Phytosanitary condition and yield of wheat (*Triticum aestivum*) and einkorn wheat (*Triticum monococcum*) after application of different types of organic compost in organic and biodynamic farming systems

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Abstract

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The experiment was conducted in the period 2013-2016 on the experimental fields of the Institute of Agriculture in Karnobat, Bulgaria. Wheat and einkorn wheat were grown in biodynamic and organic farming systems after application of different types of organic compost. Studies were conducted on the effect of compost types on phytosanitary condition and yield of the crops. The experiments established that the phytosanitary condition of wheat was better when it was biodynamically cultivated with applied standard biodynamic compost in the soil. No diseases and pests were reported for einkorn wheat in the three variants, whereas weeds had lower density and species composition in einkorn than in wheat and the variant with standard biodynamic compost was the most weakly infested. The highest yields of wheat and einkorn wheat were obtained at biodynamic cultivation with applied standard biodynamic compost, followed by the variant of biodynamic compost according to Maria Thun's compost preparations.

Keywords: wheat; einkorn; organic farming; biodynamic farming; organic compost

Wheat is one of the most widely distributed crops in Bulgaria. In recent years, the increased demand of healthy foods has led to an increase in the production of einkorn wheat. The cereal crops are some of the major crops grown in an unconventional way. Organic cultivation excludes the use of synthetic fertilizers, pesticides and growth regulators (Bozhanova & Dechev, 2009). Biodynamic farming is an improved organic farming system, which attracts increasing interest due to its accent on food quality and soil health (Diver, 1999). Biodynamic and organic farming are similar in that they are both ecologically oriented and do not use chemical fertilizers and pesticides. The main difference is that biodynamic farmers add nine specific amendments, called preparations, to their soils, crops, and composts. Recently, there has been an increasing interest in biodynamic farming practices and systems because they show potential for mitigating some detrimental effects of chemical-dependent conventional agriculture. Only a few studies examining biodynamic methods or comparing biodynamic farming with other farming systems have been published in the refereed scientific literature, especially in English. These studies have shown that the biodynamic farming systems generally have better soil quality, lower crop yields, and equal or higher net returns per hectare than their conventional counterparts. Two studies that included organic management treatments with and without preparations showed that preparations improved biological soil properties and increased crop root growth. However, more research is needed to determine whether preparations affect soil physical, chemical, and biological properties and crop growth and, if so, to determine their mode of action (Reganold, 1995).

A distinguishing feature of biodynamic farming is the use of nine biodynamic preparations described by Steiner for the purpose of enhancing soil quality and stimulating plant life. They consist of mineral, plant, or animal manure extracts, usually fermented and applied in small proportions to compost, manures, the soil, or directly onto plants, after dilution and stirring procedures called dynamizations (Diver, 1999). Carpenter-Boggs et al. (2000) conclude that organically and biodynamically managed soils had similar microbial status and were more biotically active than soils that did not receive organic fertilization.

The aim of this research was to report on the effect of different types of organic compost on the phytosanitary condition and yield of wheat and einkorn wheat.

MATERIALS AND METHODS

The experiment was conducted in the period 2013-2016 on the certified experimental fields for organic farming at the Institute of Agriculture in Karnobat. Three farming variants of wheat (*Triticum aestivum*) variety Miryana and einkorn (*Triticum monococcum*) (ancient wheat, local race) were set up. Sowing-time was the optimal period between September 20th and September 30th, wheat were sown at 550 seeds/m^2 and einkorn at 450 seeds/m^2. The first one was organic farming with application of pure organic compost (cow manure) in the soil at rate of 40 t/ha. The second variant was biodynamic cultivation of the crops with applied organic compost (cow manure) 40 t/ha, with the standard compost biodynamic preparations according to the standards of Demeter International (http://www.demeter.net) (the classic Steiner technology). The third variant was again biodynamic cultivation, but the standard compost preparations were replaced with plant ones (according to Maria Thun), the compost (cow manure) was deposited again at the rate of 40 t/ha. The applied biodynamic compost preparations in both variants were within the recommended standard rates according to the requirements of Demeter International. The size of each variant plot per crop was 0.1 ha. The total experimental plot area was 0.6 ha. Organic variant with applied pure organic compost (cow manure) was used as control. The manure application was done annualy, in September. In the period of the study, all the variants were subjected to phytosanitary monitoring for diseases, pests and weeds. Phytosanitary conditions were observed in the wheat and eincorn during April - May. Weeds were determined according to Delipavlov et al. (2003) in number/m^2. The aphid‘s population size was determined by direct measures at 10 locations on 10 stalks in each crop (Dewar et al., 1982). Taxonomic analyzes of the aphids are made according to Van Emden (1972) and Blackman & Eastop (2000). The state of the crops in terms of diseases was observed during the growing season. Readings were carried out on the route method, via the plants (Stepanov and Chumakov, 1972; Krivchenko, 1984).

Data was analyzed and yields from the different variants were compared for both crops and was processed by analysis of variance (BIO program).

RESULTS AND DISCUSSION

In Southeastern Bulgaria, winter is comparatively warm, spring is short and cool, summer is hot and dry, autumn is long and warm. The studied period was marked by excessive rainfall and in the first year it was by 8% more than the multi-annual values, in the second – by 40%, in the third – by 30% more. Rainfall was unevenly distributed by months, but provided humidity during the specific periods and the conditions for growing cereal crops were favorable (Fig. 1).

The phytosanitary monitoring on diseases in the three variants established that no diseases were found in einkorn wheat over the three-year period. The warm and humid weather during the three years of the study (Fig. 1) created favorable conditions for the occurrence of diseases in wheat. As wheat is generally more susceptible than einkorn wheat, diseases were found in the two variants of the experiment (Table 1). Single plants were found with *Ustilago tritici* in the wheat organically grown with organic compost (the attack is <0.1%). *Puccinia recondita* and *Septoria tritici* were also found in the same variant. In the variant with standard biodynamic compost (Steiner, 1924), no diseases were reported. This is probably due to the applied standard compost biodynamic preparations, which Hagel (1988) found to have beneficial effect on plants. In the third variant of biodynamic cultivation with

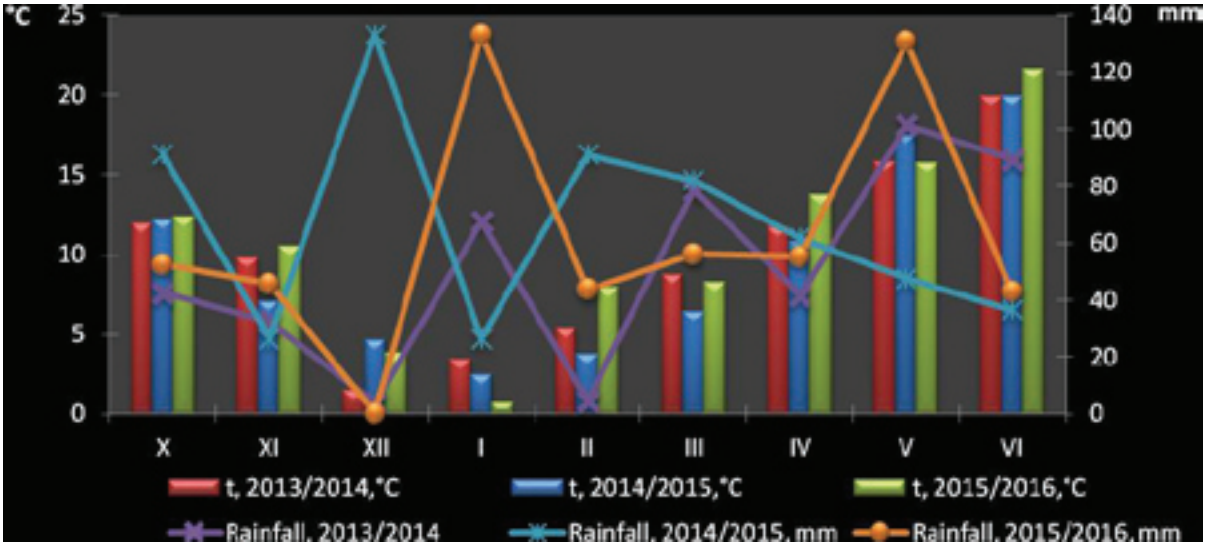

Figure 1. Agrometeorological characterization of the study period

Table 1. Species composition of diseases in wheat grown in two farming systems, and application of three types of organic compost (2013-2016)

Diseases	Organic farming with organic compost	Biodynamic farming with standard compost	Biodynamic farming with compost of Maria Thun
Ustilago tritici	+	-	-
Puccinia recondita	+	-	-
Septoria tritici	+	-	+

applied compost according to Maria Thun's biodynamic preparations, only *Septoria tritici* was reported. This probably came as a result of the weaker effect of this type of biodynamic preparations, but at the same time it was still better than the application of pure organic compost.

The phytosanitary monitoring on einkorn wheat has found no pests in the three variants. In wheat, unlike einkorn wheat, pests were found in the three variants (Table 2). Fewest species were observed in biodynamic cultivation with applied compost of standard biodynamic preparations. This is probably also due to the biodynamic preparations, which affected plant development and consequently its attractiveness for the pests. In the three variants, the density of pests was very low, and over the years only single pests were found. As a result, only the species composition was commented on. The low density of the pests was probably caused by the torrential rains over the study period, which washed away aphids and gave rise to the occurrence of fungal diseases on pests.

Average for the study period, the highest level of weed infestation was established in wheat fertilized with manure – 31 plants/m^2. In this variant, the species diversity was also greatest –13 weed species were reported. In einkorn wheat fertilized with manure, the weed density was twice lower compared to wheat in the same variant – 15 weeds/m^2. The species diversity and weed density in the biodynamic variants were significantly lower. The lowest density and species composition were reported for the variant with standard biodynamic compost.

The analysis of the wheat yield over the years in the three variants showed higher yield in biodynamic cultivation (Fig. 2, Table 4). When standard biodynamic compost was applied (4410 t/ha), that is 152.48% more than the variant with pure organic compost in organic farming. In the variant of biodynamic compost with Maria Thun's compost

Table 2. Species composition of pests in wheat grown in two farming systems, and application of three types of organic compost (2013-2016)

Pests	Organic farming with organic compost	Biodynamic farming with standard compost	Biodynamic farming with compost of Maria Thun
Sitobion avenae L.	+	-	+
Eurygaster sp.	+	+	+
Aelia sp.	+	-	+
Haplothrips tritici Kurd.	+	+	+

Table 3. Species composition of weeds in wheat and einkorn wheat grown in two farming systems, and application of three types of organic compost (2013-2016)

Weeds	Wheat			Einkorn		
	Organic farming with organic compost	Biodynamic farming with standard compost	Biodynamic farming with compost of Maria Thun	Organic farming with organic compost	Biodynamic farming with standard compost	Biodynamic farming with compost of Maria Thun
Anthemis arvensis L.	8	2	10	7	1	10
Centaurea cyanus L.	1			2		
Consolida regalis S.F.Gray.	1					
Convolvulus arvensis L.	1		3		1	
Papaver rhoeas L.	2	1	5		1	1
Polygonum convolvulus L.	3	1				
Ranunculus spp.	1					
Sinapis arvensis L.	2			1		
Vicia hirsuta (L.) S.F.Gray	1		10	1		1
Vicia striata M.B.	1			1		1
Viola tricolor L.	2	1				
Alopecurus mysouroides L.	3			1		
Bromus ssp.	5	2		2	1	
All species of weeds	**13**	**5**	**4**	**7**	**4**	**4**
Total weeds, nb/m^2	**31**	**7**	**28**	**15**	**4**	**13**

preparations, wheat yield exceeded the control with 120.99%, with an average yield of 3860 t/ha. It was found that the type of organic compost had an effect on wheat yield (96.38%).

Einkorn wheat demonstrated a similar tendency. The highest yield was obtained after biodynamic cultivation and application of standard biodynamic compost – 2456.7 t/ha, which is 65.25% above the control, followed by biodynamic cultivation with applied Maria Thun's compost preparations – 2140 t/ha, which is 43.95% above the control. The type of applied compost to einkorn wheat demonstrated 91.82% effect on yield (Fig. 3, Table 5).

CONCLUSIONS

The phytosanitary condition of wheat crops was better in the variant of biodynamic cultivation with applied standard biodynamic compost in the soil. No

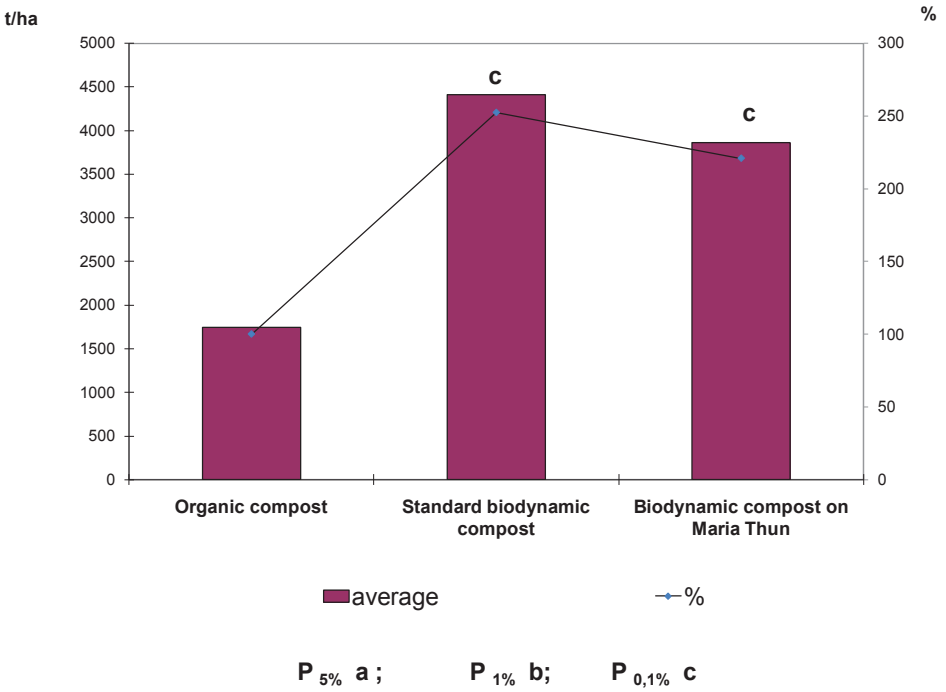

Figure 2. Average yield of wheat, after application of three types of organic compost (2013-2016), t/ha

Table 4. Analyses of variance for grain yield of wheat, after application of three types of organic compost

Source of variation	SQ	DF	η^2 (%)
Total variation	123072.89	8	
Years	1956.22	2	1.59
Types of organic compost	118620.22	2	96.38
Accidental factors	2496.44	4	2.03

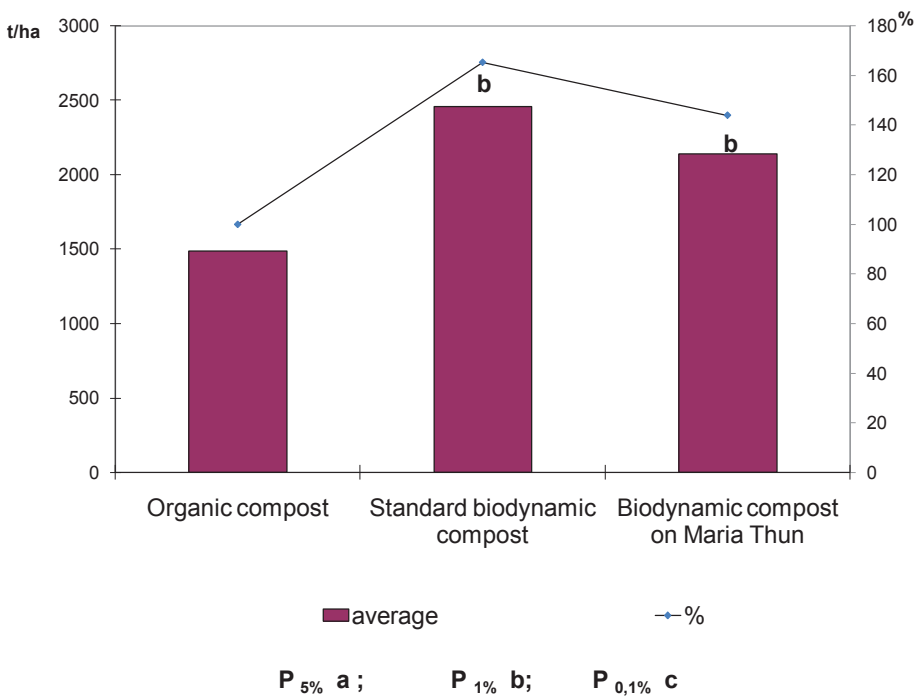

Figure 3. Average yield of einkorn, after application of three types of organic compost (2013-2016), t/ha

Table 5. Analyses of variance for grain yield of einkorn, after application of three types of organic compost

Source of variation	SQ	DF	η^2 (%)
Total variation	15987.56	8	
Years	522.89	2	3.27
Types of organic compost	14680.22	2	91.82
Accidental factors	784.44	4	4.91

diseases and pests were reported for einkorn wheat in the three variants of this experiment, whereas weeds had lower density and species composition than wheat, and the lowest weed infestation was observed in the variant with standard biodynamic compost. The highest yields of both wheat and einkorn wheat were obtained after their biodynamic cultivation with applied standard biodynamic compost, followed by the variant with biodynamic compost with Maria Thun's compost preparations.

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