18. Naz RK., Ahmad K., Kumar R., Role of membrane phosphotyrosine proteins in human spermatozoa function. 1991. Journal of Cell Science. 99. 157-165
19. Naz RK., Involvement of protein tyrosine phosphorylation of human sperm in capacitation/acrosome reaction and zona pellucid binding. 1996. Frontiers in Bioscience. 1. 206-213
20. Niedenberger B. A., Chappell V. K., Kaye E. P., Renegar R. H., Geyer C. B. Nuclear localization of the actin regulatory protein Palladin in sertoli cells. 2013. Molecular Reproduction and Development. 80(5). 403-13
21. Novak S., Smith T.A., Paradis F., Burwash L., Dyck M.K., Foxcroft G.R., Dixon W.T. 2010. Biomarkers of in vivo fertility in sperm and seminal plasma of fertile stallions. Theriogenology.74. 956-967
22. Reineke A., Hess O., Schambony A., Petrunkina A.M., Bader H., Sieme H., Topfer-Petersen E., Sperm associated seminal plasma proteins—a novel approach for the evaluation of sperm fertilizing ability of stallions? 1999. Pferdeheilkunde. 6. 531–537
23. Rodriguez-Martinez H., Kvist U., Ernerudh J., Sanz L., Calvete J. J. Seminal plasma proteins: what role do they play? 2011. American Journal of Reproductive Immunology. 66. 11-22
24. Swegen A., R.J. Aitken, Characterisation of the stallion sperm proteome. 2014. Journal of Equine Veterinary Science. 34. 35-37
25. Swegen A., Curry B.J., Gibb Z., Lambourne S.R., Smith N.D., Aitken R.J., Investigation of the stallion sperm proteome by mass spectrometry. 2015. Reproduction. 149. 235–244
26. Topfer-Petersen E., Ekhlas-Hundrieser M., Kirchhoff C., Leeb T., Sieme H., The role of stallion seminal proteins in fertilization. 2005. Animal Reproduction Sciences. 89. 159-170

THE EFFECT OF FITODOCTOR APPLICATION ON YIELDING ABILITY AND MINERAL COMPOSITION OF WHITE MUSTARD (SINAPIS ALBA L.) ABOVE GROUND BIOMASS

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Introduction. White mustard is grown as oil and spice crop but it also used as fodder, green manure or mulch. It is applied in modern or in traditional medicine. Comparing to other oil crops grown in temperate climate zones (oil seed rape or sunflower) it has minor importance but it is grown on larger area than black or Indian mustard together. When used as a cover crop beneficial effects of white mustard (i.e. amount of available nutrients and organic matter) can be compared with full rate of farm yard manure of good quality [Harasimowicz-Hermann and Hermann 2006]. White mustard can produce high yield of biomass capable to fix nutrients. In some reports it is pointed out phytosanitary, soil protection role of this crop as well as the fact that white mustard can be applied as supporting crop for plants of soft stems in mixed stands [Szymczak-Nowak and Nowakowski 2000; Ceglarek

et al. 2004]. Therefore white mustard should be treated as multipurpose crop.

Because of a general and rapid progress in 20th and 21st centuries in understanding of role of soil biota lots of attention has been paid to application of microorganisms as a tool in agricultural practice. Nowadays, microbial preparations are used instead of pesticides in organic farming but its usage in so called integrated systems is getting more common [Alabourette 2000; Martyniuk 2011]. Most frequently isolates representing antagonists of known pest and pathogens are used. The earliest application of microorganisms in agriculture refers to usage of symbiotic bacteria (rhizobia being the most known example) and mycorrhizas [Martyniuk 2011]. There are reports of successful soil application of non-symbiotic microbial preparations as growth promoters in crops production [Bethlenfalvay 1993; Al-Taweil et al. 2009].

Aim of study. The aim of our studies was to evaluate effects of soil application microbial biostimulant FITOdoctor (currently under the name of Protect bacter) on yield and chemical composition of above ground biomass of white mustard (*Sinapis alba* L.) grown as a cover crop.

Material and methods. The pot experiment was conducted in cold greenhouse owned by Warmia and Mazury University in Olsztyn in 2013 using completely randomized design in four replicates. Polyethylene pots (modified Kick-Brauckmann's system) of capacity of 10 kg were filled with medium textured soil of pH_{KCl} at 5.33 and medium content of available phosphorus, potassium and magnesium. Microbial preparation FITOdoctor (Protect bacter produced by AGRARIUS Ltd Krasiczyn, Poland; http:// http://agrarius.eu/en/) was applied to appropriate pots as liquid. Living bacteria *Bacillus subtilis* in concentration of $0.4\text{-}0.5 \cdot 10^9 \cdot 1$ ml^{-1} were present in the tested biostimulant. Preparation was injected once in the rate of 1 g per pot (0.25 dm^3 of working solution per pot). Ten seeds of white mustard were sown in each pots twice during growing season and two harvests of above ground biomass were performed.

The following treatments were studied: „0" – control (no fertilizers); „0" + FITOdoctor no fertilizers; NPK – mineral fertilizers; NPK + FITOdoctor plus fertilizers. In pots with mineral fertilization the following rates of nutrients were applied (before sowing of white mustard): nitrogen 1.5 g N pot^{-1} as $CO(NH_2)_2$ (rate was split to three sub-rates of 0.5 g N pot^{-1} one before and two after sowing, respectively); phosphorous – 0.5 g P pot^{-1} as KH_2PO_4 (before sowing); potassium – 1.0 g K pot^{-1} as KH_2PO_4 plus KCl (before sowing).

White mustard was harvested in the phase of full blooming (at five weeks after sowing). After harvest above ground biomass after drying and

grinding was subjected to chemical analyses. Biomass samples were digested in concentrated sulfuric acid (VI) with 30% hydrogen peroxide as oxidant. In obtained digestates content of the following nutrients was analyzed: total nitrogen by colorimetric hypochlorite method; phosphorus by colorimetric vanadium-molybdenum method; calcium, potassium and sodium by emission atomic spectrometry (ESA) and magnesium by absorption atomic spectrometry (ASA). All obtained results were analyzed by ANOVA of fully randomized design and least significant difference values at level $P \leq 0.01$ was used.

Results. Application of mineral fertilizers and tested biostimulant FITOdoctor significantly increased yield of white mustard biomass (Table 1). Total biomass yield of white mustard ranged from 22.6 to 53.9 g DM pot^{-1} for control and treatment with NPK + FITOdoctor, respectively. Biostimulant FITOdoctor application without or with mineral fertilizers resulted in increase of biomass yield only at first white mustard harvest. The contrary effects were seen at the second harvest. Mean yield of biomass obtained at the second harvest was almost 40% lower than at the first. The lowest yield was noted for both treatments without mineral fertilizers. It should be noted that FITOdoctor was applied once before the first sowing.

Table 1 – Yield of white mustard biomass (g DM pot^{-1})

Treatments	Harvest		
	first	second	total
„0" – control (without fertilizers)	13.73	8.87	22.60
„0" + FITOdoctor	18.65	5.00	23.65
NPK – mineral fertilizers without FITOdoctor	27.40	25.52	52.92
NPK + FITOdoctor	29.10	24.80	53.90
Mean	22.22	16.05	38.27
$LSD_{P\leq0.01}$	8.50	7.08	–

Content of studied essential nutrients in white mustard above ground biomass was significantly affected by experimental treatments (Table 2) whereas for studied harvesting (first or second, data not shown) no differences were found. In case of nitrogen, phosphorous, calcium and magnesium in mustard biomass under effect of FITOdoctor and NPK application was higher comparing to control whereas the highest content of potassium was observed in treatment NPK without application of biostimulant.

Table 2 – Content of studied nutrients (mean of two harvests) in above ground biomass of white mustard (g kg^{-1} DM s.m.)

Treatments	N	P	K	Ca	Mg
„0" – control (without fertilizers)	14.28	1.58	38.13	13.95	1.53
„0" + FITOdoctor	20.29	2.04	41.22	18.86	1.85
NPK – mineral fertilizers without FITOdoctor	29.68	1.94	55.79	19.07	2.32
NPK + FITOdoctor	30.17	2.07	54.51	21.65	3.73

Mean	23.60	1.91	47.41	18.38	2.36

Conclusions. From the obtained results in pot experiment it can be concluded that soil application of biostimulant FITOdoctor with mineral fertilizers beneficially affected yield and mineral composition of white mustard biomass. The biomass yield was related to the time from application of biostimulant to the soil. It was found that the first harvest of biomass was by 39% higher than second and that chemical composition of plant biomass was rather stable in two harvest.

REFERENCES

1. Alabouvette C. 2000. Biological control of plant disease. (In) Biological Resource Management, Balazs E., Galante E., Lynch J.M., Schepers J.S., Werner D., Toutant J.P., Werry P.A. (eds) Springer, Germany, 257-264.
2. Al-Taweil H.I., Bin Osman M., Hamid A.A., Yuso W.M. 2009. Development of microbial inoculants and the impact of soil application on rice seedlings growth. Am. J. Agric. Biol. Sc., 4: 79-82.
3. Bethlenfalvay G.J. 1993. Mycorrhizae in the agricultural plant-soil system. Symbiosis, 14, 413-425.
4. Ceglarek F., Rudziński R., Buraczyńska D. 2004. Wpływ ilości wysiewu na elementy struktury i plony nasion wyki siewnej uprawianej w siewie czystym oraz w mieszankach z roślinami podporowymi. [The effect of the amount of seeds sown on the crop structure elements and seed yields of common vetch grown as pure and mixed crops with supporting plants]. Annales Universitatis Mariae Curie-Skłodowska, sec. E, Lublin, 59(3): 1147–1154. (In Polish with English summary).
5. Harasimowicz-Hermann G., Hermann J. 2006. Funkcja międzyplonów w ochronie zasobów mineralnych i materii organicznej gleby. [Function of intercrops in the protection of minerals resources and organic matter in soil]. Zesz. Probl. Post. Nauk Roln., 512: 147-155. (In Polish with English summary).
6. Martyniuk S. 2011. Skuteczne i nieskuteczne preparaty mikrobiologiczne stosowane w ochronie i uprawie roślin oraz rzetelne i nierzetelne metody ich oceny. [Effective and ineffective microbial preparations used in plant protection and production and methods of their evaluation]. Post. Mikrobiol., 50(4): 321-328. http://www.pm.microbiology.pl (In Polish with English summary).
7. Szymczak-Nowak J., Nowakowski M. 2000. Efekt antymątwikowy i plonowanie gorczycy białej, facelii błękitnej i rzodkwi oleistej uprawianych w plonie głównym. [Antinematode effect and yielding of white mustard, tansy phacelia and oil radish cultivated as a main crop]. Rośliny Oleiste – Oilseed Crops, XXI: 285-291. (In Polish with English summary).