EFFECT ASSESSMENT OF KELPAK SL ON THE BEAN YIELD (*PHASEOLUS VULGARIS* L.)

OCENA WPŁYWU KELPAKU SL NA PLONOWANIE FASOLI ZWYKŁEJ (*PHASEOLUS VULGARIS* L.)

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ABSTRACT

Biostimulators applied in the cultivation of plants stimulate the processes of life and increase their hardiness to stress conditions, contributing to greater and better quality of yield. One of them is Kelpak SL obtained from brown seaweed species *Ecklonia maxima*. The aim of experiment carried out was to assess a potential effect of Kelpak SL on bean (*Phaseolus vulgaris* L.) cultivar Aura yield. The trial was carried out during 2010-2011 years on the experimental field of Institute of Agricultural Sciences The State School of Higher Education in Chełm. Treatments with Kelpak were carried out in 2 different concentrations (0.2 % and 0.4%) and in two application frequencies (one application in the 2 – 3 leaves stage or two applications – first in the 2 – 3 leaves stage and second at the beginning of the bean's blooming).
Received results were compared with the control where Kelpak was not applied. The number and the weight of seeds, the number of pods and the weight of thousand seeds per 1 m^2 were recorded. The beneficial effect of seaweed extract of *Ecklonia maxima* on the yield of beans (*Phaseolus vulgaris* L.) was demonstrated. The highest number and weight of seeds and number of pods were obtainment in the combination of once application with 0.2 % solution of Kelpak SL in 2010 and once application with 0.4 % solution of Kelpak SL in 2011. Application of Kelpak SL significantly increased number and weight of seeds and number of pods compared with the control where Kelpak SL was not applied.

KEYWORDS: bean, Kelpak SL, seaweed extract, yield

STRESZCZENIE

Biostymulatory stosowane w uprawie roślin stymulują procesy życiowe i zwiększają ich odporność na warunki stresowe, przyczyniając się do uzyskania większego i lepszego jakościowo plonu. Jednym z nich jest Kelpak SL otrzymywany z brunatnych alg morskich gatunku *Ecklonia maxima.* Celem przeprowadzonego doświadczenia była

ocena wpływu preparatu Kelpak SL na plonowanie fasoli zwykłej (*Phaseolus vulgaris* L.) odmiany Aura. Doświadczenie zostało przeprowadzone w latach 2010-2011 na polu doświadczalnym Instytutu Nauk Rolniczych Państwowej Wyższej Szkoły Zawodowej w Chełmie. Rośliny opryskiwano Kelpakiem SL w stężeniu 0,2 i 0,4 %. Zastosowano dwie formy opryskiwania roślin, jednokrotny oprysk w fazie 2 - 3 liści oraz dwukrotny w fazie 2-3 liści i na początku kwitnienia fasoli. Uzyskane wyniki porównywano z kombinacją, w której nie stosowano biostymulatora. W doświadczeniu oceniono liczbę i masę nasion, liczbę strąków na 1 m^2 oraz masę tysiąca nasion. Stwierdzono, że ekstrakt z brunatnic *Ecklonia maxima* korzystnie wpływa na plonowanie fasoli zwykłej. Największą liczbę i masę nasion oraz liczbę strąków stwierdzono w kombinacji z jednokrotnym opryskiwaniem roślin 0,2 % roztworem Kelpaku SL w 2010 roku i z jednokrotnym opryskiwaniem 0,4 % roztworem Kelpaku SL w 2011 roku. Zastosowanie Kelpaku SL istotnie zwiększyło liczbę i masę nasion oraz liczbę strąków fasoli w porównaniu z kombinacją w której nie stosowano biostymulatora.

SŁOWA KLUCZOWE: fasola, Kelpak SL, ekstrakt z alg morskich, plon

STRESZCZENIE SZCZEGÓŁOWE

Biostymulatory stosowane w uprawie roślin stymulują procesy życiowe i zwiększają ich odporność na warunki stresowe, przyczyniając się do uzyskania większego i lepszego jakościowo plonu. Jednym z nich jest Kelpak SL otrzymywany z brunatnych alg morskich gatunku *Ecklonia maxima,* który zawiera proporcjonalnie większą ilość auksyn w stosunku do cytokinin (11,0 mg/l auksyn i 0,031 mg/l cytokinin). Stymuluje wydłużanie się komórek oraz przyczynia się do lepszego wzrostu roślin i ich systemu korzeniowego. Ponadto korzystnie wpływa na poprawę jakości i wielkości uzyskanego plonu oraz poprawę zdrowotności roślin. Celem przeprowadzonego doświadczenia była ocena wpływu preparatu Kelpak SL na plonowanie fasoli zwykłej (*Phaseolus vulgaris* L.) odmiany Aura. Doświadczenie zostało przeprowadzone w latach 2010-2011 na polu doświadczalnym Instytutu Nauk Rolniczych Państwowej Wyższej Szkoły Zawodowej w Chełmie. Doświadczenie założono w układzie bloków losowych w 4 powtórzeniach, na poletkach o powierzchni 4,5 m^2 (1,35 x 3,33 m). W okresie wegetacji zastosowano Kelpak SL w stężeniach 0,2 i 0,4% w formie jednokrotnego opryskiwania roślin w fazie 2 - 3 liści właściwych oraz w formie dwukrotnego opryskiwania roślin: w fazie 2 - 3 liści właściwych i na początku kwitnienia fasoli. Uzyskane wyniki porównywano z kombinacją, w której nie stosowano biostymulatora. W doświadczeniu oceniono liczbę i masę nasion, liczbę strąków w roślinie oraz masę tysiąca nasion. Wyniki badań opracowano statystycznie metodą analizy wariancji ANOVA przy użyciu programu Statistica. Do weryfikacji istotności różnic pomiędzy ocenianymi średnimi zastosowano przedziały ufności Tukeya przy poziomie istotności $P \leq 0,05$. Wartości oznaczone tą samą literą nie różnią się istotnie. Stwierdzono, że ekstrakt z brunatnic *Ecklonia maxima* korzystnie wpływa na plonowanie fasoli zwykłej. Największą liczbę i masę nasion oraz liczbę strąków stwierdzono w kombinacji, w której rośliny jednokrotnie opryskiwano 0,2 % roztworem Kelpaku SL w 2010 roku oraz jednokrotnie opryskiwano 0,4 % roztworem Kelpaku SL w 2011 roku. Zastosowanie Kelpaku istotnie zwiększyło liczbę i masę nasion oraz liczbę strąków fasoli w porównaniu z kombinacją w której nie stosowano biostymulatora.

INTRODUCTION

Biostimulators applied in the cultivation of plants stimulate the processes of life and increase planthardiness to stress conditions and contribute to higher yield and better quality. Biostimulators that include extracts from seaweeds are made from *Ecklonia maxima, Ascophyllum nodosum, Laminaria spp., Ulva spp.*, *Caulerpa scalpelliformis, Sargassum spp., Turbinaria conoides, Padina tetrastromatica, Dictyota dichotama*, *Gracilaria corticata, Kappaphycus alvarezii.* They contain mainly auxins and cytokinins, with some gibberellins, amino acids, alginates (Basak, 2008; Challen and Hemingway, 1965; Kavipriya et al., 2011; Piese and Sabale, 2010; Rathore et al., 2009; Shehata et al., 2011). One of them is Kelpak SL obtained from brown seaweed species *Ecklonia maxima*, which contains a proportionately greater amount of auxin relative to cytokinin (11.0 mg/l auxin and 0.031 mg/l cytokinin). This stimulates cells elongation and contributes to improved growth of plants and their root system (Basak, 2008; Basak and Mikos-Bielak, 2008; Beckett and van Staden, 1989; Matysiak and Kaczmarek, 2008; Russel, 2002; Stirk and van Staden, 1997; Szabo and Hrotko, 2009; Van Staden et al., 1994). Increase of the production of hormones in the plant, which is beneficial to improve the quality and amount of yield and improve plant health (Arthur, et al.,2003; Beckett et al., 1994; Horoszkiewicz-Janka and Jajor, 2006; Matysiak and Adamczewski, 2006; Matysiak and Kaczmarek, 2008; Oyoo et al., 2010; Russel, 2002; Sas-Paszt et al. 2008; Verkleij, 1992; Zodape, 2001). Kelpak stimulates growth of the root system and improves nutrient uptake from the soil solution. Plants treated with this biostimulator have better resistance to stress conditions such as nutrient deficiency in soil, salinity and drought (Beckett and van Staden, 1989).
The aim of this experiment was to assess a potential effect of Kelpak on bean (*Phaseolus vulgaris* L.) cultivar Aura yield.

MATERIALS AND METHODS

The trial was carried out during 2010-2011 years in the Depułtycze Królewskie on the experimental field of Institute of Agricultural Sciences of The State School of Higher Education in Chełm, Poland. It was established in a randomized block design, in 4 replications, on plots of 4,5 m^2 (1,35 x 3,33 m). Alltogether four different variants of spraying with Kelpak SL were compared with the control where Kelpak SL was not applied. Treatments with Kelpak SL were carried out in 2 different concentrations (0.2 % and 0.4%) and in two application frequencies (one application in the 2 – 3 leaves stage or two applications – first in the 2 – 3 leaves stage and second at the beginning of the bean's blooming). The bean's seeds were sown on the 8th of May 2010 and on the 11th of May 2011 on depth 3 - 4 cm, at spacing of drills 45 cm, to achieve the density of 30 plants per 1 m^2. The number and the weight of seeds, the number of pods per 1 m^2 and the weight of thousand seeds per plot were recorded.
The results were statistically analyzed by analysis of variance ANOVA by Statistica. To verify the significance of differences between the treatments means the confidence intervals of Tukey's test were used at the significance level $P \leq 0.05$. Results marked with the same letter do not differ significantly from each other.

RESULTS AND DISCUSSION

Results showed that the yield of bean was dependent on the concentration and application methods of Kelpak SL. The highest number of seeds was obtained in

combination of once application with 0.2 % solution of Kelpak SL in 2010 year (818 No.·m^{-2}) (table 1). In 2011 the highest number of seeds was recorded in combination of once application with 0.4% solution of Kelpak SL (656 No.·m^{-2}). Significant reduction in yield of bean in 2010 and 2011 was observed in the combination where biostimulator was not applied (443 and 466 No.·m^{-2} respectively).
Spraying plants with *Ecklonia maxima* extract increased the bean yield by 24 % (Temple and Bomke, 1989). Beckett and van Staden (1989) found that application of Kelpak resulted in a positive effect of increase of the number of grains of wheat grown under conditions of potassium deficiency. Application of seaweed liquid of *Sargassum wightii* extract increased the number of grains of *Triticum aestivum* (Kumar and Sahoo, 2011). Arthur, et al.(2003) demonstrated that application of Kelpak increased the number and size of the marketable fruits of *Capsicum annuum*.

Table 1. Dependence of number of been seeds on concentration and application method of Kelpak SL, No.·m^{-2}
Tabela 1. Liczba nasion fasoli w zależności od stężenia i formy aplikacji Kelpaku SL, szt.·m^{-2}

Aplication method Sposób aplikacji	Concentration of Kelpak SL Stężenie Kelpaku SL					
	0.2 %		0.4%		Control Kontrola	
Year Rok	2010	2011	2010	2011	2010	2011
Once spraying Jednokrotne opryskiwanie	818 a	608 ab	638 b	656 a	443 c	466 c
Twice spraying Dwukrotne opryskiwanie	595 bc	635 ab	525 bc	576 b	443 c	466 c
NIR LSD	143.8	70.0	143.8	70.0	143.8	70.0

Results marked with the same letter do not differ significantly from each other ($P \leq 0.05$)
Wartości oznaczone tymi samymi literami nie różnią się istotnie przy $P \leq 0,05$

Analysis of seeds weight in own research demonstrated the dependence between concentration and way of application of biostimulator and the weight. Once spraying with 0.2 % solution of Kelpak SL in 2010 resulted in the highest seeds weight (454.2 g·m^{-2}) (table 2). The combination of once spraying of biostimulator with 0.4 % solution of Kelpak SL in 2011 positively influenced on the plants by increase of the weight of seeds (358.4 g·m^{-2}). In control where Kelpak SL was not applied the lowest seeds weight, both in 2010 and 2011 was observed (237.6 and 235.9 g·m^{-2} respectively).
A study of *Phaseolus acutifolius* L. demonstrated that Kelpak stimulate the increase of seed weight (Beckett, et al., 1994). Application of Kelpak SL on wheat cultivated in conditions of potassium deficiency resulted in increased of grains weight (Beckett and van Staden, 1989). Kelpak used together with DAP (Di-Ammonium Phosphate) increase the fresh tuber weight of Irish potatoes (*Solanum tuberosum*) (Oyoo, et al., 2010). Foliar application of seaweed extract of *Kappaphycus alvarezii* resulted in increase of grain yield of *Glycine max* (Rathore, et al., 2009). A number of studies

increase of plants weight. Kelpak stimulated the growth of plants and cytokinin content of *Phaseolus vulgaris* L. (Featonby-Smith and van Staden, 1984). Application of seaweed extract (*Ecklonia maxima* and *Saragassum* spp.) in the form of seeds soaking and twice spraying the maize plants resulted in increase of the shoot and root weight. Additionally, soaking seeds in the extract of *Ecklonia maxima* positively influenced the weight of maize shoots (Matysiak, et al., 2011). Van Staden, et al. (1994) demontrated that application of Kelpak improved vegetative and reproductive growth of *Tagetes patula*. Szabo and Hrotko (2009) noted that application of Kelpak result in increase of the number and the weight of shoots, and the weight of cuttings of *Crataegus* and *Prunus*. Kelpak SL and Goëmar BM 86® stimulated the growth of shoots and leaves of apple, resulted in improvement in flower quality, and prolonged the blooming time (Basak, 2008; Basak and Mikos-Bielak, 2008). Seaweed extracts of *Ulva fasciata, Sargassum ilicifolium* and *Gracilaria corticata* positively influenced on shoot growth and fresh biomass of *Trigonella foenum-graecum* L. (Piese and Sabale, 2010). Spraying the celeriac plants with seaweed extract Alga 600 (*Ascophyllum nodosum, Laminaria* spp. and *Sargassum spp*.) increased plant height, fresh and dry weight of leaves, green yield (leaves) and root field (Shehata, et al., 2011). Seaweed extract derived from *Ulva lactuca*, *Caulerpa scalpelliformis, Sargassum plagiophyllum, Turbinaria conoides, Padina tetrastromatica, Dictyota dichotama* positively influenced on germination, growth and yield of *Vigna radiata* (Kavipriya, et al., 2011). Thirumaran, et al. (2009) demonstrated that application of Seaweed Liquid Fertilizer of *Rosenvigea intricata* increased growth, yield and chlorophyll pigment of *Abelmoschus esculentus*. Extract of the *Ecklonia maxima* has a positive effect on the yield of spring cereals, maize, potato and blue lupine (Matysiak and Adamczewski, 2006; Matysiak and Kaczmarek, 2008). Crouch, et al. (1990) found that Kelpak increased the yield and amounts of Ca, K and Mg in the leaves of lettuce. Biostimulators containing seaweed extract (Kelpak SL and Goëmar BM 86®) improved yield in the strawberry cultivar 'Elkat', however they reduced fruit quality (Masny, et al., 2004; Sas-Paszt, et al., 2008). Wrona and Misiura (2008) noted that Goëmar BM 86 improved fruit set, increased fruit diameter and yield of apple.

The highest number of pods in the study was recorded in combination with once spraying of plants with 0.2 % solution of Kelpak SL in 2010 (252 No.·m^{-2}) (table 3). In 2011 the highest number of pods was noted in the combination of once application with 0.4 % solution of Kelpak SL (210 No.·m^{-2}). The lowest number of pods formed per plants was observed in control in 2010 and 2011 (136 and 150 No.·m^{-2} respectively). Temple and Bomke (1989) demonstrated that application of Kelpak in bean cultivation increased the number of pods per plant. Russo and Berlyne (1992) have noted increase the dry weight of bean pods after application of seaweed extract Roots2.

The tendency to increase the weight of thousand seeds in the study was observed in combination with once application with 0.4 % solution of Kelpak SL in 2010 and 2011 (575.9 and 545.3 g·m^{-2} respectively) (table 4). The lowest quantity of the investigated trait was noted in combination with twice sprayed with 0.4 % solution of Kelpak SL in 2011 (502.7 g·m^{-2}) and in control in 2010 (538.1 g·m^{-2}).

Spraying of the winter rape plants with Kelpak solution resulted in increase of the weight of thousand seeds (Matysiak and Kaczmarek, 2008). However, in research Matysiak and Adamczewski (2006) and Matysiak and Kaczmarek (2008) demonstrate the decrease of the weight of thousand seeds of pea and white mustard, as compared to the combination where Kelpak was not applied, as well as the decrease of the weight of thousand seeds of maize and spring wheat, as compared to the combination where the higher dose of biostimulator was applicated (2 l/ha) in the cultivation.

Table 2. Dependence of weight of been seeds on concentration and application method of Kelpak SL, g·m^{-2}

Tabela 2. Masa nasion fasoli w zależności od stężenia i sposobu aplikacji Kelpaku SL, g·m^{-2}

Aplication method Sposób aplikacji	Concentration of Kelpak SL Stężenie Kelpaku SL					
	0.2 %		0.4%		Control Kontrola	
Year Rok	2010	2011	2010	2011	2010	2011
Once spraying Jednokrotne opryskiwanie	454.2 a	308.9 ab	370.7 ab	358.4 a	237.6 c	235.9 c
Twice spraying Dwukrotne opryskiwanie	336.6 b	327.4 ab	288.2 bc	289.7 bc	237.6 c	235.9 c
NIR LSD	85.9	58.9	85.9	58.9	85.9	58.9

Results marked with the same letter do not differ significantly from each other (P≤0.05)

Wartości oznaczone tymi samymi literami nie różnią się istotnie przy P≤0,05

Table 3. Dependence of number of pods on concentration and application method of Kelpak SL, No.·m^{-2}

Tabela 3. Liczba strąków fasoli w zależności od stężenia i sposobu aplikacji Kelpaku SL, szt.·m^{-2}

Aplication method Sposób aplikacji	Concentration of Kelpak SL Stężenie Kelpaku SL					
	0.2 %		0.4%		Control Kontrola	
Year Rok	2010	2011	2010	2011	2010	2011
Once spraying Jednokrotne opryskiwanie	252 a	189 ab	197 b	210 a	136 c	150 c
Twice spraying Dwukrotne opryskiwanie	183 bc	193 ab	161 bc	174 bc	136 c	150 c
NIR LSD	43.3	23.8	43.3	23.8	43.3	23.8

Results marked with the same letter do not differ significantly from each other (P≤0.05)

Wartości oznaczone tymi samymi literami nie różnią się istotnie przy P≤0,05

Table 4. Dependence of the weight of thousand seeds on concentration and application method of Kelpak SL, g·m^{-2}

Tabela 4. Masa tysiąca nasion fasoli w zależności od stężenia i sposobu aplikacji Kelpaku SL, g·m^{-2}

Aplication method Sposób aplikacji	Concentration of Kelpak SL Stężenie Kelpaku SL					
	0.2 %		0.4%		Control Kontrola	
Year Rok	2010	2011	2010	2011	2010	2011
Once spraying Jednokrotne opryskiwanie	554.0	507.1	575.9	545.3	538.1	505.4
Twice spraying Dwukrotne opryskiwanie	566.2	515.0	551.2	502.7	538.1	505.4
NIR LSD	46.4	50.2	46.4	50.2	46.4	50.2

Results marked with the same letter do not differ significantly from each other ($P \leq 0.05$)
Wartości oznaczone tymi samymi literami nie różnią się istotnie przy $P \leq 0,05$

CONCLUSION

The study demonstrated the beneficial effect of seaweed extract of *Ecklonia maxima* on the yield of beans (*Phaseolus vulgaris* L.). The highest number and weight of seeds and number of pods were obtained in the combination of once application with 0.2 % solution of Kelpak SL in 2010 and once application with 0.4% solution of Kelpak SL in 2011. Application of Kelpak SL, independently of the concentration, significantly increased number and weight of seeds and number of pods of bean compared with the combination where biostimulator was not applied.

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