THESES OF PHD DISSERTATION

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Use of biostimulant microalgae to influence the growth and development of rapeseed (*Brassica napus* L.)

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1. INTRODUCTION AND OBJECTIVE

Humans have been purposefully producing agricultural products for about 10.000 years. In recent decades, the control of agricultural pests has been mainly carried out with chemical pesticides. However, the environmental and health problems encountered in their application have increasingly focused attention on biological control. The previously well-functioning cultivation and technological guidelines are now being replaced by modern, environmentally friendly farming efforts. The aim is to minimize the use pesticides that are harmful to the environment as little as possible. Sustainable development and the focus on environmentally friendly farming also entail a change in agricultural production.

It is now a proven fact that cyanobacteria and eukaryotic microalgae produce, accumulate, or secrete into their environment many bioactive compounds, such as the plant hormones most responsible for the biostimulant effect (auxin, cytokine, gibberelin, etc.), and therefore have a wide range of effects. Among cyanobacteria, in addition to hormones of the *Anabaena, Anabaenopsis, Calothrix, Chlorogloeopsis, Cylindrospermum, Gloeothece, Nostoc, Plectonema, Haplosiphon, Synechocystis, Arthrospira, and Oscillatoria* strains, its secondary metabolites include lipopeptides (40%), amino acids (5.6%), fatty acids (4.2%), macrolides and amids (9%).

By applying plant biostimulants, the resistance of cultivated plants to environmental stress can be increased, their growth, development and crop results can be positively influenced.

The correct choice of the sowing date of rapeseed (*Brassica napus* L.) and the successful wintering of the plants can significantly increase the amount of the crop. In addition, with the help of moderate nutrient supply and biostimulants, the successful wintering of rapeseed can be ensured, and the amount of the crop can be increased. Numerous studies have shown that biostimulants induced a powerful root development, which increased the length and mass of rape roots, the leaf surface of rapeseed and the mass of the shoot, which can have a beneficial effect on wintering, ultimately on the quantity and quality of the crop. The plant hormones and secondary metabolic products found in microalgae have had a positive effect on the development of the root system, and the use of substances that regulate plant growth can increase the tolerance of plants to cold, as well as the ratio of fruiting elements to generative organs. Biologically, the degree of growth and the length of the development cycle determine the amount of crop, but we still have little information about what physiological changes lead to the formation of biomass and crop.

Today, second- and third-generation regulators that selectively affect the development of organs of different plants in small quantities are of increasing importance but are not vital elements of cultivation. These advanced regulators do not produce metabolites or residues in plants, which can be harmful to sustainable development and human health.

Objectives:

1. Selection of the most suitable strains for plant experiments based on their auxin and cytokine-like effects from certain (16 strains) cyanobacteria and eukaryotic algae in the Mosonmagyaróvár Algae Collection.

2. Setting small-cell field autumn rape experiments, determining the most suitable time for selected microalgae treatments, i.e., the most suitable plant phenophases.

3. Determination of properties affecting the overwintering of microalgae treatments in rapeseed culture.

4. Explanation of the change in yields by microalgae treatments with changes in certain crop elements.

5. Proposal for the introduction of a new cultivation technology procedure, ensuring the growth of rapeseed and crop safety under different weather conditions.

2. MATERIALS AND METHODS

The test plant was in both years *Brassica napus* L. cv. *Orlando 1*, a winter rapeseed hybrid. For the treatment of experimental plants, two strains were obtained from the Mosonmagyaróvár Algal Culture Collection: a cyanobacterium MACC-612 *Nostoc piscinale* and a green microalga MACC-430 *Tetracystis* sp. (Figure 1).

Figure 1 Microscopic images of Macc-612 *Nostoc piscinale* (left) and MACC-430 *Tetracystis* sp. microalgae at 400 times magnification

2.1 Experimental settings

In both years, the number of repetitions in the randomized 7 treatment trials was 4. The treatments were carried out in combination with or without algae preparations, in addition to commercially available preparations used in the plant protection technology of rapeseed: (a) Route: liquid fertilizer with a high zinc content; (b) Wuxal® Boron: concentrated leaf manure containing boron; (c) Folicur: 250 g L^{-1} tebukonazole, fungicide and regulator.

The treatment of plants was carried out in three phenological phases in both years:

(1) In a leaf state of 4-6 (BBCH-14-16), on 15th of October 2010; October 10th of 2013.

(2) Beginning of stem elongation– (BBCH-30, 29) March 2011; March 15, 2014

(3) At the beginning of flowering, in a green bud state - BBCH-51, 13th of April 2011; On April 5, 2014

Figure 2 Dried *Nostoc piscinale* cyanobacteria biomass used for experiments in the laboratory of the Department of Crop Production on 12 October 2010.

The amount of spray volume applied to fully cover the plant stocks of the parcels was 400 liters for the first and second time, and 700 liters per hectare for the third treatment. In addition to treating the plants of the control parcel only with water, the two microalgae were placed on the plants at concentrations of 0.3 and 1.0 g of L^{-1}, which correspond to suspensions of 0.03 and 0.1 percent. The sixth parcel was treated in a combined way, where the first spraying was carried out with foliar manure of MACC-612 cyanobacterium 400 L ha^{-1}, 0.1%, and in the second and third case Wuxal ® Boron 200 L ha^{-1} with a high boron content of 0.5%. In the case of the series of treatments commonly used in the protection of rapeseed production in the plants of the seventh parcel, in the autumn period, in the state of 4-6 foliage Route® 200 L ha^{-1}, 0.4 % and Folicur®Solo 200 L ha^{-1}, 0.5 %, during the spring vegetation period, in the green bud state, solution of Wuxal®Boron 400 L ha^{-1}, 0.5 was added to the stock.

The dates of each spraying have been included in the list of plant protection treatments in such a way that they can be applied in general large-scale practice, and other treatments affecting the stock of the board do not impact the effects of microalgae applications.

At the beginning of the spring period, after examining the overwintering, the number of plants per parcel and per hectare was determined. At the beginning of the start of the stem or in a green bud state (13.04.2011; 15.03.2014) the second and third treatments in the plant stock were carried out in accordance with the work plan. After the interventions, only stock-level surveillance was observed. Before harvesting, the average height of the plants was measured and determined, the average number of branches, after harvesting the number per branch and the number of pods per plants.

2.3 Laboratory tests of rapeseed

The laboratory tests took place at the Széchenyi István University, Faculty of Agriculture and Food Sciences, Department of Plant Sciences between September 2010 and June 2014. After the first treatment, for five weeks during the autumn observation period, the leaves were analyzed once a week from fresh leaf samples, dry matter content a, chlorophyll-a, chlorophyll-b and all carotenoid content. The top of the shoots, the average number of leaves, the length of the root system, the number of branches, the fresh and dried mass of roots, and the thickness of the root neck were also recorded. Studies in both experimental years took place in mid-December, at the end of the autumn vegetation period, and at the beginning of the soil freezing. The examination of the length of the pods, the total mass of the pods, the number of seeds in the pods and their weight were carried out after harvesting. With the help of the samples collected in the field, the weight of one thousand seeds and the total amount of the crop were determined (g/m^2; $t\ ha^{-1}$). After harvest, average oil and moisture content were analyzed by NIR (near infrared) InfratecTM 1241 Grain Analyzer.

3. RESULTS AND THEIR EVALUATION

3.1 Results of field measurements

The number of plants in the spring

The results in spring showed that lower doses of cyanobacteria and green algae (0.3 g L^{-1}) increased the number of successfully overwintered plants by 21-32% (P=5%) in both experimental years, compared to the control. Preparations used in the traditional cultivation technology method increased the number of overwintered plants by 17% in the first year and up to 24 % (P=5%) in 2014.

Plant height

The examination of plant height was completed 2-2 times in both years (before wintering 13.12.2010; 07.12.2013 and harvested 20.06.2011; 06.06.2014). Combined sprayings of MACC-612 cyanobacteria, at doses of 0.3 and 1 g L^{-1} and Wuxal Boron significantly increased autumn plant height by 22-65% (P=0.1 to P=5%) in both years. After the treatment of MACC-430, there was only a verifiable deviation in the first experimental year (28-30%; P=0.1%) according to control. After the traditional cultivation technology spraying, the plants were 21-26% shorter according to control in both years.

In both years, the plant heights measured at harvesting were significantly increased only by sprayings of MACC-612 *Nosotoc piscinale* (7-12%).

Number of branches

The number of mean branches increased by 17-99% in both years (P=0.1; P=1%; P=5%) after the leaf treatments of *Nostoc piscinale* 1 and 0.3 g L^{-1} and MACC-430 at 0.03% (Figure 3). The number of lower ranged branches in the both experimental years was increased only by the doses of 1 and 0.3 g L^{-1} of MACC-612 (70-100%).

Figure 3 Plant height and plant foams of rapeseed formed under the influence of MACC-612 cyanobacteria at harvest. (From left to right, macc-612 0.3 g L^{-1}, 1 g L^{-1}, 1 g L^{-1} + Wuxal and samples collected from the parcel of the traditional cultivation technology process)

3.2 Laboratory tests

Hormone effects of the microalgae strains

At the beginning of the experimental work, 16 strains of MACC microalgae were selected to confirm the hormone-like effects. The primary aspect of the selection of strains was the length of the breeding time and the content of dry matter produced during the study time. In the tests, cucumber cotyledon rooting and cucumber leaf mass growth under the influence of the strains MACC-612 (*Nostoc piscinale*) and MACC

430 (*Tetracystis* sp.) showed the slightest variance during each repetition. The maximum biomass available was smaller than cyanobacteria (0.75-1.75 g L^{-1}), and that of eukaryotic algae (1-3 g L^{-1}). Based on the results of the cucumber cotyledon study, a strain of cyanobacterium (MACC-612) and a strain of green algae (MACC-430) were selected for further field experiments.

Pigment and dry matter content in the leaves

In the two experimental years, the largest deviation from control was the 0.3 g L^{-1} (+219%) concentrations of MACC-612 at the fifth measurement date, while the 1 g L^{-1} interventions of cyanobacterium increased the amount of pigment constituents in the leaves by 99-138% (Figure 4). Macc-612 treatments with concentrations of 0.3 and 1 g of L^{-1} increased the amount of chlorophyll-a by an average of 93-219% each year, while leaf treatments with MACC-430 green algae increased the amount of chlorophyll-a by 108-185%. The largest quantitative change in chlorophyll-b content was caused by MACC-612 treatments with a concentration of 0.03% (+184%). Leaf treatments of MACC-430 0.3 g L^{-1} increased the content of chlorophyll-b in the leaves by an average of 91-16%, while sprays with a concentration of 1 g of L^{-1} increased chlorophyll-b content by 101-122%. In both years, the carotenoid content of the leaves was highest after 0.03% treatments with MACC-612 *Nostoc piscinale* compared to control (0.34 - 0.37 mg/g). Microalgae treatments increased the amount of carotenoids by an average of 23-85% in the experimental years in comparison to control. The different chlorophyll content of acetone solutions made at the time of the fifth measurement of the second test year is illustrated in Figure 5.

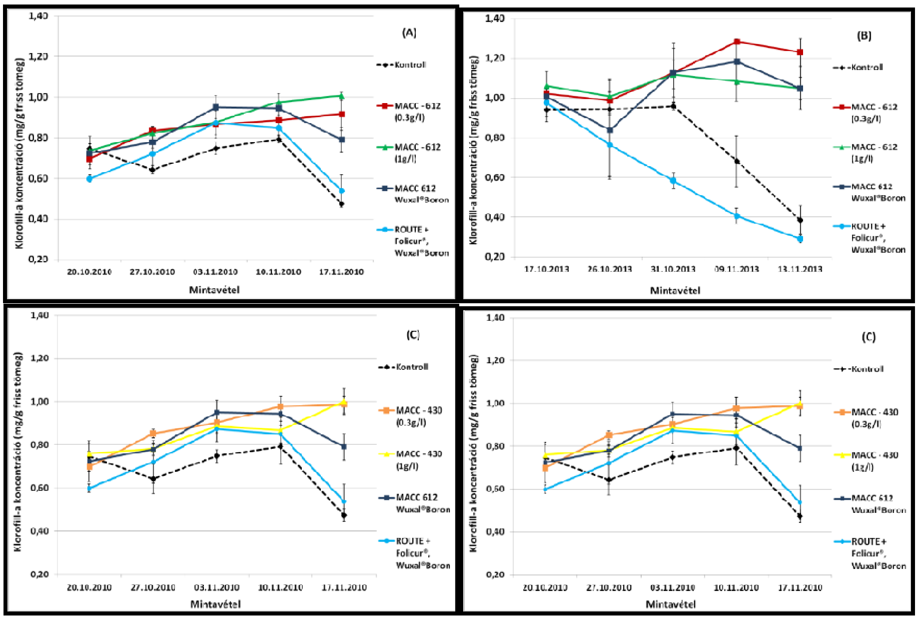

Figure 4 Changes in the concentration of chlorophyll in fresh rapeseed leaf samples 10.10.2010-17.11.2010 (15.10.2010 and 10.10.2010) because of leaf treatments containing microalgae and in combination with cyanobacteria (15.10.2010 and 10.10.2013). Data from fresh rapeseed leaf samples from 20.10.2010-17.11.2010 (A; C) and 17.10.2013-13.11.2013 (B; D) from Mosonmagyaróvár are shown.

The dry matter content of rapeseed leaves after using microalgae treatments increased continuously during the study period. The highest dry matter content in 2010 resulted from treatments of MAAC-612 with 0.3 g L^{-1}, while in the second pilot year, *Tetracystis* sp. sprays with a concentration of 1 g L^{-1}. In the case of control and traditional cultivation techniques, the dry matter content of leaves decreased in both years.

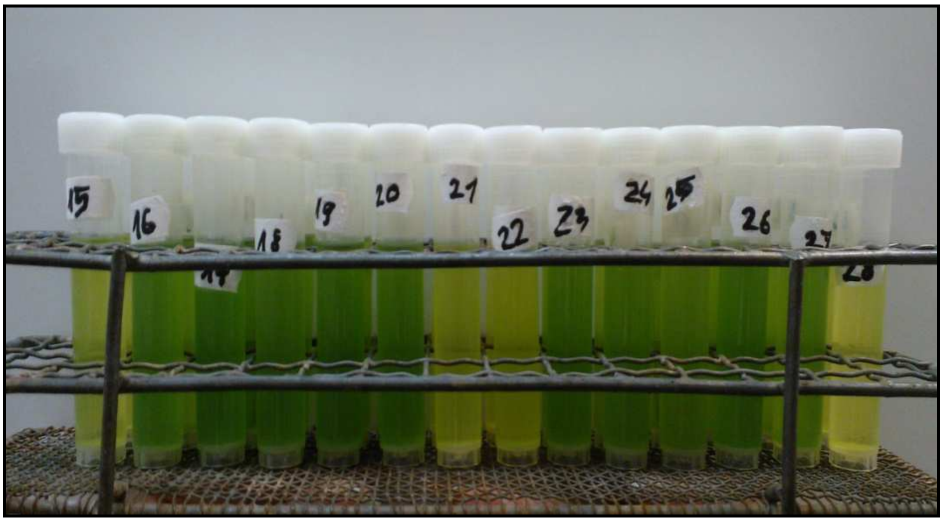

Figure 5 Acetone solutions prepared from the leaf samples of each experimental parcel in the laboratory of the Department of Crop Production on 13.11.2013. (15-control; 16-MACC 612 0.03%; 17-MACC-612 0.1%; 18-MACC-430 0.03%; 19-MACC-430 0.1%; 20-MACC-612+Wuxal; 21-Route+Folicur Solo)

The results of root measurements

The examination of the root system was carried out at the same time in the autumn, as the leaf number (Figure 6). The thickness of the root neck was increased by 36% by the higher dose (0.1%) of MACC-612, while the 0.03% dose of MACC-612 increased by 39% (P=1%). The combination of the MACC-430 at 0.03% and MACC-612 0.1% + Wuxal® increased the diameter of the root neck by an average of 29.3% (P=5%). The higher dose treatment of the MACC-612 strain and the combination of the MACC-612 strain with Wuxal® increased the length of the root system by 16-17% (P=5%), in comparison with the control. The 0.03% treatment of the MACC-430 strain resulted in 44% more (P=0.1) root branches that were thicker than 3 mm in diameter.

Figure 6 Plant samples of MACC-612 1g/L (left, III/3) and traditional treatment andoroz (III/7) in the laboratory of the Institute of Crop Production on 07.12.2013.

The traditional treatments did not cause a demonstrable change in the length and number of branching of the root system. In all cases, the root samples were dried at 106 °C, up to a constant mass (4 days). The results showed that treatments with both concentrations of the MACC-430 strain increased the dry root mass by an average of 12.5%. Sprayings of MACC-612 cyanobacterium with a concentration of 0.03% increased dry root mass by 38% (P=5%) compared to control plots.

The results of the leaf and shoot measurements

The length of the shoot tip was significantly increased in both years only by the leaf treatments with the MACC-612 cyanobacterium (14-36%). Both microalgae treatments significantly increased the diameter of the root collar compared to the control, with Route+ Folicur treatments with 1 g L^{-1} MACC-612 being the most effective. Based on the variance chart of two-way ANOVA, the microalgae treatments had a significant (P=0.1%) impact on the diameter of the root collar, while the traditional treatment did not cause a statistically verifiable change in the thickness of the shoot tip. The autumn leaf number of the plants was significantly increased by microalgae treatments in both years. Before wintering, the control plants had an average of 8-10 adult leaves in both years, while micro-algae treatments resulted in 11-13 adult leaves, which represented a difference of 15-40%. Similarly, both microalgae treatments significantly increased the average leaf number per plant with 1 g L^{-1} MACC-612 and MACC-430 being the most effective.

The results of the pod-measurement

Microalgae treatments increased the number of seed per crop by an average of 72-134% (P=0.1%). Both microalgae strains and the combined treatments; increased the number of pods per branch by 16-33% statistically (P=1%). The average length of pods each microalgae treatment increased by an average of 7-25%, however the total weight of the seeds was increased in both years only by the combined treatments of MACC 430 0,3 g L^{-1} and MACC-612 1 g L^{-1} and Wuxal Boron (20-41%). The number of seeds in the pods increased in both study years after the treatments with MACC-612 (0.3 and 1 g L^{-1}) and combined treatment with Wuxal Boron. The lower doses (0.3 g L^{-1}) of treatments with MAC-430 (0.3 g L^{-1}) enhanced seed content by 12-49%, while the average total weight of the seeds in the pods was increased in both years after the 0.3 g L^{-1} treatment of MACC-430.

The effects on the yield

The 0.3 g L^{-1} spraying of the MACC-430 significantly increased the weight of the measured thousand seeds during both years (P=5%), on the average by 18-25%. Lower doses of MACC-612 (0.3 g L^{-1}) increased the weight of thousand seeds by 7-18%, while treatments with concentrations of 1 g of L^{-1} increased the weight of thousand seeds by 4-25%. The moisture content of the seeds in both years was increased by 5-11% by the treatment of *Tetracystis* sp. 0.3 g L^{-1}, while the oil content of the seeds was on average 4-4% lower in both years compared to control. The 0.3 g L^{-1} treatments of MAAC-612 cyanobacterium increased the yield by an average of 28-33% (P=0.1%, P=1%) in both years, while sprayings with concentrations of 1 g L^{-1} increased yield by 12-28% (P=5%). After lower dose spraying of green algae, the total yield was increased by an average of 28-33 % (P=1%) in both years. After higher dose spraying of MACC-430, the total yield increased by an average to 16-28% (P=5%).

4. NEW SCIENTIFIC RESULTS

1. From the Mosonmagyaróvár Alga Culture Collection (MACC), for the first time, I specifically selected 16 cyanobacteria and eukaryotic strains with a proven hormone-like effect to promote rapeseed production. Based on biotest results and reproduction, I used the microalgae strains *Nostoc piscinale* and *Tetracystis* sp. to conduct small-cell experiments on rapeseed (*Brassica napus* L.).

2. In rapeseed cultivation, it was the first time to test the use of *Nostoc piscinale* and *Tetracystis* sp. with concentrations of 0.3 and 1 g L^{-1}, at the exact phenological phases, for an effect in stimulating rapeseed plants by BBCH 14-16, BBCH-30 and BBCH-51.

3. I have demonstrated that the 0.3 and 1 g L^{-1} autumn leaf treatments with MACC-612 and MACC-430 microalgae strains, can be ensured by rapeseed in the 4-6 leaf phenological phase (BBCH-14-16), regardless of the vintage, and yields a positive effect on the number of leaves, their content of pigment and dry matter. For the first time, I demonstrated the positive effect of the leaf treatments of *Nostoc piscinale* and *Tetracystis* sp. 0.3 and 1 g L^{-1} on the autumn vegetative development of rapeseed (leaf count, plant height, shoot tip length, root neck thickness, root system development), thereby demonstrating the positive effect of leaf treatments on rapeseed wintering.

4. In my experiments with small-cell rapeseed, I have demonstrated for the first time that the 0.3 g L^{-1} treatments of the MACC-612 and MACC-430 strains in the 4-6 leaf (BBCH-14-16),

stem elongation (BBCH-30) and green bud (BBCH-51) phenological phases, positively influenced the development of the crop-forming elements (number of branches of plants, number of pods per plant, the length and seed count of pods), and the spraying increased the weight of one thousand seeds by 24-25%, regardless of the year, and the amount of total yield.

5. Following the results of the small-cell experiments, I am the first to propose a microalgae-based new bio-cultivation technology procedure based on rapeseed production, which include the following treatments:

Spraying rapeseed plants in a leafy state of 4-6 leaves (BBCH 14-16) with a suspension solution containing *Nostoc piscinale* or *Tetracystis* sp. strains with a concentration of 0.3 - 1 g L^{-1}, at a rate of 400 L ha^{-1} spray volume. The second spraying is due with a suspension solution containing *Nostoc piscinale* or *Tetracystis* sp. strains with a concentration of 0.3 to 1 g L^{-1} at the beginning of stem elongation rapeseed plants (BBCH-30) at a level of 400 L ha^{-1} spray volume. The third treatment should be carried out in the green bud state of rapeseed plants (BBCH-51) with a suspension solution containing *Nostoc piscinale* or *Tetracystis* sp. strains with a concentration of 0.3 to 1 g L^{-1} at a level of 700 L ha^{-1} spray volume.

Further increase in the proven beneficial effect of autumn treatment with spring treatments (2 and 3) is most desired and recommended if the general physiological state of the plants requires it.

5. SCIENTIFIC PUBLICATIONS ON THE SUBJECT OF THE DISSERTATION

Publication published in a Hungarian educational journal:

J. Tóth (Notterpek, T. J.); J. Iváncsics 2009: Cultivation and nutrient supply of spice peppers, Value-resistant Golden Crown. - 12/12/2010.10.2010.1.13-15. p., pp. 13-15.2009

Foreign language presentations at a national and international conference:

Tóth, J. (Notterpek, T. J.), Berzsenyi, Z., Ördög, V. 2019: Effect of Arthrospira platensis on the growth and condition of nursery plants, 9th Symposium on "Microalgae and Seaweed Products in Plant/Soil-Systems", Mosonmagyaróvár, 25-26 June 2019.

Tóth, J., (Notterpek, T. J.), Ördög, V., Kramer, B. 2017: *Nostoc piscinale*, *Tetracystis* sp. and *Arthrospira platensis* are promising plant biostimulants, 8th Symposium on "Microalgae and Seaweed Products in Plant/Soil-Systems", Mosonmagyaróvár, 26-27. June 2017.

Pőthe, P., Gergely, I., Ördög, V., **Tóth, J. (Notterpek, T. J.)** 2016: Effect of a plant biostimulating cyanobacterium *Nostoc piscinale* on sunflower and winter rapeseed in field experiments, 18th Annual Meeting of the Research Centre for Plant Growth and Development, University of KwaZulu-Natal, Pietermaritzburg Campus, Republic of South Africa, 17-18 November 2016.

Tóth, J. (Notterpek, T. J.), Gergely, I., Ördög, V. 2015: Winter oilseed rape stimulated by *Nostoc piscinale* and *Tetracystis* sp., 7th Symposium on "Microalgae and Seaweed Products in Plant/Soil-Systems", Mosonmagyaróvár, 29-30 June 2015.

Tóth, J. (Notterpek, T. J.), Ördög, V. 2014: Effect on the growth, condition, number of quality and other parameters of red pepper *Kaldom* by using *Nostoc entophytum* microalgae-treatment, Advances in Plant Breeding and Biotechnology Techniques" Pannonian Plant Biotechnology Association Conference, Mosonmagyaróvár, 274-29 April 2014.

J. Tóth (Notterpek, T. J.), Ördög, V. 2014: Effect on the growth and development of MACC-612 *Nostoc piscinale* on red pepper *Kaldóm*, XXXV. Óvári Scientific Day, Opportunities of the Hungarian and international agricultural and food economy, Mosonmagyaróvár, 10.11.2016.

Tóth, J. (Notterpek T. J.), Ördög V. 2011: Effect of MACC-612 *Nostoc piscinale* on red pepper, 5th Symposium on "Microalgae and Seaweed Products in Plant/Soil-Systems", Mosonmagyaróvár 23-24. June 2011.

Hungarian-language presentations held at a Hungarian conference

Notterpek T. Jácint –Daood H. - Gergely I. – Berzsenyi Z. – Ördög V. 2023: Changes in pigment content of field and horticultural crops due to microalgal leaf and soil treatment, XXXIX. Óvári Scientific Day – „ The challenges of the agricultural, food and rural economy". 16th November. 2023, pp. 1-16

Toth, J. (Notterpek, T.J.), Berzsenyi, Z., Ördög, V. 2018: The effect of *Arthrospira platensis* cyanobacterium and steinkraft biopellet on nursery plants, XXXVII Óvári Scientific Day, Sustainable Agriculture and Environment of the Academy of Mosonmagyarovar 200 years-past, present, future, Mosonmagyaróvár 2018.11.9-10

Toth, J. (Notterpek, T.J.), Gergely, I., Ördög, V. 2016: The impact of microalgae-containing biostimulants on the autumn development of rapeseed, XXXVI. Óvári Scientific Day - Tradition and Innovation in the Agricultural and Food Economy, István Széchenyi University Faculty of Agriculture and Food Sciences, Mosonmagyaróvár, 10-11.11.2016

Published scientific articles

Stirk, W., Balint, P., Siroka, J., Novak, O., Retfalvi, T., Berzsenyi, Z., **Notterpek, T. J.**, Chukwujekwu, J. C., Varga, Z., Maroti, G., van Staden, J., Strnad, M., Ördög, V. 2024: Comparison of plant biostimulating properties of *Chlorella sorokiniana* biomass produced in batch and semi-continuous systems supplemented with pig manure or acetate, *Journal of Biotechnology,ISSN:0168-1656, Vol.381., pp. 27-35, IF: 4.1*

Abstract

Microalgae-derived biostimulants provide an eco-friendly biotechnology for improving crop productivity. The strategy of circular economy includes reducing biomass production costs of new and robust microalgae strains grown in nutrient-rich wastewater and mixotrophic culture where media is enriched with organic carbon. In this study, Chlorella sorokiniana was grown in 100 l bioreactors under sub-optimal conditions in a greenhouse. A combination of batch and semi-continuous cultivation was used to investigate the growth, plant hormone and biostimulating effect of biomass grown in diluted pig manure and in nutrient medium supplemented with Na-acetate. C. sorokiniana tolerated the low light (sum of PAR 0.99 ± 0.18 mol/photons/ (m2 /day) and temperature (3.7-23.7° C) conditions to maintain a positive growth rate and daily biomass productivity (up to 149 mg/l/day and 69 mg/l/day dry matter production in pig manure and acetate supplemented cultures respectively). The protein and lipid content was significantly higher in the biomass generated in batch culture and dilute pig manure (1.4x higher protein and 2x higher lipid) compared to the Na-acetate enriched culture. Auxins indole-3-acetic acid (IAA) and 2-oxindole-3-acetic acid (oxIAA) and salicylic acid (SA) were present in the biomass with significantly higher auxin content in the biomass generated using pig manure (> 350 pmol/g DW IAA and > 84 pmol/g DW oxIAA) compared to cultures enriched with Na-acetate and batch cultures (<200 pmol/g DW IAA and <27 43 pmol/g DW oxIAA). No abscisic acid and jasmonates were detected. All samples had plant biostimulating activity measured in the mungbean rooting bioassay with the Na-acetate supplemented biomass eliciting higher rooting activity (equivalent to 1-2 mg/l IBA) compared to the pig manure (equivalent to 0.5-1 mg/l IBA) and batch culture (equivalent to water control) generated biomass. Thus C. sorokiniana MACC-728 is a robust new strain for biotechnology, tolerating low light and temperature conditions. The strain can adapt to alternative nutrient (pig manure) and carbon (acetate) sources with the generated biomass having a high auxin concentration and plant biostimulating activity detected with the mungbean rooting bioassay.

Keywords: Auxin; Low light; Low temperature; Proteins; Rooting activity; Salicylic acid

Notterpek, T. J., Ördög, V. 2021: The effect of *Arthrospira platensis* cyanobacterium on nursery plants; *Acta Agronomica Óváriensis, Vol 62 No1; pp 4-20*; Mosonmagyaróvár

Abstract

The aim of our experiments was to improve the growth and development of container nursery plants by using *the biomass of Arthrospira platensis* cyanobacteria fed into the soil. In the spring of 2017, we treated the experimental plants at the Kramer & Kramer nursery in Austria, namely: *Ribes sativum* cv. *Weiße Versailler,* ribes *rubrum* cv. *Jonkheeer van Teets*, the *Ribes nigrum* cv. *Titania* currant varieties. The powdered dry cyanobacterium biomass (*Arthrospira platensis*) used in the experiment was supplied from Myanmar by Agro-Bioferment Ltd. 2, 4 or 6 grams of cyanobacteria biomass was added to the soil of containerized (5 L) plants at the beginning of the experiment. We measured the relative chlorophyll content of the leaves, their trunk thickness, the height of the plants, and the number of branches. According to the data measured at the end of the 120-day experiment, *Arthrospira platensis* soil treatments had a positive but different effect on certain properties of the three currant varieties studied. The chlorophyll content of the leaves increased the most (75-88 %) in the type of *R. rubrum* tested, which was accompanied by an increase in the body thickness (42 %) and the number of branches (37 %) in 4 g of treatment. For the R. *sativum* and *R. nigrum* varieties tested, a significant increase in the number of branches (81-85 %) was achieved with soil treatment of 6 g, while the core thickness did not deviate from the control. The opposite trend was observed between the thickness of the varieties and the number of branches. More branching was accompanied by a smaller thickness of the trunk and vice versa, a smaller number of branches with a higher trunk thickness.

Keywords: cyanobacteria, biostimulant, berry fruit, growth, development, chlorophyll content

Tóth, J. (Notterpek T. J.), Gergely, I., Berzsenyi, Z., Ördög, V. 2019: Influence of Nostoc piscinale and Tetracystis sp. on winter survival of rapeseed, *Journal of Agricultural Science and Technology B 9, pp. 251-271*, DOI 10.17265/2161-6264/2019.04.004

Abstract

Bioassay results proved that several microalgae strains of the Mosonmagyaróvár Algal Culture Collection (MACC) enhanced plant growth, due to their hormone content and other secondary metabolites. The aim of the current research was to improve autumn growth and winter survival of rapeseed (*Brassica napus L.*) by treatment with two microalgae strains selected by bioassay results. Experimental plots were set up in Mosonmagyaróvár in 2010 and 2013. Winter rapeseed hybrid (*Brassica napus* L. cv. *Orlando*) plants were treated in 4-6 leaf stage with 0.3 and 1 g L^{-1} suspensions of MACC-612 *Nostoc piscinale* Bornet & Flahault and MACC-430 *Tetracystis* sp in middle of October. After the treatments, the following parameters were recorded: chlorophyll-a, and b, carotenoid, dry matter content of leaves, average amount of autumn foliage, diameter of root collar, length of shoot tips, fresh and dry weight of root, and number of plants in autumn and spring. Both microalgae treatments significantly increased pigment concentration and dry matter content of leaves, number of fully grown leaves (13-46 %), and dry root weight (16-36 %). Treatments with 0.3 and 1 g L^{-1} MACC-612 suspensions increased the length of shoot apices by 14-18% and 25-35%, respectively. Number of overwintered control plants decreased significantly in both years (31 %), but there was no decrease in parcels treated with 1 g L^{-1} of MACC-612 and MACC-430. Microalgae treatments could increase plant growth and survival, which contributed to the significant increase of thousand seed weight (18-25 %) and total yield (by 10-24 %).

Keywords: microalgae, photosynthetic pigments, winter oilseed rape, winter survival

Tóth, J. (Notterpek T. J.), Gergely, I., Ördög, V. 2016**:** The effect of microalgae treatments on the growth and development of autumn cabbage rape (*Brassica napus*), Plant production 65 (2016) 1, pp. 81-106

Summary:

The transformation of earth's climate makes it difficult to produce agriculture safely. With the focus on sustainable development and environmentally friendly farming, agricultural production is also changing. The aim of our experiment was to measure the effect of microalgae treatments on the growth and development of rapeseed (*Brassica napus* L.) in two experimental years. In our communication, we present the detailed results of the first year of experiment and, for comparison, the results of the experiment repeated during the 2013/14 growing season. The experimental plots were set up in 2010 near Mosonmagyaróvár. Our experimental plant, an autumn rape hybrid (*Brassica napus* L. cv. *Orlando*) treated in combination with or without suspensions of 0.03 % and 0.1 % of MACC-612 *Nostoc piscinale* and MACC-430 *Tetracystis* sp., as well as with or without the preparation used in traditional rapeseed cultivation technology. We examined the indicators characteristic of the growth of plants, the amount of photosynthetic pigments, as well as the fruiting elements and the quality parameters of the seeds. Autumn treatments of MACC-612 and MACC-430 of 0.03 % and 0.1 % increased the dry matter content of leaves by 90-110 %, chlorophyll by 80-101 % of chlorophyll b, by 66-81 % by total carotenoids and by 25-37 % by dry matter in leaves. The two microalgae strains increased the total yields in both years in 2010/11 (10-14 %) and 2013/14 (10-21%) compared to the control plots, but the average oil content of the seeds did not change in either year because of the treatments.

According to the results of the two-year series of experiments, the combined treatments of MACC-612 with a concentration of 0.03% and a suspension of 0.03 % of MACC-430 had a positive impact on the growth and development of rapeseed and increased the amount of crop.

Keywords: microalgae, rapeseed, organic, physiological stimulation, photosynthetic pigments, morphology, crop growth