisely. The stage for nitrogen fertilizer incorporation is from the beginning of tillering to the beginning of stem extension of the crop. Earlier incorporation is not desirable because the plants are too small and the high nitrogen concentration cannot be properly taken up by the roots. Later application is also not recommendable because the plants form abundant biomass, become more susceptible to drought and pathogens, and it is possible the yield to be reduced.

For spring fertilization, it is necessary to provide an energy machine – a tractor and a standard trailed or mounted spreader. Also, an agricultural mechanic will be needed to drive the tractor, who is also qualified to work with the spreader so that he can administer the fertilizer norm. When necessary, one more agricultural worker should be available to help loading the fertilizers in the spreader.

4.2. Plant protection

Plant protection in triticale is one of the most crop-friendly practices since triticale is genetically not predisposed to a large number of diseases and pests, and its powerful biological development suppresses most of the economically important diseases.

The seeds do not have to be treated with fungicides prior to sowing because the crop is not attacked by the pathogens of the blight species, which are seed-borne. The only danger, which may require seed treatments, is the occurrence and presence of fusarium, although if sowing is within the optimal dates and the crop develops properly, such problems are not observed. During the vegetative growth, triticale suffers from the pathogens of yellow and brown rust; their distribution may vary significantly depending on the conditions of the environment. For protection against both pathogens (yellow and leaf rust), preventive spraying with fungicides is recommended at the occurrence of the first symptoms of yellow rust (occurrence of single sores on the leaves).

Yellow rust spreads very fast, especially if sufficient moisture or rainfalls in combination with high temperatures are available. Usually, its occurrence and mass distribution are in May. The high degree of occurrence may entirely compromise the triticale crop and therefore its control is of key importance. It should be emphasized, that the distribution of the pathogen is permanent and its reoccurrence is possible after the introduced plant protection product expires. This implies that there should be a constant monitoring and measures should be taken as soon as it is detected in the crop.

The pathogen of brown rust in triticale causes comparatively lower damages. This is related to the fact that the cultivars registered in Bulgaria are highly resistant to brown rust. Nevertheless, single sores on the leaves of aging and weak plants may occur in the late stages of the crop's vegetative growth. In this period, the pathogen does not have economic importance. If it occurs earlier, however, on more susceptible triticale cultivars, disease control is done simultaneously with the management of yellow rust.

In more humid years, triticale suffers also from septoriosis, which, however, does not have economic importance for this crop under the soil and climatic conditions of Dobrudzha region. Its distribution should be nevertheless monitored and when it reaches a certain threshold of economic harmfulness, respective control of the pathogen should be undertaken. The high temperatures usually limit its high propagation and it does not have the harmful potential to seriously decrease productivity.

In relation to the control of the pathogens, with the aim to achieve better comparability in the experiment carried out, it is necessary to undertake at least one treatment with a fungicide at heading stage to eliminate the possibility of occurrence of yellow rust and fusarium head blight. The treatment should be done according to the legitimate practices, the good plant protection practices in the cereal crops and the good agricultural practices.

Weed control is a must-do activity even in triticale. In spite of its powerful development and its ability to suppress most of the annual weeds, it is important to undertake adequate protection with chemicals against some groups of weeds. Of high economic importance are creeping thistle and field bindweed among the perennials, and among the annual weeds these are forking larkspur, charlock, wild oat, etc.

Wild oat is a major problem in triticale since it emerges comparatively late and is also a cereal plant. This means that extreme attention should be paid when treating against wild oat and that a stage of triticale development should be chosen, in which minimal damages will be caused to the crop. The respective plant protection product must be registered for use on triticale.

The treatment for the rest of the weeds is usually undertaken early in spring after nutrition, during the active vegetative growth of the weeds and triticale, provided that there is a sufficient level of weed infestation. In practice, the treatment with herbicides is not economically justified (with the exception of the soil herbicides) if there is not sufficient infestation with weeds (except for some rather dangerous ones). When applying the herbicides, the rule to avoid strong wind must be observed since the herbicides will not have a sufficient effect due to their uneven distribution.

In secondary weed infestation, especially during the period of maturation, the occurrence of field bindweed is possible after long rainfalls. In this case, the treatment with system total herbicides must be avoided since their action is slow and they are economically unjustified. A considerably more efficient technique, although a more risky one, is the mowing of the maturing crop and its subsequent harvesting with a pick-up header. If the conditions of the environment are good, a slight increase of yield is possible in this case. Using such a practice, the field bindweed and other available weeds dry out without forming viable seeds, provided that the mowing was done at the beginning of the flowering of weeds.

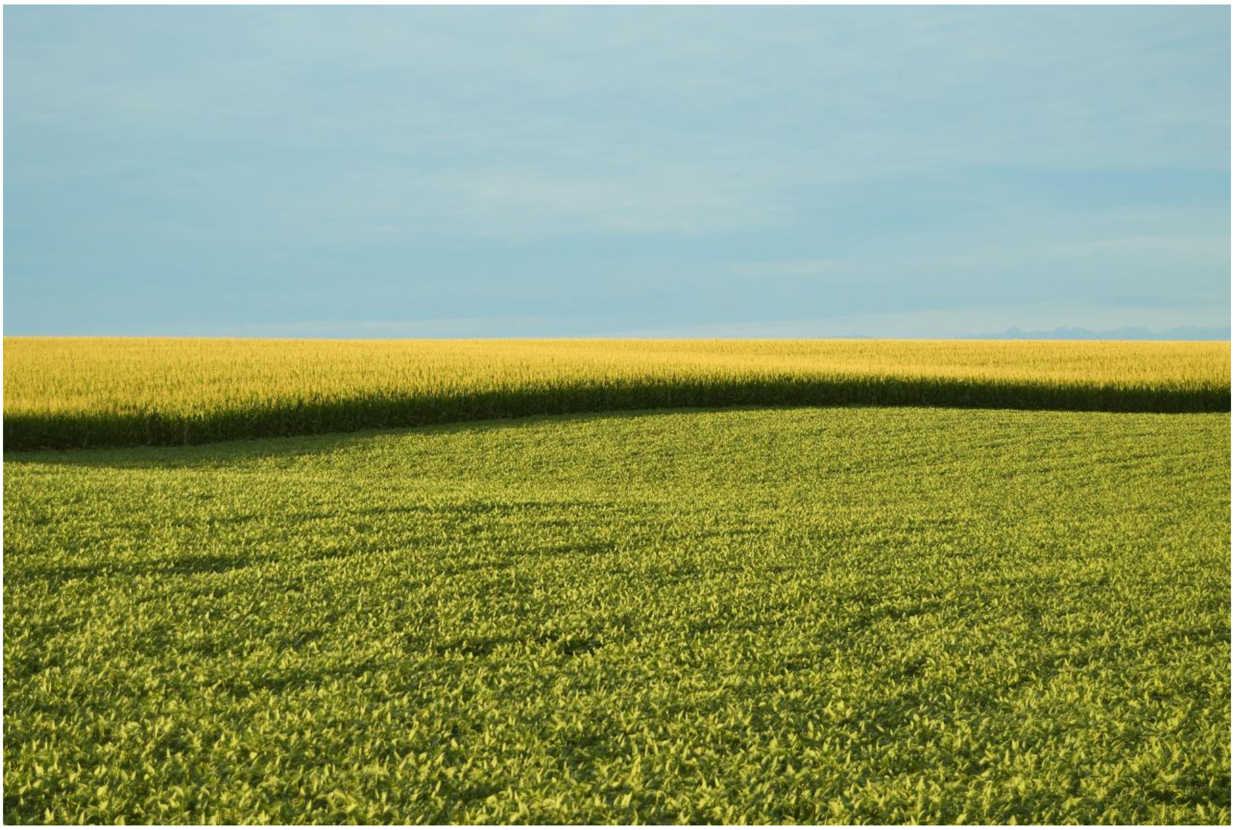
Similar to fertilization, the treatment with plant protection products follows certain rules. Since chemical substances are applied, most of them are regulated by the Law on plant protection and the respective laws and regulations. In this respect, each intention of treatment must be registered in the Electronic platform for declaring of the plant protection, disinfection and disinsection activities.

From an agronomic point of view, the plant protection should be carried out in a certain meteorological situation. Treatment should not be undertaken if there are rainfalls and wind because the chemical products would not distribute and be assimilated properly by the plants. During certain periods of the diurnal cycle, treatment should be avoided, especially if there are flowering plants, due to the risk of damages on the useful apifauna (honey bee and other pollinator species).

In order to provide adequate plant protection, it must be carried out according to the directions of an agronomist, who is a specialist in plant protection and who is competent enough and meets the legal requirements. It is necessary to observe all requirements for health and safety at work related to the implementation of the plant protection activities. After their completion, the pesticides packages are considered hazardous waste according to the Waste management law. Therefore, they should be registered as such in the National information system of waste.

5. Harvesting

Each plant production process ends with the harvesting. In this case harvesting is actually the most important stage of the growing of the plants. It should be done with good quality, in time and without losses. Since the triticale crop matures uniformly, and does not form tillers under most of the environments where it is grown, harvesting is done at its full maturity, in one stage. Harvesting is carried out by a combine harvester with an attached header for harvesting of whole-area crops. Usually, triticale ripens in the first decade of July, but the exact timing of the harvest depends on the relative moisture content of the grain. According to the requirements of the Bulgarian State Standard, the grain should be harvested and stored at moisture content not higher than 14%.



C2. Choosing triticale cultivars

Two triticale cultivars were chosen, which were developed at Dobrudzha Agricultural Institute – General Toshevo: Respekt and Dobrudzhanets.

Cultivar Respekt is characterized by exceptionally high cold resistance and can be successfully grown in low and high mountainous regions, in lowland basins and on sloping terrains with extreme winter conditions, which other triticale and cereal cultivars could not tolerate. It is suitable for growing under organic production due to its non-intensive type of growth – it requires considerably less resources with regard to nutrients in soil. Its major disadvantage is its later development, and it often suffers from late spring and summer droughts typical for Dobrudzha region. Therefore, its growing under a No-till system and reduced soil tillage is a possibility for ensuring higher yields from this cultivar.

Dobrudzhanets is a highly intensive triticale cultivar characterized by high drought resistance. On the other hand, it is also characterized by insufficient waxiness of stem and leaves, which, in spite of the lack of susceptibility to soil moisture, makes it less resistant to intensive solar radiation during the entire vegetative growth. In this relation, its use in a No-till system would allow reducing the thermal stress on this genotype and increasing its productivity.

Both cultivars have not been tested up now for suitability to be grown under No-till system. At the same time, the recent experiments showed that the two cultivars gave satisfactory results under field conditions, especially under the adverse weather observed in Dobrudzha in the past three years.

D. Parameters measured

D1. Parameters of soil

- Determining of soil moisture during periods critical for the growing of the crop – booting, heading, anthesis, grain formation, transition from milk to wax maturity. In each of the above growth stages, direct measurement was performed using soil hydrometer. Thirty permanent measurement locations were appointed in the experimental area for each variant of the experiment. Five readings were done at each location. A phenophase was considered active when 75% of the plants had entered it. Each reading was filled in a preliminary prepared Table (Appendix 1).

- Determining soil PH during the period of active vegetative growth. The measurement of this parameter is related to providing of favorable response for the growth and development of the crop. The more-favorable soil reaction is related to the better nutrition regime of the plants. The readings are done ten days apart from one another, or at the beginning of each phenophase of the crop development, by direct measurement with a soil pH-meter. Thirty permanent locations in the experimental area are chosen for each variant of the experiment to be carried out. Five readings are done at each location. The beginning of a phenophase is when 75% of the plants have entered it. Each reading is filled in a preliminary prepared standard Table (Appendix 1).

D2. Parameters of the 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 is 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 booting, heading and milk maturity. Thirty random plants are selected from each variant. The measurement is performed on the three upper leaves of each tiller. One reading is done on each leave. Each reading is filled in a standard Table (Appendix 2).

- 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 can be done in two ways:

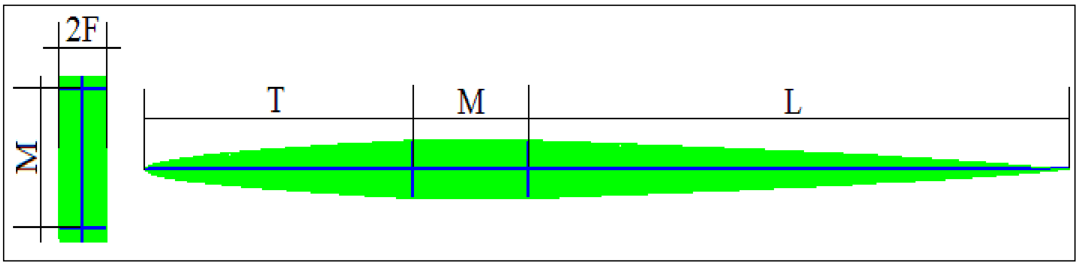
- Standard method: the length and width of the leaf are multiplied and then a correction is made with a coefficient adopted in the literary sources.

- Method, developed by Stoyanov (2013). According to this method, the leaf area and the leaf area index are determined with much greater precision. The leaf area LA of a given plant is the sum of the areas S_i of each leaf of the plant

$$LA = \sum_{i=1}^{n} S_i$$

where *n* is the total number of leaves on the entire plant.

If we look at the shape of the leaf of common winter wheat (*Triticum aestivum*), it is bilaterally symmetrical, its outer edge being a curve. The apex of each leaf is pointed, then the leaf shape becomes rectangular, and at a certain distance from the lower end, the leaf again narrows, forming a parabolic tip.



Outline and elements of a leaf from a cereal plant

The total area of each leaf is the sum of the areas of its three main parts:

- *top*

- *middle*
- *low*

According to the developed methodology, the leaf area *LA* is

$$LA = \sum_{i=1}^{n} \frac{F_i \left(7L_i + 12M_i + 8T_i\right)}{6}$$

, where
L – length of the upper part of the leaf
M – length of the middle part of the leaf
T – length of the lower part of the leaf
F – half of the width of the leaf at its widest part.

In this method, it is necessary to measure the above parameters for each leaf of a given plant. Twenty random plants are chosen from each variant, the leaves are measured *in situ*, and the reading for each parameter is filled in a standard Table (Appendix 3). The obtained results can be used to determine the leaf area applying both methods.

The leaf area index *LAI* is:

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

, where

GLA – total leaf area of the plants per unit area;
A – 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 number of plants per m^2 are determined using a 50 x 50 cm sampling frame, which covers an area of 0.25 m^2. The frame is placed in the crop at booting stage, when the danger of plants perishing due to negative temperatures is no longer present, and the plants have entered active vegetative growth. The plants within the sampling frame are counted. Ten readings are to be done for each variant of the experiment.
The leaf area is determined in three stages – booting, heading and grain filling. Thus, it is possible to determine the intensity of biomass accumulation in the leaves and the effective photosynthetic area under the two technologies of growing.

- Temperature of the leaf area – it is measured by an infrared thermometer during the periods critical for the growing of the crop: booting, heading, anthesis, grain formation, transition from milk to wax maturity. 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 4).

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 spike and the length of the spike without the awns. To properly determine plant height, the plants and the spikes 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 tip of the spike (without the awns). Each reading is filled in a standard Table (Appendix 5).

- Days to heading. The days to heading are an important indicator for the phenological development of triticale and are a source of information about the rate of the plant's development during its vegetative growth. The measurement is performed on 30 random plants from each variant. The parameter is determined as number of days from 1st January of the year, in which the plants will be harvested. The beginning of the heading of a plant is considered commencing when at least 50% of the spike has emerged above the flag leaf. A variant in heading stage is when at least 75% of the plants have entered heading stage as described above. Each reading is filled in a standard Table (Appendix 5).

- Number of productive tillers – it is measured as number of productive stems per m^2. The number of productive tillers is a major parameter in triticale since it is a main component of the crop's productivity. It is measured as number of productive stems per m^2. The number is determined using a 50 x 50 cm sampling frame covering an area of 0.25 m^2. The frame is placed in the crop at phenophase milk maturity, when all the tillers are headed. The plants should be in active vegetative growth and the leaf mass should be fresh, because when the biomass dies out, the stems become fragile and the reading of this parameter is considerably more difficult. The tillers within the sampling frame are counted. Thirty readings are planned for each variant of the experiment. The obtained results are multiplied by 4 to set them equal to 1 m^2. Each reading is filled in a standard Table (Appendix 5).

- Length of spike. It shows the generative development and indicates if the plant's productivity has reached its potential. To a large degree, it reflects the total vegetative growth. This parameter is determined in 20 locations from each variant by picking 10 well-formed spikes not damaged by pathogens and pests. Each spike is measured along its length from the base of the first spikelet to the end of the last spikelet, without the awns. The results for each of the spikes are filled in a standard Table (Appendix 6).

- Number of spikelets in spike. This parameter gives idea about the production potential of the spike. It is determined in 20 locations from each variant, picking up 10 well-formed spikes without damages by pathogens and pests. All formed spikelets are counted on each of the spikes, no matter if a grain is formed in them or not. The results for each spike are filled in a standard Table (Appendix 6).

- Number of grains in spike. This is the most important parameter for measuring the productivity of triticale and a main component of yield. This parameter is determined in 20 locations from each variant, picking up 10 well-formed spikes undamaged by pathogens and pests. The grains are detached from each spike manually, the glumes, awns and the pieces from the rachis are removed, and the grains from each spike are counted separately and placed in paper or polyethylene envelopes. The results for each spike are filled in a standard Table (Appendix 6).

- Weight of grains in spike. A weight parameter reflecting the actual productivity of each spike. The detached and already counted grains from each spike are weighed. Standard scales for measurement to two decimal places (0.01 g) are used for this purpose. The results for each spike are put down in a standard Table (Appendix 6).

- 1000 kernel weight. There are two approaches for determining this parameter:

- By direct calculation based on the previous two parameters. In this case, the weight of grains in spike is divided by the number of grains in spike and the obtained number is multiplied by 1000. This approach is appropriate when investigating the spike productivity, not the variants as a whole. The results for each spike are put down in a standard Table (Appendix 6).

- By counting a certain number of samples of 250 grains from each variant, after harvesting of the variants. Eight samples from each variant are usually sufficient to determine this parameter. To obtain more precise data, the processing of 20 samples of 250 grains from each variant is planned in this experiment. This approach is appropriate for characterization of the entire variant.

- Spike density. It is determined as ratio of the number of spikelets in spike to the length of the spike. The higher the values, the more dense spikes have been formed. It gives idea about the effect of the stress factors on the development of the spikes. The results for each spike are put down in a standard Table (Appendix 6).

- Fertility. The fertility indicates to what degree the processes of pollination and fertilization occurred properly and how they were affected by unfavorable events and processes observed during the vegetative growth. It is calculated as ratio of the number of grains in spike to the number of spikelets in spike. The results for each spike are put down in a standard Table (Appendix 6).

APPENDIXES

APPENDIX 1. Table for registering the parameters soil moisture and pH over phenophases

PROTOCOL

№………… Date…………

Variant: □ No-till □ Conventional

Location	Booting		Heading		Anthesis		Grain formation		Transition from milk to wax maturity	
	Moisture	pH	Moisture	pH	Moisture	pH	Moisture	pH	Moisture	pH
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
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30										

Responsible person ……………………………………………

APPENDIX 2. Table for registering the parameter chlorophyll content over phenophases

PROTOCOL

№........... Date...........

Variant: □ No-till □ Conventional

Leaf	Booting			Heading			Milk maturity		
	1	0	-1	Flag	Second leaf	-1	Flag	Second leaf	-1
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
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27									
28									
29									
30									

Responsible person ....

APPENDIX 3. Table for registering the leaf parameters for calculation of leaf area

PROTOCOL

№………… Date…………

Variant: □ No-till □ Conventional

Plant №…

Leaf	Leaf 1				Leaf 2				Leaf N			
	L	M	T	F	L	M	T	F	L	M	T	F
1												
2												
3												
4												
5												
6												
7												
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9												
10												
11												
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16												
17												
18												
19												
20												

Responsible person …………………………………………

APPENDIX 4. Table for registering the temperature on the leaf area

PROTOCOL

№………… Date…………

Variant: ☐ No-till ☐ Conventional

Location	Booting					Heading					Anthesis					Grain formation					Transition from milk to wax maturity				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1																									
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Responsible person …………………………………………

APPENDIX 5. Table for registering some parameters in the investigated variants

PROTOCOL

№………… Date…………

Variant: □ No-till □ Conventional

№	Days to heading	Plant height	Number of productive tillers
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
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29			
30			

Responsible person…………………………………………

APPENDIX 6. Table for registering biometric parameters of the investigated variants

PROTOCOL

№………… Date…………

Variant: □ No-till □ Conventional

Location №…

№	Spike length	No of spikelets in spike	No of grains in spike	Weight of grains in spike	1000 kernel weight	Spike density	Fertility
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Responsible person …………………………………………

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