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THE INFLUENCE OF BIOORGANIC PREPARATIONS ON THE PRODUCTIVITY OF CONVENTIONALY GROWN WINTER WHEAT ACTIVATING AND SAVING THE USE OF SYNTHETIC CHEMICALS

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The influence of *Raskila* bioorganic fertilisers on the productivity of conventional winter wheat *'Olivin'*, was investigated in order to stimulate and save synthetic herbicide *Arrat* and fungicide *Tango Super* for spring spraying. Scheme of treatment: 1. Control; 2. Winter wheat sprayed (BBCH 20-29) with fertilizer *Raskila* 3 l ha^{-1}; 3. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1}; 4. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1}+*Raskila* 3.0 l ha^{-1}; 5. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.1 kg ha^{-1}+*Tango super* 0.75 l ha^{-1}+*Raskila* 3.0 l ha^{-1}. The best result in the period of 2014-2016 was received after application of the following combination in spring: *Arrat* + *Tango super* + *Raskila*. This combination allows to reduce the rate of pesticides in half (50%), the differences compared to control are significant, statistically reliable. A statistically significant increase in the following winter wheat *'Olivin'* quality parameters was found: protein 13.1-14.8%, gluten 24.3-29.7%, number of falls 228-292 s, starch 65.7-70.0%. Application of *Raskila* fertilizers has raised the grain quality class. The best results were in variants 3 and 4, where the I class of grain quality was achieved. Combination of *Raskila* fertilisers and pesticides: herbicide *Arrat* and fungicide *Tango super* statistically significantly increased the following winter wheat *'Olivin'* characteristics - plant height 101.2-104.2 cm, ear length 6.9-7.1 cm, grain number per ear 28,96- 30.02, grain yield 6.71-7.03 t ha^{-1}. Application of *Raskila* fertilizer 1.0 l ha^{-1} and herbicide *Arrat* 0.1 kg ha^{-1} decreased the number of weeds from 62.5 to 57.6 units per m^2 and the weed weight decreased from 41.30 to 33.70 g m^2. Stronger wheat crop overshadowed weeds better. Combination of *Raskila* and *Tango super* reduced the prevalence and severity of diseases in winter wheat such as *Septoria spp*., *Pyrenophora tritici-repentis*, *Erysiphe graminis*, powdery rust (*Puccinia recondita*).

Keywords: winter wheat 'Olivin', organic fertilizers Raskila, herbicide Arrat, fungicide Tango super, grain yield, efficiency

INTRODUCTION

Evaluation of the farming conditions: soil properties, technical and material basis, it is necessary in order to use agricultural land more efficiently and to ensure proper plant nutrition. We exhaust the soil obtaining the maximum yield, at the same time we use its resources and often forget about restoration of soil fertility (Jakienė, Venskutonis, 2008). Production of good quality products without proper nutrients supply and balanced fertilization is difficult goal to achieve. High quantities of nutrients are carried out from the soil together with agricultural production. The deficit of needs to be compensated and rebuilt, otherwise soil will degrade (Žekonienė, 2008). Applying an intensive plant growing technologies, synthetic mineral fertilizers, pesticides and other components are used extensively, and soil properties may deteriorate. We can face with soil aeration problem, leading to accumulation of excess moisture. The soil becomes squeeze, microbiological processes are decreasing. Recently, farmers, gardeners and florists have been increasingly focusing on ecological products. People seek for healthy food and a healthy and beautiful environment. It is very important to maintain a biological balance - undisturbed and productive soil – fertile and healthy plants – good quality food and healthy and beautiful environment (Svirskis, Vilkonis, 2008; Spruogis et al. 2013; Baležentienė et al. 2012; Jakienė et al. 2015).

Biological preparations and bioorganic fertilizers can help to prevent all these problems, to obtain a higher and healthy yield, to maintain a clean and beautiful environment (Минеев, 2008). Bioorganic preparations help to save chemicals and synthetic mineral fertilizers, prevent pests and stop the spread of diseases, these treatments protect the plants from stress and strengthen their immune system, thereby reducing environmental pollution (Brazauskienė, 2004).

Certification organization "Ekoagros" in 2011 certified bioorganic fertilizers *Raskila* in Lithuania (Gavenauskas et al., 2013; Spruogis et al. 2013; Jakienė et al. 2015). *Raskila* fertilizers contain all the essential components that are inherent to organic fertilizers. It improves the quality of the soil and increase the amount of humus in it. *Raskila* fertilizer can be successfully used for mitigating the effects of climate change, environmental pollution, air pollution, soil degradation (Mokslinės…, 2013). Increasing the natural potential of soil through bioorganic fertilizers will balance the quality of the soil, improve the financial indicators and reduce the effects of climate change (Drulis, 2014).

The aim of the research was to investigate the effect of bio-organic fertilizer *Raskila* on the yield and quality of conventional winter wheat, reducing environmental pollution by activating and saving synthetic herbicide *Arrat* and fungicide *Tango super* for spring spraying. Research objectives: 1. to investigate the effect of bioorganic fertiliser *Raskila* on winter wheat yield and production quality; 2. to analyse the parameters of yield quality, to carry out biometric measurements and chemical analyses; 3. to assess the weediness and morbidity of the winter wheat.

RESEARCH METHODS

The research was carried out in 2014 - 2016 at Experimental Station of Aleksandras Stulginskis University. Investigation was carried out according to the following treatment scheme: 1. Control; 2. Winter wheat sprayed (BBCH 20-29) with fertilizer *Raskila* 3 l ha^{-1}; 3. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1}; 4. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1}+*Raskila* 3.0 l ha^{-1}; 5. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.1 kg ha^{-1}+*Tango super* 0.75 l ha^{-1}+*Raskila* 3.0 l ha^{-1}.

Experiment fields arranged sequentially in four replications. The total size of the plot was 30 m^2 (3 × 10), accounting – 17.6 m^2 (2.2 × 8). The agrochemical properties of the soil were determined before experiment. The analysis was performed using PSCO/ISI Infrared Spectrometer IBM-PC 4250 according to data bank calibrations. The samples were analysed using the following methods (soil pH – potentiometric method, mobile phosphorus P_2O_5 and mobile potassium K_2O (mg kg^{-1} soil) - Egner-Rim-Domingo (A-L) method, organic carbon - Thurin method). The agrochemical properties of soil was analysed at the Agrochemical Research Laboratory of the Lithuanian Research Centre for Agriculture and Forestry and at the Soil Laboratory of the State Land Foundation in Kaunas (Spruogis et al. 2013).

The experiments were carried out on a loam in a clay loam (*Calc(ar)i-Epihypogleyic Luvisol-LVg-p-w-cc*). The water regime was regulated by a closed drainage. The soil was close to neutral and neutral (pH 6.8-7.1), amount of phosphorus 171–178 mg kg^{-1}, potassium – 129–141 mg kg^{-1}, mean amount of humus – 2.26–2.49 %, total nitrogen 0.168–1.172 %.

Mineral fertilizers were applied NPK 8-20-30, 300 kg ha^{-1}. Winter wheat was sown in I decade of September. The average seed rate was ~ 4 mln ha^{-1}, the sowing depth – 4 cm. Harvested at the end of July. The meteorological conditions were close to the perennial averages during the research.

Bioorganic fertilizers *Raskila* were developed and produced in Lithuania (UAB Raskilė). Fertilizers are produced from 100% biohumus and suitable for all plants. Fertilizers contain the whole complex of macro-and trace elements, humic substances, fulvic acids, nitrogen, potassium, phosphorus, phytovitamins and useful soil micro-organisms (Spruogis et al., 2013).

'Olivin' – the variety of winter wheat was created in the United States, breeding company Monsanto. Herbicide *Arrat* is a broad spectrum systemic herbicide for the elimination of two-headed weeds in winter and summer wheat, spring barley and maize. Fungicide *Tango super* – as systemic fungicide, used for winter and summer wheat and winter and summer barley, sugar beet protection against fungal diseases.

Winter wheat plants were unrooted and tied in the sheafs before harvesting from two places (0.25 m^2) of each experimental plot. The elements of the harvest structure: plant height, ear length, grain number per ear were determined by measurement method. Weediness of the crop was determined at the end of winter wheat vegetation in each variant with two replications in 3-5 different places (0.25 m^2), weeds were unrooted and counted, then dried to air dry condition and weighed.

Leaf diseases were recorded in winter wheat (BBCH 37). The phyto-sanitary state of 60 plants from each variant all vegetable leaves. Visually identified diseases and separately estimated the prevalence of all observed diseases (percentage of damaged leaves) and their intensity (percentage of damaged leaf area) on a scale of 0, 1, 5, 10, 25, 50, 75%, which are standardized by the European Plant Protection Organization methodologies. The severity of the disease (R) is calculated according to the formula: $R=\sum(n\times b)/N$, where $\Sigma(n\times b)$ is the sum of equally damaged leaves number and the violation value product; N - number of checked leaves (Žemės ūkio…, 2002).

The yield structure elements were determined. The grain was dried up to 14%, estimated the purity and grain yield t ha^{-1} and the chemical composition was analysed. Proteins and gluten in winter wheat grain were determined according to LST 1522, sedimentation (according *to Zeleny*) according to LST 1498 by the infrared spectroscopy method (AACC method 39-25: 1998) with a computer analyser Infratec. The number of fall was determined in accordance with LST ISO 3093, the gross weight of grain - according to LST 1578. The chemical composition of grains was analysed at Chemical Research Laboratory and Agrochemical Research Laboratory of the Lithuanian Research Centre for Agriculture and Forestry.

The research data was statistically evaluated by means of dispersion analysis of quantitative attributes using the computer program ANOVA (Tarakanovas, Raudonius, 2003).

RESULTS AND DISCUSSION

A very important factor is the economic efficiency of the use of pesticides. Application of combination of *Raskila* fertilizer with herbicide *Arrat* and fungicide *Tango Super* on winter wheat *'Olivin'* guaranteed the highest income, respectively, from 314.53 to 351.89 € ha^{-1} (Table 1). This combination reduces the use of pesticides by half, which means we save 50% of pesticides. Economic calculation there plays a crucial role. Estimating economic efficiency we get the

best results: income from 314.53 to 351.89 € ha^{-1}, grain yields 6.89–7.03 t ha^{-1} and an Extra or I Class best quality grains. Compared to control, the differences are significant, statistically reliable.

Table 1. The effect of bioorganic fertilizer *Raskila* and synthetic pesticides: herbicide *Arrat* and fungicide *Tango super* on winter wheat *'Olivin'* productivity and cost-effectiveness

Treatment	Grain yield t ha^{-1}	Grain yield increase t ha^{-1}	Grain yield increase value € ha^{-1}	Premium for the qualitative class of grain €	Cost of *Raskila* and pesticides € ha^{-1}	Income € ha^{-1}
1. Control	5.10	-	-	-	-	-
2. Winter wheat sprayed (BBCH 20-29) with fertilizer *Raskila* 3 l ha^{-1}	6.78	1.68	301.49	+17.38	5.79	313.08
3. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1};	6.71	1.61	289.04	+11.58	23.17	277.46
4. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1}+*Raskila* 3.0 l ha^{-1}	6.89	1.79	331.90	+17.38	34.75	314.53
5. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.1 kg ha^{-1}+*Tango super* 0.75 l ha^{-1}+*Raskila* 3.0 l ha^{-1}	7.03	1.93	357.68	+17.38	23.17	351.89
LSD_{05}	0.78					

Application of combination of *Raskila* fertilizer with herbicide *Arrat* and fungicide *Tango Super* significantly increased the following winter wheat *'Olivin'* grain quality parameters: proteins by 13.1–14.8 %, gluten – 24.3–29.7%, and the number of falls by 228–292 s, starch by 65.7–70.0 %. *Raskila* fertilizers have raised the grain quality class. The best results were in the 2nd 4th and 5th variants, where I grain quality class was achieved (Table 2).

Table 2. The effect of bioorganic fertilizer *Raskila* and synthetic pesticides: herbicide *Arrat* and fungicide *Tango super* on winter wheat *'Olivin'* grain quality

Treatment	Proteins %	Gluten %	Weight of hectolitre kg hl^{-1}	Falling number s	Starch %	Quality class of grain
1. Control	11.0	20.2	70	203	63.9	3
2. Winter wheat sprayed (BBCH 20-29) with fertilizer *Raskila* 3 l ha^{-1}	14.2	26.0	76	235	68.0	1
3. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1};	13.1	24.3	74	228	65.7	2
4. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1}+*Raskila* 3.0 l ha^{-1}	14.7	29.1	78	284	70.0	1
5. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.1 kg ha^{-1}+*Tango super* 0.75 l ha^{-1}+*Raskila* 3.0 l ha^{-1}	14.8	29.7	79	292	70.0	1
LSD_{05}	0.7	1.7	2	51	0.7	

Raskila fertilizers and pesticides significantly increased biometric parameters of winter wheat *'Olivin'*: the plant height – 101.22–104.23 cm, the ear length was 6.86-7.14 cm, number of grain per ear 28.96–30.02, grain yield 6.71–7.03 t ha^{-1} (Table 3). The assessment of the quality of grain and calculation of economic efficiency proved the most rational treatment combination: herbicide *Arrat* 0.1 kg ha^{-1}, fungicide *Tango super* 0.75 l ha^{-1} and *Raskila* fertilizers 3.0l ha^{-1}.

Table 3. The effect of bioorganic fertilizer *Raskila* and synthetic pesticides: herbicide *Arrat* and fungicide *Tango super* on winter wheat *'Olivin'* yield and biometric parameters

Treatment	Plant height cm	Ear length cm	Number of grain per ear	Grain yield t ha^{-1}	Grain yield increase %
1. Control	88.76	5.62	24.88	5.10	100
2. Winter wheat sprayed (BBCH 20-29) with fertilizer *Raskila* 3 l ha^{-1}	102.00	6.92	29.88	6.78	132.94
3. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1}	101.22	6.86	28.96	6.71	131.57
4. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1}+*Raskila* 3.0 l ha^{-1}	103.45	7.01	29.48	6.89	135.10
5. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.1 kg ha^{-1}+*Tango super* 0.75 l ha^{-1}+*Raskila* 3.0 l ha^{-1}	104.23	7.14	30.02	7.03	137.84
LSD_{05}	10.79	0.79	0.47	0.78	

An analysis of crop morbidity and weedness data allows broader assessment of applied treatments interaction. The research data shows, that winter wheat receiving different pesticides rates, and especially in combination with Raskila fertilizers, strengthened and were able themselves to control weeds. The number of weeds decreased from 62.5 to 57.6 units per m2 and weed mass – from 41.30 to 33.70 g m^{-2} (Table 4).

Table 4. The effect of bioorganic fertilizer *Raskila* and synthetic pesticides: herbicide *Arrat* and fungicide *Tango super* on weedness

Treatment	Number of weeds m^{-2}	Weeds mass g m^{-2}
1. Control	105.1	73.93
2. Winter wheat sprayed (BBCH 20-29) with fertilizer *Raskila* 3 l ha^{-1}	101.6	73.55
3. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1}	62.5	41.3
4. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1}+*Raskila* 3.0 l ha^{-1}	57.6	36.60
5. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.1 kg ha^{-1}+*Tango super* 0.75 l ha^{-1}+*Raskila* 3.0 l ha^{-1}	58.4	33.7
LSD_{05}	13.45	11.08

Analysing winter wheat morbidity data, it is evident that *Raskila* fertilizers and pesticides have reduced the occurrence and intensity of diseases such as *Septoria spp*., *Pyrenophora tritici-repentis*, *Erysiphe graminis*, *Puccinia recondita* in different stages of their growth (Table 5).

Table 5. The effect of bioorganic fertilizer *Raskila* and synthetic pesticides: herbicide *Arrat* and fungicide *Tango super* on winter wheat morbidity (BBCH-37)

Treatment	*Septoria* spp.		*Pyrenophora tritici-repentis*		*Erysiphe graminis*		*Puccinia recondita*	
	Occurrence %	Intensity %	Occurrence %	Intensity %	Occurrence %	Intensity %	Occurrence %	Intensity %
1. Control	36.73	4.82	9.88	1.45	1.11	0.1	10.56	1.83
2. Winter wheat sprayed (BBCH 20-29) with fertilizer *Raskila* 3 l ha^{-1}	36.00	4.75	9.54	0.98	1.11	0.01	2.65	0.24
3. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1}	35.86	4.62	9.26	0.55	1.11	0.01	2.22	0.11
4. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.2 kg ha^{-1}+*Tango super* 1.5 l ha^{-1}+*Raskila* 3.0 l ha^{-1}	35.80	4.70	6.67	0.50	0	0	2.59	0.37
5. Winter wheat sprayed (BBCH 20-29) with *Arrat* 0.1 kg ha^{-1}+*Tango super* 0.75 l ha^{-1}+*Raskila* 3.0 l ha^{-1}	32.84	4.35	5.93	0.56	0	0	3.33	0.5

CONCLUSIONS

1. The best economic efficiency growing conventional winter wheat was got applying together bioorganic fertilizer *Raskila* (3.0 l ha^{-1}), herbicide *Arrat* and fungicide *Tango super* in spring. The income was 314.53–351.89 € ha^{-1}, grain yield 6.89–7.03 t ha^{-1} and grain the I Class of quality. This combination reduces necessity of pesticides in half (50 %). The differences are significant, statistically reliable compared to control.
2. Application of combination of *Raskila* fertilizer with herbicide *Arrat* and fungicide *Tango Super* significantly increased the following winter wheat *'Olivin'* grain quality parameters: proteins by 13.1–14.8 %, gluten – 24.3–29.7 %, and the number of falls by 228–292 s, starch by 65.7–70.0 %. *Raskila* fertilizers have raised the grain quality class.
3. *Raskila* fertilizers and pesticides: herbicide *Arrat* and fungicide *Tango super* significantly increased biometric parameters of winter wheat *'Olivin'*: the plant height – 101.22–104.23 cm, the length of the ear was 6.86–7.14 cm, number of seeds per ear 28,96-30,02 pcs, grain yield 6,71–7,03 t ha^{-1}.
4. Treatment with bioorganic fertilizers *Raskila* (3.0 l ha^{-1}) and herbicide *Arrat* (0.1-0.2 kg ha^{-1}) decreased number of weeds from 62.5 to 57.6 units per m^2 and weed mass – from 41.30 to 33.70 g m^{-2}. Winter wheat strengthened and were able themselves to control weeds
5. Treatment with bioorganic fertilizers *Raskila* (3.0 l ha^{-1}) and fungicide *Tango super* (0.75–1.5 kg ha^{-1}) reduced the occurrence and intensity of diseases such as *Septoria spp*., *Pyrenophora tritici-repentis*, *Erysiphe graminis*, *Puccinia recondita* in different stages of winter wheat growth.

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