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Research Article

EVALUATION OF THE IMPACT OF THE ECKLONIA MAXIMA EXTRACT ON SELECTED MORPHOLOGICAL FEATURES OF YELLOW PINE, SPRUCE AND THUJA STABBING

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ABSTRACT

The study was focused on the impact of an extract of Ecklonia maxima on selected morphological features of yellow pine (*Pinus ponderosa* Dougl. ex C. Lawson), prickly spruce (*Picea pungens* Engelm.) Variety Glauca, thuja (*Thuja occidentalis*) variety Smaragd. The experiment was established in April 12, 2012 on the forest nursery in Ceranów. April 15, 2013 was introduced research agent in the form of a spraying an aqueous solution extract of *Ecklonia maxima* with trade name Kelpak SL. Biologically active compounds in the extract are plant hormones: auxin and cytokinin. There were studied increment in plant height, needle length of yellow pine, twigs length in prickly spruce and thuja. The measurements of increment in length of twigs and needles were made in each case on the same, specially marked parts of plants and have carried them on the 27th of each month beginning in May and ending in September. The results were evaluated statistically using the analysis of variance. Medium differentiations were verified by Tukey's test at a significance level $p \leq 0.05$. The study showed that the diversity of traits features in the experiment was depended on the extract, the tree species and the measurement time. The best results after the extract using showed a pine and spruce. Seaweed preparation contributed to increment increased of trees height for in the pine and spruce and the needles length of pine and twigs of spruce. The species showing no reaction to the extract was thuja.

Keywords: extract, growth, twigs, needles

INTRODUCTION

In regard to the presence of mineral compounds and plant hormones [Moller and Smith 1998; 1999; El-Yazied et al. 2012], seaweed extracts help to increase the resistance of plants to disease and stress conditions, thus improving their appearance [Verkleij 1992; El-Yazied et al. 2012; Sosnowski et al. 2013b,c]. The chemical composition of extracts are complex, they have a very high content of organic carbon, polysaccharides and micronutrients and macroelements such as nitrogen, phosphorus and potassium [Crouch and Staden 1993]. According to Khan et al. [2009] and Craigie [2011] their beneficial effect on plant is also associated with existing of vitamins and amino acids in its composition.

Wajahatullah et al. [2009] reported that *Ecklonia maxima* preparations are treat as a natural fertilizer of new generation. Contrary to mineral fertilizers, bio-components derived from seaweed are biodegradable, non-toxic, harmless to the environment and for the health of humans and animals. Extracts can be therefore may an alternative to a conventional farming systems [Wajahatullah et al. 2009]. Therefore, they are the subject of many scientific studies [Temple and Bomke 1989; Crouch and Staden 1991; Zodape 2001; Pietryga and Matysiak 2003; Matysiak 2005; Matysiak and Adamczewski 2005; Bai et al. 2007;

Zodapea et al. 2009; Matysiak et al. 2012; El-Yazied et al. 2012; Sosnowski et al. 2013 a; b]. In this study they confirmed the beneficial effects on the crop. The authors reported that the extracts accelerate the germination of seeds, increased the amount of biomass produced, stimulating the greenness leaf index SPAD and conductive to the accumulation of some micro- and macronutrients in plant dry matter [Sosnowski et al. 2013a,c]. According to Verkleij [1992] and Galbiattia et al. [2007], effect of the use of seaweed extracts was also improve the plants vigor. So, the use of extracts as natural bio-stimulators, was quickly accepted as horticulture practice [Verkleij 1992; Crouch, Staden 1993].

The aim of the study was to determine the effect of the extract from *Ecklonia maxima* on the development of selected morphological features of yellow pine, spruce prickly and thuja. The study concerned the volatility of increase of trees height, length of pine needles and twigs of spruce and thuja under the influence of spraying with seaweed extract in particular time periods measured during the growing season of plants.

MATERIALS AND METHODS

The experiment was established in trees field in Ceranów. In April 2012 into the soil 6 plants of the following species: yellow pine (*Pinus ponderosa* Dougl. Ex C. Lawson), blue spruce (*Picea pungens* Engelm.) Variety Glauca, thuja (*Thuja occidentalis*) variety Smaragd were planted. In the first year the plant were only controlled and inter-rows weeded. In April, 2013 research factor in a form of spraying with an aqueous solution (100 ml in 400 ml of water) of seaweed extract of *Ecklonia maxima* (trade name Kelpak SL) was introduced.

Experimental objects were: control (only water spraying), E – spraying with 20 ml of an aqueous extract on the plant. According manufacturer's extract include: plant hormones, ie. auxin – 11 mg · dm^{-3}, cytokinins – 0.03 mg · dm^{-3}, carbohydrate – 35%, alginic acid – 10%, amino acids – 6%, mannitol – 4%, macronutrients: N – 3.12%, P_2O_5 – 2.61%, K_2O – 4.71%, Ca – 0.25%, S – 3.56%, Mg – 0.58% and microelements: Fe – 150 ppm, Zn – 70 ppm, Mn – 13 ppm, B – 60 ppm, J – 30 ppm.

Tested features include: increase in plant height (cm), the increase in needle length (cm) of yellow pine, twigs increase in the length (cm) of spruce prickly and thuja. The measurements of those features were made each time on the same, specially marked parts of the plant, and it was carried out on 27th day of each month starting in May and ending in September.

The results were evaluated statistically by performing variance analysis. Medium differentiation was verified by Tukey's test at a significance level $p \leq 0.05$.

Meteorological data for the study area were obtained from Hydro-Meteorological Station in Siedlce. However, in order to determine the temporal variability of meteorological elements and their impact on the course of vegetation, the hydrothermal coefficient of Sielianinov was calculated [Bac et al. 1993].

From the data presented in Table 1 indicate that the most favorable distribution and the amount of precipitation, with the optimal air temperatures in the period of plants growing, were in May and in September. For those months the highest coefficient (K > 2) was recorded, which shows the optimal relation of the air temperature to the precipitation. It should also be noted that in August aqueous translates into strong drought (K = 0.25) was in deficit.

RESULTS AND DISCUSSION

The study showed (tab. 2) that the highest annual increase – mean 51.1 cm, after using of the extract spray occurred in pine. This value was more than 26% higher than the average height of this species achieved on the control objects. Positive reaction to the preparation showed spruce, which treated with extract achieved more than 22% higher increases in height. For thuja no effect was observed. This species from 27 May to 27 September on all the objects obtain an average 40 cm increments.

Table 1. The value of the hydrothermic Sielianinov index (K) in each month of the growing season

Year	Month						
	IV	V	VI	VII	VIII	IX	X
2013	1.60	2.20	1.80	1.50	0.25	2.70	1.22

K < 0.5 – serve drought; 0.51 – 0.69 – drought; 0.70 – 0.99 – weak drought; K > 1 – no drought

Table 2. The annual increment of trees, height depending on the species and *Ecklonia maxima* extract

Species	Factor		Mean
	Control	Extract	
Pinus ponderosa Dougl. ex C. Lawson	37.8^{Ab}	51.1^{Aa}	44.5^{A}
Picea pungens Engelm	24.7^{Bb}	31.9^{Ba}	28.2^{B}
Thuja occidentalis	40.4^{Aa}	40.3^{Aa}	40.4^{A}
Mean	34.3^{b}	41.1^{a}	

Means in lines marked with the same small letters do not differ significantly
Means in columns marked with the same capital letters do not differ significantly

The study also showed significant differences in the high increase of studied trees species in different dates of measurement (Table 3). The biggest monthly increases in height (mean 18.3 cm), regardless of the species and the extract was reported in June. Quite a lot of growing trees were also observed in May (mean 7.67 cm) and in July (mean 6.72 cm). The smallest increases occurred in September (mean 1.17 cm). It should be noted, however, that regardless of the species, at each measurement time, trees treated with the extract, obtained the higher increase to control. On average, the difference in the measurement was 22%.

Data presented in Figure 1 showed, that the spraying of trees with *Ecklonia maxima* extract also caused up to 0.95 cm increase in the annual regrowth of the length of pine needles and 2.15 cm increase in the length of spruce twigs. Also, the value of length increments of thuja twigs on the objects with extract was about 0.80 cm higher than the values obtained for control, but it was not confirmed statistically.

On the other hand, analyzing the value of length increment of pine needle in particular months (Table 4), it is noted that the greatest differences in mean values of this feature between control object (Q) and the objects with factors (E) was observed in August. Perhaps on this effect the course of the weather conditions in this month has directly influenced. High daily temperatures in sunny and dry weather favored to plants increments especially after a period with heavy precipitation, as indicated by the values of Sielianinov index in May, June and July (Table 1). The extract has also contributed to an increase in increments of spruce stinging twigs (Table 5). An average, regardless of the date of measurement, increase in the plants sprayed with extract was about 45% higher than on the control object. Noteworthy is the fact that as time goes from spraying, the difference between the value in increments between factor objects and control object has decreased, and since July it has ceased to be statistically significant. Statistical analysis, regardless of the date

Table 3. Increment of trees height in particular measurement time in depending on the species and the extract of *Ecklonia maxima*

Species	Factor	The measurements term (month)					Mean
		0.5	0.6	0.7	0.8	0.9	
Pinus ponderosa Dougl. ex C. Lawson	Control	12.3^{Ab}	20.7^{Ba}	3.12^{Bc}	1.09^{Bc}	0.57^{Bc}	7.56^{B}
	Extract	13.8^{Ab}	23.2^{Aa}	6.10^{Ac}	4.34^{Ac}	3.61^{Ac}	10.2^{A}
	Mean	13.1^{b}	22.0^{a}	4.61^{c}	2.71^{c}	2.09^{c}	8.90^{A}
Picea pungens Engelm	Control	6.24^{Ab}	15.7^{Ba}	1.18^{Bc}	0.93^{Ac}	0.62^{Ac}	4.94^{B}
	Extract	7.38^{Ab}	19.5^{Aa}	2.59^{Ac}	1.47^{Ac}	0.89^{Ac}	6.37^{A}
	Mean	6.81^{b}	17.6^{a}	1.89^{c}	1.20^{c}	0.76^{c}	5.65^{C}
Thuja occidentalis	Control	2.47^{Abc}	16.5^{Aa}	13.5^{Aa}	7.09^{Ab}	0.82^{Ac}	8.08^{A}
	Extract	3.82^{Abc}	14.2^{Ba}	13.8^{Aa}	8.00^{Ab}	0.50^{Ac}	8.06^{A}
	Mean	3.15^{bc}	15.4^{a}	$13,7^{a}$	7.55^{b}	0.66^{c}	8.09^{B}
Control		7.00^{Ab}	17.6^{Ba}	5.93^{Bb}	3.04^{Bbc}	0.67^{Ac}	6.85^{B}
Extract		8.33^{Ab}	19.0^{Aa}	7.50^{Ab}	4.60^{Abc}	1.67^{Ac}	8.89^{A}
Mean		7.67^{b}	18.3^{a}	6.72^{b}	3.82^{bc}	1.17^{c}	

Means in lines marked with the same small letters do not differ significantly
Means in columns marked with the same capital letters do not differ significantly

Table 4. Increment of needle length (cm) of pine in particular measurement time in depended on an extract of *Ecklonia maxima*

Species	Factor	The measurements term (month)					Mean
		0.5	0.6	0.7	0.8	0.9	
Pinus ponderosa Dougl. ex C. Lawson	Control	0.20^{Bab}	0.30^{Aab}	0.10^{Ac}	0.45^{Ba}	0.10^{Bc}	0.23^{B}
	Extract	0.40^{Ab}	0.40^{Ab}	0.10^{Ac}	1.01^{Aa}	0.20^{Ac}	0.42^{A}
	Mean	0.20^{c}	0.30^{b}	0.10^{d}	0.45^{a}	0.10^{d}	

Means in lines marked with the same small letters do not differ significantly
Means in columns marked with the same capital letters do not differ significantly

Table 5. Increment of the twigs length (cm) of spruce in particular measurement time in depended on an extract of *Ecklonia maxima*

Species	Factor	The measurements term (month)					Mean
		0.5	0.6	0.7	0.8	0.9	
Picea pungens Engelm	Control	2.01^{Ba}	0.98^{Bb}	1.02^{Ab}	0.50^{Ac}	0.20^{Ac}	0.94^{B}
	Extract	3.00^{Aa}	2.00^{Ab}	0.93^{Ac}	0.70^{Acd}	0.23^{Ad}	1.37^{A}
	Mean	2.50^{a}	1.49^{b}	0.98^{bc}	0.60^{c}	0.22^{c}	

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Means in columns marked with the same capital letters do not differ significantly

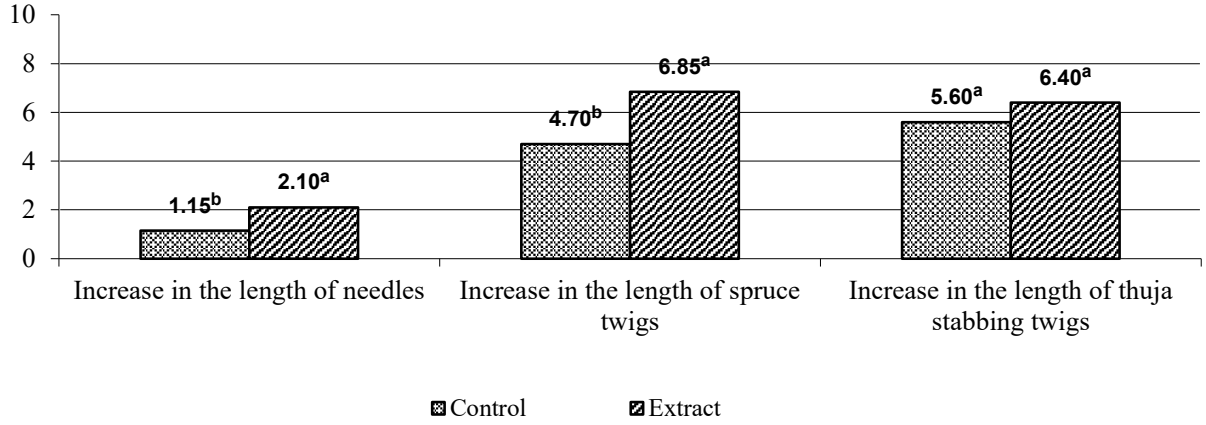

Figure 1. The annual increment in the needles length of pine and o the spruce and thuja twigs in depending on the extract of *Ecklonia maxima*

of measurement, also showed no significant difference in the mean values of thuja twigs growth under the influence of the extract (Tab. 6). Moreover, as the data indicated, in May it a significant decrease in the average value of the characteristics under the influence of experimental factor was reported.

Numerous studies [Verkleij 1992; Zodape 2001; Fornes et al. 2002; Russell, 2002; Pietryga and Matysiak 2003; Matysiak, 2005; Matysiak and Adamczewski 2005; Thirumaran et al. 2009] show that *Ecklonia maxima* extract can not damage the crops but stimulates some organs to increase of its dimensions. This was confirmed in studies on the reaction of pine, spruce and thuja. In turn, Bai et al. [2007] as a result of foliar application of algae extracts on plant compared to the control crop obtained the stems longer by 35% and the roots by about 22%. Similar results were presented by Thevanathan et al. [2005]. Significant impact of biostimulator hormone from seaweed of *Ecklonia maxima* on the yield of plants describe Pietryga and Matysiak [2003] and Matysiak [2005]. However, from research of Matysiak and Adamczewski [2006] resulted that the plant which most responsive to applied biopreparations was corn. The application of the extract resulted in an increase in the plants yield by over 21% compared to the control object. The listed studies show differences in response to extract of individual grains. The authors showed that spring cereals react more strongly than win-

Table 6. Increment of the twigs length (cm) of thuja in particular measurement time in depend on an extract of *Ecklonia maxima*

Species	Factor	The measurements term (month)					Mean
		0.5	0.6	0.7	0.8	0.9	
Thuja occidentalis	Control	2.50^{Aa}	1.60^{Ab}	0.10^{Ac}	1.30^{Ab}	0.10^{Bc}	1.12^{A}
	Extract	1.70^{Bab}	2.00^{Aa}	0.10^{Ac}	1.70^{Aab}	0.90^{Ab}	1.28^{A}
	Mean	2.10^{a}	1.80^{a}	0.10^{b}	1.50^{a}	0.50^{b}	

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Means in columns marked with the same capital letters do not differ significantly

ter crops. It should be noted, however, that there are also experiments in which there was no significant effect of this type of extracts on plants [De Villiers et al. 1983; Temple and Bomke 1989; Nour et al. 2010; Zodape at al. 2010; Sridhar and Rengas 2011]. Research in most cases, confirming the beneficial effects of the extract on the crop but indicate a greater importance of the application date than the dose [Matysiak et al. 2012]. Further, it was demonstrated [Matysiak and Adamczewski 2005], that species and even varieties of the same species can react differently to the seaweed preparations. This may be explained with the lack of effect of the extract from *Ecklonia maxima* to increase the height and length of thuja twigs. Some studies [Matysiak and Adamczewski, 2005] showed that greater effects were obtained by plant sprayed with an extract from Monocotyledones. In contrast, species such as white mustard and pea are less responsive to the effects of this preparation.

CONCLUSIONS

1. The study showed that the reaction of the analyzed trees on sprayed with seaweed extract from *Ecklonia maxima* depended on the species and the measurement date.
2. The best results after the extract applying were showed by pine and spruce. The total increases in the course of growing on the factor objects in both of these species were on average 24% higher, compared to the control.
3. The largest increases of plant height, regardless of the extract, was reported in June. Their values, depending on the tree species, ranged from 22 cm in yellow pine to 15.4 cm in thuja.
4. Seaweed preparation contributed to regrowth increase in the length of pine needles and spruce twigs.
5. Thuja showed no significant effects on the extract used in the experiment.

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