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The effect of bioproducts on organically grown winter wheat

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The study was aimed to examine the effect of the bioproducts Biokal 01 and Fitokondi on the germination of organically grown winter wheat (*Triticum aestivum* L.) cultivar 'Širvinta 1' seed and its contamination with microscopic fungi as well as the impact on the occurrence of foliar diseases, plant biometric indicators and grain quality. Laboratory analyses showed that the tested bioproducts did not exert any significant effect on seed vigour and germination. Fitokondi gave the highest efficacy against pathogens of seeds, its biological efficacy against *Fusarium* and *Alternaria* spp. fungi was 50.0% and against *Penicillium* spp. it was 20.0%. Biokal 01 statistically significantly reduced only grain contamination with *Mucor* spp. and *Aspergillus* spp. The bioproducts significantly decreased the incidence of crown rot diseases in the coleoptiles of wheat seedlings and roots. In the field conditions, the bioproducts did not have any significant effect on the incidence of Septoria leaf blotch (*Mycosphaerella graminicola* (Fuckel) J. Schröt. anamorph *Zymoseptoria tritici* (Desm.) Quaedvlieg & Crous) and tan spot (*Helminthosporium tritici-repentis* Died.). A significant increase in plant height and ear length, grain number per ear and 1000 grain weight was recorded. Grain yield increased by 0.66–0.79 t ha^{-1} or 18.64–22.32%, as well as protein, wet gluten and dry gluten content in response to both bioproducts.

Keywords: wheat, bioproducts, organic farming, fungi, yield

INTRODUCTION

Organic production farms face two major challenges of securing nutrient supply for crops and controlling plant diseases, since the use of fertilizers and crop protection products is strictly limited by the EU regulations (Finch et al., 2006). Compared with intensive farming, considerably lower yields are produced in the organic cropping system because of the stringent requirements that organic farms have to abide by, one of which is a ban on the use of synthetic fertilizers and pesticides. As a result, it is vital to search for adequate alternative solutions to plant nutrient supply and disease control problems (Pekarskas, 2008).

The research done in Lithuania suggests that the grain yield and quality of organically grown winter wheat depends not only on the cultivar grown and organic fertilization applied but also on the application of liquid bioproducts and growth promoters (Sliesaravičius et al., 2006; Pekarskas, 2008). Higher crop yield requires more nutrients which can be spray-applied with foliar fertilizers. Foliar fertilization reduces nutrient shortage at critical moments for plants, including adverse climate, soil and other stress-induced conditions (Budzynski et al., 2003; Knittel, Albert, 2003). Bioactive substances promote crop growth and consequently enhance the competitive ability of crop plants against weeds, which is very important in organic crop production (Bond et al., 2001).

Diseases in organically grown winter wheat crops are becoming an increasingly pressing problem. Various foliar diseases occur in winter wheat crops annually; however, their severity differs between years. Septoria leaf blotch (*Mycosphaerella graminicola* (Fuckel) J. Schröt. anamorph *Zymoseptoria tritici* (Desm.)) and tan spot (*Helminthosporium tritici-repentis* Died.), caused by necrotrophic pathogens, is important, difficult to control winter wheat diseases, inflicting severe damage to crops (Bhathal et al., 2002). Due to the decreased plant assimilating surface and prematurely withered leaves, wheat grains grow small in size and exhibit poor quality indicators (Gaurilčikienė et al., 2008). Research has shown that bioproducts, used for crop nutrition during the growing season, can be also used for pre-sowing treatment of cereal seeds since they not only supply plants with nutrients but also reduce seed contamination with microscopic fungi and bacteria of some pathogenic genera (Pekarskas, 2008). Biologically active substances of various plant extracts and essential oils present in the bioproducts can act as biofungicides influencing the spread of fungal diseases (Fawzi et al., 2009; Al-Askar, Rashad, 2010).

The range of solid and liquid fertilizers, growth promoters currently available for use in organic farms, is rather wide; however, these products are little investigated and their effects are not completely clear. A very limited choice of biological plant protection products is one of the reasons restricting an effective control of harmful organisms in organic farms. The relevance of the problem prompts a search for alternative means intended for disease control and plant nutrient supply.

The current study was aimed to investigate the effect of the bioproducts Biokal 01 and Fitokondi on winter wheat seed germination and contamination with microscopic fungi, on the occurrence of fungal diseases in the wheat crop, as well as the impact on plant biometric indicators and grain quality.

MATERIALS AND METHODS

The research was done during 2014–2015 at the Research Laboratory of the Institute of Biology and Plant Biotechnology, Faculty of Agronomy, VMU Agriculture Academy, and on an organic farm of the Experimental Station in Kazliškiai Village (54°52′N, 23°51′E). The experiments involved the winter wheat cultivar 'Širvinta 1' and were aimed to investigate the effects of the bioproducts Biokal 01 and Fitokondi on seed germination, contamination with microscopic fungi, as well as on the occurrence of foliar diseases during the growing season, plant biometric indicators, weed incidence and grain yield quality.

Laboratory experiments

Winter wheat seed samples, consisting of 200 g per sample, were treated with a seed treater Maxim Star 025 FS (fludioxonil 18.75 g l^{-1} and cyproconazole 6.25 g l^{-1}) at a dose rate of 1.0 l t^{-1} and with the bioproducts Biokal 01 (10 l t^{-1}) and Fitokondi (6 l t^{-1}). Biokal 01 contains 57% medicinal herb extracts (*Urtica dioicia* L., *Equisetum arvense* L. and *Chelidonium majus* L.), 38% bio-humus extract, and 5% essential oils and mineral water. The chemical composition of Biokal 01 is the following: N – 230.0 mg l^{-1}, P_2O_5 – 370.0 mg l^{-1}, K_2O – 480.0 mg l^{-1}, Ca – 110.0 mg l^{-1}, Mg – 30.0 mg l^{-1}, Co – 50.0 mg l^{-1}, Cu – 100 mg l^{-1} and Se – 5.0 mg l^{-1}. Fitokondi contains 80% water extract of medicinal herbs (*Urtica dioica* L., *Symphytum officinale* L., *Quercus imbricaria* bark, *Equisetum arvense* L., *Artemisia absinthium* L., *Tagetes* and *Chelidonium majus* L.) and 13.3% bio-humus extract, 6.6% potassium soap (50.0 ml l^{-1}) and 0.1% essential oils (eucalyptus oil – 1.5 ml l^{-1}). The chemical composition of Fitokondi is the following: N – 20.0 mg l^{-1}, P_2O_5 – 10.0 mg l^{-1}, K_2O – 150.0 mg l^{-1}, Ca – 20.0 mg l^{-1}, Mg – 10.0 mg l^{-1}, Co – 50.0 mg l^{-1}, Cu – 100 mg l^{-1} and Se 5.0 mg l^{-1} (Pekarskas, 2008).

Four 100-seed samples were collected from each experimental treatment for the determination of seed vigour and germination. Winter wheat seeds were germinated in the dark in Petri dishes on wet filter paper at 8–12°C for 3–4 days, later at 20°C. Seed vigour was established after 3 days and germination after 7 days.

The incidence of the causal agents of crown and root rots in the coleoptiles of wheat seedlings and roots, and seed contamination were determined by the filter paper roll method. Each experimental treatment was replicated four times on a 50-seed sample per replication. The seeds were incubated in wet rolls for 21 days at 20°C temperature, at the 16 h-day and 8 h-night regime. Root and crown rot incidence on seedlings was estimated in points (0 – all seeds healthy, 1 – weakly, 2 – moderately, 3 – heavily affected) and disease severity index % was calculated.

The effect of different products (Biokal 01, Fitokondi and Maxim Star 025 FS) on wheat seed surface contamination with microscopic fungi was determined by the Potato dextrose agar (PDA) medium (Mathur, Kongsdal, 2003). Mycological tests on 50-seed samples from each experimental treatment were replicated four times. The seeds were incubated in a thermostat at 24 ± 2° C temperature. Fungal colonies were identified on the 7th day of their development. Generic composition of fungi was identified on the basis of Leslie, Summerell (2006), Satton et al. (2001) descriptors.

Field experiments

The soil of the experimental site is *Eutric Planosol – PLe-gln – w*, with a pH close to neutral (6.6–6.9), moderate in humus (2.3%), phosphorus (145.5 P_20_5 mg kg^{-1}) and potassium (126.3 K_20 mg kg^{-1}), total N 0.2%.

The field experiments involved four replications on the winter wheat cultivar 'Širvinta 1'. The total area of the experimental plot was 21 m^2 and that of the harvested plot 11.0 m^2. The plots were laid out in a randomised order. The pre-crop of winter wheat in 2014–2015 was oat-pea mixture for seeds.

The experiment included the following treatments: 1) control (not sprayed with the bioproducts), 2) Biokal 01 treated seeds and sprayed at a rate of 10 l ha^{-1}, 3) Fitokondi treated seeds and sprayed at a rate of 6 l ha^{-1}.

Winter wheat was sprayed at tillering (BBCH 20), booting (BBCH 35–38) and heading (BBCH 55–58) stages according to Meier (2001). A knapsack sprayer 'Garden 15' (Germany) was used for the spray application. Assessments of disease severity and incidence were carried out before the spray application of the bioproducts and 2–3 weeks after the application. A total of 25 randomly selected plants per each plot were assessed. Disease incidence and severity were estimated on three upper fully expanded leaves, later assessments were done on the remaining vegetating upper leaves according to the disease-affected leaf area in percentage, following the methodology approved by the EPPO standards (PP1/26(4), 1997).

The biological efficacy of the tested products was calculated according to Abbot's formula (Korol et al., 1990): $X = a\text{-}b/a \times 100$, where X is biological efficacy of the tested product %; a is disease incidence or severity in the control, %; b is disease incidence or severity in the treatment where the test products have been used, %.

Analysis of yield

For the determination of winter wheat biometric indicators, the plant samples were uprooted before harvesting at the complete maturity stage (BBCH 89) from three replications of individual treatments from four different spots 0.25 m^2 in size and were analysed.

Winter wheat grain quality indicators (protein, wet and dry gluten, sedimentation, falling number) were analysed at the LAMMC Agrochemical Research Laboratory according to the standard methods. One thousand grain weight was established using an Elmor C1 seed counter (Switzerland).

The research results were analysed by the ANOVA technique, the least significant difference ($P \leq 0.05$) was estimated (Raudonius, 2017).

Meteorological conditions

2014 presented higher air temperature and a low rainfall level in May and June compared to the multiannual averages. In May 2014, the mean daily temperature was higher than the long-term average. The highest amount of rainfall (22 mm) fell in the second ten-day period. The mean monthly temperature of June was by 2.6°C higher than the long-term mean. The mean daily temperature of July was 19.6°C, and the monthly amount of rainfall was 146 mm.

In 2015, during the plant vegetation period (May–August), the sum of active temperatures was 2457.0°C, the rainfall amounted to 173.0 mm. The mean monthly temperature of May varied from 14.6 to 17.9°C. In the first ten-day period of May, there was no rainfall, but in the second and third ten-day periods the rainfall amounted to 17.1 and 46.7 mm. A dried period occurred in the second ten-day period of June. The air temperature in

June was higher than the long-term average and varied within the 17.2–19.7°C range. July and August were characterised by a weak and very heavy drought.

The weather conditions during the cultivar development period were favourable for the evaluation of the main diseases and lodging resistance as well as the measurement of grain yield and quality stability.

RESULTS AND DISCUSSION

The effect of the products on winter wheat seed germination and contamination with microscopic fungi

Biokal 01 ir Fitokondi were found to increase seed vigour and germination. Biokal 01 had a greater positive effect on seed vigour, while Fitokondi on seed germination; however, both products did not have a significant effect on seed vigour and germination, only a trend was established, which suggests that winter wheat seed treatment with Biokal 01 and Fitokondi results in an increase in seed vigour and germination.

During the experimental years, fungal infection of winter wheat grain was relatively low: *Fusarium* spp. was identified in 2.0%, *Alternaria* spp. in 20.0% and *Penicillium* spp. in 30.0% of the total tested samples (Table 1). Compared with the untreated control, the standard seed treater significantly decreased the fungal infection level on grain. Of all bioproducts tested, Fitokondi exhibited the highest efficacy against seed-borne fungi. The biological efficacy of this product against *Fusarium* and *Alternaria* spp. fungi was 50.0%, against *Penicillium* spp. it was 20.0%. Having treated the seed with Biokal 01, a statistically significant difference was obtained only against various other fungi, including *Mucor* spp., *Aspergillus* spp. and *Mycelia sterilia*, the biological efficacy of the product was 3.8; however, Biokal 01 was inefficient in reducing seed contamination with pathogenic *Fusarium* spp., and did not have any effect on the reduction of fungi of *Alternaria* and *Penicillium* genera either.

Bioproducts that contain pesticidal plant extracts influence the occurrence of causal agents of some diseases. The research has found that plants possessing pesticidal properties inhibit the development of fungi of *Alternaria*, *Fusarium*, *Aspergillus*, *Botrytis* genera (El-Assiuty et al., 2006; Fawzi et al., 2009). The bioproduct Fitokondi contains extracts of seven medicinal plant species, therefore it can be assumed that it reduced the wheat seed contamination more efficiently than Biokal 01.

In the laboratory experiment, where winter wheat was grown by the wet filter paper roll method, crown rot was identified on 84.0% of winter wheat seedlings, on 74.0% of roots and on 100% of seeds (Table 2). Due to the application of the bioproducts Biokal 01 and Fitokondi the severity of crown rots on the coleoptiles significantly decreased by 12.0–16.0%; however, the biological efficacy of both products was low – 19.0 and 14.3%, respectively. Biokal 01 and Fitokondi contain extracts of various plants, including *Chelidonium majus,* which inhibits the spread of pathogenic fungi *Fusarium culmorum*, *F. graminearum* and *F. oxysporum* and is characterised by antibacterial properties (Saglam, Arar, 2003; Pârvu et al., 2008).

In the control treatment, the average incidence of crown rot diseases on winter wheat roots was 74.0% and the disease severity was as low as 2.0%. Biokal 01 gave a more effective protection of wheat roots against the causal agents of diseases

Table 1. **The effect of products on the winter wheat cultivar 'Širvinta 1' seed contamination with fungi, 2014**

Products	Seed affected by fungi, %							
	Fusarium spp.		*Alternaria* spp.		*Penicillium* spp.		Other fungi	
	1	2	1	2	1	2	1	2
Untreated seeds	2.0	–	20.0	–	30.0	–	37.0	–
Maxim Star 025 FS 1 l t^{-1}	0*	100	6.0*	70.0	5.0*	83.3	14.0*	62.0
Biokal 01 10 l t^{-1}	2.0	0	21.0	0	33.0	0	23.0	38.0
Fitokondi 6 l t^{-1}	1.0	50.0	10.0*	50.0	24.0*	20.0	28.0*	26.0

1 is incidence, %; 2 is biological efficacy, %; * is significantly different from the control at $P \leq 0.05$.

Table 2. **The effect of the products on the incidence and severity of infection on winter wheat cultivar 'Širvinta 1' coleoptiles, roots and seeds in 2014**

Products	Coleoptiles			Roots			Seeds	
	1	2	3	1	2	3	1	3
Untreated seeds	84.0	3.7	–	74.0	2.0	–	100	–
Maxim Star 025 FS 1 l t^{-1}	28.0*	1.5*	67.0	22.0*	0.8	70.3	12.0*	88.0
Biokal 01 10 l t^{-1}	68.0*	3.4	19.0	20.0*	2.0	73.0	100	0
Fitokondi 6 l t^{-1}	72.0*	4.4	14.3	53.0*	3.2	28.4	76.0*	24.0

1 is incidence, %; 2 is severity, %; 3 is biological efficacy, %; * means significantly different from the control at $P \leq 0.05$.

compared to Fitokondi. The efficacy of Biokal 01 against crown rot diseases was 73.0%, while that of the seed treater Maxim Star 025 FS 1 was 70.3%. Based on the previous studies of the bioproducts in wet filter paper rolls (Gaurilčikienė et al., 2008), it can be assumed that Biokal 01 gives a more effective control of some *Fusarium* and *Penicillium* spp. causal agents for which wet filter rolls provide more favourable development conditions.

The tests of winter wheat seeds in wet filter paper rolls revealed that under the effect of Fitokondi, contamination with seed-borne fungi (*Fusarium* spp., *Penicillium* spp., *Alternaria* spp.) decreased by 24.0%, compared with the control. However, the effect of Biokal 01 on the reduction of fungal contamination of seed did not stand out.

The effect of the bioproducts on the incidence of foliar fungal diseases in winter wheat crops

In the years of research, during the winter wheat tillering stage (BBCH 25–30) Septoria leaf blotch began to spread. The prevalence of Septoria leaf blotch in control fields was low at 2.2%, the intensity at 1.3%. The first symptoms of the disease are markedly influenced by the weather conditions – air temperature, moisture and light (Ponomarenko et al., 2011). The bioproducts Fitokondi and Biokal 01 have reduced the intensity of the disease very slightly – 0.1%, compared to the control – non-essential. During the wheat booting stage (BBCH 40–45), the intensity of Septoria leaf blotch was 6.6%. The Biokal 01 Septoria leaf blotch intensity did not decrease, compared to the control, bioproducts in sprayed fields, it increased by 0.3%, respectively. Only Fitokondi wheat has a 0.4% reduction in intensity, but it did not differ significantly from the control. During the cereal flowering stage (BBCH 60–65), the intensity of Septoria leaf blotch on two upper wheat leaves reached 13.3%. The bioproducts studied had no effect on limiting the development of Septoria leaf blotch. In Biokal 01 and Fitokondi-sprayed

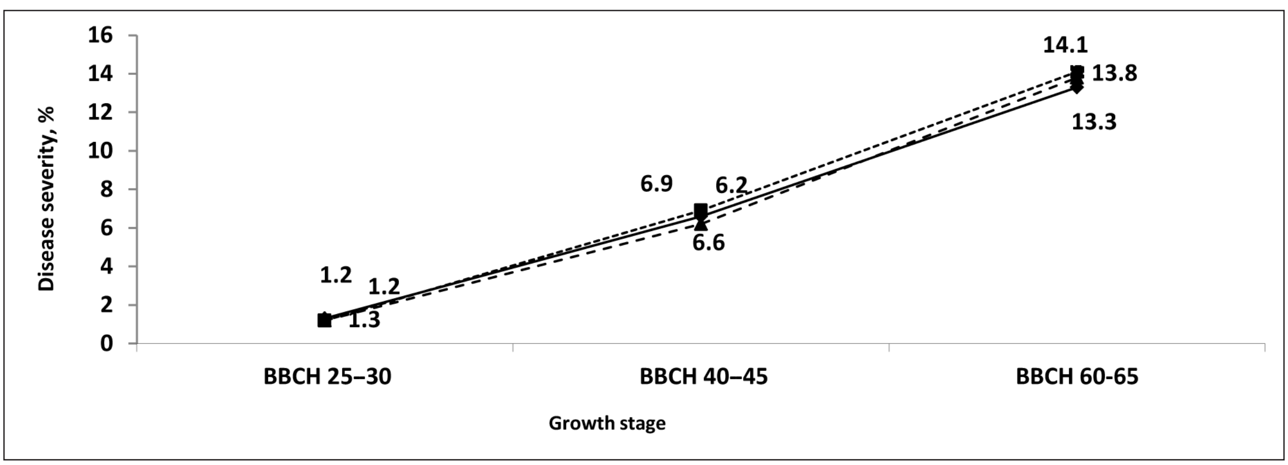

Fig. 1. Septoria leaf blotch severity in unsprayed (–), sprayed with Biokal 01 (···) and with Fitokondi (---) winter wheat cultivar 'Širvinta 1' treatments, 2014–2015

wheat, the intensity of disease was slightly increased compared to the control, 0.8 and 0.5%, respectively.

Winter wheat tan spot, caused by *Pyrenophora tritici-repentis* (Died.) Drechs. (anamorph: *Drechslera tritici repentis* (Died.) Shoemaker), is a widespread disease in winter and spring wheat crops. Tan spot is currently a more aggressive and less controlled disease than Septoria leaf blotch when wheat is continuously grown after wheat (Eurostat, 2017). Yield losses to tan spot may reach up to 50.0% (Ronis et al., 2006). The incidence of the disease on wheat leaves at the tillering stage (BBCH 25–30) was low, in the control treatment disease-affected plants accounted for up to 1.2%. In the treatments spray-applied with Biokal 01 and Fitokondi, the disease severity was by 0.1% lower and insignificant compared with the control treatment (Fig. 2). At the wheat shooting stage (BBCH 40–45), the incidence of tan spot was not high due to the weather conditions which were not favourable for the occurrence of the disease. Under the conditions of a frequent alternation of wet and dry periods tan spot forms fewer spots on plants. This happens due to the fact that during a dry period germinating conidia lose water and perish (Sah, 1991). A very negligible reduction (0.02%) in tan spot severity was recorded under the effect of Fitokondi.

At the wheat shooting stage (BBCH 60–65), the tan spot severity on wheat leaves amounted to 15.0%. The tested bioproducts did not have a positive effect on limiting the incidence of tan spot.

The effect of the bioproducts on winter wheat biometric indicators and grain yield

Biokal 01 and Fitokondi increased the number of productive stems m[2], but no significant effect was identified compared with the control treatment (Table 3). The spray application of organically grown winter wheat with Biokal 01 and Fitokondi significantly increased the plant length by 6.1–6.6 cm or 6.5–6.9%, the ear length by 0.6–0.7 cm or 6.9–8.5%, the grain number per ear by 3.5–4.02 grains or 14.5–16.9%, and the 1000 grain weight by 1.6–2.0 g or 4.4–5.6%; however, the comparison of the effect of the two products did not reveal any significant differences between

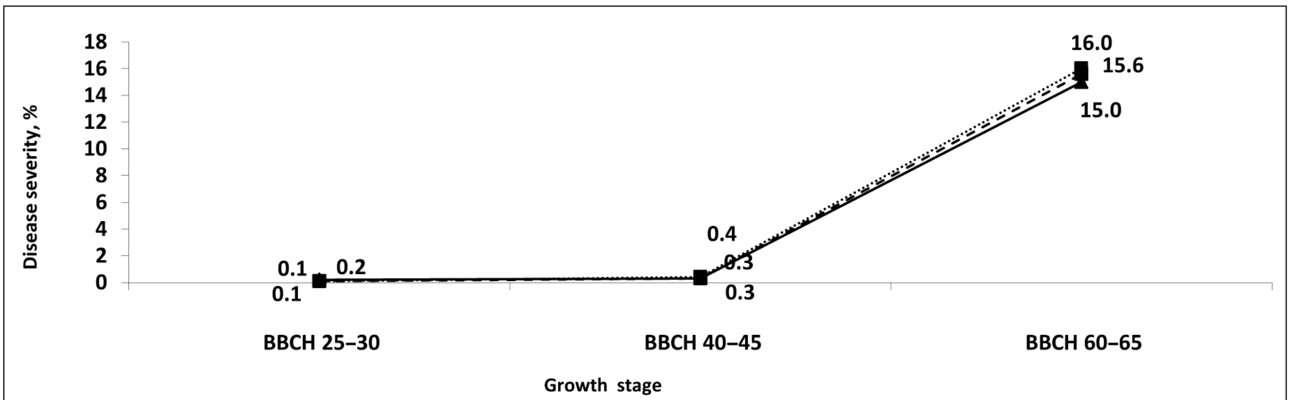

Fig. 2. Tan spot severity in unsprayed (—), sprayed with Biokal 01 (···) and with Fitokondi (---) winter wheat cultivar 'Širvinta 1' treatments, 2014–2015

Table 3. **The effect of bioproducts on the biometric characteristics of winter wheat cultivar 'Širvinta 1', 2014–2015**

Bioproducts	Number of productive stems, m^{-2}	Stem height, cm	Ear length, cm	Number of grains per ear, units	Number of productive stems per plant, units	1000 grain weight, g
Unsprayed	371.7	94.6	7.4	23.8	1.4	36.4
Biokal 01 10 l ha^{-1}	385.7	101.2	8.1	27.8	1.5	38.4
Fitokondi 6 l ha^{-1}	380.5	100.7	8.0	27.2	1.4	38.0

Note: no differences, $P \leq 0.05$.

the values of the above-presented indicators. Only a trend was established suggesting that the spray application with Biokal 01 exerted a greater effect than Fitokondi. These bioproducts also slightly increased the total number of productive stems per plant.

In the field trials, the bioproducts Biokal 01 and Fitokondi were found to significantly increase the grain yield of the organically grown winter wheat cultivar 'Širvinta 1' (Table 4). The grain yield was also influenced by the weather conditions during the wheat growing season. Under the effect of the bioproducts, the grain yield increased by on average 0.7–0.8 t ha^{-1} or 18.6–22.3%. Biokal 01 gave a greater grain yield increase than Fitokondi; however, the difference was not significant. The tested bioproducts contain different amounts of an aqueous extract of biohumus. As a result, due to a greater nutrient content, Biokal 01 tended to increase grain yield more than Fitokondi. The previous research has proved the efficacy of Biokal 01 for organically grown agricultural crops (Pekarskas, 2008; Jablonskytė-Raščė et al., 2012).

The averaged data suggest that the biological products influenced the grain chemical composition. Under the effect of these products the grain protein content increased by 0.5–0.7, the wet gluten content by 0.9–1.3, and the dry gluten content by 0.5–0.7 percentage points. The spray application of wheat crops with Biokal 01 significantly increased the protein, wet and dry gluten content compared with Fitokondi. This can be explained by the different nutrient content in the bioproducts. The research has established that the grain quality indicators were significantly influenced by the spray application of Biokal 01, under the effect of which the grain protein content and gluten content increased by 2.1 and 2.6%, respectively, compared with the control (Jablonskytė-Raščė et al., 2012). However, these products did not have a significant effect on the values of the sedimentation and falling number. A trend was determined that under the effect of Biokal 01 and Fitokondi the value of sedimentation increased and that of the falling number decreased.

CONCLUSIONS

1. Fitokondi exhibited the highest efficacy and protection of winter wheat grain against pathogens. Its biological efficacy against *Fusarium* and *Alternaria* spp. fungi amounted to 50.0%, against *Penicillium* spp. to 20.0%. Biokal 01 statistically significantly reduced seed contamination with *Mucor* spp. and *Aspergillus* spp.

2. The bioproducts tested by the filter paper roll method significantly reduced the incidence of crown rot diseases in the coleoptiles and roots of wheat seedlings; however, they did not exert any significant effect on the disease severity. Biokal 01 was most efficient in inhibiting the incidence of crown rot diseases in wheat coleoptiles and roots. Fitokondi significantly reduced seed contamination with microscopic fungi – by 24.0%.

3. The tested bioproducts did not significantly limit the incidence of Septoria leaf blotch and tan spot during the growing season.

4. Biokal 01 and Fitokondi significantly increased the wheat plant height and ear length, seed number per ear and 1000 grain weight.

5. Biokal 01 and Fitokondi significantly increased the winter wheat grain yield by 0.7–0.8 t ha^{-1} or 18.6–22.3%, and the content of protein by 0.5–0.7, wet gluten by 0.9–1.3 and dry gluten by 0.5–0.7 percentage points in wheat grain.

Table 4. **The effect of biological products on the winter wheat cultivar 'Širvinta 1' grain yield and chemical composition, 2014–2015**

Bioproducts	Yield, t ha^{-1}	Protein, %	Wet gluten, %	Dry gluten, %	Sedimentation, ml	Falling number, s
Unsprayed	3.5	10.0	19.0	6.0	28.4	231.8
Biokal 01 10 l ha^{-1}	4.33	10.7	20.3	6.6	30.9	227.8
Fitokondi 6 l ha^{-1}	4.20	10.5	19.9	6.4	29.8	226.0

Note: no differences, $P \leq 0.05$.

However, Biokal 01 increased the grain protein, wet and dry gluten contents more than Fitokondi.

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REFERENCES

1. Al-Askar A. A., Rashad Y. M. 2010. Efficacy of some plant extracts against *Rhizoctonia solani* on pea. *Journal of Plant Protection Research*. Vol. 50(3). P. 239–243.
2. Bhathal J. S., Loughman R., Speijers J. 2002. Yield reduction in wheat in relation to leaf disease from yellow (tan) spot and *Septoria nodorum* blotch. *European Journal of Plant Pathology*. Vol. 109. P. 435–443.
3. Bond W., Grundy A. C. 2001. Non-chemical weed management in organic farming systems. *Weed Research*. Vol. 41. P. 383–405.
4. Budzynski W. S., Jankowski K. J., Szemplinski W. 2003. Cultivar-related and agronomic conditions of rye yielding on good rye soil suitability complex. Part I: Yield and its relationship with the yield components. *Agronomy*. Vol. 6(1). P. 1–11.
5. El-Assiuty E. M., Bekheet F. M., Fahmy Z. M., Ismael A. M., El-Alfy T. S. M. 2006. Potentiality of some isolated compounds from Halfa Barr *Cymbopogon proximus* Stapf. against the toxigenic fungi *Fusarium verticillioides* and *Aspergillus flavus*. *Egyptian Journal of Phytopathology*. Vol. 34(2). P. 75–84.
6. EPPO Standards. *Guidelines for the efficacy evaluation of plant protection products. Fungicide* (Vol. 2. 197 p.). Paris, 1997.
7. Eurostat. 2017. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Main_annual_crop
8. Fawzi E. M., Khalil A. A., Afifi A. F. 2009. Antifungal effect of some plant extracts on *Alternaria alternata* and *Fusarium oxsysporum*. *African Journal of Biotechnology*. Vol. 8(11). P. 2590–2597.
9. Finch M. R., Schulte-Geldermann E., Bruns C. 2006. Challenges to organic potato farming: disease and nutrient management. *Potato Research*. Vol. 49. P. 27–42.
10. Gaurilčikienė I., Suproniene S., Ronis A. 2008. The impact of the biological agent biojodis on the incidence of pathogenic fungi in winter wheat and spring barley. *Žemdirbystė–Agriculture*. Vol. 95(3). P. 406–414.
11. Jablonskytė-Raščė D., Maikštėnienė S., Cesevičienė J., Mankevičienė A. 2012. Ekologiškų trąšų ir bioaktyvatorių įtaka paprastųjų kviečių (*Triticum aestivum* L.) ir spelta kviečių (*Triticum spelta* L.) produktyvumui bei derliaus kokybei. *Žemės ūkio mokslai*. T. 19(1). P. 1–10.
12. Knittel H., Albert E. 2003. *Düger und Düngung*. Bergen/Dumme: Agrimedia. 217 p.
13. Korol A. L., Preičerzon V. A. 1990. Statisticheskaya otsenka biologicheskoi effektivnosti preparata s pomoshchyu EVM. *Zashchita rastenii*. Vol. 10. P. 22–23.
14. Leslie J. F., Summerell B. A. 2006. *The Fusarium Laboratory Manual*. Iowa, USA. 388 p.
15. Mathur S. B., Kongsdal O. 2003. *Common Laboratory Seed Health Testing Methods for Detecting Fungi*. Copenhagen. 425 p.
16. Meier U. 2001. *Growth Stages of Mono- and Dicotyledonous Plants: BBCH – Monograph*. 2nd ed. Berlin, Germany: Federal Biological Research Centre for Agriculture and Forestry. 158 p.
17. Pârvu M., Pârvu A. E., Crăciun C, Barbu-Tudoran L., Tămaş M. 2008. Antifungal activities of *Chelidonium majus* extract on *Botrytis cinerea in vitro* and ultrastructural changes in its conidia. *Journal of Phytopathology*. Vol. 156. P. 550–552.
18. Pekarskas J. 2008. *Tręšimas ekologinės gamybos ūkiuose*. Kaunas. 189 p.
19. Ponomarenko A., Goodwin S. B., Kema G. H. J. 2011. *Septoria tritici* blotch (STB) of wheat. *Plant Health Instructor.* DOI: 10.1094/PHI-I-2011-0407-01.
20. Raudonius S. 2017. Application of statistics in plant and crop research: important issues. *Žemdirbystė–Agriculture*. Vol. 4(4). P. 377–382.
21. Ronis A., Semaškienė R. 2006. Development of tan spot (*Pyrenophora tritici-repentis*) in winter wheat under field conditions. *Agronomy Research*. Vol. 4. P. 331–334.
22. Saglam H., Arar G. 2003. Cytotoxic activity and quality control determinations on *Chelidonium majus*. *Fitoterapia*. Vol. 74. P. 127–129.
23. Sah D. N. 1991. Influence of interrupted leaf wetness duration and relative humidity on development of tan spot in wheat. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz*. Vol. 101. P. 148–153.
24. Satton D., Fotergill A., Rimaldi M. 2001. *Opredelitel patogennykh i uslovno patogennykh gribov*. Moskva. 451 s.
25. Sliesaravičius A., Pekarskas J., Rutkovienė V., Baranauskis K. 2006. Grain yield and disease resistance of winter cereal varieties and application of biological agent in organic agriculture. *Agronomy Research*. Vol. 4. P. 371–378.

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BIOLOGINIŲ PRODUKTŲ ĮTAKA EKOLOGIŠKAI AUGINTIEMS ŽIEMINIAMS KVIEČIAMS (*TRITICUM AESTIVUM* L.)

Santrauka

Tyrimų tikslas – ištirti biologinių produktų Biokal 01 ir Fitokondi įtaką ekologiškų žieminių kviečių (*Triticum aestivum* L.) veislės 'Širvinta 1' grūdų priešsėjiniam daigumui ir užterštumui mikroskopiniais grybais, kviečių lapų ligų plitimui vegetacijos metu, biometriniams rodikliams ir derliaus kokybei. Laboratoriniais tyrimais nustatyta, kad biologiniai produktai neturėjo esminės įtakos sėklų dygimo energijai ir daigumui. Veiksmingiausiai kviečius nuo patogenų ant PDA terpės apsaugojo Fitokondi, kurio biologinis efektyvumas nuo *Fusarium* ir *Alternaria* spp. grybų buvo 50,0 %, nuo *Penicillium* spp. – 20,0 %. Biokal 01 statistiškai patikimai sumažino grūdų užterštumą kitais grybais (*Mucor* spp., *Aspergillus* spp. ir kt.). Filtro popieriaus rulonų metodu tirtų bioproduktų poveikis daigų koleoptilėse ir šaknyse pašaknio ligų plitimą sumažino iš esmės, ligų intensyvumui esminės įtakos nenustatyta. Biokal 01 efektyviausiai apribojo pašaknio ligų išplitimą kviečių koleoptilėse ir šaknyse. Dėl Fitokondi poveikio sėklos užterštumas mikroskopiniais grybais sumažėjo iš esmės. Lauko tyrimų metu biologiniai produktai neturėjo esminės įtakos lapų septoriozės (*Mycosphaerella graminicola*) ir kviečių dryžligės (*Helminthosporium tritici-repentis* Died.) plitimui. Dėl Biokal 01 ir Fitokondi iš esmės padidėjo augalų ir varpų ilgis, grūdų skaičius varpoje ir 1 000 grūdų masė, 0,66–0,79 t ha^{-1} arba 18,64–22,32 % padidėjo grūdų derlius, padaugėjo baltymų, šlapiojo glitimo ir sausojo glitimo. Dėl Biokal 01, palyginti su Fitokondi, grūduose iš esmės padaugėjo baltymų, šlapiojo ir sausojo glitimo.

Raktažodžiai: kviečiai, bioproduktai, ekologinis ūkininkavimas, mikroskopiniai grybai, derlius