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COMPARATIVE STUDY OF GROWTH AND DEVELOPMENT OF COMMON WHEAT IN ORGANIC AND CONVENTIONAL AGROCENOSES

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Abstract

The study was conducted in the period 2017-2020 at the Agricultural University, Plovdiv, Bulgaria. A comparative study of growth and development of common winter wheat variety Trakiyka under organic and conventional farming conditions was conducted. To achieve the objective, a two-factorial field experiment was set up using the method of fractional plots with a plot size of 10.5 m^2, in three replications. The soil fertilizers YaraMila Complex (for the conventional) and Italpolina (for the organic) were applied in the two agrocenoses. No differences were found in the occurrence and duration of phenological phases and interphase periods. Differences in plant height were found on average over the study period. In conventional technology, plants at full ripeness are 3.4 cm taller than those in organic - 94.45 cm. Under conditions of conventional agrocenosis, the cultivar forms a higher number of tillers per plant - 3.2 compared to the organic - 2.7. The tendency is maintained in the indicators number of productive tillers per plant and number productive stem/m^2. The cultivar shows comparative stability of both indicators under conventional and organic cultivation.

***Key words**: organic farming, wheat, Triticum aestivum L., fertilization, development.*

INTRODUCTION

Organic farming is a total management system that combines the best practices for protecting the environment. In modern conventional agriculture, large amounts of synthetic chemical compounds are applied in the cultivation technologies of agricultural crops. This, in turn, has a negative impact on the environment, soil, landscape and biodiversity in agro-ecosystems.

In Bulgaria, there are very good prerequisites for the development of organic production - areas preserved from an ecological point of view. The organic form of agriculture restores and maintains soil fertility (Hepperly et al., 2006), ensures balance in ecosystems (Mäder et al., 2002), reduces the negative impact of agriculture on climate change, leads to the production of healthy and quality food products in perfect harmony with nature and contributes to the nutrition of the planet's population (Badgley et al., 2012). Common wheat (*Triticum aestivum* L.) is the most important cereal crop grown conventionally or organically in the world, Europe and Bulgaria (Konvalina et al., 2012). In Bulgaria, it occupies about 34% of the arable land. However, with organically grown common winter wheat, the yield is lower and the grain has lower values for some quality indicators. Even in the best organic farms, the yield is 20-30% lower than conventional. According to some authors, organic cultivation also negatively affects the technological qualities of wheat grain (Moudry & Prugal, 2002). Improving wheat production in organic farming is the goal of many researchers from all over the world - USA, France, Austria (www.saatzucht.edelhof.at), England, Czech Republic (Konvalina et al., 2009), Croatia (Marijan & Samobor, 2011), Lithuania (Cesevičienė et al., 2009), etc. Variety selection is believed to be the critical factor for a well-functioning organic farming system (Bozhanova & Dechev, 2009). Nearly 95% of the varieties used in organic farming were developed for high-input conventional farming. Agro-ecological conditions (Delibaltova & Dallev, 2018) and growing conditions are essential for correct variety selection and stable yield (Gubatov & Delibaltova, 2020). Currently, breeding programs for creating specific varieties suitable for organic farming are few. The most common practice involves studying the suitability of conventional varieties in organic conditions, their propagation and propagation of the best ones for the needs of organic production.

Organic farming is characterized by environmental conditions that are much different than conventional farming. Therefore, the varieties that are created for it must be highly adaptable and resistant, and the stability of the yield is much more important than its size (Bozhanova & Dechev, 2009). Mainly four groups of characters are indicated as critical for the differences between "conventional" and "organic" wheat varieties, these are - efficient use of nutrients, competitive ability against weeds, resistance to diseases and enemies and last but not least stability of yield and quality.

Weed control, although difficult, is one of the factors for successful production in organic farming. In the conditions of organic farming, weeds reduce yields in many crops such as peas - up to 46%, barley - from 29 to 16%, including common winter wheat - from 63 to 8% (Kirkland & Hunter, 1991). In conventional agriculture, weeds also have a negative impact on wheat and yield, necessitating the use of various herbicides (Yanev, 2022; Yanev et al., 2021; Dimitrov et al., 2016).

Differences in competitive ability against weeds have been found in crops such as wheat, barley, pea and rice (O'Donovan et al., 2000; Caton et al., 2003). It is useful for growers to know the competitive ability of cultivars in order to select the most suitable ones for specific growing conditions (Lemerle et al., 2001a). Many researchers consider plant height as a factor in its competitiveness with weeds. Tall varieties of wheat suppress weeds more strongly than low varieties, in which the yield decreases significantly. Considers medium to tall varieties to be more suitable. Wicks et al. (1986) believed that height alone could not fully explain weed competition, as some short cultivars were also competitive. A high degree of twining is one means of competitive ability against weeds (Kruepl et al., 2006). The good ability of cultivars to assimilate nutrients under organic farming conditions as well as their ability to shade also increase the ability to suppress weeds in wheat (Eisele & Köpke, 1997). It is clear that the competitiveness of a cultivar against weeds is likely due to many traits working together. Many of the varieties created for conventional conditions have a stable yield under the organic farming system, but they need to be studied, as a result of which high-yielding varieties with a stable yield suitable for organic farming conditions can be identified. The grain yield of varieties grown under organic farming conditions is on average 28.92% lower than that of conventional farming systems (Ivanov, 2019). The application of organic fertilizers, such as manure, has a positive effect on the yield of grain and straw. Organic fertilizers have a double effect. The most indirect effect lies in the beneficial effect of soil parameters such as Nmin, earthworm abundance (Biau et al., 2012) and soil organic matter (Yu et al., 2012).

Many authors have confirmed the significant effect of weather conditions on grain protein content, protein content being inversely proportional to rainfall during the growing season.

There are many varieties of common wheat in practice, selected for conventional agriculture. This raises the question of how these varieties would behave in the conditions of organic farming and which of them are suitable for it, so as to realize a stable yield and quality, not yielding to conventional technology. This directed attention to the common wheat variety Trakiyka, whether it is suitable for organic farming, placing it under the same weather conditions, but with two different cultivation technologies.

MATERIALS AND METHODS

The study was conducted in the Agroecological Center - Demonstration Center for Organic Agriculture and in the training field at the Agricultural University (Bulgaria) in the period 2017-2020. The Agroecological Center has been a member of the International Federation of Organic Agriculture (IFOAM) since 1993.

To achieve the goal, a two-factor field experiment with common wheat cultivar Trakiyka was set. The polish experiment was set up according to the block method with the size of the reporting plot 10.5 m^2, in three repetitions. Factors A: Vegetation year (A1–2017/18, A2–2018/19, A3–2019/20) and factor B: cultivation conditions (B1 - in organic agrocenosis and B2 - in conventional agrocenosis) were monitored. The indicators of phenological development, plant height by phenophases (tillering, stem elongation, full ripeness), overal and productive tillering, productive stems.

The purpose of the study is to compare the growth and development of common wheat cultivar Trakiyka in the conditions of organic and conventional agriculture and determine the potential for organic production.

Statistical processing of the experimental data was performed using SPSS V.13.0 for Microsoft Windows using Duncan's method, Anova (SAS Institute Inc. 1999).

For the entire experimental area in the conventional agrocenosis, NPK fertilizer YaraMila Complex - 300 kg/ha before sowing and Ammonium nitrate - 250 kg/ha, in early spring as feeding was used. In the biological agrocenosis, Italpolina organic fertilizer was used in a dose of 700 kg/ha, introduced into the soil before sowing.

Description of the fertilizers used: Italpolina - dried, granulated poultry manure rich in: Total nitrogen (N) 4%, Phosphorus (P_2O_5) 4%, Potassium (K_2O) 4%, Water-soluble magnesium (MgO) 0.5%, Water-soluble iron (Fe) 0.8%, Water soluble boron (B) 0.2%, Organic carbon (C) 41%, Organic matter 70.7%, Humic acids 5%, Fulvic acids 12%, Moisture 12%, PH7. In a short time, it leads to an increase in the microbiological, physical (structure, water retention) and chemical (buffering) properties of the soil. Approved for organic farming.

YaraMila Complex - (12-11-18 + 2.7 MgO + 20 SO3 + 0.015 B + 0.2 Fe + 0.02 Mn + 0.02 Zn) - contains balanced and effective nutrients in each granule. Complex fertilizer created to achieve the maximum yield and quality of crops. The nutritional elements in YaraMila COMPLEX act in synergy, which gives us much better nutrition of agricultural crops and greater application efficiency.

RESULTS AND DISCUSSIONS

The main climatic factors influencing the growth, development and yield of wheat are temperatures and precipitation with their distribution during the growing season. The growing season 2017-2018 is characterized as warm and humid in terms of wheat vegetation (Tables 1, 2), exceeding the values for the long-term period (1965-1995) in most of the months during the growing season. The warmer winter and the higher temperatures during the growing season, combined with the abundant rainfall in May and June, have a positive effect on the growth and development of wheat.

The abundant rainfall, times above the norm for the months of May and June 2018, had an adverse effect on the yield indicators (quality, etc.) (Table 2).

The winter period of the 2018-2019 vegetation year has positive temperature values above the norm, provided with precipitation, which favors the normal wintering of crops (Tables 1, 2). The vegetation year is characterized as warm and humid.

The months from January to March have rainfall values below the norm compared to the long-term period (Table 2). Abundant rainfall in the month of April - 76.5 mm/m^2, which is 37.5 mm/m^2 above the average for the period 1965-1995, favors the phenophase tillering and stem elongation when measuring the size and number of spikes per plant.

Heavy rainfall of 196.7 mm/m^2 was reported in June, which is 160.7 mm/m^2 above the long-term average.

These rains at the beginning of the month favor the processes for better nutrition of the grain, but have an adverse effect on the wheat harvest.

The third growing year 2019-2020 is characterized by temperature values higher than those for the long-term period and with a good provision of rainfall from February to June.

On average for the study period, the wheat vegetation takes place under the conditions of meteorologically different years - uneven distribution of rainfall during the vegetation and high temperature values.

This has its impact on the different critical phases of the growth and development of Trakiyka wheat in the two agrocenoses.

Table 1. Average monthly air temperatures (°C) for ten days during the wheat growing season in the period 2017-2020

Months Ten days	Vegetation year	IX	X	XI	XII	I	II	III	IV	V	VI
I	2017/2018	21.1	13.8	8.3	6.8	3.8	6.4	4.5	14.4	18.6	23.3
	2018/2019	34.4	14.1	10.4	1.3	-0.2	5.2	10.9	10.8	15.8	21.2
	2019/2020	22.1	16.2	11.2	2.3	2.7	5.8	9.7	8	15.8	19.6
II	2017/2018	24.4	14.4	11.9	4.3	2.1	3.9	10.5	15.8	19.1	22.3
	2018/2019	20.7	14.0	6.2	2.5	2.8	4.9	11.4	11.6	18.1	24.9
	2019/2020	20.1	15.4	11.7	5.1	2.8	6.5	8.9	13.6	21.8	21.5
III	2017/2018	16.0	11.6	6.4	3.8	2.8	0.1	6.3	19.0	19.9	20.3
	2018/2019	15.4	13.0	5.4	4.8	4.9	3.9	9.6	15.3	20.9	24.2
	2019/2020	17.7	12.1	11.4	6.0	5.1	7.0	8.1	13.0	15.6	23.0
Average monthly t°C	2017/2018	20.5	13.3	8.9	5.0	2.9	3.5	7.1	16.4	19.2	22.0
	2018/2019	19.8	13.7	7.3	2.8	2.5	4.7	10.6	12.6	18.2	23.4
	2019/2020	19.9	14.6	11.4	4.5	3.5	6.4	8.9	11.5	17.8	21.4
Average for the period 1965-1995		18.3	12.6	7.4	2.2	-0.4	2.2	6	12.2	17.2	20.9

Table 2. Amount of rainfall (mm/m^2) for the month and by ten days during the wheat growing season in the period 2017-2020

Months Ten days	Vegetation year	IX	X	XI	XII	I	II	III	IV	V	VI
I	2017/2018	0.5	42.4	0.4	10.8	0.7	12.5	11.4	16.0	10.5	1.1
	2018/2019	7.8	22.9	0.0	0.0	2.7	6.9	1.4	46.9	3.6	129.6
	2019/2020	0.0	5.4	9.9	22.2	1.1	43.2	18.5	63.4	29.4	19.5
II	2017/2018	0.0	0.0	11.8	12.5	12.9	38.0	14.6	1.3	52.9	12.3
	2018/2019	0.0	4.4	25.7	16.3	1.1	4.3	7.2	26.1	4.7	21.7
	2019/2020	13.6	0.3	26.5	2.3	0.0	1.9	18.7	14.2	0.0	22.0
III	2017/2018	35.6	28.0	35.4	0.4	8.1	42.1	26.2	7.7	48.9	105.5
	2018/2019	0.5	7.0	36.8	1.6	27.1	6.0	0.2	3.5	13.0	45.4
	2019/2020	3.8	4.5	54.0	0.8	1.9	5.6	36.9	11.5	51.3	13.9
Monthly amounts	2017/2018	36.1	70.4	47.6	23.7	21.7	92.6	52.2	25.0	112.3	118.9
	2018/2019	8.3	34.3	62.5	17.9	30.9	17.2	8.8	76.5	21.3	196.7
	2019/2020	17.4	10.2	90.4	25.3	3.0	50.7	74.1	89.1	80.7	55.4
Average for the period 1965-1995		65	47	35	36	40	48	44	39	32	36

1. Phenological development

The duration of the phenological phases and interphase periods is strongly influenced by the genotype of the cultivar, the external conditions of the environment, temperature and rainfall.

Table 3. Comparison of phenological development by dates of entry in Trakiyka cultivar grown in conventional and organic agrocenosis

Variant Year	Sowing	Phenophases							
		Germination	3-rd leaf	Tillering	Stem elongation	Heading	Milk ripeness	Wax ripeness	Full ripeness
	2017-2018								
Conventional	22.X	02.XI	16.XI.	27.XI.	30.III.	27.IV	23.V.	05.VI.	27.VI.
Organic	22.X	02.XI	16.XI.	27.XI.	30.III.	27.IV	23.V.	05.VI.	27.VI.
	2018-2019								
Conventional	19.X	29.X.	6.XI.	15.XI.	18.IV.	30.IV	16.V.	31.V.	25.VI.
Organic	19.X	29.X.	6.XI.	15.XI.	18.IV.	30.IV	16.V.	31.V.	25.VI.
	2019-2020								
Conventional	12.X	10.XI	28.XI.	09.XII.	10.IV.	24.IV	20.V.	02.V.	24.VI.
Organic	12.X	10.XI	28.XI.	09.XII.	10.IV.	24.IV	20.V.	02.V.	24.VI.

The uneven distribution of rainfall or its lack combined with high temperatures shortens the interphase periods and negatively affects the duration of vegetation, productivity and vice versa.

On average for the 2017-2020 study period, no differences were found in the occurrence and duration of the individual phenological phases and interphase periods in wheat cultivar Trakiyka in the frame of the year grown under the conditions of conventional and organic agrocenosis.

2. Height of the plants, cm

The height of the plants is a varietal characteristic that would be affected by the growing conditions, in particular the feeding regime. Depending on the growing conditions, the plants realize a greater height in the conventional agrocenosis compared to the organic. This is determined by the type of soil and the types of fertilizers used for soil nutrition.

During the separate phases of development, the difference in plant heights can be observed for the cultivar in the two types of agrocenoses - conventional and organic (Table 4).

Table 4. Plant height of Trakiyka wheat cultivar by phenophases in conventional and organic agrocenoses during the study period, cm

Variant	Phenophases											
	Tillering				Stem elongation				Full ripeness			
Year	2018	2019	2020	Average	2018	2019	2020	Average	2018	2019	2020	Average
Conve-ntional	51.9	51.1	51.3	51.4a	79.6	70.9	75.1	75.2a	106.6	88.4	98.5	97.8a
Organic	49.8	50.2	50.3	50.1b	71.4	73.4	73.1	72.6a	95.1	92.0	96.2	94.4a

*Means followed by the same letter are not statistically different ($P<0.05$) by Duncan's multiple range test

These differences are also due to the types of fertilizers used, as part of the complex of agroenvironmental factors in individual agrocenoses. Organic fertilizer releases nutrients to plants more slowly than conventional fertilizer. The rapid release leads to faster absorption, and from there to the growth in height of the plants in the conventional agrocenosis. In the joint action of the factors determining the growth and development in 2018, in the phenophase of full ripeness, the plants were 11.5 cm higher in the conventional (106.6 cm) than in the organic sowing (95.1 cm), while in the second and third year in same phase, this trend is preserved, but the difference in plant height in the two agrocenoses is much lower. This shows the strong influence of the conditions of the year as an environmental factor. On average over the study period, the height of plants in the conventional agrocenosis was greater compared to the organic one during the three phases of measurement - tillering (by 1.3 cm), stem elongation (by 2.6 cm) and full ripeness (by 3, 4 cm), the difference being statistically proven only in the tillering phase. At full ripeness, the plants in the conventional agrocenosis have a height of 97.8 cm compared to 94.4 cm for those in the organic one.

3. Number of emergence, number of harvested plants and productive stems per m^2

The density of sowing and the productive stems directly affect the formation of the yield. Unfavorable weather conditions - low rainfall values in September and October (Table 2), uneven or lack of moisture in the soil, make sowing difficult and lead to lower values for the number of emergence plants (Table 5).

Table 5. Number of emergence plants, number of harvested plants and productive stems in wheat cultivar Trakiyka, m^2

Variant	Structural elements of production											
	Number of emergence plants				Number of harvested plants				Productive stems			
Year	2018	2019	2020	Average	2018	2019	2020	Average	2018	2019	2020	Average
Conve-ntional	379	398	491	422.6a	363	371	472	402.2a	497	505	643	548.2a
Organic	383	386	475	414.8a	349	367	444	386.6a	475	513	605	531.1a

*Means followed by the same letter are not statistically different ($P<0.05$) by Duncan's multiple range test

An extension of the germination period and a reduction in the number of emergence seeds is achieved. However, a relatively good emergence density is achieved.

On average for the period 2018-2020, both crops, organic and conventional, emergence with more than 400 plants/m^2, and no proven difference in the number of emergence plants was found between the two agrocenoses. Until full ripeness, part of the plants are reduced, and the number of harvested plants remains close to 400. In organic agrocenosis, the number of harvested plants is smaller than conventional, but this difference is not proven.

Under the specific conditions of the year and environment, 2020 is the year with the highest productive stem, followed by 2019 and 2018. In individual years, the productive stem has higher values in the conventional agrocenosis compared to the organic one. On average for the period of the study, the trend is maintained in favor of the conventional agrocenosis (548.2 units) compared to the organic one (531.1 units), but the difference is not statistically proven.

This determines the productive stem stand indicator of Trakiyka cultivar as stable in the conditions of two agrocenoses - organic and conventional.

4. Overall and productivity tillering

The uneven rainfall in autumn and the lack of moisture in the soil (Table 2) leads to a delay and uneven emergence of the plants, which also affects the development, in particular the tillerings of the plants. In 2018, although the plants formed a larger number of tillers compared to the other two years, the number of productive tillers was the smallest in both agrocenoses (Table 6). Although small differences are observed in the general and productive tillerings of the cultivar in the two agrocenoses.

Table 6. Overall and productive tillering by variants in the study period 2018-2020

Variant / Year	Tillering									
	Overall tillering			Average	Rank, %	Productive tillering			Average	Rank, %
	2018	2019	2020			2018	2019	2020		
Conve-ntional	3.15	3.63	2.86	3.21a	100	1.18	3.36	1.51	2.01a	100
Organic	2.22	3.40	2.67	2.76a	85.9	1.30	2.76	1.33	1.79a	89.05

*Means followed by the same letter are not statistically different ($P<0.05$) by Duncan's multiple range test

In conventional agrocenosis, plants form a greater overall number of tillers and realize more productive tillers compared to those in organic. This can be explained by the faster absorption of nutrients in the conventional technology in the unfavorable period for plant development.

On average for the study period, in the conventional sowing cultivar Trakiyka formed a total number of tillers 3.21, and in the organic 2.76. Although the values have small differences, differences in the number of productive tillers are also formed. In the organic agrocenosis, the average number of productive tillers per plant is 1.79, and in the conventional 2.01. Despite these percentage differences, the cultivar shows a comparative stability of the tillering indicator in the conditions of the two agrocenoses and the difference is not proven.

CONCLUSIONS

No differences were found in the period of occurrence and duration of the individual phenological phases of wheat cultivar Trakiyka, grown under the conditions of organic and conventional agriculture.

In the conditions of the conventional agrocenosis, the plants have a greater height in the tillering (by 1.3 cm), stem elongation (by 2.6 cm) and full ripeness (by 3.4 cm) phenophase, compared to the organic one. At full ripeness they reach a height of 97.8 cm compared to 94.4 cm in the organic, but this difference is not proven.

A greater number of emergence, harvested plants and productive stems of Trakiyka cultivar were reported in the conventional agrocenosis compared to the organic one, but the difference was not proven. This defines the indicators as stable and the cultivar as suitable for the agro-ecological conditions of organic farming.

In the conventional agrocenosis, the Trakiyka cultivar forms a overal number of tiller 3.21 to 2.01 productive tiller, and in the organic 2.76 to 1.79 number of productive tillers. The percentage difference in the indicators between the two agrocenoses is not proven.

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MISCELLANEOUS