Influence of predecessor on the phytosanitary status and the productivity of common and durum wheat in organic farming

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Abstract

During the period 2015-2017, in the Institute of Agriculture – Karnobat, in field certified organic farming is conducted field experience. Common and durum wheat are sown after chickpea, lentil, potatoes and pumpkins. The aim is to study the influence of predecessors on the phytosanitary status and productivity of crops in organic farming. When growing common and durum wheat in the field of organic farming, the level of weed infestation varies depending on the predecessors. It is lowest after chickpea and lentil and rises after potatoes and pumpkins. In the highest density the pests are observed after the predecessors - chickpea and lentil. The number of pests in common wheat is much higher than in durum wheat. In the case of ordinary wheat variety Miryana, the grain yield depends on 82.13% of the years of cultivation and 16.78% of the predecessors. In the case of durum wheat, the grain yield depends on 83.28% of the year conditions and on 14.75% of the predecessors. The predecessors in the organic crop rotation do not affect the hectoliter mass of the grain in Miryana common wheat and Predel durum wheat. The content of crude protein and wet gluten in the grain is very low and varies slightly depending on the conditions of the year and the predecessor, with a tendency to rise slightly after chickpea and lentil.

Key words: organic farming; common and durum wheat; predecessors; yield; weed infestation; insects

INTRODUCTION

Organic farming is a reasonable approach to soil and plants, in which ecological balance is achieved without the use of chemical fertilizers, pesticides, GMO-organism. Its essence is to organize the farm as a natural ecosystem in which each entity has its own destiny and lives in harmony with others (Masanobu Fukuoka, 1978). It is an alternative viable option for sustainable development and clean food production with minimal environmental pollution (Ravisankar et al., 2021).

Predecessors are important in the cultivation of cereals, especially in the conditions of organic farming. Correctly constructed crop rotations, in accordance with the agro-ecological conditions and the production tendency of the organic farm, are the basis for the effective use of the remaining factors - soil treatment and plant protection measures when growing crops (Koteva, 2004; Zarkov, 2006; Atanasova & Zarkov, 2007). Crop rotation ensures better use of soil moisture and significantly prevents the negative impact of drought and has a positive effect on crop productivity (Vasilev, 1986; Zarkov, 1996; Olesen et al., 2000). Crop rotation based on leguminous crops are much better than monoculture wheat (Lui et al, 2020).

Crop rotation is a key factor in reducing the level of weed infestation, the density of pests and diseases in organic farming (Atanasova & Koteva, 2009; Baldivieso-Freitas et. al., 2018; Headrick, 2021). The question is, in the case of organic farming of cereal crops, to achieve a balance in the ecosystem between the density of cultural and weed plants, between the density of pests and predators, and from there also in the yield level. Results indicate that longer rotations with more phenologically diverse crops can reduce soil seed bank populations and broadleaf weed species abundance in organic production systems (Teasdale et. al., 2003).

The main goal of this study was to investigate the influence of the predecessors on the phytosanitary status and productivity of common and durum wheat under organic farming.

MATERIALS AND METHODS

The study was conducted on Eutric Vertisols soil type (Ninov, 2005) in a certified organic farming field keep by the Institute of Agriculture - Karnobat. The field experiment was carried out in 2014 - 2017. The object of the study was common wheat variety Miryana and durum wheat variety Predel, sown after four predecessors - chickpea, lentil, potatoes and pumpkins. The size of the experimental plot is 75 m^2, and the yield plot - 35 m^2.

Phytosanitary monitoring was carried out in the experimental plots. Weed infestation - species composition and density, was carried out by the quantitative-weight method (nb/m^2; g/m^2), in the phase of the end of tillering and the beginning of the ear of wheat. Surveys for pests were carried out during the spring growing season of the crops. Aphids were counted with standard entomological methods - mowing with an entomological bag and direct counting on 100 stems (in 10 places on 10 stems). Their species composition and numerical dynamics were determined. The taxonomic analysis of aphids was carried out according to Emden (1972) and Blackman & Eastop (1984). Observations were carried out weekly until the crops were harvested. After harvesting, crop yield ($kg.da^{-1}$), hectoliter weight (*kg*), protein content (%) and wet gluten (%) were recorded. The data were processed mathematically by analysis of variance (statistical package BIO).

In Southeastern Bulgaria, the climate is transitional-continental with an average annual precipitation of 549 *mm*. Winter is relatively warm, spring is short and cool, summer is hot and dry, autumn is long and warm. The vegetation year 2014/2015 is characterized by a warm and wet autumn, a cold and wet winter, a wet spring and summer, and the weather conditions for another year emphasize their exceptional role in the growth, development of crop plants and weeds and the formation of crop productivity (Figure 1). Average monthly temperatures for all months, except for October and November, have higher values compared to the perennial ones. The following year, 2015/2016, was characterized by a wet autumn, a warm winter, a warm and wet spring and a dry summer. After the significant amount of precipitation that fell during the third ten days of November (45.6 *mm),* December was relatively warm and dry, but at the end of the month there was a sharp cooling with significant precipitation (132.1 *mm*). High temperatures in February, March and April, as well as good soil

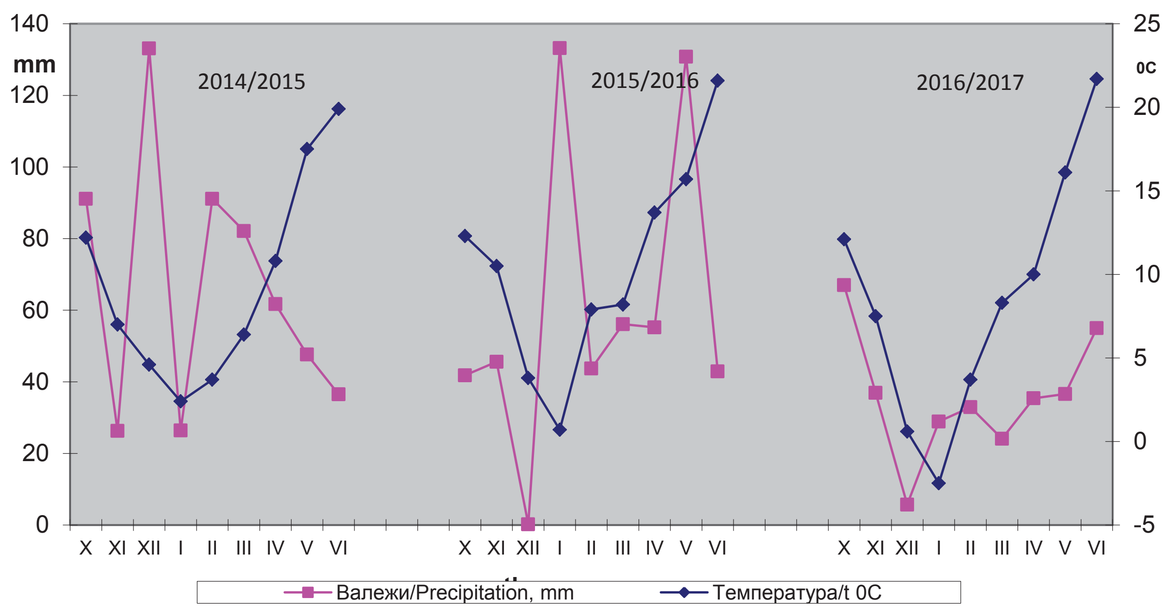

Figure 1. Rainfall and average daily temperatures (2014-2017)

moisture, favor the growth and development of the culture.

The vegetation year 2016 / 2017 is characterized by a dry autumn, a cold and snowy winter, a warm and dry spring and a dry and hot summer, and these conditions are quite unfavorable for winter cereals (Figure 1).

RESULTS AND DISCUSSION

There is a wide species diversity of weeds in the organic farming field, as organic farming aims to achieve a sustainable equilibrium in the created ecosystem, i.e. a relative balance between weeds and crop plants (Masanobu Fukuoka, 1978; Stolze et al., 2000).

Of the annual broad-leaved weeds *Papaver rhoeas, Anthemis arvensis, Sinapis arvensis, Polygonum aviculare, Polygonum convolvulus* prevail, in a smaller density - *Caucalis daucoides, Centaurea cyanus, Consolida regalis*, the species of *Lathyrus* spp. and *Vicia* spp., which in conventional farming are very sensitive to herbicides from the 2.4-D group, begin to appear.

The level of weed infestation varies with the crop and the predecessors. It is lowest after chickpea and lentil and rises after potatoes and pumpkins (Figure 2).

After the entomological examinations of durum wheat variety Predel and common wheat variety Miryana, 7 pests from three orders and after the four predecessors (Table 1) were found to be harmful, this shows that the predecessors do not influence the species composition of the pests. The greatest species diversity is observed in the *Nemipter*a order.

The numerical dynamics of the main pests of durum and common wheat after the different predecessors were reported (figures 3 and 4). In the highest density, pests from all three orders are observed after precursors of chickpea and lentil. This is probably due to nitrogen-fixing bacteria in legume crops providing nitrogen to the soil, resulting in plants that grow better and are more attractive to pests than those grown after the other two predecessors. The largest differences in attack after the predecessors are observed in the order *Nemiptera*. The order includes aphids and cicads, which are suckers and prefer more protein-rich plant juices, which are likely obtained from plants grown after a legume ancestor. The number of pests in common wheat is much higher than that in durum wheat.

For the study period, the productivity of common and durum wheat varied significantly depending on the agrometeorological conditions of the year and predecessor (Tables 2 and 3). In common wheat variety Miryana, the grain yield is influenced 82.13% by the year of cultivation (agrometeorological conditions) and 16.78% by the predecessors. In the case of Predel durum wheat, the grain yield depends 83.28% on the conditions of the years and 14.75% on the predecessors. These results confirm the thesis of other authors that environmental factors have the greatest influence on the grain yield of common (Uhr et al., 2020) and durum wheat (Aberkane et al., 2021).

In the case of common wheat variety Miryana, the highest yield was obtained in 2015 after the pre-

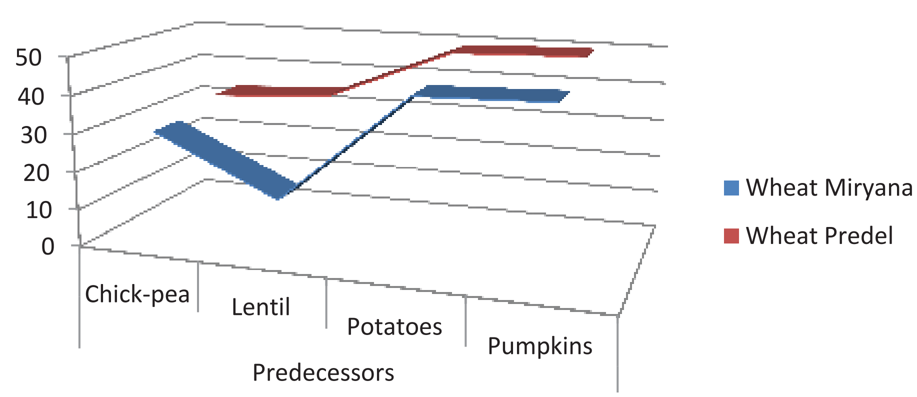

Figure 2. Weed infestation of common and durum wheat after four predecessor average for the period (*pcs/m²*)

Table 1. Main pests of durum wheat Predel and common wheat Miryana, after four predecessors

Order	Species	Predel	Miryana
After Chick-peas			
Hemiptera	*Sitobion avenae*	+	+
	Schizaphis graminum	+	+
	Rhopalosiphum maidis	+	+
	Philaenus spumarius	+	+
Coleoptera	*Oulema melanopa*	+	+
Heteroptera	*Eurygasterintegriceps*	+	+
	Aelia acuminate	+	+
After Lentil			
Hemiptera	*Sitobion avenae*	+	+
	Schizaphis graminum	+	+
	Rhopalosiphum maidis	+	+
	Philaenus spumarius	+	+
Coleoptera	*Oulema melanopa*	+	+
Heteroptera	*Eurygaster integriceps*	+	+
	Aelia acuminata	+	+
After Potatoes			
Hemiptera	*Sitobion avenae*	+	+
	Schizaphis graminum	+	+
	Rhopalosiphum maidis	+	+
	Philaenus spumarius	+	+
Coleoptera	*Oulema melanopa*	+	+
Heteroptera	*Eurygaster integriceps*	+	+
	Aelia acuminata	+	+
After Pumpkins			
Hemiptera	*Sitobion avenae*	+	+
	Schizaphis graminum	+	+
	Rhopalosiphum maidis	+	+
	Philaenus spumarius	+	+
Coleoptera	*Oulema melanopa*	+	+
Heteroptera	*Eurygaster integriceps*	+	+
	Aelia acuminata	+	+

decessor chickpea - 395 *kg.da*$^{-1}$, and the lowest - in 2017 after the predecessor potatoes - 196 *kg.da*$^{-1}$. On average for the study period, the yield was the highest after predecessors chickpea 328 *kg.da*$^{-1}$ and lentil – 324 *kg.da*$^{-1}$. As in individual years, yields after these crops overlap.

For durum wheat Predel, the highest yield was obtained in 2015 after the predecessor chickpea – 357 *kg.da*$^{-1}$, and the lowest – in 2017 after the predecessor pumpkins – *152 kg.da*$^{-1}$. For the study period, the trend is also maintained here, as with common wheat.

Averaged over the period, after the four predecessor, the hectoliter mass of both common and durum wheat did not vary significantly (Table 4).

Crude protein, although genetically determined, in the grain of wheat is strongly influenced by the factors of the growing environment, including some agrotechnical measures (Terman, 1979; Hlisnikovský, et al., 2019). Crude protein content

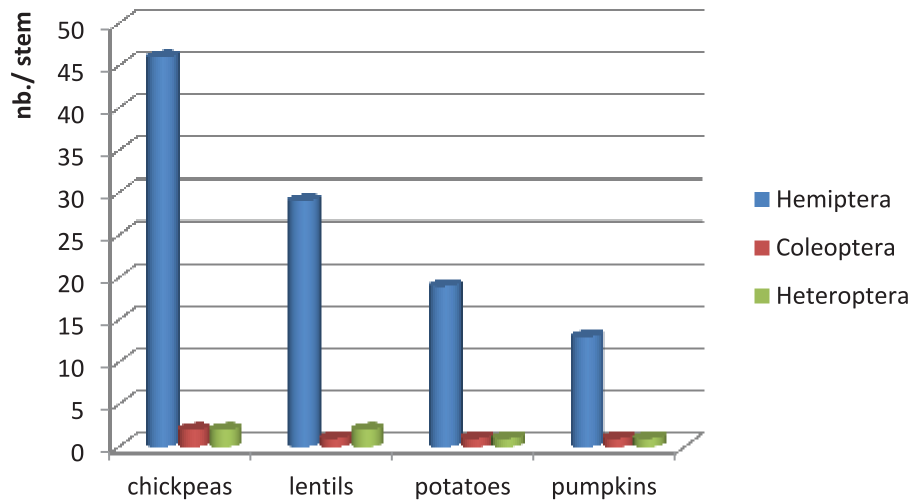

Figure 3. Pests dynamics of durum wheat variety Predel after four predecessors (average for three years, 2015 - 2017)

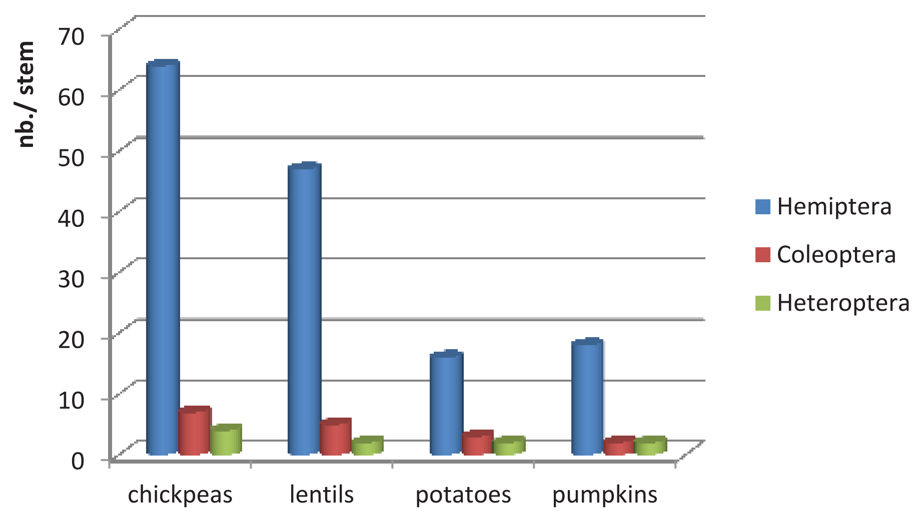

Figure 4. Pests dynamics of common wheat variety Miryana after four predecessors (average for three years, 2015 - 2017)

Table 2. Analysis of variance for grain yield of common and durum wheat after four predecessors, average 2014-2017

Sourse of variability	Wheat					
	Common wheat Miryana			Durum wheat Predel		
	SQ	df	η 2 (%)	SQ	df	η 2 (%)
Total	48004.25	11		43304.67	11	
Years	39423.50	2	82.13	36062.17	2	83.28
Predecessor	8056.25	3	16.78	6386.67	3	14.75
Residuals	524.50	6	1.09	855.83	6	1.98

Table 3. Grain yield of common and durum wheat after four predecessors (*kg.da*$^{-1}$)

Predecessor	Years			
	2015	2016	2017	Average
Common wheat Miryana				
Chickpea	395	340	248	328
Lentil	380	348	244	324
Potatoes	310	294	196	267
Pumpkins	345	308	201	285
LSD 5%	10.50	12.34	12.20	
1%	15.90	18.60	17.53	
0.1%	25.55	31.56	30.40	
Durum wheat Predel				
Chickpea	357	291	242	297
Lentil	350	295	211	285
Potatoes	325	277	192	265
Pumpkins	298	258	152	236
LSD 5%	16.20	14.22	12.80	
1%	24.53	24.20	19.10	
0.1%	39.40	36.10	34.88	

Table 4. Main quality indicators for common wheat Miryana and durum wheat Predel after four predecessors, average for the period

Predecessor	Hectoliter mass (kg)	Crude protein content, %	Wet gluten content, %
Common wheat Miryana			
Chickpea	79.2	10.5	13.9
Lentils	80.2	9.2	13.3
Potatoes	79.2	8.1	10.5
Pumpkins	79.7	8.8	11.3
Durum wheat Predel			
Chickpea	80.6	10.1	16.6
Lentil	81.5	9.6	18.6
Potatoes	80.9	8.9	17.1
Pumpkins	80.2	8.7	16.0

is very low in both types of wheat, which is characteristic of the organic cultivation of these crops, also confirmed by the research of Witten, et al (2018).

The content of wet gluten and its quality and crude protein content are the main indicators characterizing the milling and baking quality of wheat grain. In organic farming and in common wheat variety Miryana and durum wheat variety Predel, the content of wet gluten is very low. In the grain of the common wheat variety Miryana after the predecessor lentil reaches 13%, and in the grain of the durum wheat variety Predel - after lentil - 18.6%, and after chickpea - 16.6%.

CONCLUSIONS

The common and durum wheat, cultivation in organic farming, the level of weed infestation varies depending on the predecessors. It is lowest after chickpea and lentil and rises after potatoes and pumpkins.

In the highest density, pests are observed after predecessors chickpea and lentil. The number of pests in common wheat is much higher than that in durum wheat.

In common wheat variety Miryana, the grain yield is affected 82.13% by the year of cultivation and 16.78% by the predecessors. In durum wheat variety Predel, the grain yield depends 83.28% on the conditions of the year and 14.75% on the predecessors.

Predecessors in the organic crop rotation do not influence the hectoliter mass of the grain in common wheat variety Miryana and durum wheat variety Predel. The crude protein and wet gluten content of the grain is very low and varies little with year and precursor conditions, tending to rise slightly after chickpeas and lentils.

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