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In vitro Allelopathic Effects of Plant Extracts on Germination of *Vicia fabia* (partim) Seeds

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ABSTRACT

The experiment evaluated the effect of plant extracts on germination and contamination of *Vicia fabia* seed "Bobas" variety of horse beans. The materials used for the studies were aqueous extracts made of 40 plant species. The studies aimed to indicate those plant species, which extracts limited their contamination, simultaneously having a stimulating impact on seeds germination. The germination capability of seeds stimulated extracts from green parts of *Satureja hortensis*, *Zea mays* stigmata, *Verbascum thapsiforme* flowers. The number of seeds colonised by microorganisms was limited by extracts from *Zea mays* stigmata, *Taraxacum officinale* roots, *Urtica dioica* leaves. The analysis of the germination capability of seeds and their contamination by germs showed that extracts prepared in the form of brew had the most favourable effect. All forms of extracts from green parts of *Artemisia vulgaris,Taraxacum officinale* roots,*Urtica dioica* leaves had the most favourable effect on germination of horse bean seeds and at the same time on limitation of their contamination.

Key words: Allelopathic effects, Plant extracts, *Vicia fabia* seeds.

INTRODUCTION

The interest in horse beans as a high-protein Fabaceae has decreased recently due to low and unstable yield. (Kulig *et al.*, 2009) of the plant and its high exposure to numerous pests - mosty to pathogenic fungi (Frąc *et al.*, 2015), during its vegetation period. Increasing the acreage of the horse bean is an opportunity to acquire an ecological and cheap protein - an important component of fodder, it also offers a possibility to increase in the quality of cereals' position by crop rotation. It contributes to the reduction of costs of mineral fertilisation and it is important for balanced agriculture. In the years 2011-2015, the horse bean cultivation area has increased considerably (from 442,000 ha to 2095,000 ha (*GUS 2015*), which was likely related to the grants from the European Union. The regulation of the European Parliament and of the Council (EU) no 1307/2013 of 17 December 2013 established rules for direct payments for the years 2014-2020, and from the 1st of January 2015 "greening" payment for agricultural practices beneficial for the climate and environment has become one of the new components (Adamska *et al.*, 2016). Chemisation of agriculture and an increasing area of ecological crops result in limitation of excessive application of chemical compounds and impose the interest in biological methods of crops protection and the quality of seeds. (Grzesik *et al.*, 2012; Kocira *et al.*, 2015 a-c; Kocira *et al.*, 2017a-b; Dymkowska-Malesa *et al.*, 2014).

One of the basic agrotechnical treatments which aims at protection of germinating seeds and rising young plants against pathogens is seed treatment (Kryczyński and Weber, 2010). It is correlated with smaller use of chemical agents for fighting pests which are replaced by other treatments-e.g. bio preparations (Sas-Piotrowska and Piotrowski 2012; Kocira *et al.*, 2018). Using plant extracts popular in herbalism or medicine for seeds treatment is permitted. The condition for effectiveness of seed protection is to indicate such plant extracts that will stimulate energy and the germination capacity of seeds and, at the same time, will limit their colonisation by pathogens. The activity of extracts is based on the phenomenon of allelopathy and its significance in agriculture increased along with main objectives of using allelopathy in plant productivity (Ashfaq *et al.*, 2014, Joshi and Joshi 2016, Mukherjee and Barik 2013).

Considering the above, in order to minimise the factors that have affect yielding of horse beans, the study aimed to define those plant species which extracts limit their surface contamination by microorganisms, through the stimulation of seeds' germination. In addition, the study also indicated which methods of gaining extracts were the most effective for viability and healthiness of tested seeds.

MATERIALS AND METHODS

Field experiment: The research material inlcuded untreated seeds of horse bean *Vicia fabia* (partim) of "Bobas" variety.

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The plants, from which water extracts were prepared for the seed treatment, are listed in Table 1.

Plant extracts as macerations, brews and decoctions were prepared according to the presented methodology. Maceration–5g of dried plants was poured over with 100 ml of cold water and left for 24 hours in the temperature of 20°C, and drained afterwards; brew–5 g of dry plants was poured over with 250 ml of boiling water and left under the cover for 30 minutes. After cooling down the brew was also drained. Decoction–8.75 g of each dried plant was weighted out and poured over with one litre of distilled water. The suspension was thoroughly stirred, left for 24 hours and then boiled for 15 minutes. Boiled decoctions were sieved on the sieve with a gauze into glass containers and after cooling down used for the study (Tyszyńska-Kownacka and Starek 1989). In the extracts after filtration, the seeds were shaken out for 10 minutes in a laboratory shaker - type 358. Then they were left for 20 hours in the temperature of 20°C, covered with aluminium foil (Sas-Piotrowska and Piotrowski 2012).

The experiment was carried out with the use of a tissue paper test (ISTA 2010 International Regulations of Seed Evaluation – Chapter 7), having defined the germination and contamination capacity. When discussing the obtained research results, the values of germination and contamination capacity were presented in a reference to the control object where seeds of horse bean were treated only with sterile water. The formula used to calculate % of seeds compared to the control group:

$$X\% = (100 \cdot a/k) - 100 \quad (1)$$

where:
X% - deviation from the control combination;
a – average number of grains in the test sample.
k – average number of grains in the control sample.

With regards to the germination capacity, the values marked with a (+) sign indicate the increase in germination relative to the control. While regarding the healthiness of the seeds the values marked with a (-) sign indicated decreased contamination of the seed by microorganisms in relation to the control. All tests were done in five repetitions and each of them included 100 seeds.

Statistical analysis: The obtained results were statistically developed by the analysis of variance (ANOVA) with single classification (P=95%), separately for each extracted plant, the way of extract preparation and assessment criterion. The least significant difference was also determined (Fisher test - $NIR_{0,05}$). The statistical analysis was done with the use of ANW software (Analysis of Variance for Experiments).

RESULTS AND DISCUSSION

The analysis of variance showed that both germination capacity and the number of seeds settled by microorganisms changed, depending on the species of the plant from which the extract was made of and the way of its preparation. I- and II- degree interactions turned out to be significant.

Treating seeds of horse bean with extracts resulted in decreasing the germination capacity by -7,0% on average, compared to the control group. The germination capacity was stimulated by the extracts from 42,5% plants (range from +1,5% to +15,1% in relations to the control). The extract from green parts of *Satureja hortensis* (average germination capacity +15,1%), from *Verbascum thapsiforme* flowers (average germination capacity +13,7%), from *Zea mays* stigmata (average germination capacity +14,4%) had the most favourable effect in comparison to the control seeds.

Some extracts tested in the experiment inhibited seeds germination comparing to the control group. The germination capacity in relation to the control was limited

Table 1: Plants from which prepared aqueous extracts.

1. Acorus calamus L; Sweet flag (root)
2. Aesculus hippocastanum L; Horse chestnut (bark)
3. Aesculus hippocastanum L.; Horse chectnut (flowers)
4. Allium sativum L.; Garlic (bulbs)
5. Archangelica officinalis Hoffm.; Garden angelica (root)
6. Arctium lappa L.; Greater burdock (root)
7. Artemisia absinthium L., Absinthe wormwood (herb)
8. Artemisia vulgaris L.; Common mugwort (herb)
9. Betula verrucosa Ehrh.; Silver birch (leaves)
10.Calendula officinalis L., Pot mirigold (flower)
11.Camelina sinensis L.; Redbush tea (leaves)
12.Carum carvi L.; Caraway (fruit)
13.Coriandrum sativum L.; Coriander (fruit)
14.Crataegus oxyacantha L.; Midland hawthorn (flowers)
15. Equisetum arvense L. (herb); Field horsetail (herb)
16. Frangula alnus Mill. (bark); Alder buckthorn (bark)
17. Hyssopus officinalis L. (herb); Hyssop (herb)
18. Inula helenium L. (roots); Elecampane (roots)
19. Juglans regia L. (leaves); Common walnut (leaves)
20. Juniperus communis L. (fruit); Common juniper (fruit)
21. Lavandula vera L.; Common lavender (flowers)
22. Levisticum officinale L.; Lovage (roots)
23. Linum usitatissimum L.; Common flax (seeds)
24. Marrubium vulgare L.; Common horehound (herb)
25. Matricaria chamomilla L.; Chamomile (heads)
26. Melissa officinalis L.; Lemon balm (leaves)
27. Mentha piperita L.; Peppermint (leaves)
28. Origanum majorana L.; Majoram (herb)
29. Pinus sylvestris L.; Scots pine. (young shoots)
30. Quercus robur L.; Common oak (bark)
31. Ribes nigrum L.; Blackcurrant (leaves)
32. Rosa canina L.; Dogrose (fruit)
33. Salix alba and S. purpurea L.; White and purple willow (bark)
34. Sambucus nigra L.; Elderberry (flowers)
35. Saponaria officinalis L.; Common soapwort (roots)
36. Satureja hortensis L.; Summer savory (herb)
37.Taraxacum officinale Web.; Common dandelion (roots)
38.Urtica dioica L.; Common nettle (leaves)
39.Verbascum thapsiforme L.; Denseflower mullein (flowers)
40. Zea mays L.; Maize (stigmata)

Table 2: Germination capacity [%] of seeds depending on plant species from which prepared extracts and method of its preparation.

Plant species from which the extract was prepared	Extract form			Average %
	Maceration %	Brew %	Decoction %	
Acorus calamus	93,5	96,8	53,9	81,4
Aesculus hippocastanum (bark)	100	88,8	59,4	82,7
Aesculus hippocastanum (flowers)	97,5	94,6	53,1	81,7
Allium sativum	97,7	90,4	58,9	82,3
Archangelica officinalis	96,8	62,1	67,2	75,4
Arctium lappa	90,3	60,5	70,7	73,8
Artemisia absinthium	70,0	52,8	71,2	64,7
Artemisia vulgaris	84,0	80,2	88,2	84,1
Betula verrucosa	83,5	77,6	84,2	81,8
Calendula officinalis	62,2	40,3	72,0	58,2
Camelina sinensis	78,7	86,1	81,0	81,9
Carum carvi	82,0	60,0	76,0	72,7
Coriandrum sativum	73,0	71,2	67,1	70,4
Crataegus oxyacantha	90,0	66,4	73,9	76,8
Equisetum arvense	57,0	53,9	69,8	60,2
Frangula alnus	71,2	93,8	88,9	84,6
Hyssopus officinalis	77,5	77,9	81,0	78,8
Inula helenium	72,5	82,3	88,0	80,9
Juglans regia	65,3	79,4	80,2	75
Juniperus communis	62,8	78,9	61,7	67,8
Lavandula vera	57,3	69,9	70,6	65,9
Levisticum officinale	36,0	85,4	63,4	61,6
Linum usitatissimum	45,8	93,9	70,9	70,2
Marrubium vulgare	27,2	85,9	69,8	61
Matricaria chamomilla	49,0	75,2	57,1	60,4
Melissa officinalis	40,3	89,0	76,5	68,6
Mentha piperita	21,3	89,0	70,7	60,3
Origanum majorana	48,5	99,0	93,0	80,2
Pinus sylvestris	52,3	86, 4	82,7	67,5
Quercus robur	20,8	49,2	65,1	45
Ribes nigrum	23,8	49,4	56,8	43,3
Rosa canina	19,8	39,2	40,4	33,1
Salix alba i S. purpurea	60,4	73,7	63,2	65,8
Sambucus nigra	43,4	57,2	83,3	61,3
Saponaria officinalis	71,4	90,1	91,2	84,2
Satureja hortensis	88,3	90,8	88,8	89,3
Taraxacum officinale	81,0	82,2	90,1	84,4
Urtica dioica	88,5	87,0	86,7	87,4
Verbascum thapsiforme	80,3	88,6	95,7	88,2
Zea mays	86,5	91,7	88,1	88,8
Control			**77,6**	

NIR: plant species = 5,77%; extract form = 2,76%; interaction = 8,169%.

by 57,50% of extracts (range from -1,0% to -57,3%). The extract from *Rosa canina* fruits (average germination capacity -57,3%), *Ribes nigrum* leaves (average germination capacity -44,2%)and *Quercus robur* bark (average germination capacity – 42%) had the strongest effect. Despite the differences in the strength of extracts influencing the germination capacity of seeds, ranking them with regards to their activity was significantly compliant (r> limiting r).

The way of extracts preparation irrespective the other tested factors (Table 2) differentiated the germination capacity of horse bean seeds. Brew decresed the germination capacity in relation to the control samples on average by -1,5%, decoctions by -4,95%, whereas macerations limited it by -14,7%. Thus, it was concluded that the reaction of tested seeds of horse bean depend on the way of extracts preparation.

Analysing the reaction of seeds to the water extracts (Table 2) depending on their origin and the way of their preparation (I° interaction) it was concluded that among 120 tested combinations in 47,5% cases there was a significant increase in the germination capacity (as compared to the absolute control combination).

Comparison of the reaction of horse bean seeds to the extracts used for its treatment showed that to some extent

the germination capacity was positively affected by all forms of extracts (maceration, brew, decoction) prepared from the green parts of *Satureja hortensis*, *Zea mays*stigmata, *Verbascum thapsiforme* flowers, *Urtica dioica*, leaves, *Taraxacum officinale* roots, green parts of *Artemisia vulgaris* and also *Camelina sinensis* leaves.

In relation to the control, brews prepared from 62,5% of tested plants (range from +1,7% to +27,6%) and especially brews prepared from young shoots of *Pinus sylvestris* (average +27,6%), from *Acorus calamus* roots (average +24,7%), from *Aesculus hippocastanum* flowers (average +21,9%) had the most favourable effect on the germination capacity of horse bean. Macerates prepared from 40,0% of plants (range from +1,4% to +28,9%) stimulated the germination capacity with reference to control seeds. They stimulated the most when they were prepared from *Aesculus hippocastanum* bark (+28,9%),*Allium sativum* bulbs (+25,9%) and *Aesculus hippocastanum* flowers (+21,92%). The germination capacity of horse bean increased with decoctions prepared from 40,0% of plants (range from +3,4% to 23,3%), in relation to the control. Decoctions from *Verbascum thapsiforme* flowers (+23,3%), green parts of *Origanum majorana* (+19,9%) and *Saponaria officinalis* roots (+17,5%) had a positive effect.

Treating seeds of horse bean with plant extracts showed that the number of germinating seeds colonised by microorganisms dropped on average by -12,1% in relation to the control. Limiting colonisation, compared to the control seeds, was observed in the case of 67,5% of extracts. Extracts prepared from *Taraxacum officinale* roots (-70,1%), *Allium sativum*bulbs (-60,2%) and *Urica dioica* leaves (-59,4%) (Fig 1-2) had the most favourable effect.

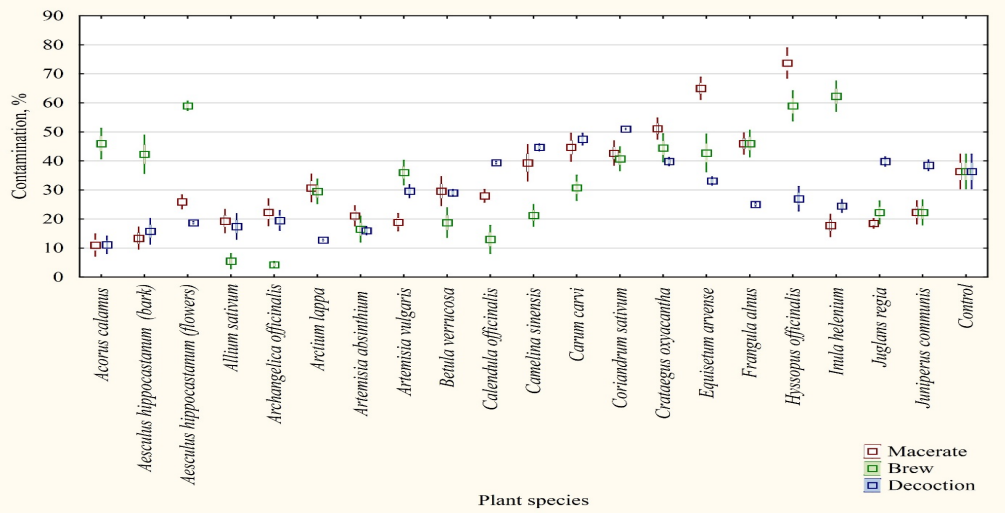

Fig 1: Contamination (%) of seeds depending on plant species from which prepared extracts and method of its preparation.

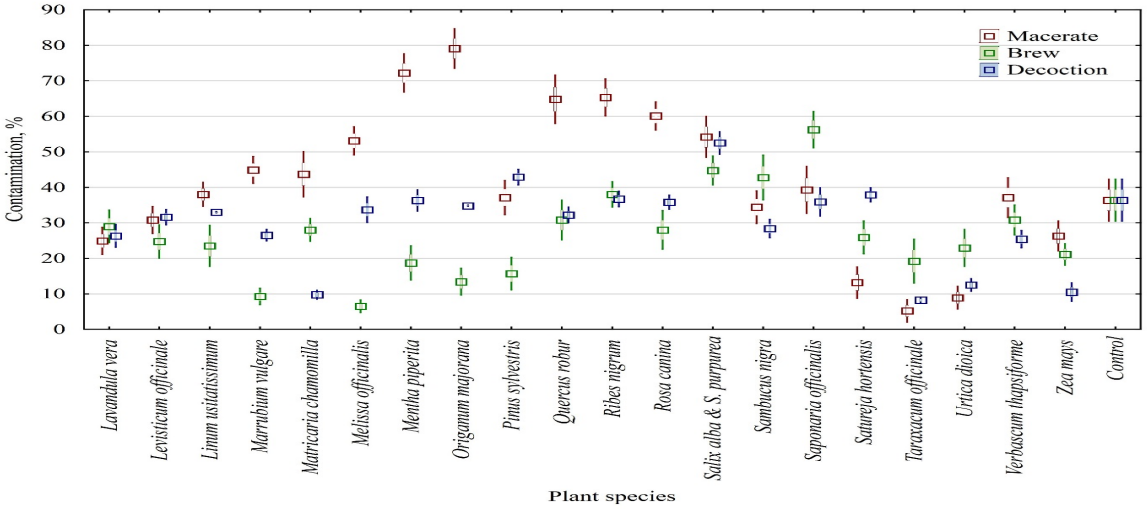

Fig 2: Contamination (%) of seeds depending on plant species from which prepared extracts and method of its preparation.

Statistical analysis of colonisation of horse bean seeds by microorganisms showed significant differences between extracted plant species – NIR = 5,8%, and the form of extract – NIR = 4,7%. Significant differences in interaction (species of plant and formof extract) were also observed – NIR = 8,2%.

Treating seeds with extracts from 32,5% of plants caused the increase in the number of germinating seeds colonised by microorganisms. The best colonisation was observed when extracts were prepared from the green parts of *Hyssopus officinalis* (+46,4%), *Salix alba and S. purpureaa*bark (+38,85) and also the green parts of *Equisetum arvense* (+29,1%).

Treating horse bean seeds with brews from 67,5% of plants, decreased their contamination by microorganisms. The biggest reduction was observed after treating seeds with brews of *Archangelica officinalis*roots (-88,3%), *Allium sativum* bulbs (-84,9%) and *Melissa officinalis* leaves (-82,1%). Macerations made of 50,0% of plants caused the decrease in the number of colonised seeds. The biggest reduction was observed when macerations from *Acorus calamus*roots (-69,8%), green parts of *Satureja hortensis* (-63,8%) and *Aesculus hippocastanum* bark (-63,2%) were used.

Also decrease in colonisation of horse bean seeds as a result of treating them with decoctions from 72,5% of plants was observed. The biggest decrease was observed when decoctions from *Taraxacum officinale* roots (-77,4%), *Zea mays* stigmata (-71,1%) and also *Acorus calamus*roots (-69,5%) were used. Contamination of horse bean seeds with microorganisms was limited as a result of using all forms of extracts (maceration, brew, decoction) from *Zea mays* stigmata, *Taraxacum officinale* roots, *Urtica dioica* leaves, *Allium sativum* bulbs, *Archangelica officinalis* roots and green parts of *Artemisia absinthium.*

It was also proven that 63,3% out of 120 tested combinations significantly limited the number of seeds colonised with microorganisms in comparison to the control absolute combination, and 36,7% caused its increase. All forms of extracts prepared from *Corriandrum sativum* fruits and *Crataegus oxyacantha* flowers and *Sambucus nigra* flowers caused the most significant increase of surface contamination of horse bean seeds. It was also conlcuded that the stronger extracts limited microorganisms contamination of the seeds, the better their germination was.

In the research conducted by Sas-Piotrowska and Piotrowski effect of macerations, brews and decotions were observed, (2003, 2005, 2010) the significant differences between theprobably due to different solubility of active compounds in extracts as well as losses caused during evaporation of solvent during their preparation.

Also, researchers (Sas-Piotrowska *et al.*, 2005, 2010) showed significant differentiation of the effect of extracts made of different plants on the germination capacity and contamination of grains with microorganisms.

Czerwińska and Szparaga's research (2015) showed that viability of seeds and their contamination with microroganisms changed, depending on the origin of the aqueous extract and the way of its preparation. Similarly, in the studies of Sas-Piotrowska *et al.*, (2004) 20 water extracts were used for treatment of grains of wheat, rye and triticale. Their activity significantly differentiated viability of cereals grains. However, when analysing plants of stimulating activity on seeds germination and of inhibiting activity on their colonisation with microbes, preparations from *Frangula alnus*bark and *Crataegus oxyacantha* flowers should be singled out (Sas-Piotrowska *et al.*, 2004). In the case of the herein research it was concluded that mentioned aqueous extracts had a favourable effect on viability of horse bean seeds.

Numerous publications presenting *in vitro* research on activity mechanisms and safety of plant extracts and their particular ingredients do not contribute to their use in agricultural practice. Therefore, the research should be made public as soon as possible due to the fact that obtaining the plant extracts and the methods of preparing them are considerably cheaper than plant protection pesticides available on the market (Mangal *et al.*, 2014).

CONCLUSION

The germination capacity of horse bean seeds and the number of seeds with symptoms of microorganisms' contamination changed depending on the extract origin (plant species which extract was made of) and a method of its preparation. Extracts prepared in the form of brews had the most favourable effect. Comparing the average reaction of horse bean seeds for extracts used for their treatment, it was stated that all forms of extracts from green parts of *Artemisia vulgaris, Taraxacum officinale*roots, *Urtica dioica*leaves, *Verbascum thapsiforme* flowers, and young stigmata of *Zea mays* had the most favourable effect on seeds germination and limiting their contamination at the same time.

REFERENCES

Adamska H., Gniadzik M., Gołąb I., Kozak M. (2016). Opłacalność uprawy wybranych roślin bobowatych, Stowarzyszenie Ekonomistów Rolnictwa i Agrobiznesu, Roczniki Naukowe XVIII (**4**): 9-13.

Ashfaq, M. Ali A., Haider, M. S. Ali M., Ullah A., Mubashar U., Mubashar H., Saleem I. Sajjad M. (2014). Allelopathic Association Between Weeds Extract and Rice (*Oryza sativa* L.) Seedlings. *Journalof Pure & Applied Microbiology*. Nov. **8**(Spl. Edn. 2): 573-580.

Czerwińska, E., and Szparaga, A. (2015). Antibacterial and antifungal activity of plant extracts. *Rocznik Ochrona Środowiska*. **17**: 209-229.

Dymkowska-Malesa M., Szparaga, A., Czerwińska, E., (2014). Evaluation of polychlorinated biphenyls content in chosen vegetables from warmia and mazury region. *Rocznik Ochrona Środowiska*. **16**(1): 290-299.

Frąc, M., Oszust, K., Kocira, A., Kocira S. (2015). Molecular identification of fungi isolated From*Dracocephalum moldavica* L.seeds. *Agric. Agric. Sci. Proc.*,**7**: 74-79, DOI: 10.1016/j.aaspro.2015.12.036.

Grzesik, M., Janas, R., Górnik, K., Romanowska-Duda, Z. (2012). Biologiczne i fizyczne metody stosowane w produkcji i uszlachetnianiu nasion. *Journal of Research and Applications in Agricultural Engineering*. **57**(3): 147-152.

GUS. (2016). *Produkcja upraw rolnych i ogrodniczych lata 2005-2015*. dostêp czerwiec 2016, http://stat.gov.pl/ obszary-tematyczne/ rolnictwo lesnictwo/uprawy-rolne-i-ogrodnicze/produkcja-upraw-rolnych-i-ogrodni-czych-w-2015-roku,9,14.html.ISTA (2010). *International rules for seed testing*. Zurich: International Seed Testing Association

Joshi, N. Joshi, A. (2016). Allelopathic effects of weed extracts on germination of wheat *Annals of Plant Sciences.* **5.5** (2016): 1330-1334 .

Kocira, A., Kocira, S., Świeca, M., Złotek, U., Jakubczyk, A., Kapela, K. (2017a). Effect offoliarapplication of a nitrophenolate–based biostimulant on the yield and quality of two beancultivars. *Sci. Hortic*. **214**: 76–82. DOI: 10.1016/j.scienta.2016.11.021.

Kocira, S., Kocira, A., Kornas, R., Koszel, M., Szmigielski, M., Krajewska, M., Szparaga, A., Krzysiak, Z. (2017b). Effects of seaweed extract on yield and protein content of two common bean (*Phaseolus vulgaris* L.) cultivars. *Legume Res*., DOI: 10.18805/ LR-383.

Kocira, S., Kocira, A., Szmigielski, M., Piecak, A., Sagan, A., and Malaga-Toboła, U. (2015a). Effect of an amino acids – containing biostimulant on common bean crop. *Przem. Chem*. **94**: 1732-1736. doi:10.15199/62.2015.10.16

Kocira, S., Sujak, A., Kocira, A., Wójtowicz, A., Oniszczuk, A. (2015b). Effect of Fylloton application on photosynthetic activity of Moldavian dragonhead (*Dracocephalum moldavica* L.). *Agric. Agric. Sci. Proc.* **7**: 108-112. doi:10.1016/j.aaspro.2015.12.002.

Kocira, A., Kocira, S., Stryjecka, M. (2015c). Effect of Asahi SL application on common bean yield. *Agric. Agric. Sci. Proc.***7**: 103-107. DOI: 10.1016/j.aaspro.2015.12.045.

Kocira, S., Szparaga, A., Kocira, A., Czerwińska, E., Wójtowicz, A., Bronowicka-Mielniczuk, U., Koszel, M., Findura, P. (2018). Modeling biometric traits, yield and nutritional and antioxidant properties of seeds of three soybean cultivars through the application of biostimulant containing seaweed and amino acids. *Front. Plant Sci.* **9**: 388: DOI: 10.3389/fpls.2018.00388.

Kryczyński, S., Weber, Z. (2010). *Podstawy fitopatologii*. Poznañ: Powszechne Wydawnictwo Rolnicze i Leśne.

Kulig, B., Oleksy, A., Sajdak, A., (2009), Plonowanie wybranych odmian bobiku w zależnościod sposobu ochrony roślin i gęstości siewu,*Fragm. Agron.* **26**(3): 93-101.

Mangal, K. M., Kumar, A., Saini, P. (2014). Germination and seedling vigour of vigna sinensis as affected by allelopathy of calotropis gigantea L. *Indian J. Agric. Res.* **48**(1): 29-34, DOI- 10.5958/j.0976-058X.48.1.005

Mukherjee, A., Barik,A. (2013). Potential allelopathic effects of *Ludwigia adscendens*. On the seed germination and seedling growth of rice.*Indian J. Agric. Res*. **47**(1): 1.

Sas-Piotrowska B., Piotrowski, W., Kaczmarek-Cichosz, R. (2004). Plant extracts and their influence on some properties of seeds of cultivated plants-grain plants. *Annual Set the Environment Protection*. **6**: 77-89.

Sas-Piotrowska, B., Piotrowski, W. (2003).Wpływ wyciągów roślinnych na żywotność i zdrowotność korzeni roślin strączkowych zarażonych przez *Fusariumoxysporum* (Schl.). *Rocznik Ochrona Środowiska*. **5**: 191-202.

Sas-Piotrowska, B., Piotrowski, W. (2010). Vitality and healthiness of barley (*Hordeum vulgare* L.) seeds treated with plant extracts. *Journal of Plant Protection Research.* **50**(1): 117-124.

Sas-Piotrowska, B., Piotrowski, W. (2012). Żywotność i zdrowotność nasion *Lupinusangustifolius* L. traktowanych wyciągami roślinnymi. *Rocznik Ochrona Środowiska*. **14**: 525-537.

Sas-Piotrowska, B., Piotrowski, W., Kaczmarek-Cichosz, R. (2005). Longevity and healthiness of oat (*Avena sativa* L.) seeds treated with plant extracts. *Journal of Plant Protection Research*. **45**(3):181-193.

Tyszyńska-Kownacka, D., Starek, T. (1989). Zioła w polskim domu. Warszawa: Wydawnictwo Warta.