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INFLUENCE OF ORGANIC FERTILIZERS ON SOME QUANTITATIVE AND QUALITATIVE INDICATORS OF STRAW AND HARVEST INDEX (HI) ON WILD WHEATS (*Triticum dicoccum* Sch., *Triticum spelta* L. AND *Triticum monococcum* L.) IN ORGANIC FARMING

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Abstract

Worldwide, as in Bulgaria, the significance of crops as Triticum dicoccum Sch., Triticum spelta L., and Triticum monococcum L. consistently increases. This is due to the rich genome of crops on one hand and their importance as a healthy food for people (low gluten content, etc.) on the other. In the present study influence of five types of fertilizers on organic farming on some quantitative (straw yield), qualitative (content of cellulose) and the Harvest Index (HI) for three types of wheat - Triticum dicoccum Sch., Triticum spelta L., and Triticum monococcum L. has been researched. The field experiment was conducted during the 2014-2017 period at the Demonstration Center for Organic Farming at the Agricultural University of Plovdiv, Bulgaria. Treatment with Amalgerol and Baikal EM-1U increases the yield of straw at Triticum dicoccum Sch. (4538 kg/ha and 4527 kg/ha, respectively), and Tryven treatment in all three species of wild wheat. Tryven increases cellulose content in straw at Triticum dicoccum Sch. (42.1%), Baikal EM-1U (46.3%) at Triticum spelta L., Lithovit at Triticum spelta L. (45.8%) and Triticum monococcum L. (43.25%). Highest cellulose content in the straw was recorded at Triticum spelta L., followed by Triticum monococcum L., and Triticum dicoccum Sch. All biofertilizers increase HI at Triticum monococcum L.

***Key words**: organic farming, harvest index, Triticum dicoccum Sch., Triticum spelta L., Triticum monococcum L.*

INTRODUCTION

Agroecosystems are open systems that exhibit certain stability in functioning of biological cycles. One of the aims of agroecosystems is to obtain higher biomass (i.e. biological productivity) (Vlahova and Popov, 2014a). In recent years, the cultivation of the ancient wheat species *Triticum spelta* L. (dinkel), *Triticum monococcum* L. (einkorn) and *Triticum dicoccum* Sch. (emmer) is of great interest in the conservation of genetic resources and biodiversity in agriculture. They are particularly suitable for organic farming because of their identity (Wolfe et al., 2008), and interest in producing organic and healthy foods draws attention to their study. *Triticum dicoccum* Sch. also grows on nutrient-poor soils. This makes the species suitable for cultivation of less fertile soils in mountainous areas (Marino et al., 2009; Giuliani et al., 2009).

Triticum dicoccum Sch. is tetraploid wheat (2n = 28). Their straw is not as coarse as that of *Triticum aestivum* L. or *Hordeum sativum* L. It is suitable as rough forage for ruminants. The use of fertilizers leads to higher yields and grain quality, but also to a better development of the green mass, resulting in more straw. In recent years, biofertilisers have emerged as a promoting component of an integrated nutrient supply system in agriculture (Vlahova et al., 2014b). Strong variations in the straw:grain ratio are observed depending on the variety of wheat, and depending on the presence or absence of awns (Koutev et al., 2014). Another study indicates the role of nitrogen fertilizer norm and that the harvest index, characterizing the proportion of grain in total biomass, is lowest in the non-tiller variants. This is a consequence from the formation of fewer grains in the low mass class (Kirchev et al., 2014). According to Dai et al. (2016) though strong relationships may exist among HI and yield parameters, and high HI does not necessarily suggest high grain yield or low straw yield; and vice versa .The low HI, observed in ND in 2009 coincided with severe foliar fungal diseases caused by, *Septoria* spp. and leaf rust. Therefore it is possible that biotic stresses may also affect HI. Other contributing environmental factors include pest and disease activity. Foliar fertilization is a necessary additional activity in the overall system of optimal mineral nutrition of plants, which supplements the effect and corrects.

When considering wheat straw as a commodity, it is important to understand the links between biomass, grain production and straw production.

Harvest index (HI), indicates directly the distribution of biomass to grain and indirectly the partitioning between grain and straw production. Grain yield is proportional to harvest index and their correlation is 1.00, because biological yield and harvest index are unrelated (Donald and Hamblin, 1976). HI values for modern wheat varieties usually range within 0.3-0.6 (Hay, 1995). A number of studies show that HI is influenced by genetic changes within a particular class of cereals and environmental changes in a particular climate region. Larsen et al. (2012) find, that the difference in straw production in the years and places of cultivation cannot be avoided, but the choice of varieties with higher straw yields can be successfully used as a way to increase the straw's resource in biofuel production.

HI is influenced by abiotic factors (Akram, 2011) as well as early or late sowing date (Donaldson et al., 2001).

Effective weed control in winter field crops is an essential part of successful and profitable agricultural production (Mitkov et al., 2017). Large-scale weeding in winter wheat (*Triticum aestivum* L.) can reduce yields by up to 70% (Tonev et al., 2019). The purpose of the study was to investigate the effect of some leaf fertilizers supplementing nutrition on straw yields, some quality indicators of straw and harvest index (HI) in *Triticum dicoccum* Sch., *Triticum spelta* L. and *Triticum monococcum* L. in organic farming conditions.

MATERIALS AND METHODS

The study was conducted at the experimental field in the Agroecological center - Demonstration center of organic farming the Agricultural University of Plovdiv (Bulgaria) during the 2014-2017 period.

A two-factor field experiment, based on block method has been set in three replications and with a plot size of 10.5 m^2. 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 1000 kg/ha.

The following factors have been studied: Factor A - wheat species A1 - *Triticum dicoccum* Sch.; A2 - *Triticum spelta* L.; A3 - *Triticum monococcum* L., and Factor B - Organic fertilizers: B1 - Amalgerol; B2 - Lithovit; B3 - Baykal EM - 1U; B4 - Tryven. Soil fertilizing Agriorgan pellet - 1000 kg/ha for all variants of the experiment; Amalgerol, Lithovit, Baykal EM - 1U, Tryven - foliar fertilizers, sprayed during the vegetation of the wheats. The following indicators were studied: straw yield (kg/ha); cellulose content in straw (%), harvest index (HI).

Fertilizers used: Amalgerol® is a liquid fertilizer rich in hydrocarbons and natural plant growth hormones. Contains extracts from seaweed, distilled paraffin oil, vegetable oils, distilled herbal extracts. Stimulates the growth of plants, increases the quality and quantity of crop yields in grain production.

Lithovit contains 79.19% ($CaCO_3$) Calcium Carbonate, 4.62% ($MgCO_3$) Magnesium Carbonate, 1.31% (Fe) Iron. It is applied as leaf manure for fodder crops, trenches, meadows and pastures.

Baykal EM - 1U - probiotic product containing useful microorganisms (lactic acid bacteria, yeast, bifidobacteria, ferments and spore bacteria) that are antagonists of pathogenic and conditionally pathogenic microflora. The preparation contains a large group of microorganisms that live in a mode of interaction with a nutrient medium.

Tryven contains Nitrogen (N) total 24.4%, Ammonium Nitrogen (N) 2.60%, Nitrate Nitrogen <0.01%, Carbamide Nitrogen 4.47%, Organic Nitrogen 17.3%, Phosphorus (P_2O_5) water-soluble 17.2%, potassium (K_2O) water-soluble 7.42%. It is a complex mixture of NPK intended for leaf-feeding use.

Agriorgan Pellet - organic fertilizer made of sheep fertilizer, enriched with microorganisms and microelements. Contains: Total Nitrogen (N) - 3.0%, Organic Nitrogen (N) - 2.5%, Phosphorous Oxide (P_2O_5) Total - 3.0%, Organic (K_2O) carbon (C) - 28.5%, Humic acids - 6.0%. The biochemical analysis of the straw for cellulose content is made by Ŝchtoman and Heneberg method. Statistical processing of the data was carried out with the program SPSS for Microsoft Windows (SAS Institute Inc. 1999).

RESULTS AND DISCUSSIONS

Straw yield, kg/ha

Studies on the productive capacity of cereals in Bulgaria are focused mainly on grain production, however there is insufficient information on straw production and data on organic farming are lacking.

Determination of straw yields enables the production cycle to be closed, as well as for the agro-ecosystem (when used as an organic substance) to function better on the organic farm.

The study period is characterized as suitable for crop development, but no three-way trend for straw production is observed in all three wheat varieties (*Triticum dicoccum* Sch*, Triticum spelta* L. and *Triticum monococcum* L.), since climatically in the three years they differ from each other both in the distribution of rainfall and in temperature.

Straw extraction is an indicator that is formed on the basis of the complex influence of soil-climatic conditions and factors that directly influence the absorption of nutrients, as well as the specific microclimate during the particular year.

Average over the study period, it can be seen that the type is a strong factor in the straw yield indicator. This influence is confirmed by a study by other authors (Koutev et al., 2014), according to which the ratio of straw and grain varies depending on the species, variety, acuminate or powerless. *Triticum monococcum* L., proven to realize the highest yield of 5738.2 kg/ha compared to the other two wheat species, with no difference between them (Table 1). There is no tendency in results across years, based on the preparations used. Only Tryven treatment on *Triticum dicoccum* Sch. and *Triticum spelta* L. show a trend in increasing straw yields. However, this effect in *Triticum monococcum* L. varies widely.

Table 1. Straw yield (kg/ha) according to the applied organic fertilizer and the type of wheat during the study period

Variant	Straw, kg/ha											
	Triticum dicoccum Sch.				*Triticum spelta* L.				*Triticum monococcum* L.			
Year	2015	2016	2017	Average of the period	2015	2016	2017	Average of the period	2015	2016	2017	Average of the period
Controla (Agriorgan pellet)	3481c	4445c	4800b	4242ab	4089b	4167b	4587b	4281ab	5782bc	5812c	6987a	6194a
Amalgerol	4282b	4331c	5000b	4538ab	3447c	5081ab	3521c	4016ab	4499d	6764b	5533b	5599a
Lithovit	3605c	4479c	4200c	4095b	3454c	4585ab	3267c	3768b	6088a	6668b	5453b	6069a
Baykal EM	3596c	4773b	5213b	4527ab	3561c	2943c	4083b	3529b	5420c	3213d	4961c	4531a
Tryven	4782a	5296a	5840a	5306a	4217a	5407a	5760a	5128a	5903b	7151ab	5840ab	6298a
Wheat species	4541.5b				4144.6b				5738.2a			

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

During the study period, the application of foliar fertilizers showed that Tryven treatment, proven leads to increasing in straw yields at *Triticum dicoccum* Sch. - 5306 kg/ha and *Triticum spelta* L. - 5128 kg/ha, compared to controls, fertilized only with Agrigorgan pellets. This shows the positive effect of foliar Tryven feeding and the nitrogen contained in it to accumulate more biomass. The influence of nitrogen in the fertilizer rate is confirmed by another authors, (Kirchev et al., 2014). The straw yield in *Trticum monococcum* L. is also highest when Tryven was applied - 6298 kg/ha, but tis nis not statistically proven, compared to the control. The effect of the other foliar fertilizers varied over the years, taking into account the proven values of the indicator compared to the control after application of Amalgerol and Lithovit.

Cellulose content in straw, %

The cellulose content in straw varied across the wheat varieties in the range of 33.34-46.27% in the different variants, but compared to the cellulose content of the common wheat (*Triticum aestivum* L.) - 39.5% were quite similar. This indicates that the straw of the ancient wheat species can be used as a substitute for that of common wheat.

With highest cellulose content is characterized the straw of *Triticum spelta* L., followed by the straw of *Triticum monococcum* L. Its lowest content is at *Triticum dicoccum* Sch. With few exceptions, the application of the studied biofertilizers increased the content of cellulose in leafs of all three wheat species relative to their controls (Table 2).

There is a species reaction of wheat, about the cellulose accumulation in straw due to fertilization. The srongest effect is reported at Lithovit-treated variants, namely, a decrease in cellulose % in straw in *Triticum dicoccum* Sch. - 33.34% and a significant increase in *Triticum spelta* L. - 45.88% and *Triticum monococcum* L. - 43.25% over their controls.

Table 2. Harvest index (HI) and cellulose content in straw of the studied species and variants averaged for the study period

Variant	Cellulose, %	Grain yield, kg/ha	Straw yield, kg/ha	Abovegraund biomass, kg/ha	HI
Triticum dicoccum Sch.					
Wheat species	-	*2218.3a*	*4541.5b*	*6759.8*	*0.489a*
Control (Agriorgan pellet)	36.53	2175.5a	4242ab	6417.5	0.510a
Amalgerol	36.35	2182.8a	4538ab	6720.8	0.476a
Lithovit	33.34	2172.2a	4095b	6267.2	0.533a
Baykal EM	38.53	2180.4a	4527ab	6707.4	0.483a
Tryven	42.14	2380.4a	5306a	7686.4	0.443a
Triticum spelta L.					
Wheat species	-	*2520.9a*	*4144.6b*	*6662.5*	*0.498a*
Control (Agriorgan pellet)	43.79	2389.5a	4281ab	6670.5	0.550a
Amalgerol	40.11	2479.6a	4016ab	6495.6	0.446a
Lithovit	45.88	2568.7a	3768b	6336.7	0.483a
Baykal EM	46.27	2468.9a	3529b	5997.9	0.500a
Tryven	44.29	2697.8a	5128a	7825.8	0.510a
Triticum monococcum L.					
Wheat species	-	*2655.6a*	*5738.2a*	*8393.8*	*0.476a*
Control (Agriorgan pellet)	39.26	2597.7a	6194a	8791.7	0.416a
Amalgerol	41.34	2671.2a	5599a	8270.2	0.493a
Lithovit	43.25	2593.5a	6069a	8662.5	0.430a
Baykal EM	40.76	2538.3a	4531a	7069.3	0.576a
Tryven	39.99	2877.2a	6298a	9175.2	0.463a

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

Harvest index (HI)

Harvest index (HI), characterizing the proportion of grains in total biomass is highest with *Triticum spelta* L. - 0.498, followed by *Triticum dicoccum* Sch. (0.489) and *Triticum monococcum* L. (0.476), but all the differences are not proven (Table 2). Fertilizer treatment increases the harvest index to varying degrees in the individual variants, but with no statistically confirmation. Higher values of the indicator were reported with *Triticum dicoccum* Sch. after Lithovit application - 0.533. All studied leaf fertilizers for *Triticum monococcum* L. increased the harvest index, but with no statistically effect. At Baykal EM treatment, the harvest index was 0.576, followed by variants treated with Amalgerol - 0.493, Tryven - 0.463 and Lithovit - 0.430. The values of the harvest index for *Triticum spelta* L. after are close to those of control.

CONCLUSIONS

At all three wheat species, *Triticum monococcum* L., demonstrates highest straw yield - 5738.2 kg/ha, compared to other two species.

Tryven treatment increase the straw yield at *Triticum dicoccum* Sch. - 5306 kg/ha and *Triticum spelta* L. - 5128 kg/ha, compared to controls.

The highest cellulose content in straw is reported at *Triticum dicoccum* Sch. when Tryven was applied (42.14%), and at *Triticum spelta* L., after application of Baikal EM (46.27%). At *Triticum monococcum* L. all studied biofertilizers increase cellulose content, the most significant increase was observed at Lithovit application (43.25%).

The harvest index (HI) is highest at *Triticum spelta* L. - 0.498, followed by *Triticum dicoccum* Sch. (0.489) and *Triticum monococcum* L. (0.476), but no statistically significance. Fertilizer treatment increases the harvest index to varying degrees in the individual variants.

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