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THE INFLUENCE OF SEED DRESSINGS AND EFFECTIVE MICROORGANISMS ON THE DEVELOPMENT AND HEALTH STATUS OF SELECTED SPECIES OF CEREALS

Summary

The aim of the study was to assess how synthetic seed dressings, effective microorganisms (EM) and the combination of both influenced the development and the health status of wheat, barley and rye at early phases of their growth. The following seed dressings were used in a greenhouse experiment: EM MG, Astep 225 FS, Baytan Trio 180 FS and Vibrance Gold 100 FS. They were applied individually and in combination with EM MG. The emergence of plants, the percentage of plants with blight symptoms, the fresh and dry weight as well as the length of the aerial part and roots were assessed at the phase of 9 leaves (BBCH 19). There were significant differences in the number of infested winter wheat and winter barley plants between the combinations with seed treated seeds and the control variant. The greatest increase in the fresh and dry weight as well as the length of the aerial part of winter wheat and winter barley plants was observed when their seeds were dressed with Astep 225 FS, Baytan Trio 180 FS and Baytan Trio 180 FS with EM MG.
***Key words**: cereals, inoculation, effective microorganisms, seedling blight, biometric features*

WPŁYW ZAPRAW NASIENNYCH I EFEKTYWNYCH MIKROORGANIZMÓW NA ROZWÓJ I ZDROWOTNOŚĆ WYBRANYCH GATUNKÓW ZBÓŻ

Streszczenie

Celem badań była ocena wpływu syntetycznych zapraw, efektywnych mikroorganizmów (EM) i ich łącznego stosowania z zaprawami na rozwój i zdrowotność pszenicy, jęczmienia oraz żyta we wczesnych fazach wzrostu. W doświadczeniu szklarniowym wykorzystano: EM MG, zaprawy: Astep 225 FS, Baytan Trio 180 FS i Vibrance Gold 100 FS oraz ich łączne zastosowanie z EM MG. W fazie 9 liści właściwych oceniano wschody roślin, procent roślin z objawami zgorzeli oraz świeżą i suchą masę części nadziemnej i korzeni oraz długość części nadziemnej i korzeni. Stwierdzono istotne statystycznie różnice pomiędzy kombinacjami, których ziarno zostało zaprawione, a kombinacja kontrolną w ilości porażonych roślin pszenicy ozimej i jęczmienia ozimego. Zastosowanie Astep 225 FS i Baytan Trio 180 FS oraz Baytan Trio 180 FS z EM MG wykazały największy wpływ na zwiększenie świeżej i suchej masy części nadziemnej oraz jej długości po zastosowaniu do zaprawienia ziarna pszenicy ozimej i jęczmienia ozimego.
***Słowa kluczowe**: zboża, zaprawianie, efektywne mikroorganizmy, zgorzel siewek, cechy biometryczne*

1. Introduction

According to the guidelines of Directive 2009/128/EC of the European Parliament of 21 October 2009, on 1 January 2014 all the member-states of the European Union were obliged to grow crops following the rules of Integrated Pest Management (IPM) and, in consequence, to achieve the sustainable use of pesticides [4]. According to the rules of IPM, all available methods and techniques of limiting the number of pests should be used and simultaneously, the application of chemical crop protection products should be limited in order to protect the natural environment [12]. Integrated Plant Protection emphasises reduction of the amount of active ingredients used in agriculture [3]. According to the Regulation of the Minister of Agriculture and Rural Development of 18 April 2013 concerning the requirements of IPM, it is necessary to minimise the number of treatments and the amount of crop protection products [10]. The introduction of the rules of integrated protection enables effective limitation of the number of pests by using available breeding, biological and chemical methods. By combining these methods it is possible to limit the occurrence of pests so much that they will not cause economic loss. The application of effective microorganisms (EM) is one of the possibilities to combine these methods to limit the number of diseases caused by pathogenic fungi. According to Higa [6], these preparations are the most effective in plant protection if they supplement other agrotechnical treatments applied to limit pests. When they are applied into soil, they do not limit diseases directly but they increase the bioactivity of soil. They accelerate organic matter decomposition and limit the development of pathogenic fungi in soil and crop residue. Many authors confirm the fact that effective microorganisms limit the development of causal agents of diseases in cereals during the growth period [2, 8, 9, 11]. EM Multi Grower (EM MG) is a microbial inoculant stimulating the development of the root system and increasing the resistance of plants. It is applied as a seed dressing and spraying at the initial phase of growth. It contains a special composition of effective microorganisms, which aids healthy development of plants as early as the moment of germination and improves their condition during growth.

The aim of the study was to assess how synthetic seed dressings, effective microorganisms (EM) and the combination of both influenced the development of cereals and limited the number of pathogenic fungi at early phases of their growth.

2. Material and methods

Three species of cereals were assessed in greenhouse experiments: winter wheat (Arkadia variety), winter barley

(Calypso variety) and rye (Tur variety). Two weeks before sowing pots were filled with soil collected from the upper layer of the field used for agricultural production. Before sowing the seeds of cereals were dressed with EM Multi Grower (EM MG) as well as standard seed dressings: Astep 225 FS, Baytan Trio 180 FS and Vibrance Gold 100 FS. They were applied at registered doses. EM MG was also applied in combination with the seed dressings. 25 seeds were sown into each pot. Table 1 lists the combinations of products used for seed inoculation and characterises them. The number of plants' emergences and the number of infested plants (the percentage of plants with seedling blight) were counted in the experiment. The fresh and dry weight as well as the length of the aerial part of the plants were measured. The infestation with seedling blight by pathogens and the biometric features were assessed at the phase of 9 leaves (BBCH 19). There were two series of experiments, with four replicates. The results were analysed statistically and the effectiveness of dressings and EM was calculated according to the Abbott formula.

Seed dressing is the treatment which limits the occurrence of pathogens (*Fusarium* spp., *Gibberella* spp., *Pythium* spp. *Rhizoctonia* spp. and others) at the initial phases of plant development. A relatively small amount of an active ingredient is applied. The same ingredient is applied to plants by spraying at later phases of development. The Astep 225 FS contains imidachlopryd – an active ingredient of the neonicotinoid group. The substance controls aphids, which are vectors of viral diseases. According to the manufacturer's specifications, depending on the method of application, the EM Multi Grower preparation intensifies the development of the root system, strengthens and levels seed germination, increases the yield potential, stimulates the regeneration of plant tissues after stress-induced damage, improves plant health and reduces the development of pathogenic microflora [7].

3. Results and discussion

The seed dressings used in the experiment had diversified influence on the percentage of infested plants, which depended on the species of cereals. The seed dressings are registered as products controlling seedling blight and other diseases caused by fungi remaining on the seed surface or inside as well as by soil fungi [13]. The winter wheat which grew from untreated seeds was the most infested by seedling blight pathogens – about 17%. It was followed by spring barley – about 11% and rye – about 7% (Tables 2, 3 and 4). All the registered seed dressings applied in winter wheat by itself and in mixture with EM MG caused a significant reduction in the percentage of plants with the symptoms of seedling blight (Table 2). The highest effectiveness was observed after applying standard seed dressings in combination with EM MG as well as standard seed dressings on their own. Depending on the combination, the effectiveness ranged from 69% to 79%. When EM MG was applied without chemical seed dressing, seedling blight was reduced to 45% of its effectiveness. The experiment conducted on winter barley gave analogical results to the experiment on winter wheat (Table 3). When the seed dressings were applied on their own and in combination with EM MG, seedling blight was reduced to 47-69%. When EM MG was applied at doses of 2.5 and 5.0 ml to dress winter barley seeds, the infestation by seedling blight pathogens was significantly reduced. Rye was the least infested cereal. When the seed dressings were applied on their own and in combination with EM MG, the infestation was reduced to 48-81%. When EM MG was applied to dress rye seeds, the infestation with seedling blight was not reduced significantly. In the study by Borgen & Davanlou [1] the authors noted that the development of common bunt of wheat (*Tilletia caries*) – a disease transferred with seeds, was inhibited when seeds were inoculated with effective microorganisms in organic farming.

There were no significant differences in the emergence of wheat and rye between the control variant and the combinations treated with the seed dressings (Tables 2 and 4). As far as barley is concerned, the emergence was slightly worse after treatment with Baytan Trio 180 FS and Brytan Trio 180 FS + EM MG (Table 3). When Baytan Trio 180 FS, Astep 225 FS and Baytan Trio 180 FS in combination with EM MG were applied, there was a significant increase in the fresh and dry matter of the aerial part of winter wheat (Table 5). The highest increase was noted after treatment with Baytan Trio 180 FS in combination with EM MG. It was greater by 34% than in the control variant. The increase in the weight of the aerial part was correlated with greater length of this part.

Table 1. A list of preparations used for dressing winter wheat, winter barley and rye seeds
Tab. 1. Wykaz preparatów stosowanych do zaprawiania nasion pszenicy ozimej, jęczmienia ozimego i żyta

Variants	Description / content of active ingredient (chemical group)	Dose per 1 kg of seeds
Control	-	-
EM MG	lactic bacteria (*Lactobacillus casei*, *Streptococcus lactis*), photosynthetic bacteria (*Rhodopseudomonas palustris*, *Rhodobacter sphaeroides*), yeasts (*Saccharomyces albus*, *Candida utilis*), actinobacteria (*Streptomyces albus*, *S. griseus*) and moulds (*Aspergillus oryzae*, *Mucor hiemalis*) [5, 14]	2.5 ml + 7.5 ml H_20
EM MG		5 ml + 5 ml H_20
Baytan Trio 180 FS	triadimenol (triazoles), fluoxastrobin (strobilurins), fluopyram (carboxamides)	2 ml + 4 ml H_20
Baytan Trio 180 FS + EM MG	triadimenol (triazoles), fluoxastrobin (strobilurins), fluopyram (carboxamides)	2 ml + 4 ml H_20 + 2.5 ml (EM) + 5 ml H_20
Astep 225 FS	prothioconazole (triazoles), imidachlopryd (neonicotinoids)	2 ml + 4 ml H_20
Astep 225 FS + EM MG	prothioconazole (triazoles), imidachlopryd (neonicotinoids)	2 ml + 4 ml H_20 + 2.5 ml (EM) + 5 ml H_20
Vibrance Gold 100 FS	sedaxane (carboxamides), fludioxonil (phenylpyrroles), difenoconazole (triazoles)	2 ml + 5 ml H_20
Vibrance Gold 100 FS + EM MG	sedaxane (carboxamides), fludioxonil (phenylpyrroles), difenoconazole (triazoles)	2 ml + 5 ml H_20 + 2.5 ml (EM) + 5 ml H_20

Source: own work / Źródło: opracowanie własne

Table 2. The effect of seed dressing products on the percentage of plants infested with seedling blight and on the emergence of winter wheat

Tab. 2. Wpływ zapraw nasiennych na ilość (w procentach) roślin porażonych zgorzelą i wschody pszenicy ozimej

Variant	Percentage of infested plants	Effectiveness (%)	Emergence	Comparison with control variant (%)
Control	16.92	-	88.0	100.0
EM MG	9.32	44.9	87.5	99.4
EM MG	9.03	46.6	84.5	96.0
Baytan Trio 180 FS	4.86	71.3	87.5	99.4
Baytan Trio 180 FS + EM MG	3.50	79.3	85.5	97.2
Astep 225 FS	5.41	68.0	87.5	99.4
Astep 225 FS + EM MG	5.19	69.3	87.0	98.9
Vibrance Gold 100 FS	5.08	70.0	86.5	98.3
Vibrance Gold 100 FS + EM MG	4.32	74.5	89.0	101.1
LSD(0.05)	2.37	-	insignificant difference	-

Source: own work / Źródło: opracowanie własne

Table 3. The effect of seed dressing products on the percentage of plants infested with seedling blight and on the emergence of winter barley

Tab. 3. Wpływ zapraw nasiennych na ilość (w procentach) roślin porażonych zgorzelą i wschody jęczmienia ozimego

Variant	Percentage of infested plants	Effectiveness (%)	Emergence	Comparison with control variant (%)
Control	10.95	-	87.0	100.0
EM MG	6.99	36.2	85.0	97.7
EM MG	5.68	48.1	86.0	98.9
Baytan Trio 180 FS	3.99	63.5	80.0	92.0
Baytan Trio 180 FS + EM MG	3.43	68.7	74.5	85.6
Astep 225 FS	3.54	67.7	84.5	97.1
Astep 225 FS + EM MG	2.99	72.7	83.5	96.0
Vibrance Gold 100 FS	4.86	55.6	86.5	99.4
Vibrance Gold 100 FS + EM MG	5.94	45.7	82.0	94.3
LSD(0.05)	1.89	-	5.98	-

Source: own work / Źródło: opracowanie własne

Table 4. The effect of seed dressing products on the percentage of plants infested with seedling blight and on the emergence of rye

Tab. 4. Wpływ zapraw nasiennych na ilość (w procentach) roślin porażonych zgorzelą i wschody żyta

Variant	Percentage of infested plants	Effectiveness (%)	Emergence	Comparison with control variant (%)
Control	6.60	-	78.5	100.0
EM MG	6.59	0.2	74.5	94.9
EM MG	5.09	22.9	77.0	98.1
Baytan Trio 180 FS	3.17	51.9	82.5	105.1
Baytan Trio 180 FS + EM MG	3.31	49.9	79.0	100.6
Astep 225 FS	2.32	64.9	73.5	93.6
Astep 225 FS + EM MG	1.26	80.9	71.0	90.4
Vibrance Gold 100 FS	2.84	57.0	76.0	96.8
Vibrance Gold 100 FS + EM MG	3.42	48.2	74.5	94.6
LSD(0.05)	1.80	-	insignificant difference	-

Source: own work / Źródło: opracowanie własne

When EM MG was applied at a dose of 10 ml per 1 kg of seeds and when all the synthetic seed dressings were applied and when the combinations of Baytan Trio 180 FS + EM MG and Astep 225 FS + EM MG were applied, all the plants grew taller. There was a significant increase in the fresh weight of roots. Treatment with Astep 225 FS, Vibrance Gold 100 FS and the mixtures of these products and EM MG as well as Baytan Trio 180 FS + EM MG resulted in more intense growth of the underground part. There were no significant differences in the root length, but the root system was longer after treatment with Astep 225 FS and Astep 225 FS + EM MG. Hu & Qi [8] conducted an eleven-year-long study during which EM was applied three times a year. The authors cultivated winter wheat and maize and observed significant differences in the height of the plants at the phase of stem elongation as well as differences in the dry weight of the roots and the aerial part. When winter barley seeds were dressed with all combinations of dressings, except EM MG at a dose of 5 ml and Vibrance Gold 100 FS, the fresh weight of the aerial part increased (Table 6).

Table 5. The effect of seed dressing products on the fresh and dry weight and length of the aerial part and roots of winter wheat
Tab. 5. Wpływ zapraw nasiennych na świeżą i suchą masę oraz długość naziemnej części i korzeni pszenicy ozimej

Variant	Fresh weight of aerial part (25 plants)		Dry weight of aerial part (25 plants)		Fresh weight of roots (25 plants)		Dry weight of roots (25 plants)		Length of aerial part		Length of roots	
	(g)	Comparison with control variant %	(g)	Comparison with control variant %	(g)	Comparison with control variant %	(g)	Comparison with control variant %	cm	Comparison with control variant %	cm	Comparison with control variant %
Control	14.13	100.0	2.45	100.0	1.23	100.0	0.41	100.0	37.86	100.0	10.23	100.0
EM MG	13.31	94.2	2.69	109.8	1.09	88.4	0.46	112.1	38.82	102.2	10.36	101.3
EM MG	14.67	103.8	2.67	108.9	1.22	99.3	0.41	98.6	39.87	105.0	10.48	102.5
Baytan Trio 180 FS	16.60	117.5	3.01	122.7	1.42	115.1	0.47	114.8	41.60	109.5	10.14	99.2
Baytan Trio 180 FS + EM MG	19.91	133.9	2.79	113.6	2.21	179.9	0.43	104.7	40.36	106.3	10.42	101.8
Astep 225 FS	16.18	114.5	2.82	115.0	2.08	169.1	0.60	145.5	40.88	107.6	11.39	111.4
Astep 225 FS + EM MG	15.45	109.5	2.51	102.5	2.08	169.5	0.57	139.5	39.81	104.8	11.53	112.7
Vibrance Gold 100 FS	15.80	111.8	2.71	110.7	1.96	159.3	0.54	131.0	39.99	105.3	10.41	101.8
Vibrance Gold 100 FS + EM MG	12.94	91.6	2.44	99.5	1.93	156.6	0.60	144.9	37.49	98.7	11.49	112.3
LSD(0.05)	1.56	-	0.31	-	0.22	-	insignificant difference	-	1.79	-	insignificant difference	-

Source: own work / Źródło: opracowanie własne

Table 6. The effect of seed dressing products on the fresh and dry weight and length of the aerial part and roots of winter barley
Tab. 6. Wpływ zapraw nasiennych na świeżą i suchą masę oraz długość naziemnej części i korzeni jęczmienia ozimego

Variant	Fresh weight of aerial part (25 plants)		Dry weight of aerial part (25 plants)		Fresh weight of roots (25 plants)		Dry weight of roots (25 plants)		Length of aerial part		Length of roots	
	(g)	Comparison with control variant %	(g)	Comparison with control variant %	(g)	Comparison with control variant %	(g)	Comparison with control variant %	cm	Comparison with control variant %	cm	Comparison with control variant %
Control	19.70	100.0	4.32	100.0	5.78	100.0	0.99	100.0	34.35	100.0	15.44	100.0
EM MG	22.91	116.3	4.60	106.4	5.95	102.8	1.06	107.2	35.79	104.2	14.61	94.6
EM MG	24.72	125.5	4.93	114.1	5.27	91.1	1.02	103.6	35.99	104.8	14.20	91.9
Baytan Trio 180 FS	27.83	141.3	5.11	118.2	5.45	94.2	1.10	111.3	35.81	104.2	14.07	91.1
Baytan Trio 180 FS + EM MG	32.48	164.9	5.69	131.7	6.81	117.8	1.14	115.7	36.49	106.2	15.23	98.7
Astep 225 FS	28.44	144.4	5.51	127.4	7.59	131.3	1.34	135.9	37.69	109.7	15.28	99.0
Astep 225 FS + EM MG	23.48	119.2	4.57	105.7	5.67	98.0	1.16	117.9	36.48	106.2	15.64	101.3
Vibrance Gold 100 FS	22.22	112.8	4.33	100.2	5.95	102.8	1.07	108.4	36.12	105.1	15.37	99.5
Vibrance Gold 100 FS + EM MG	23.58	119.7	4.49	103.9	5.63	97.3	1.05	106.4	35.25	102.6	14.80	95.9
LSD(0.05)	3.52	-	0.65	-	1.09	-	insignificant difference	-	1.69	-	insignificant difference	-

Source: own work / Źródło: opracowanie własne

Table 7. The effect of seed dressing products on the fresh and dry weight and length of the aerial part and roots of rye
Tab. 7. Wpływ zapraw nasiennych na świeżą i suchą masę oraz długość części naziemnej części i korzeni żyta

Variant	Fresh weight of aerial part (25 plants)		Dry weight of aerial part (25 plants)		Fresh weight of roots (25 plants)		Dry weight of roots (25 plants)		Length of aerial part		Length of roots	
	(g)	Comparison with control variant %	(g)	Comparison with control variant %	(g)	Comparison with control variant %	(g)	Comparison with control variant %	cm	Comparison with control variant %	cm	Comparison with control variant %
Control	19.78	100.0	3.07	100.0	6.95	100.0	1.19	100	34.05	100.0	16.00	100.0
EM MG	24.04	121.5	4.13	134.5	6.41	92.3	1.31	110.1	35.71	104.9	16.62	103.9
EM MG	23.69	119.8	3.97	129.2	6.89	99.2	1.27	107	35.40	104.0	17.18	107.3
Baytan Trio 180 FS	22.94	116.0	4.70	153.1	9.23	132.8	1.68	142	36.05	105.9	17.03	106.4
Baytan Trio 180 FS + EM MG	23.40	118.3	4.01	130.6	9.55	137.4	1.82	153.4	36.27	106.5	17.25	107.8
Astep 225 FS	23.93	120.9	4.02	131.0	8.07	116.1	1.31	110.5	37.34	109.7	15.48	96.7
Astep 225 FS + EM MG	22.91	115.8	3.88	126.3	7.34	105.6	1.32	111.2	37.30	109.6	16.05	100.3
Vibrance Gold 100 FS	25.14	127.1	4.29	139.7	8.00	115.2	1.26	106.3	37.95	111.5	16.12	100.7
Vibrance Gold 100 FS + EM MG	24.85	125.6	3.99	129.8	7.46	107.3	1.28	108.4	35.57	104.5	15.96	99.7
LSD(0.05)	insignificant difference	-	insignificant difference	-	1.22	-	0.25	-	1.29	-	insignificant difference	-

Source: own work / Źródło: opracowanie własne

In comparison with the control variant, the greatest increase (by 65%) was observed after treatment with a combination of Baytan Trio 180 FS and EM MG. The dry weight of the aerial part was significantly greater. There were also significant differences after treatment with Baytan Trio 180 Fs, Baytan Trio 180 FS + EM MG and Astep 225 FS. These results were partly in line with assessment of the length of the aerial part. The tallest plants (significant differences) were observed after dressing the seeds with Baytan Trio 180 FS + EM MG, Astep 225 FS, Astep 225 FS + EM MG and Vibrance Gold 100 FS. The Astep 225 FS dressing significantly increased the root weight and length. The analysis of the biometric measurements of rye revealed a significant increase in the fresh and dry weight of the roots after treatment with Baytan Trio 180 FS and Baytan Trio 180 FS + EM MG (Table 7). In all the combinations the rye plants were taller than in the control variant. Piskier [9] conducted a field experiment on spring wheat and observed an increase in the yield, the elements of its structure and biometric features after treatment with effective microorganisms (EM-1).

4. Conclusions

1. Seedling blight infestation was reduced after treating wheat, barley and rye seeds with effective microorganisms (EM MG), synthetic seed dressings and the seed dressings in combination with EM MG.
2. Astep 225 FS and Baytan Trio 180 FS as well as the combination of Baytan Trio 180 FS and EM MG caused the greatest increase in the fresh and dry weight and the length of the aerial part of winter wheat and winter barley seeds.

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