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EFFECT OF N PRO TECHNOLOGY AND SEACTIV COMPLEX ON GROWTH, YIELD QUANTITY AND QUALITY OF 'SZAMPION' APPLE TREES

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Abstract. Recent years have been marked with a more common use of mineral fertilizers comprising marine algal extracts in horticultural production. Seaweed extracts are reported to possess, among others, biostimmulatory potential that improves yield growth and its quality as well as promotes plant resistance to adverse environmental agents. The marine alga processing technologies facilitate the extraction of active substances valuable for plant crops as stimulants for a number of plant physiological processes. The substances can be incorporated into both, soil or foliar applied fertilizers. The present research objective was to assess the influence of N Pro technology and Seactiv complex based on marine algal extracts on apple tree 'Szampion' growth, yield quantity and quality. The experimental material comprised 'Szampion' apple trees grafted on M.26 stock, the trees were aged 10 years at the experiment onset. The study aimed at evaluation of growth, yield quantity and quality of 'Szampion' apple trees fertilized according to two following programs. The measurements performed showed that introduction of the fertilization programs based on marine algal extracts had significant effect on total yield, one fruit weight, firmness and sugar extract content in apple tree 'Szampion' fruits. It was found that the N Pro technology and Seactiv complex had significantly beneficial influence on the percentage of big fruits, i.e. above 7.5 cm diameter and marketable yield in each experimental year. Cropping efficiency coefficient (CEC) of 'Szampion' apple trees fertilized according to N Pro technology and Seactiv base was significantly higher compared to control solely in 2008, in the other research years the differences were insignificant. The fertilization program based on marine algal extracts had positive influence on the 'Szampion' apple tree`s annual increments and each year the trees under N Pro and Seactive complex fertilization technology produced higher increments as against control; the differences in the last research year were significant. The N Pro technology and Seactiv base had positive impact on 'Szampion' apple tree leaf surface area, significant influence was observed in the second and third research year.

Key words: marine algae, fertilization, cropping efficiency coefficient – CEC, one fruit weight, extract, annual growth, leaf surface area

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INTRODUCTION

In horticultural production, fertilization is the first priority management practice providing optimal conditions for plant growth and yielding. The key to improve fertilization efficiency is to apply preparations enriched with biostimulants [Schmidt et al. 2003]. Biostimulant is a general term used to define a substance that is not a plant nutrient but has a positive impact on plant health [Berlyn and Sivaramakrishnan 1996], growth and metabolism, increases antioxidant content and enhances nutrient availability [Verkleij 1992, Zhang and Schmidt 1997]. There is a great diversity of such products but as Karnok [2000] reports, seaweed extracts contain many compounds of this type. It was found that marine algal extracts are rich in macro and microelements, amino acids, vitamins, cytokinins, auxins, abscisic acid (ABA) [Stephenson 1968, Munda and Gubensek 1975, Abetz 1980, Finnie and Van Staden 1985, Mooney and Van Staden 1986, Crouch et al. 1992, Verkleij 1992, Crouch and Van Staden 1993, Reitz and Trumble 1996, Durand et al. 2003, Stirk et al. 2003, Ordog et al. 2004, Khan et al. 2009].

Currently, a comprehensive range of horticultural products are marketed with emphasis on those comprising biostimulants, plant and animal amino acids, vitamins and macro and microelements. Most commonly these are single separate preparations whose rational application requires extensive knowledge and profound experience. The firm Timac Agro has operated in the Polish market for several years and offers the complex fertilization system enriched with additional compounds, namely the Seactiv complex® (a series of foliar sprays Fertileader) that contains, among others, IPA cytokinin (exhibits systemic activity, enhances mineral intake and availability and activates their transport), glycine – betaine (shows potent anti-stress activity, stimulates the root system growth and photosynthesis process) as well as amino acids (as the building blocks of plant proteins transport nutrients of very small size and the shortest penetration time into foliage and fruits). Soil-applied fertilizers provided by Roulle group contain N Pro complex which promotes nitrite reductase and thus, contributes to faster uptake and more efficient nitrogen conversion [Jeannin et al. 1991].

The aim of the present study was to evaluate the effect of N Pro technology and Seactiv complex based on marine seaweed extracts on apple tree ‘Szampion’ yield quantity and quality.

MATERIAL AND METHODS

The studies were carried out in 2008–2010 at the Sandomierz Upland (50º39’N; 21º34’E). The experimental material included ‘Szampion’ cultivar trees aged 10 years at the research start and grown from M.26 rootstock. The trees were planted in spring 1998 at the 3.0 × 1.0 m row spacing on loess soil as maiden trees. There were formed axial-shaped tree crowns which were supported with wire and metal stakes or wooden posts. The experiments aimed to estimate the growth, yield quantity and quality of apple trees ‘Szampion’ under two fertilization programs:

1. Control:

– Hydrocomplex 12-11-18 – 300 kg·ha^{-1} broadcasting at the green bud stage,
– Tropicote Ca nitrate – 200 kg·ha^{-1} broadcasting post blossom,
– Agroleaf 52%P – 5 kg·ha^{-1} spraying at the green bud stage,
– Agroleaf 52%P – 5 kg·ha^{-1} spraying at the pink bud stage,
– Calcinit-calcium nitrate – 5 kg·ha^{-1} spraying 7–10 days later – 4 applications at 7–10 day intervals,
– Calcium chloride – 6 kg·ha^{-1} spraying 6 applications at 7–10 intervals.

2. N Pro technology and seactiv complex:

– Eurofertil 34 N Pro 8-8-18 + 9 CaO – 300 kg·ha^{-1} broadcasting at the green bud stage,
– Sulfammo 30 N Pro – 100 kg·ha^{-1} broadcasting post blossom,
– Fertileader Leos – 5 l·ha^{-1} spraying at the green bud stage,
– Fertileader Gold BMO – 3 l·ha^{-1} spraying at the pink bud stage,
– Fertileader Axis – 3 l·ha^{-1} spraying post blossom,
– Fertileader Vital 954 – 3 l·ha^{-1} spraying 2 applications at 10–14 day intervals,
– Fertileader Elite – 3 l·ha^{-1} spraying 3 applications starting from the walnut stage at 14 day intervals.

The combinations were made by the mentioned above two technologies of fertilization.

The experiment was set up according to randomized block design and involved two combinations in 5 replications, i.e. the plots with 10 plants each.

Throughout the experiment time, apple crop load was reduced in both combinations each year by the chemical fruit let thinning performed after flowering and followed by hand thinning after the June drop so as to obtain a similar number of fruits on tree. The measurements and observations conducted over 2008–2010 focused on growth, fruit yielding and quality. Fruits were harvested on 10–15 September, separately from each tree within each combination. The harvest maturity date was determined on the grounds of a starch content and organoleptic evaluation. A group of 100 apple fruits chosen randomly from each replication was divided on the basis of fruit size. Marketable yield was expressed as a percentage of fruits over 7.5 cm in total fruit yield. Fruit flesh firmness was measured with a penetrometer one day after the harvest in 10 apples from each replication. A sugar extract content in fruits was estimated using an Abbe type refractometer to determine the percent extract in juice squeezed from 10 representative fruits from each replication. Tree growth was estimated each autumn after the vegetative season completion by measuring trunk diameter at 30 cm height above the place of grafting. Cropping efficiency coefficient (CEC) was expressed as the ratio between tree yield and trunk cross-sectional area (TCSA) measured in the same year. The measurements of the annual shoot increments were made each autumn after the vegetative period end when 5 long shoots were measured on each tree. Leaf surface area was estimated on the grounds of the ratio between mass of leaves and 2 cm diameter punched holes, the measurement was made on 20 leaves from each replication.

The obtained research results were analyzed statistically using the variance analysis and Tukey confidence intervals. Inferences were based on the 5% significance level.

RESULTS

Table 1 summarizes the mean and minimum monthly air temperatures as well as total precipitation in the years 2008–2010. It was observed that the weather conditions at each study year favored the crops. The mean annual air temperature in the successive years was slightly lower than the long-term mean. It was shown that in the years 2008––2010, the last air temperature drops below 0ºC were recorded in March, in 2009 the first autumn temperature falls occurred in October, while in the other years in November. Annual total precipitation at each research year was higher than the long-term mean. In the year 2008,precipitation distribution was found to be the least favorable for horticultural crops as in February, June, August and November markedly lower total precipitation amount was reported as compared to the long-term mean.

Mean total yield of 'Szampion' trees oscillated between 72.7 and 76.9 $t \cdot ha^{-1}$ and did not differ significantly (tab. 2). Alike, no significant differences between the studied combinations were found each experimental year. It was observed that the trees fertilized each year according to N Pro technology and Seactiv complex yielded slightly higher as against the control and in 2010 the difference amounted to more than 7 $t \cdot ha^{-1}$.

Mean fruit weight of 'Szampion' cultivar apples was found within the 185.0 and 198.0 g range and did not differ significantly between the combinations (tab. 2). In the successive research years, there were not shown any significant differences between the evaluated technologies. However, it was established that each year the trees in the N Pro technology and Seactiv complex combination produced fruits of higher weight as against the control.

A percentage of fruits of diameter above 7.5 cm varied between 71.3 and 75.8% and did not differ significantly between the combinations under investigation, whereas each year the control trees produced significantly less large fruits than in the N Pro technology and Seactiv complex combination (tab. 3).

Marketable yield for the mean from the 2008–2010 period ranged from 52.1 in the control trees up to 58.9 $t \cdot ha^{-1}$ in the N Pro technology and Seactiv complex combination and did not differ significantly (tab. 2). It was stated that each experimental year, marketable yield of trees in N Pro technology and Seactiv complex combination was significantly higher as compared to control.

Mean firmness estimation value of the 'Szampion' cultivar apples was found within the 7.0 and 7.2 $kg \cdot cm^2$ range and it did not differ significantly between the research combinations (tab. 3). Each experimental year indicated no significant influence of the technologies applied on the studied trait, yet fruits obtained under the N Pro technology and Seactiv complex combination proved to be a little firmer than control.

Average extract content in 'Szampion' fruits oscillated from 12.6 up to 12.7% and it did not differ (tab. 3). Similar relationship was determined in each research year.

The mean cross-sectional trunk area of the studied trees averaged from 38.9 up to 41.7 cm^2 and did not differ significantly (tab. 4). In the first research years, the analysis showed the control trees have significantly thicker trunks than in the N Pro technology and Seactiv complex combination, the differences were not significant last year.

Average cropping efficiency coefficient (CEC) of 'Szampion' apple trees was found within the range of 0.55–0.63 $kg \cdot cm^2$ (tab. 4). The statistical analysis indicated the sig-

Table 1. Mean and minimum monthly air temperatures and total precipitation according to weather station in Sandomierz 2008–2010

Month	Mean air temperature, °C				Minimum air temperature, °C			Amount of precipitation, mm			
	2008	2009	2010	mean for years 1988–1998	2008	2009	2010	2008	2009	2010	mean for years 1988–1998
January	0.4	-2.9	-7.6	-1.4	-10.1 5.01	-13.8 6.01	-19.8 26.01	29.4	18.9	23.8	17.7
February	2.3	-1.0	-1.8	0.0	-7.0 16.02	-9.6 21.02	-8.9 7.02	11.7	18.4	29.2	21.2
March	3.8	2.1	3.6	2.7	-0.6 20.03	-1.8 2.03	-6.5 08.03	45.8	66.4	16.6	25.6
April	9.4	11.1	9.4	8.2	5.4 2.04	6.8 1.04	4.3 22.04	59.0	7.6	34.1	48.1
May	13.5	13.7	14.0	13.8	9.7 20.05	8.3 13.05	9.2 5.05	74.3	72.6	168.4	61.7
June	18.2	16.6	17.8	16.6	13.1 15.06	10.3 04.06	12.3 24.06	29.4	89.2	44.8	69.7
July	18.8	20.2	21.2	18.6	14.6 9.07	14.8 26.07	14.1 26.07	99.4	71.7	125.7	65.1
August	18.9	18.5	19.5	18.1	13.5 30.08	15.2 23.08	11.9 31.08	31.0	57.8	106.1	69.3
September	12.7	15.1	12.3	13.0	6.3 16.09	8.3 30.09	5.4 30.09	83.3	44.7	88.9	65.5
October	9.8	7.2	5.6	8.0	3.0 26.10	-0.2 31.10	2.6 28.10	36.8	101.2	9.2	42.5
November	5.0	5.2	6.5	1.8	-2.1 22.11	-2.0 3.11	-10.9 30.11	19.2	48.7	48.2	33.4
December	0.9	-1.2	-4.7	-1.6	-6.1 31.12	-15.1 20.12	-14.4 1.12	37.1	49.7	34.3	25.4
Mean annual air temperature, °C	9.48	8.72	7.98	12.3	–	–	–	–	–	–	–
Amount of precipitation, mm	–	–	–	–	–	–	–	556.4	646.9	729.3	545.2

* according to the Sandomierz weather station

Table 2. Effect of N Pro technology an Seactiv complex on yield quantity of 'Szampion' apple tree in 2008–2010

	Combination	2008	2009	2010	Mean
Yield, $t \cdot ha^{-1}$	control	89.3	86.3	42.5	72.7
	N Pro technology and Seactive complex	90.8	89.9	50.2	76.9
	$LSD_{0.05}$	n. s.	n. s.	n. s.	n. s.
Fruit weight, g	control	169.0	205.0	182.0	185.0
	N Pro technology and Seactive complex	185.0	223.0	186.0	198.0
	$LSD_{0.05}$	n. s.	n. s.	n. s.	n. s.

Explanation: Means followed by the same letter are not significantly different at $\alpha = 0.05$

Table 3. Influence of N Pro technology and Seactiv complex on quality of 'Szampion' apple tree yield in 2008–2010

	Combination	2008	2009	2010	Mean
Fruit with diameter > 7.5 cm, %	control	54.5 b	91.0 b	68.3 b	71.3
	N Pro technology and Seactive complex	59.5 a	97.0 a	70.7 a	75.8
	$LSD_{0.05}$	3.1	1.3	1.5	n. s.
Marketable field, $t \cdot ha^{-1}$	control	48.7 b	78.5 b	29.0 b	52.1
	N Pro technology and Seactive complex	54.0 a	87.2 a	35.5 a	58.9
	$LSD_{0.05}$	2.1	1.3	2.4	n. s.
Fruit firmness, $kg \cdot cm^2$	control	6.6	7.1	7.4	7.0
	N Pro technology and Seactive complex	6.8	7.2	7.6	7.2
	$LSD_{0.05}$	n. s.	n. s.	n. s.	n. s.
Ekstrakt, %	control	12.6	12.9	12.2	12.6
	N Pro technology and Seactive complex	12.8	12.9	12.3	12.7
	$LSD_{0.05}$	n. s.	n. s.	n. s.	n. s.

Explanation: Means followed by the same letter are not significantly different at $\alpha = 0.05$

nificant differences between the combinations only in the first research year. There was observed the higher CEC value of the trees in the N Pro technology and Seactiv complex combination each experimental year as against control.

Average annual shoot length increments ranged from 43.1 up to 48.7 cm and did not differ significantly (tab. 4). Similar relationship was established in the first experimental years, while in 2010 the trees showed significantly higher annual shoot length increments.

Mean leaf area of the studied trees oscillated between 42.4 and 45.5 cm^2 and did not differ significantly between the combinations (tab. 4). In 2009 and 2010, the trees under

Table 4. Effect of N Pro technology and Seactive base on growth and productivity of 'Szampion' apple trees in 2008–2010

	Combination	2008	2009	2010	Mean
Trunk cross-sectional area – TCSA, cm^2	control	36.2 a	42.5 a	46.5	41.7
	N Pro technology and Seactive complex	32.5 b	39.6 b	44.8	38.9
	$LSD_{0.05}$	1.0	2.6	n. s.	n. s.
Cropping Efficiency Coefficient – CEC, $kg \cdot cm^2$	control	0.75 b	0.61	0.28	0.55
	N Pro technology and Seactive complex	0.85 a	0.69	0.34	0.63
	$LSD_{0.05}$	0.04	n. s.	n. s.	n. s.
Mean shoot length, cm	control	32.1	46.0	51.0 b	43.1
	N Pro technology and Seactive complex	34.7	53.0	58.6 a	48.7
	$LSD_{0.05}$	n. s.	n. s.	2.4	n. s.
Leaf surface area, cm^2	control	33.9	45.0 b	48.2 b	42.4
	N Pro technology and Seactive complex	34.4	51.0 a	51.0 a	45.5
	$LSD_{0.05}$	n. s.	1.9	1.7	n. s.

Explanation: Means followed by the same letter are not significantly different at $\alpha = 0.05$

N Pro and Seactiv complex fertilization technology displayed leaves of significantly higher area as compared to control.

DISCUSION

Recently horticultural production has been characterized by application of higher rates of mineral fertilizers incorporating marine algal extracts which are said to have promising benefits to promote yield quality and growth as well as increase plant resistance to unfavorable environmental stressors [Jolivet et al. 1991, Durand et al. 2003]. Currently the biostimulant application makes an integral part of the crop plants production system but biostimulants were primarily meant to correct deficiencies in plant development under unpredictable and stress conditions [Jankiewicz and Lipecki 2011].

The development of new technologies for marine seaweed processing allowed to extract compounds valuable for plant cultivation as stimulants for diverse physiological processes. The compounds can be applied to plants with both, foliar fertilizers or mineral fertilizers for soil application. According to Mancuso et al. [2006], foliar feeding to higher plants proves to be a faster way to provide nutrients as compared to dry top dressing.

In the coastal regions of western Europe, algae have been used as soil conditioner for many years as the earliest records are found in the XVI century in Scotland and Brittany in France. Then seaweeds were popular as organic soil-applied fertilizer, while now they are more common in the form of liquid extracts. The first foliar sprays of marine algae-based preparations were performed as early as in 1950 [Blunden and Gordon 1986, Metting et al. 1988, Temple and Bomke 1988]. According to FAO

[2006], ca 15 million metric tons of seaweeds products are used annually to produce fertilizers and seaweed formulations as biostimulants.

Abetz [1980], Abetz and Young [1983], Featonby-Smith and Van Staden [1987], Arthur et al. [2003] report that application of marine algae extract-based preparations triggers earlier flowering, better fruit set and development of fruits of numerous crop plants. The studies of Crouch and Van Staden [1992] showed that tomato seedlings treated with seaweed extracts produced average higher by 30% and better quality fruits than control. Positive effects of *Ascophyllum nodosum* (L.) algae on the yield and quality of 'Thompson Seedless' grape were indicated by Norrie and Keathley [2006]. The authors observed that throughout the 3-year experimental period, the plants treated with marine algal concentrate showed yield higher by 60.4%, produced heavier berries and more bunches per plant compared to control plants. Beneficial impact of seaweeds on yield increase and quality was also highlighted by Van Staden et al. [1994], Aldworth and Van Staden [1987], Abetz and Young [1983], Featonby-Smith and Van Staden [1987], Arthur et al. [2003] etc. The weather conditions observed over the years 2008––2010 were considered conducive for apple tree growing, therefore the present paper has indicated only minor effect of fertilization technology based on marine algae extracts on total yield, one fruit weight, firmness and extract content. These parameters reached some higher results in the N Pro technology and Seactiv complex combination as against the control.

In the studies of Featonby-Smith and Van Staden [1983a, b] the effect of seaweed extracts on fruit size was shown to be associated with the presence of substances displaying hormonal activity, primarily cytokinins which are responsible for cell division. Nooden and Leopold [1978] observed that treatment of plants with marine algal extracts makes the substances promoting plant growth and development translocate from the vegetative organs, i.e. roots, shoots and young shoots to fruits to be used for further plant development. Faetonby-Smith and Van Staden [1984] indicated that tomato fruits originating from plants treated with seaweed formulations exhibit higher cytokinin concentration as compared to fruits from non-treated plants. This finding agrees with the present research results as the marine algae-based technology exerted significantly positive effect on the percentage of large fruits, namely those of diameter over 7.5 cm, and marketable yield in each experimental year.

The field trials conducted by Yvin and Dufils [2010] involved three applications of foliar sprays of Fertileader Elite formulated on the Seactiv base that consequently, did not elicit favourable influence on apple firmness at harvesting 'Pink Lady® Cripps Pink Cov.' cultivar fruits as compared to three calcium chlorine treatments. It was found that after the 3-month storage, fruits treated with Fertileader Elite showed lower firmness loss than control fruits.

The present paper shows that employment of N Pro technology and Seactiv complex affected the firmness of 'Szampion' cultivar apple fruits to a small degree because the air temperature arrangement and total precipitation amount favored the production. Fruits treated by the above mentioned technology were characterized by higher firmness as compared to control, but the differences were not significant.

Biostimulant role in improving plant growth has remained unclear primarily due to a number of products and their composition as well as a fact that biostimulant effective-

ness is subject to a plant species [Mancusso et al. 2006]. Berlyn and Sivaramakrishnan [1996] report that in the case of such species like, *Coffea, Alnus* and *Pinus* the growth rate of plants treated with biostimulants was higher than that of non-treated ones, yet no significant differences were observed. Similar positive effect of the biostimulant (IPA) application on *Vitis vinifera* growth rate was indicated by Mancusso et al. [2006].

The studies of Ferrini and Nicese [2002] concluded that the biostimulant-treated *Quercus robur* seedlings showed positive responses in terms of leaf area and dry matter but no effect was observed in the fresh to dry leaf weight ratio. Alike, beneficial influence of biostimulants on leaf area has been found in the present research as the N Pro technology and Seactiv base application had significantly positive impact on the estimated growth parameter in 2009 and 2010. Kelting et al. [1998] assessed the effect of different biostimulants on growth and quality of *Acer rubrum* and *Cratageus phaenopyrum* seedlings and showed that the preparations applied positively influenced plant height, trunk diameter and root length solely in the case of *Cratogeus*.

The present study results do not fully support the findings of Kelting et al. [1998] as during the 3-year experimental period trunk cross-sectional area of 'Szampion' apple trees in the N Pro technology and Seactiv complex combination was smaller than in control; in the first two research years the differences were significant. It is noteworthy that a difference between the assessed combinations was smaller from one year to the next. Ameliorative effect of the N Pro technology and Seactiv complex was noted while estimating the annual shoot length increments of trees, this parameter reached higher values in the N Pro technology and Seactiv complex combination each year as compared to control.

According to Schmidt et al. [2003] biostimulants with mineral fertilization additive applied as foliar spray are unable to supply all the essential nutrients in the quantities plant needs to grow and function since their major task is to improve plant tolerance to environmental stresses. Beside the proper mineral fertilization, biostimulants can enhance the effectiveness of conventional fertilizers [Frankenberger and Arshad 1995], ameliorate macronutrient absorption and accumulation at leaf level [Mancuso et al. 2006]. Mancuso et al. [2006] demonstrated in their studies the effectiveness of IPA extracts shown in improved accumulation of nitrogen, phosphorus and potassium in almost all the organs of grapevine plants. However, the role of biostimulants in amelioration of nutrient absorption at plant tissue level has remained largely unknown. Salat [2004] reports that biostimulants may contain chelating compounds (e.g. mannitol in seaweeds) that can promote nutrient availability and improved absorption of chelated compounds by leaves. Durand et al. [2003] applied the N PRO technology in *Arabidopsis thaliana* and reported increased nitrate reductase (NR).

CONCLUSIONS

1. Application of N Pro technology and Seactiv base did not have significant impact on total yield, one fruit weight, firmness and a sugar extract content in 'Szampion' cultivar apple tree fruits. These parameters in the N Pro technology and Seactiv complex combination were slightly higher as compared to control.

2. Seaweed extract-based technologies have been found to affect significantly the percentage of large fruits, i.e. of diameter over 7.5 cm and marketable yield in each experimental year.

3. Cropping efficiency coefficient of 'Szampion' apple trees under N Pro and Seactiv base fertilization technology was significantly higher compared to control in solely 2008, in the other years the differences were not significant.

4. The fertilization program based on seaweed extracts had positive impact on annual shoot length increments of 'Szampion' apple trees. Each year the trees fertilized according to N Pro technology and Seactiv complex were characterized by higher annual shoot length increments than control; the differences were significant in the final research year.

5. The N Pro technology and Seactiv base exerted beneficial effect on leaf area of 'Szampion' apple trees; the impact was significant in the second and third experimental year.

REFERENCES

Abetz P., 1980. Seaweed extracts: Have they any place in Australian agriculture or horticulture? J. Aust. Inst. Agric. Sci. 46, 23–29.

Abetz P., Young C.L., 1983. The effect of seaweed extract sprays derived from *Ascophyllum nodosum* on lettuce and cauliflower crops. Bot. Mar. 26, 487–492.

Aldworth S.J., Van Staden J., 1987. The effect of seaweed concentrate on seedling transplants. S. Afr. J. Bot. 53, 187–189.

Arthur G.D., Stirk W.A., Van Staden J., 2003. Effect of a seaweed concentrate on the growth and yield of three varieties of *Capsicum annuum*. S. Afr. J. Bot. 69, 207–211.

Berlyn G.P., Sivaramakrishnan S., 1996. The use of organic biostimulants to reduce fertilizer use, increase stress resistance, and promote growth. National Proceedings Forest and Conservation Nursery Association Meeting. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, USA, 106–112.

Blunden G., Gordon S.M., 1986. Betaines and their sulphono analogues in marine algae. In: Progress in phycological research, Round F.E., Chapman D.J. (eds), vol. 4. Biopress Ltd, Bristol, 39–80.

Crouch I.J., Van Staden J., 1992. Effect of seaweed concentrate on the establishment and yield of greenhouse tomato plants. J Appl. Phycol. 4, 291–296.

Crouch I.J., Van Staden J., 1993. Evidence for the presence of plant growth regulators in commercial seaweed products. Plant Growth Reg. 13, 21–29.

Crouch I.J., Smith M.T., Van Staden J., Lewis M.J., Hoad G.V., 1992. Identification of auxins in a commercial seaweed concentrates. J. Plant. Physiol. 139, 590–594.

Durand N., Briand X., Meyer C., 2003. The effect of marine bioactive substances (N Pro) and exogenous cytokinins on nitrate reductase activity in *Arabidopsis thaliana*. Physiol. Plant. 119, 489–493.

FAO, 2006. Yearbook of fishery statistics, vol. 98 (1–2). Food and Agricultural Organisation of the United Nations, Rome.

Featonby-Smith B.C., Van Staden J., 1983a. The effect of seaweed concentrate on the growth of tomato plants in nematode-infested soil. Sci. Hortic. 20, 137–146.

Featonby-Smith B.C., Van Staden J., 1983b. The effect of seaweed concentrate and fertilizer on the growth of *Beta vulgaris*. Z. Pflanzenphysiol. 112, 155–162.

Featonby-Smith B.C., Van Staden J., 1984. The effect of seaweed concentrate and fertilizer on growth and the endogenous cytokinin content of *Phaseolus vulgaris*. S. Afr. J. Bot. 53, 375–379.

Featonby-Smith B.C., Van Staden J., 1987. Effects of seaweed concentrate on grain yield in barley. S. Afr. J. Bot. 53, 125–128.

Ferrini F., Nicese F.P., 2002. Response of English oak (*Quercus robur* L.) trees to biostimulants application in the urban environment. J. Arboricult. 28, 70–75.

Finnie J.F., Van Staden J., 1985. The effects of seaweed con – centrate and applied hormones on in vitro cultured tomato roots. J. Plant Physiol. 120, 215–310.

Frannkenberger W.T., Arshad M., 1995. Phytohormones in soils. Marcel Dekker, New York (USA).

Jankiewicz L.S., Lipecki J., 2011. Fizjologia roślin sadowniczych. PWN, 1, 460.

Jeannin I., Lescure J.C., Morot-Gaudry J.F., 1991. The effect of aqueous seaweed sprays on the growth of maize. Bot. Mar. 34, 169–473.

Jolivet E., de Langlais-Jeannin I., Morot-Gaudry J.F., 1991. Les extraits d'algues marines: propriétés phytoactives et intérêt agronomique. Anne'e Biologique, Paris, France, 109–126.

Karnok K.J., 2000. Promises, promises: can biostimulants deliver? Golf Course Management 68, 67–71.

Kelting M., Harris J.R., Fanelli J., Appleton B., 1998. Biostimulants and soil amendments affect two-year post transplant growth of red maple and Washington hawthorn. Hort. Sci. 33, 819–822.

Khan W., Rayirath U.P., Subramanian S., Jithesh M.N., Rayorath P., Hodges D.M., Critchley A.T., Craigie J.S., Norrie J., Prithiviraj B., 2009. Seaweed extracts as biostimulants of plant growth and development. Plant Growth Reg. 28, 386–399.

Mancuso S., Azzarello E., Mugnai S., Briand X., 2006. Marine bioactive substances (IPA extract) improve foliar ion uptake and water stress tolerance in potted *Vitis vinifera* plants. ADV. Hort. Sci. 20(2), 156–161.

Metting B., Rayburn W.R., Reynaud P.A., 1988. Algae and agriculture. In: Algae and human affairs, Lembi C.A., Waaland J.R. (eds). Cambridge Univ. Press, Cambridge, UK, 335–370.

Mooney P.A., Van Staden J., 1986. Algae and cytokinins. J. Plant Physiol 123, 1–21.

Munda M., Gubensek F., 1975. The amino acid composition of some common marine algae from iceland. Bot. Mar. 19, 85–92.

Nooden L.D., Leopold A.C., 1978. Phytohormones and the endogenous regulation of senescence and abscission. In: Phytohormones and related compounds: a comprehensive treatise letham, D.S. Goodwin P.B., Higgins T.J. (eds). Elsevier/Holland, Amsterdam, 329–369.

Norrie J., Keathley J.P., 2006. Benefits of *Ascophyllum nodosum* marine-plant extract applications to 'Thompson seedless' grape production. Proceedings of the Xth International Symposium on Plant Bioregulators in Fruit Production, 2005. Acta Hortic. 727, 243–247.

Ordog V., Stirk W.A., Van Staden J., Novak O., Strnad M., 2004. Endogenous cytokinins in the three genera of microalgae from the Chlorophyta. J. Phycol 40, 88–95.

Reitz S.R., Trumble J.T., 1996. Effects of cytokinin-containing seaweed extract on *Phaseolus lunatus* L.: influence of nutrient availability and apex removal. Bot. Mar. 39, 33–38.

Salat A., 2004. Les biostimulants. PHM. Rev. Hortic. 454, 22–24.

Schmidt R.E., Ervin E.H., Zhang X., 2003. Questions and answers about biostimulants. Golf Course Management 71, 91–94.

Stephenson W.A., 1968. Seaweed in agriculture and horticulture. Faber and Faber, London, UK.

Stirk W.A., Novak M.S., Van Staden J., 2003. Cytokinins in macroalgae. Plant Growth Reg. 41, 13–24.

Temple W.D., Bomke A.A., 1988. Effects of kelp (*Macrocystis integrifolia*) on soil chemical properties and crop responses. Plant Soil 105, 213–222.

Van Staden J., Upfold J., Dewes F.E., 1994. Effect of seaweed concentrate on growth and development of the marigold *Tagetes patula*. J. Appl. Phycol. 6, 427–428.

Verkleij F.N., 1992. Seaweed extracts in agriculture and horticulture: a review. Biol. Agric Hort. 8, 309–324.

Yvin J.C., Dufils A., 2010. Incidences of Fertileader Elite® foliar spray applications on the improvement of Fruits quality and their conservation. Trials realized on Pink Lady® Cripps Pink Cov. J. Hort. Forest. Biotech. 14(3), 1–4.

Zhang X., Schmidt R.E., 1997. The impact of growth regulators on the a-tocopherol status in water-stressed *Poa pratensis* L. Int. Turfgrass Soc. Res. J. 8, 1364–1373.

WPŁYW TECHNOLOGII N PRO I KOMPLEKSU SEACTIV NA WZROST, WIELKOŚĆ I JAKOŚĆ PLONU JABŁONI ODMIANY 'SZAMPION'

Streszczenie. W ostatnich latach w produkcji ogrodniczej coraz częściej stosuje się nawozy mineralne wzbogacone w substancje pochodzące z wyciągów z alg morskich, którym przypisuje się liczne właściwości, m.in. o charakterze biostymulującym (korzystny wpływ na wzrost i jakość plonu oraz zwiększanie odporności na niekorzystne czynniki środowiska). Dzięki opracowanym technologiom przetwarzania alg morskich udało się wyekstrahować ważne dla upraw roślinnych związki, które stymulują wiele procesów fizjologicznych w roślinach. Związki te mogą być dodawane zarówno do nawozów doglebowych, jak i dolistnych. Celem przeprowadzonego doświadczenia była ocena wpływu technologii N Pro i kompleksu Seactiv bazujących na wyciągach z alg morskich na wzrost, wielkość i jakość plonu jabłoni odmiany 'Szampion'. Materiałem doświadczalnym były drzewa odmiany 'Szampion' okulizowane na podkładce M.26 w wieku 10 lat w momencie rozpoczęcia doświadczenia. W doświadczeniu oceniano wzrost, wielkość i jakość plonu drzew jabłoni odmiany 'Szampion' nawożonych dwoma programami. Na podstawie przeprowadzonych pomiarów wykazano, że zastosowanie programu nawozowego opartego na wyciągach z alg morskich nie miało istotnego wpływu na plon ogólny, masę jednego owocu, jędrność oraz zawartość ekstraktu cukrowego owoców jabłoni odmiany 'Szampion'. Wykazano, że technologia N Pro i kompleks Seactiv miały istotnie korzystny wpływ na procentową liczbę owoców dużych, tj. o średnicy powyżej 7,5 cm, oraz plon handlowy w poszczególnych latach badań. Współczynnik intensywności owocowania drzew jabłoni odmiany 'Szampion' nawożonych technologią N Pro i kompleksem Seactiv był istotnie większy niż w kontroli tylko w 2008 r., w pozostałych latach różnice te były nieistotne. Program nawozowy oparty na ekstraktach z wodorostów wpływał korzystnie na długość jednorocznych przyrostów jabłoni odmiany 'Szampion', corocznie drzewa nawożone technologią N Pro i kompleksem Seactiv tworzyły dłuższe przyrosty niż kontrolne, w ostatnim roku badań różnice te były istotne. Technologia N Pro i kompleks Seactiv wpłynęły korzystnie na pole powierzchni liści drzew jabłoni odmiany 'Szampion', w drugim i trzecim roku badań wpływ ten był istotny.

Słowa kluczowe: algi morskie, nawożenie, WIO – współczynnik intensywności owocowania, plon, ekstrakt, jednoroczne przyrosty, pole powierzchni liści

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