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GROWTH AND DEVELOPMENT OF TRITICUM MONOCOCCUM L., TRITICUM DICOCCUM SCH. AND TRITICUM SPELTA L. IN ORGANIC FARMING CONDITIONS

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Summary: During the 2014-2016 period in Agroecological Center at the Agricultural University - Plovdiv, Bulgaria growth and development of three species of wheat in terms of organic farming had been tracked in order to return the species in the crop rotation, maintenance of biodiversity and receiving of cleaner and healthy products from organic farms. The three species of wheat Triticum monococcum L., Triticum dicoccum Sch, and Triticum spelta L., differ between its rate of growth, development, general and productive tillering. In tillering phase the plants reached 12,3 cm of height for Triticum monococcum L., 15,7 cm for Triticum spelta L. and 19,4 cm for Triticum dicoccum Sch. Triticum monococcum L. and Triticum dicoccum Sch, reached ear formation phase 5 days earlier than Triticum spelta L. The interfacial period of stem elongation - ear formation in them, was about 21 days compared to 25 days for Triticum spelta L.. From ear formation to full maturity inter-phase periods were shorter in Triticum dicoccum Sch., which specifies the species as an early mature (6 days earlier) compared to the other two. After phenophase of stem elongation plants were growing the most intensive and in full ripeness reached a height of 94 cm in Triticum monococcum L., 81,5 cm in Triticum dicoccum Sch. and 82,5 cm in Triticum spelta L.

Key words: Triticum monococcum L., Triticum dicoccum Sch., Triticum spelta L., organic farming, growth, development.

INTRODUCTION

The production of ancient wheat species in Europe, in the last decades, has been encouraged in relation to the the consumption of healthy food products resulted in the revival of the interest in the ancient wheat species – Triticum spelta L. *(*dinkel*),* Triticum monococcum L.*(*einkorn*)* and Triticum dicoccum Sch.*(*emmer*)*. It is considered that these species are predetermined for organic agriculture. Moreover, the share of the husk (35-35% of the grain yield), protect the grains from contamination and infections. Grains of wild einkorn wheat, preserved from the Epipaleolithic times in the area of the Middle East and in the area of Balkans were found during archeological excavations. Due to aromatic flavour, fibers, protein, vitamins, antioxidants contained in the grains, the nutritional values of Triticum monococcum significantly surpasses those of other wheat types (Ahmad et al., 2013; Hidalgo and Brandolini, 2014; Bojnanska and Francakova, 2002; Zaharieva et al, 2014).

Triticum dicoccum grows even in poor soils (Vlahova, 2013). Consequently, it supports the agricultural development of the poorer mountain regions and it is particularly appropriate for biological growing due to its identity (Giuliani et al., 2009; Wolfe et al., 2008).

Some authors direct attention of the farmers to the growing of ancient wheat types as a new sources of healthy food (Ciccoritti et al., 2012; Karagöz, 2014). The protein, which is contained in the grains of the einkorn wheat – gliadin is found to be non-toxic for people with Celiac disease (Pizzuti et al., 2006).

Not by accident, these old wheat species were used thousands of years ago by our ancestors for food and they can be found even today in their pure and unchanged form. The purpose of the present study is to follow the growth and development of the three wheat species in the conditions of organic agriculture and their return in the practice.

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MATERIAL AND METHODS OF THE STUDY

The study was conducted at the experimental field in the Agroecological centre - Demonstration center organic farming of the Agricultural University – Plovdiv (Bulgaria) during the 2014-2016 period. The Agroecological center is a member of IFOAM (International Federation of Organic Agriculture Movements) since 1993.

An experimental factorial design with two factors has been set in three replications and with a plot size of 10,5 m^2, on soil type Mollic Fulvisols based on FAO. Sowing was carried out in mid-October with seed rate of 500 g. s./ m^2, after a pepper as a predecessor. The main fertilization was carried out with organic fertilizer Agriorgan pellet at a dose of 100 kg/da.

The following factors have been studied: Factor A - Year A_1 - 2014/2015; A_2 - 2015/2016; Factor B - wheat species – B_1 - Triticum dicoccum Sch .; B_2 - Triticum spelta L.; B_3 - Triticum monococcum L.

Statistical processing of experimental data was performed through SPSS V.9.0 for Microsoft Windows (SAS Institute Inc.1999) with the use of a computer program ANOVA. The comperative analysis was as per the method of Dunkan (Dunkan, 1995) Variation proofs were indicated at significance level P 5%.

RESULTS

1. Meteorological conditions in the experimental period

The vegetation year 2014-2015 is characterized by being relatively warm, with temperature values above the normal in a long-term period (Fig. 1). The rainfalls were above the normal, with the exception of January and April, which determined the year as relatively humid (Fig. 2). The sowing for the experiment was performed on 16.X.2014 and was followed by heavy rainfall in the third ten-days period of the October (116 mm/m^2).

The heavy rainfalls and temperature value, being slightly above the normal for the October (12,8°C), allowed for the plants to germinate for about 13 days. The winter period was accompanied by high values of the rainfall and positive temperatures, above the normal. As a result of the above, the plants passed the winter successfully.

The spring vegetation started in March in the conditions of heavy rainfalls (138 mm/m^2) with values of 94 mm/m^2 above the normal. The above conditions had positive impact over the formation of the structural elements of the panicle, which is expected in the period March – April (phenophases tillerering-stem elongation with the studied species).

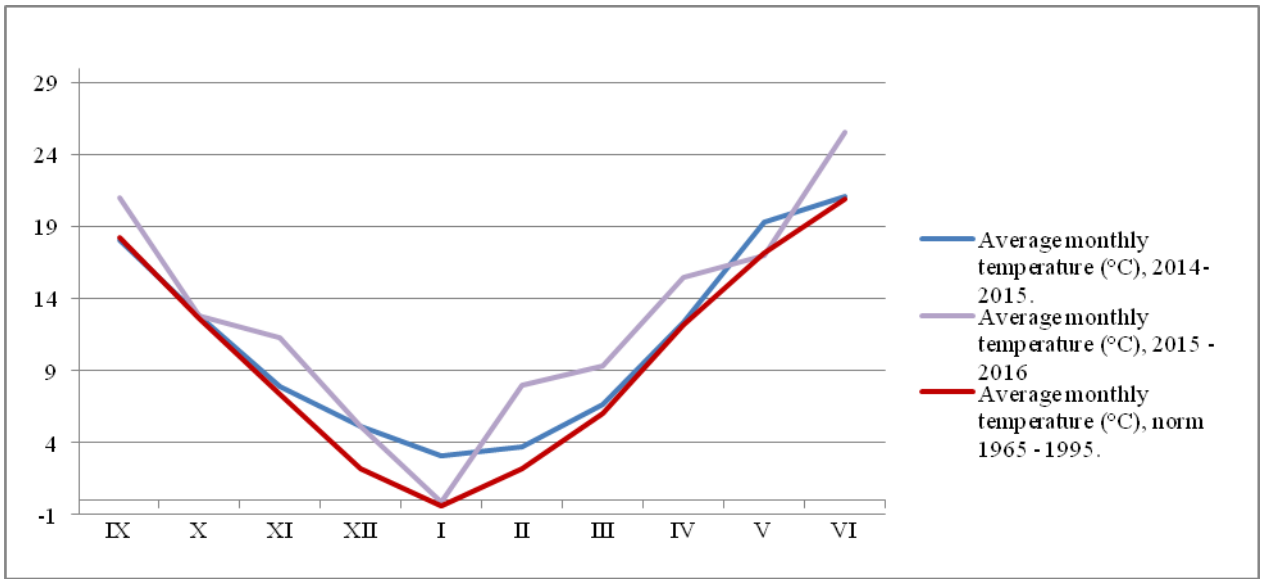

Figure 1. Average monthly air temperature (°C) during the study on einkorn, emmer and dinkel wheat in 2014 - 2016

The second vegetation year 2015-2016, like the previous one, was characterized as relatively warm, with temperature values above the norms and good quantities of rainfall. The heavy rainfalls in October resulted in the

normal germination of the sowing. The combination of these conditions (temperature and humidity) allowed for the normal sowing garnishment during germination and successful strengthening of the plants for the winter period.

The temperature values, above the norm for the period December – February, allowed the plants to successfully spend the winter.

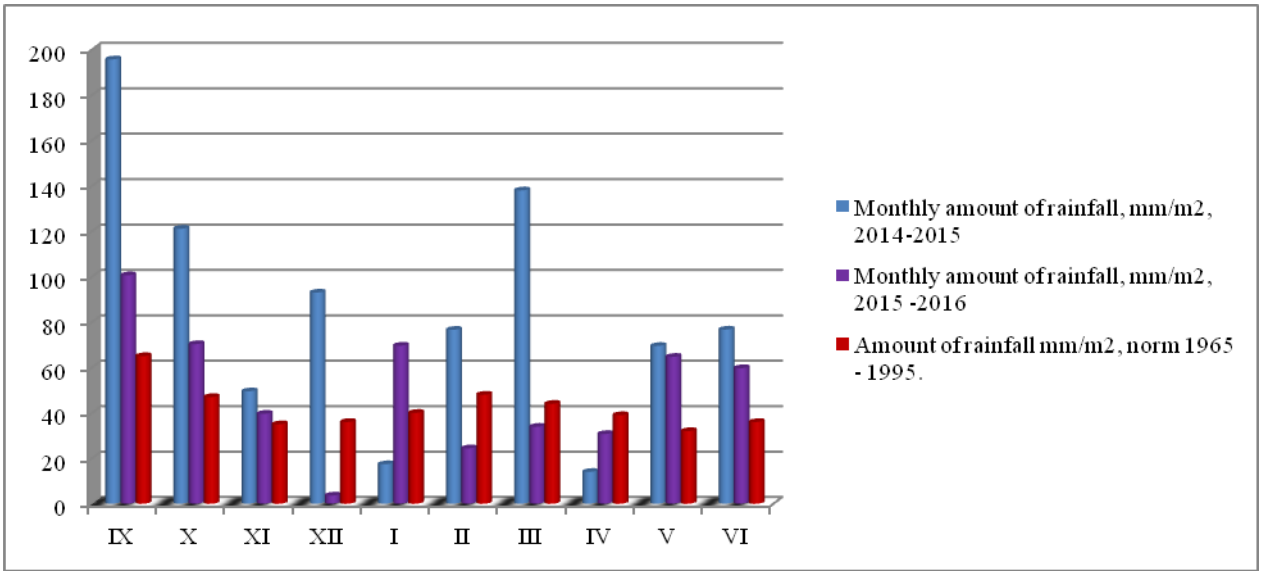

Figure 2. Amount of the rainfall during the experimental period (mm/m^2), 2014 – 2016.

2. Phenological development

No difference in the occurrence of the phenological phases and the duration of the inter-phase periods, from germination phase to heading phase, were observed in the species during the two years of the experiment. These makes these wheat species relatively close in their phenological development.

In 2014, phenophase third leaf occurred on the 28th day (26.XI), after the germination phase, and in 2015, on 23rd day (10.XII) as shown in Table 1.

In the autumn of 2014, the inter-phase period third leaf - tillerering had a duration of 14 days, while in 2015, it was only 5 days. The above difference between the individual years is explained with the unfavourable weather conditions – high temperatures above the normal, combined with low values of the rainfall in December. These conditions resulted in the shortening of the inter-phase period third leaf - tillerering and had negative impact over the plants. In 2014, the tillerering phase for all three wheat species occurred on 10.XII and in 2015 on 15.XII.

The duration of the period from sowing to tillerering is 55 days in 2014 and 42 days in 2015.

In the experimental year 2014-2015, the inter-phase period tillerering - stem elongation is 135 days and it occurred on 24.IV.2015, and in 2015-2016 it was 126 days and occurred on 20.IV.2016 (Tab. 1).

A shortening of the inter-phase period from heading to full ripeness was observed for T. dicoccum in 2015, due to which, the full ripeness occurred earliest with this species. The duration of the same inter-phase period of T. spelta and T. monococcum was the same and the species got in maturity together.

Table 1. Phenological phases of development in the studied species of wheat during the 2014 -2015 and 2015-2016 vegetation

Spacies	Phenophases								
	Sowing	Germination	3-rd leaf	Tillering	Stem elongation	Heading	Milk ripeness	Wax ripeness	Full ripeness
2014 - 2015									
Triticum dicoccum	16.X.2014	29.X	26.XI.	10.XII.	24.IV.	14.V.	04.VI.	13.VI.	23.VI.
Triticum spelta	16.X.2014	29.X	26.XI.	10.XII.	24.IV.	18.V.	09.VI.	18.VI.	29.VI.
Triticum monococcum	16.X.2014	29.X	26.XI.	10.XII.	24.IV.	14.V.	09.VI.	18.VI.	29.VI.
2015 - 2016									
Triticum dicoccum	03.XI.2015	17.XI	10.XII	15.XII	20.IV	13.V.	03.VI	14.VI.	24.VI
Triticum spelta	03.XI.2015	17.XI	10.XII	15.XII	20.IV	17.V.	10.VI	24.VI	29.VI.
Triticum monococcum	03.XI.2015	17.XI	10.XII	15.XII	20.IV	13.V.	10.VI	24.VI	29.VI.

Despite of the difference in the occurrence of the individual phenophases for the three species, the duration of the inter-phase period was almost similar – heading - milk ripeness 22 days for T. dicoccum, 23 days for T. spelta and T. monococcum; milk ripeness - wax ripeness – 10 days for the three wheat species; wax ripeness – full ripeness – 10 days for T. dicoccum and 11 days for the other two types.

In 2016 the period of heading - milk ripeness continued 20 days for T. dicoccum, 23 days with T. spelta and 27 days for T. monococcum, milk ripeness – wax ripeness – 11 days for T. dicoccum and 14 days for the other two wheat species; wax – full ripeness – 10 days for T. dicoccum and 6 for the other two species (Tab. 1).

3. Height of the plants, cm

In 2015, in the tillerering phase, the plants of T. dicoccum were the tallest – 14,33 cm, followed by T. spelta with height of 11,93 cm and the plants of T. monococcum were the shortest – 8,63 cm (Tab.2).

The results of 2016 showed increased value of the indicator height in the tillerering phase for all three wheat species, compared to the results of 2015. Again, the tallest were the plants of T. dicoccum with height of 24,57 cm, followed by T. spelta and T. monococcum, respectively with height of 19,57 cm and 16,03 cm (Tab. 2).

In 2015, during the determination of the height in the stem elongation phase, again, the highest value was reported for T. dicoccum – 56,93 cm. T. spelta had a height of 56,1 cm, and T. monococcum of 49,9 cm.

The results of 2016 were with lower values for all three wheat species. T. dicoccum had a height of 52,63 cm, but again was the tallest of all three species, followed by T. monococcum with height of 48,67 cm. The shortest stature on average was reported for T. spelta – 43,57 cm.

Table 2. Height of plants by wheat species in phenological phases tillering, stem elongaton and full ripeness (cm)

Species	Phenophases								
	Tillering			Stem elongation			Full ripeness		
	2014-2015	2015-2016	Average	2014-2015	2015-2016	Average	2014-2015	2015-2016	Average
Triticum dicoccum	14,33 a*	24,57 a	19,45	56,93 a	52,63 a	54,78	83,12 a	79,90 a	81,51
Triticum spelta	11,93 a	19,57 a	15,75	56,10 a	43,57 a	49,83	81,87 a	83,30 a	82,59
Triticum monococcum	8,63 a	16,03 a	12,33	49,90 a	48,67 a	49,29	90,73 a	97,38 a	94,06

*Means followed by the same letter are not statistically different (P<0,05) by Duncan's multiple range test

In 2015, the highest height of the plants during the phase full ripeness was reported for T. monococcum - 90,73 cm, followed by T. dicoccum – 83,12 cm and T. spelta – 81,87 cm.

The results for 2016 in full ripeness showed greater values for the height of T. monococcum and T. spelta, in comparison to the results from 2015, respectively 97,38 cm and 83,3 cm. These changes were due to the difference in the weather condition between the two years and the distribution of the rainfall in the individual phenologic development phases of the species.

4. Overall and productive tillering

Table 3. Overall and productive tillering (number of tillers/ plant, 2014-2016)

Spacies	Tillering					
	Overall tillering			Productive tillering		
Year	2014 -2015	2015 -2016	Average	2014 -2015	2015 -2016	Average
Triticum dicoccum	5,27 a	4,16 a	4,71	1,90 a	1,66 a	1,78
Triticum spelta	3,73 a	2,47 a	3,10	1,33 a	1,03 a	1,18
Triticum monococcum	3,70 a	4,13 a	3,92	1,60 a	1,73 a	1,67

*Means followed by the same letter are not statistically different (P<0,05) by Duncan's multiple range test

The data show that the highest total number of tillers per plant, average for the period 2014 - 2016, is reported for T. dicoccum - 4,71 tillers, followed by T. monococcum (3,92) and T. spelta (3,10) (Tab. 3).

With the indicator of number of productive tillers per plant, for the period 2014 - 2016, the highest values are reported for T. monococcum - 1,67 productive tillers per plant. T. dicoccum has an average of 1,78 productive tillers and T. spelta has the smallest number of productive tillers – 1,18.

DISCUSSION

Generally speaking, the weather conditions during the research period 2014-2016, were favourable for the growth and development of the three wheat species. Both vegetation years were characterized as warm and well provided with rainfalls (Fig.1, 2).

The differences between the development of the species is observed from the occurrence of the phase heading to full ripeness. In 2015 the phase heading first occurred in T. dicoccum and T. monococcum (14.V) and 4 days later, in T. spelta. Similar tendency was observed in the following year 2016 as well (Tab. 1).

The duration of the inter-phase period stem elongation – heading was 21 days for T. dicoccum and T. monococcum, 25 days for Tr. spelta in 2015 and 23 days for T. dicoccum and T. monococcum, and 27 days for T. spelta in 2016. The uneven distribution of rain falls or their absence, combined with higher ambient temperatures, shortened the inter-phase periods and had negative impact over the duration of vegetation.

The duration of the vegetation period in 2014-2015 was 250 days for T. dicoccum and 256 days for T. monococcum and T. spelta.

For the second experimental year 2015-2016 this period was 233 days for T. dicoccum and 238 days for T. monococcum and T. spelta.

In the average results for the period 2014 – 2016 confirm that T. dicoccum was the tallest in the phenological phase tillerering - with average height of 19,45 cm, followed by T. spelta L. – 15,75 cm and T. monococcum with height of 12,33 cm (Tal. 2).

Average for the period 2014 - 2016, the height of the plants in the stem elongation phase was highest for T. dicoccum - 54,78 cm, followed by T. monococcum - 49,29 cm.

Average for the period 2014 - 2016, in the full ripeness phenophase, the highest height was observed for T. monococcum - 94,06 cm, followed by T. spelta – 82,59 cm and T. dicoccum - 81,51 cm. The results of the heights of these wheat species can be used in the selection for species for a given region of the country. The shorter types are more appropriate for regions with more frequent winds, because they are more resistant to lodging.

The reduced tillering of T. spelta is a prerequisite for the usage of higher sowing norm compared to the studied one, in order to acquire higher number of head bearing stems per the relevant area.

CONCLUSION

During the phenological phases from germination to headng, no differences were found between the three wheat species T. dicoccum, T. spelta and T. monococcum, both in germination and the duration of other phases.

T. dicoccum has the highest plant height, followed by T. spelta and T. monococcum during the phases tillering and stem elongation.

From the researched wheat species with the highest height of plants in full ripeness was T. monococcum with 94,06 cm, followed by T. spelta – 82,59 cm and T. dicoccum – 81,51 cm. This shows the significant growth of T. monococcum, which almost doubled its height in the interphase period stem elongation – full ripeness.

Overall tillering has T. dicoccum with 4,71, followed by T. monococcum with 3,92 and T. spelta – 3,10 per plant.

According to number of productive tillering per plant, T. dicoccum has the most productive ones – 1,78 number, followed by T. monococcum with 1,67 and the smallest number is T. spelta – 1,18. This shows higher tillering at T. dicoccum and T. monococcum compared to spelta.

Shortest vegetation period shows T. dicoccum - 233-250 days, which is 6 days earlier compared to T. monococcum L. and T. spelta L. - 239-256 days.

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REFERENCES

AHMAD F, ASENSTORFER R, SORIANO I, MARES D: Effect of temperature on lutein esterification and lutein stability in wheat grain. Journal of Cereal Science, 58(3), 408–413, 2013.

BOJNANSKA T, FRANCAKOVA H: The use of spelt wheat (Triticum spelta L.) for baking applications, Rostlinna Vyroba, 48(4), 141-147, 2002.

CICCORITTI R, CARBONE K, BELLATO S, POGNA N, SGRULLETTA D: Content and relative composition of some phytochemicals in diploid, tetraploid and hexaploid Triticum species with potential nutraceutical properties. Journal of Cereal Science xxx, 1-7, 2012.

DUNCAN, V. Multiple – range and multiple F – test Biometrics, 1995

GULIANI A, KARAGÖZ A, ZENCIRCI N: Emmer (Triticum dicoccon)production and market potential in marginal mountainous areas of Turkey. Mountain Research and Development, 29(3), 220-229, 2009.

HIDALGO A, BRONDOLINI A: Nitritional properties of einkorn wheat (Triticum monococcum L.). J. Sci Food Agric, 94:601-612, 2014.

KARAGÖZ AL: Wheat Landraces of Turkey. Emir. J. Food Agric., 26 (2): 149-156 doi: 10.9755/ejfa.v26i2.16397, 2014.

PIZZUTI D, BUDA A, DODORICO A, DINCA R, CHIARELLI S, CURIONI A, MARTINES D: Lack of intestinal mucosal toxicity of Triticum monococcum in celiac disease patients. Scand J Gastroenterol. Nov;41(11):1305-11 2006.

SAS Institute Inc.1999. SAS Procedures Guide, SPSS for Microsoft Windows, V.9,4 edition.

VLAHOVA V: Bio Fertilizers - an environmentally friendly approach in modern agriculture. Overview. Scientific Fellowship for Agricultural and Forest Science, XII (3-4), 70-76, 2013.

WOLFE M, BARESEL J, DESCLAUX D, GOLDRINGER I, HOAD S, KOVACS G, LÖSCHENBERGER, MIEDANER T, OSTERGARD H, LAMMERTS VAN BUEREN E: Developments in breeding cereals for organic agriculture. Euphitica 163:323 – 346, DOI 10.1007/s1081-008-9690-9, 2008.

ZAHARIEVA M, MONNEVEUX PH: Cultivated einkorn wheat (Triticum monococcum L. subsp. monococcum): the long life of a founder crop of agriculture. Genetic Resources and Crop Evolution, 61(3), 677-706 2014.

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