

Full Length Research Paper

Allelopathic effect of popular medicinal plants on *Fagopyrum esculentum* (Moench), *Papaver somniferum* (L.) and *Brassica napus var. oleifera* (L.)

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Glasshouse experiments were carried out to assess the effect of popular medicinal herbs dry matter on germination and early growth of common buckwheat (*Fagopyrum esculentum*), opium poppy (*Papaver somniferum*) and two cultivars of oilseed rape (*Brassica napus var. oleifera*). Depending on species of the herb, leaves, inflorescences, fruits and whole plants were used. The greatest stimulatory effect on seedling emergence of common buckwheat was exhibited by *Urtica sp.* while seedling emergence of opium poppy was most affected by *Hypericum sp.* Seedling emergence of common buckwheat was reduced by the use of *Matricaria sp.* inflorescence, while *Euphrasia sp.* herb reduced emergence of opium poppy. *Urtica sp.* leaves caused a significant increase in fresh matter of buckwheat as well as opium poppy. The greatest reduction in fresh matter of buckwheat was noted as a result of using *Euphrasia sp.* herb, while in the case of opium poppy, fresh matter was most reduced by using *Tilia sp.* inflorescence. *Mentha sp.* exhibited a strong stimulatory effect on seedling emergence of oilseed rape cultivar Californium, while *Achillea sp.* had an inhibitory influence. All the examined medicinal plants inhibited seedling emergence of semi-dwarf hybrid oilseed rape cv. Maximus. Inhibitory or a stimulatory effect on germination of winter oilseed rape seeds was not always correlated with a reduction or an increase in plant fresh matter.

Key words: Early growth, fresh mass, germination, herbs.

INTRODUCTION

At present, there is an all-world tendency to decrease the amount of chemicals used in agricultural production by introduction of up-to-date biological and ecological methods. One possible solution is integrated plant protection, using among other things, the phenomenon of allelopathy (Aziz and Fuji, 2006; Hussain et al., 2007). A stimulatory or inhibitory effect of one species on another

is a common phenomenon in the plant world. However, it is still little known. The term allelopathy was created by Austrian physiologist Molisch and initially stood for biochemical interactions between higher plants and microorganisms. Only later researches on allelopathy were focused on isolation of a substance (allelopathin), its chemical identification and influence on other plants.

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Currently, allelopathy is considered as not only a phenomenon but also as a new field of chemical ecology (Jezierska-Domaradzka and Kuźniewski, 2007). Depending on the secreting organism (so-called donor) and a receiving organism (so-called acceptor), allelopathic compounds is divided into four groups: kolines, phytoncides, marasmins and antibiotics (Wójcik-Wojtkowiak et al., 1998). Active substances are commonly called allelopathic compounds or substances, allelopathics or allelopathins (Aldrich, 1997). According to the International Allelopathy Society, allelopathy is “each process associated with secondary metabolites produced by plants, algae, bacteria and fungi which affect growth and development of agricultural and biological systems” (Anonymus, 1996). So far, world literature data have confirmed the allelopathic influence of some plants on cultivated plants. They include such species as: *Comellina alyassum*, exhibiting a stimulatory effect on flax, *Setaria faberi*, inhibiting corn growth, *Rumex crispus*, promoting germination and growth of corn and sorghum, *Pteridium esculentum*, causing intensive elongation growth of alfalfa, and *Conyza canadiensis*, stimulating corn germination (Hussain et al., 2007). As it is stated by Gniazdowska et al. (2004), allelopathic compounds have a diverse effect. However, their most common effect described in literature is influence on the process of seed germination as well as on growth and development of seedlings. Allelopathins have been found in all organs, both vegetative and generative. However, it is stated that compounds derived from vegetative organs are of relatively the greatest importance, and they are the most abundant in leaves (Rice, 1984; Einhellig, 1995). In literature, there are many data on the use of the phenomenon of allelopathy in controlling weed infestation (Bhowmik and Inderjit, 2003; Singh et al., 2003; Vyvyan, 2002). In the present study, we describe the influence of some popular medicinal plants on early growth and amount of generated above-ground plant matter of common buckwheat opium poppy and two cultivars of oilseed rape.

MATERIALS AND METHODS

Glasshouse experiments were conducted to assess the influence of distribution of dry matter of various herb species in soil on germination and growth of common buckwheat (*Fagopyrum esculentum* Moench. cv. Kora), opium poppy (*Papaver somniferum* L. cv. Mieszko) and winter oilseed rape (*Brassica napus* var. *oleifera* cv. Californium and semi-dwarf hybrid cultivar Maximus. The experiments used inflorescences of marigold (*Calendula* sp.), chamomile (*Matricaria* sp.), hawthorn (*Crataegus* sp.) and linden (*Tilia* sp.), leaves of mint (*Mentha* sp.), nettle (*Urtica* sp.) and sage (*Salvia* sp.), herb of yarrow (*Achillea* sp.), pansy (*Viola* sp.), St John's wort (*Hypericum* sp.), euphrasia (*Euphrasia* sp.), horsetail (*Equisetum* sp.), and fennel fruit (*Foeniculi* sp.). The analyzed medicinal plants are representatives of 10 botanical families, and dry matter of the whole plants or their individual parts used in the experiment was 5 g. Detailed information on the used species of

medicinal plants is presented in Table 1. Four separate experiments on common buckwheat, opium poppy and two cultivars of oilseed rape were established in two series, with four replications. Dry matter of herbaceous plants was evenly distributed in the superficial soil layer in pots with a diameter of 10 cm. Thirty nutlets of common buckwheat, seeds of opium poppy and each cultivar of oilseed rape were placed in the prepared soil. Two weeks after sowing, seedling emergence of the cultivated plants was calculated, expressed as plants per pot. Seedling emergence expressed as a percentage was determined, adopting 30 nutlets of buckwheat and poppy and oilseed rape seeds, sown in the beginning of the experiment, as 100%. Results present also a percentage increase or a reduction in the number of germinated cultivated plants in the objects, where the medicinal plants were used in comparison with the number of plants noted in control. After the assessment, density of plants was reduced to a number of 10 plants in each pot. The number was maintained until the end of the experiment. After another three weeks, analysis of fresh matter of 10 plants was conducted. On the basis of the obtained results regarding fresh matter, its percentage increase or reduction was calculated in comparison with control. An increase or a reduction in fresh matter of the collected cultivated plants was determined, considering matter of buckwheat poppy and oilseed rape plants obtained from control as 100%. The results were statistically calculated with the use of analysis of variance at significance level $LSD_{\alpha=0.05}$. The statistical analysis was performed in FR – ANALWAR – 4.3.

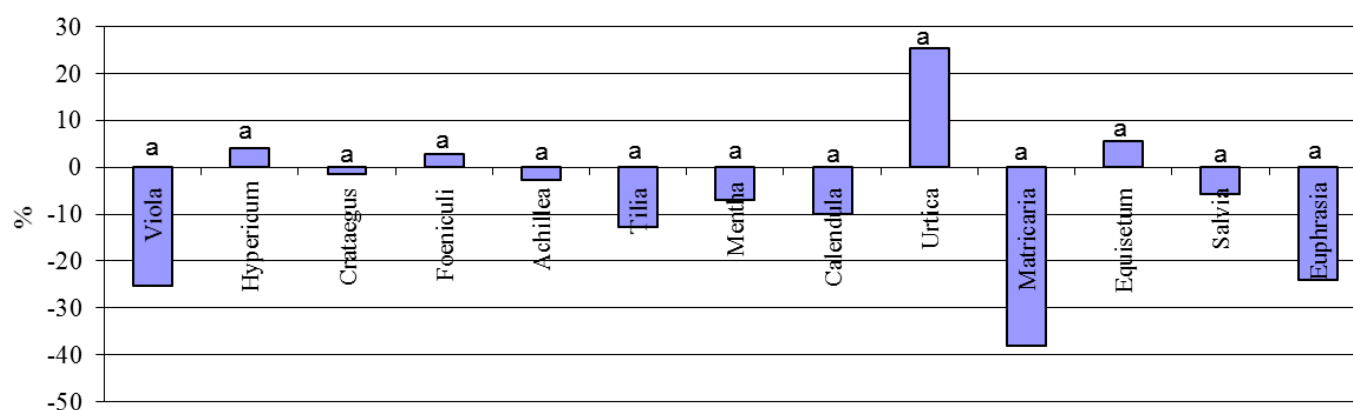
RESULTS

Assessment carried out after two weeks since the beginning of the experiment demonstrated differences in individual objects concerning seedling emergence. Mean number of buckwheat plants depending on the used substrate ranged from 11 to 22 plants. Most buckwheat plants germinated in the object where *Urtica* sp. leaves were used, while least plants were observed where *Matricaria* sp. inflorescence was applied (Figure 1). In most objects, seedling emergence of common buckwheat did not exceed 50%, apart from those where *Euphrasia* sp. (45%), *Viola* sp. (44%) and *Matricaria* sp. inflorescences (37%) were used as a substrate. In control, seedling emergence of common buckwheat amounting to 60% was noted. A reduction in seedling emergence in comparison with control for the combinations with the lowest noted percentage of seedling emergence was as follows: 38% (*Matricaria* sp.), 25% (*Viola* sp.) and 24% (*Euphrasia* sp.). However, the highest percentage increase when compared to control was noted as a result of using *Urtica* sp. leaves (25%). Nazir et al. (2007) in their study demonstrated an adverse effect of used medicinal plants, that is, *Rheum emondi*, *Saussurea lappa* and *Potentilla fulgens*, on germination of common buckwheat nutlets.

The greatest fresh matter of common buckwheat was obtained from the objects where *Urtica* sp. leaves served as a planting substrate for nutlets (Figure 2). Additionally, equally high values of fresh matter of common buckwheat were obtained after using *Equisetum* sp., *Calendula* sp.,

Table 1. Characterization of the tested medicinal plants.

Name		Botanical family/	Used part of plant
English	Latin	Latin name	
Pansy	<i>Viola sp.</i>	Violaceae	Herb
St John'swort	<i>Hypericum sp.</i>	Hypericaceae	Herb
Hawthorn	<i>Crataegus sp.</i>	Rosaceae	Inflorescence
Fennel	<i>Foeniculi sp.</i>	Umbelliferae	Fruit
Yarrow	<i>Achillea sp.</i>	Compositae	Herb
Linden	<i>Tilia sp.</i>	Tiliaceae	Inflorescence
Mint	<i>Mentha sp.</i>	Labiatae	Leaves
Marigold	<i>Calendula sp.</i>	Compositae	Inflorescence
Nettle	<i>Urtica sp.</i>	Urticaceae	Leaves
Chamomile	<i>Matricaria sp.</i>	Compositae	Inflorescence
Horsetail	<i>Equisetum sp.</i>	Equisetaceae	Herb
Sage	<i>Salvia sp.</i>	Labiatae	Leaves
Euphrasia	<i>Euphrasia sp.</i>	Scrophulariaceae	Herb

**Figure 1.** Effect of the medicinal plants on the buckwheat germination (increase/decrease comparing to control). a – insignificant change, b – significant change.

Hypericum sp., *Foeniculi sp.* and *Viola sp.* An increase in fresh matter expressed as a percentage in comparison with matter of buckwheat plants obtained from control amounted to: 30% (for *Equisetum sp.*), 33% (*Calendula sp.*), 38% (*Hypericum sp.*), 44% (*Foeniculi sp.*), 54% (*Viola sp.*) and 66% (*Urtica sp.*). The highest reduction in growth on the basis of plant matter was observed in the object where *Euphrasia sp.* herb was used (by 28% when compared to control). Buckwheat fresh matter from that combination was significantly lower than plant matter from the objects where *Viola sp.*, *Hypericum sp.*, *Crataegus sp.*, *Foeniculi sp.*, *Calendula sp.*, *Urtica sp.* and *Equisetum sp.* were used. Different influence of the tested medicinal plants was observed for opium poppy (Figure 3). Seedling emergence of this crop was strongly reduced by the use of *Euphrasia sp.*, and the percentage

of germinated seeds amounted to only 18%. *Hypericum sp.* had the most favorable effect on poppy plants as it caused 72% of seedling emergence. Apart from the mentioned combination, also, the following plants had a positive influence on poppy germination: *Crataegus sp.* (64% of seedling emergence) and *Equisetum sp.* (57% of seedling emergence). These were the only objects where the percentage of germinated seeds exceeded 50%. Relatively, the lowest percentage of seedling emergence from 18 to 33% was observed after using *Euphrasia sp.*, *Matricaria sp.* and *Foeniculi sp.* The number of germinated seeds in control in the experiment was 11, that is, 37%. The use of *Euphrasia sp.* resulted in seedling emergence of poppy plants reduced by 50% in comparison with control.

The highest fresh matter of opium poppy was obtained

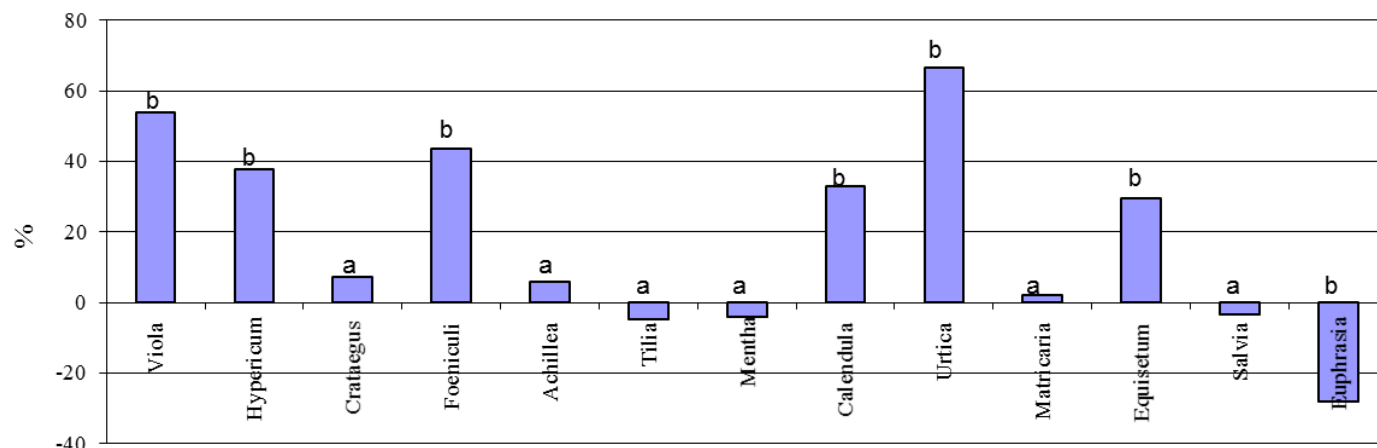


Figure 2. Effect of the medicinal plants on the fresh mass of buckwheat (increase/decrease comparing to control).
a – insignificant change, b – significant change.

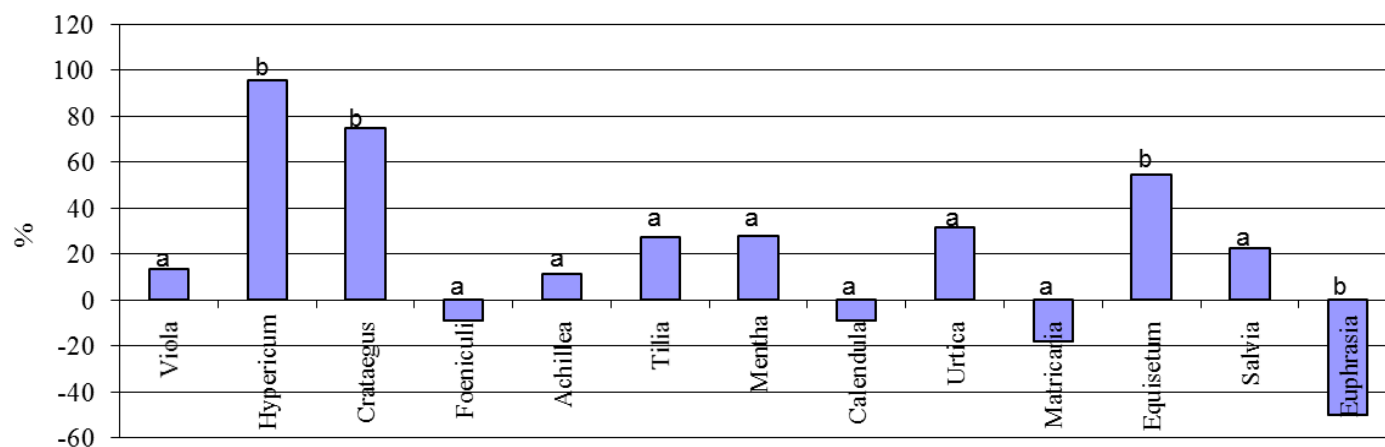


Figure 3. Effect of the medicinal plants on the opium poppy germination (increase/decrease comparing to control).
a – insignificant change, b – significant change.

in the combination where *Urtica sp.* were used (on average 7.85g), while the lowest was observed where *Tilia sp.* was applied (on average 1.46 g) (Figure 4). An increase in poppy fresh matter in comparison with control after use of *Urtica sp.* amounted to as much as 192%, and a reduction in matter resulting from the use of *Tilia sp.* was 46%. Significantly, higher values of poppy fresh matter when compared to control were noted for *Urtica sp.*, *Calendula sp.* and *Viola sp.*, respectively, by 191, 54.7 and 77%. Plants characterized by the lowest matter (after using *Tilia sp.* inflorescence) were significantly different from the objects where planting substrate included *Viola sp.*, *Hypericum sp.*, *Crataegus sp.*, *Foeniculi sp.*, *Calendula sp.* and *Equisetum sp.* from 82 to 225%. Oilseed rape cultivar Californium and semi-dwarf hybrid Maximus exhibited different response to the

examined medicinal plants. Comparison of germination of both oilseed rape cultivars showed significant differences in seed susceptibility to allelopathins contained in medicinal plants. Most of the examined species had a positive influence on germination of oilseed rape cv. Californium (Figure 5). The greatest effect of germination stimulation for this cultivar in comparison with control was obtained in the object where *Mentha sp.* was used (20%), then *Matricaria sp.* (18%), *Equisetum sp.* (16%), *Viola sp.* and *Urtica sp.* (13%), *Hypericum sp.*, *Crataegus sp.* and *Tilia sp.* (11%). More germinations of 7 and 9%, respectively were obtained for *Euphrasia sp.* and *Foeniculi sp.* in comparison with control. No influence of *Calendula sp.* on germination of this cultivar was noted, while *Achillea sp.* and *Salvia sp.* had an inhibitory influence on seedling emergence of the cultivar. The highest increase in fresh

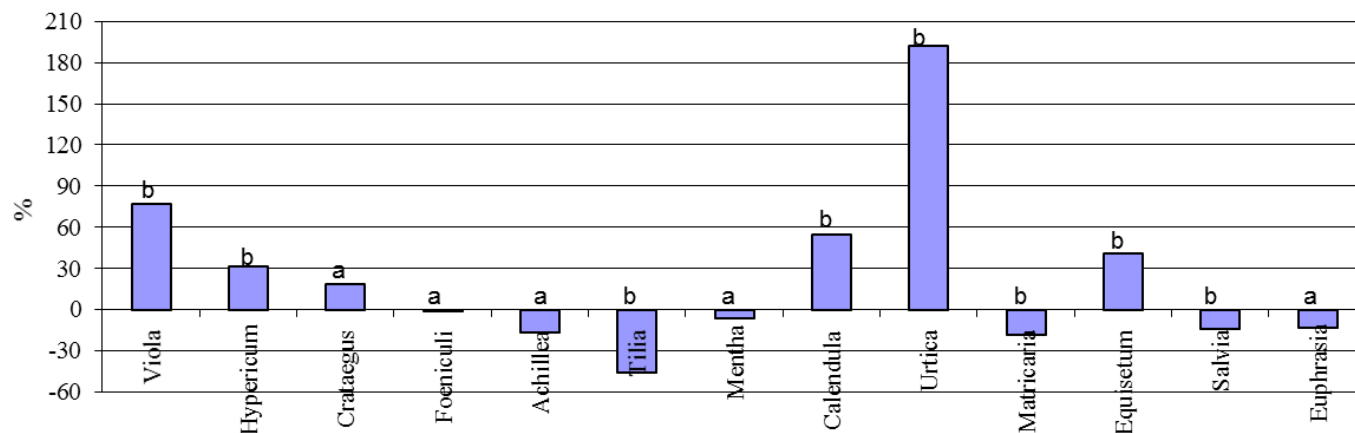


Figure 4. Effect of the medicinal plants on the fresh mass of opium poppy (increase/decrease comparing to control). a – insignificant change, b – significant change.

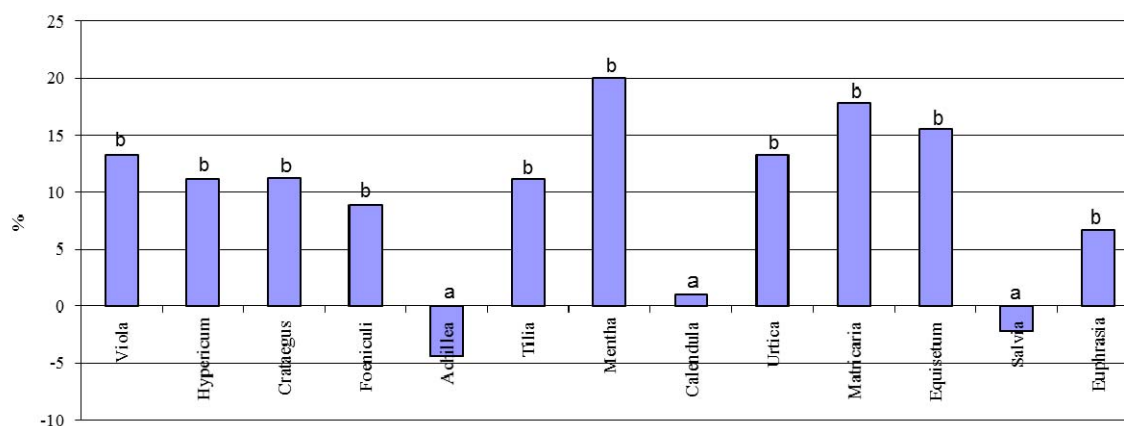


Figure 5. Effect of the medicinal plants on the traditional oilseed rape cv. Californium germination (increase/decrease comparing to control). a – insignificant change, b – significant change.

fresh matter was observed after the use of *Achillea* sp., over 100%, when compared to control (the species had a poor inhibitory effect on germination) (Figure 6). A significant increase in fresh matter of the plants was noted also in the objects where *Crataegus* sp. (45%), *Foeniculi* sp. (32%) and *Mentha* sp. (27%) were used. *Calendula* sp., *Hypericum* sp. and *Tilia* sp. (2 to 9%) had a lesser influence on an increase in plant matter. The other medicinal plants adversely affected plant matter. The greatest reduction in fresh matter was observed after using *Viola* sp. and *Matricaria* sp. (8%).

The experiments carried out on hybrid semi-dwarf cultivar of oilseed rape (Maximus) indicated an ambiguous effect of the examined medicinal plants on oilseed rape plants because most of them had a different influence on the examined traits. All the medicinal plants inhibited germination of semi-dwarf cultivar of oilseed

rape (Figure 7). The germination was the most reduced by *Salvia* sp. and *Euphrasia* sp. The experimental objects were characterized by a reduction in the number of germinated seeds, respectively by 28 and 24% in comparison with control. In these experimental objects also, the greatest reduction in plant fresh matter was noted (28 to 30%). *Hypericum* sp. inhibited oilseed rape germination by 20% and at the same time increased the level of plant fresh matter by 23%. Fruit of *Foeniculi* sp. and *Achillea* sp. inhibited germination by 16 to 18%, increasing plant matter by 35 to 43%. A similar effect was exhibited by species *Crataegus*. Inflorescence of this plant stimulated oilseed rape germination (increase by 12%), and increased plant matter by nearly 32%. The use of *Matricaria* sp. and *Equisetum* sp. resulted in 14% less germinated seeds when compared to control. Also *Matricaria* sp. had an inhibitory effect on oilseed rape

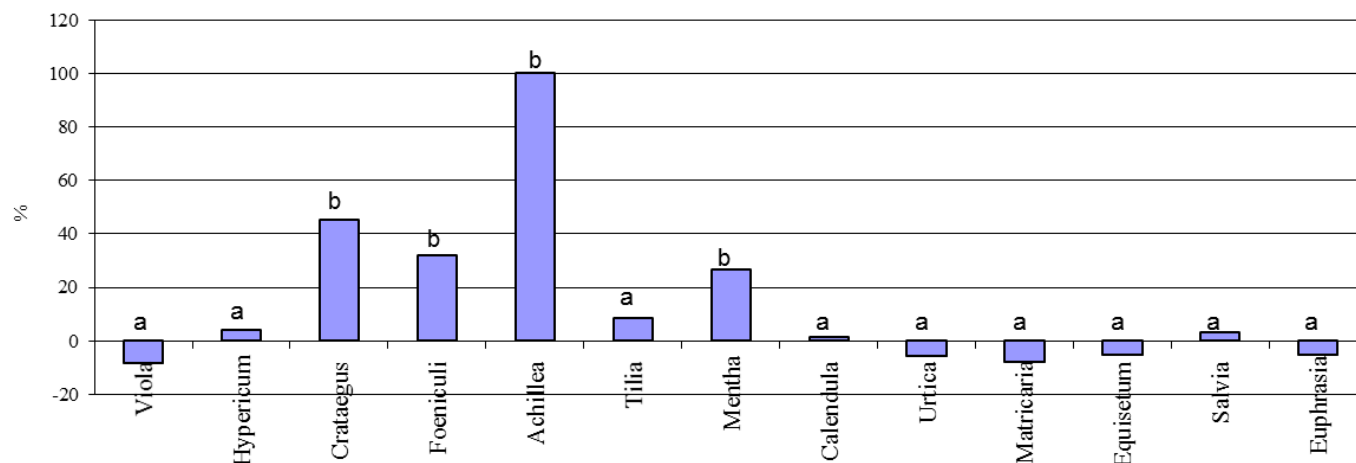


Figure 6. Effect of the medicinal plants on the fresh mass of traditional oilseed rape cv. Californium (increase/decrease comparing to control) a – insignificant change, b – significant change.

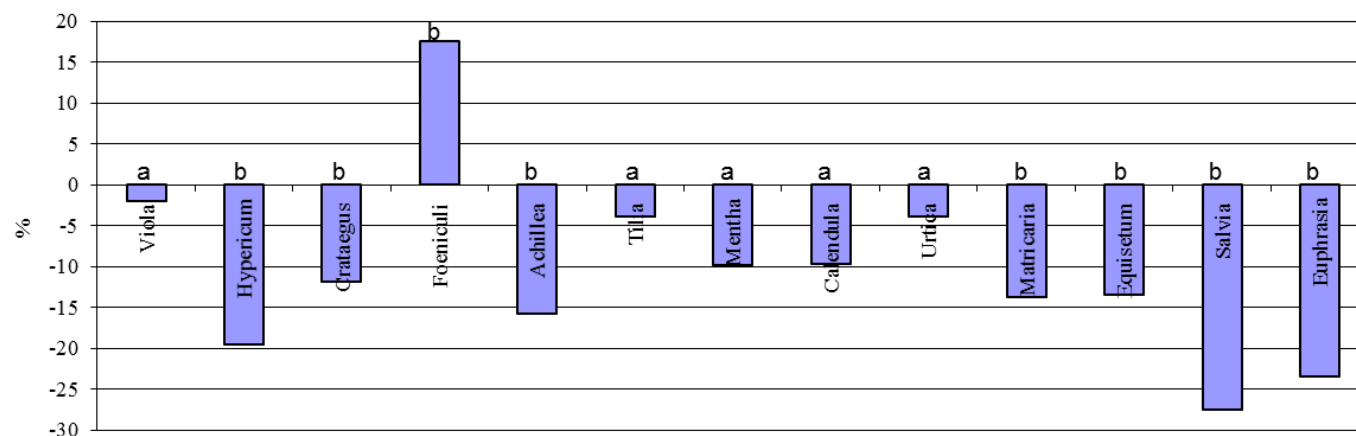


Figure 7. Effect of the medicinal plants on the semi-dwarf oilseed rape cv. Maximus germination (increase/decrease comparing to control) a – insignificant change, b – significant change.

growth (reduction in fresh matter by 23%), *Equisetum sp.* stimulated growth of the cultivated plants (increase in matter by 21%) (Figure 8). *Urtica sp.* and *Tilia sp.* (germination reduction by 4%) and *Viola sp.* herb (germination reduction by 2%) reduced germination of oilseed rape cultivar Maximus to a lesser degree. These species did not have a statistically significant influence on an increase or a reduction in fresh matter.

DISCUSSION

Allelopathic compounds have diverse effects but the most common one described in literature is the influence on seed germination as well as on growth and development of seedlings (Gniazdowska et al., 2004). Experiments assessing influence of sage extract (*Salvia officinalis*) on

germination of two weeds (*Amaranthus retroflexus* and *Portulaca oleraceae*) were conducted by Aziz and Fuji (2006). The authors showed an inhibitory effect of the extract on germination of only one of the mentioned species, *Amaranthus retroflexus*, while Arminante et al. (2006) in their research noted an adverse influence of *S. officinalis* on germination and growth of three plants: *Raphanus sativus*, *Lactuca sativa* and *Lepidium sativum*. Our experiments showed varied response of common buckwheat opium poppy to the used medicinal plants. The greatest stimulatory effect on seedling emergence of common buckwheat exhibited *Urtica* leaves, while seedling emergence of opium poppy was most affected by *Hypericum*. Seedling emergence of common buckwheat was reduced by the use of *Matricaria* inflorescence, while *Euphrasia* herb reduced emergence of field poppy. *Urtica*

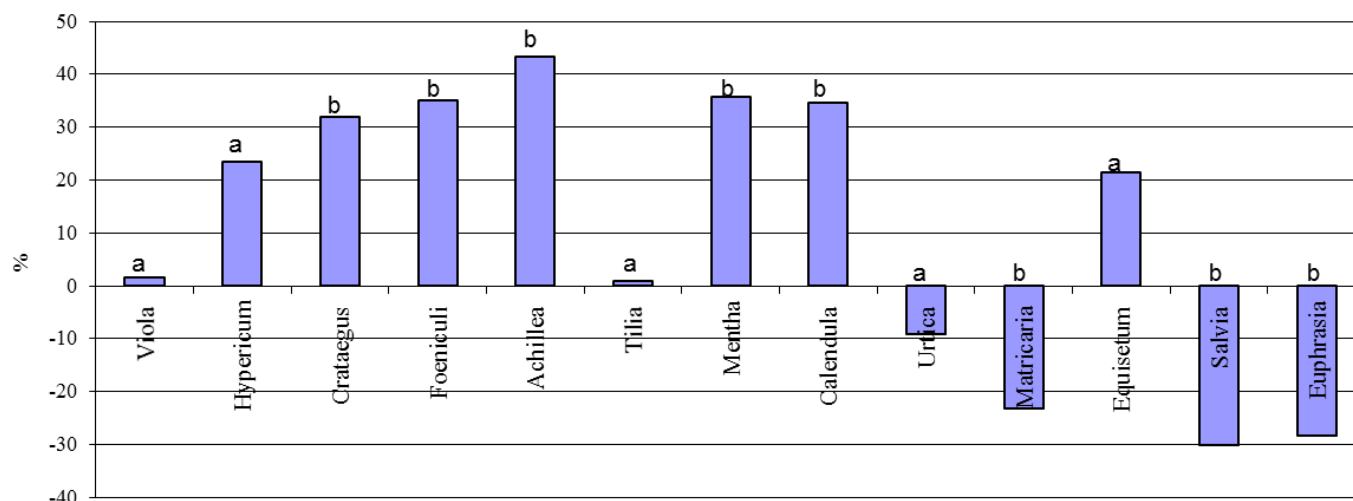


Figure 8. Effect of the medicinal plants on the fresh mass of semi-dwarf oilseed rape cv. Maximus (increase/decrease comparing to control) a – insignificant change, b – significant change.

leaves caused a significant increase in fresh matter of the common buckwheat and opium poppy. The greatest reduction in fresh matter of buckwheat was noted as a result of using *Euphrasia* herb, while in the case of field poppy, fresh matter was most reduced by using *Tilia* inflorescence. *Mentha* sp. exhibited a strong stimulatory effect on seedling emergence of oilseed rape cultivar Californium, while *Achillea* sp. had an inhibitory influence. All the examined medicinal plants inhibited seedling emergence of hybrid semi-dwarf oilseed rape cv. Maximus.

The study conducted by Habibi Lahigi et al. (2012) confirmed the presence of twenty compounds in *Urtica dioica*, most of them in leaf, in comparison with other plant parts of which neophytadiene, phtaleic acid, dibutylphtaleate, bis (2-ethyl hexyl) maleate and 1,2-benzenocli carboxylic acid were the dominating ones. Fritz et al. (2007) observed germination reduction of *Lactuca sativa* during germination and growth inhibitory effect of *Hypericum myrianthum* and *H. polyanthum* ethanolic extracts investigation. These researches indicated phenolic compounds as the main allelopathic components while Celen et al. (2008) also revealed presence of tannins as well. Sharopov et al. (2010) identified sixty-six essential oil compounds of *Hypericum perforatum*, with germacrene D, α -pinene, (E)-caryophyllene, n-dodecanol, caryophyllene oxide, bicyclogermacrene, and spathulenol as the main constituents. Composition of *Matricaria recuita* L. flowers essential oil was assessed by Ghasemi et al. (2013). Essential oil analysis by GC-MS and TLC methods revealed as a main compounds, bisabolol oxide A, bisabolone oxide, bisabolol oxide B, chamazulene, spathulenol and farnesene. Murti et al. (2012), besides

the mentioned substances, also presented sesquiterpens, apigenin, luteolin, quercetin, umbelliferone and en-yndicycloether as chemical components of chamomile. Also, *Euphrasia* contains a lot of chemical compounds represented mainly by phenolic compounds (for exexample, chlorogenic, caffeic acids, quercetin-3-O-rutinoside (9) and apigenin), organic acids (for example, citric acid, quinic acid, acetic acid), sterols (cholesterol, β -Sitosterol) and fatty acids (for example, myristic, palmitic, docosaheaxaenoic) determined by different chromatographic methods (Teixeira and Silva, 2013). Spectroscopic techniques performed by Toker et al. (2004) led to isolation of kaempferol 3,7-O- α -L-dirhamnoside (I) and quercetin 3,7-O- α -L-dirhamnoside (II) from the leaves of *Tilia argentea* (Tiliaceae) while two coumarins, one flavan-3-ol, one fatty acid, and two lignan glycosides were isolated by Choi et al. (2008).

Islam and Kato-Noguchi (2013) confirmed allelopathic property of *Mentha* (*Mentha sylvestris*). Authors suggest considering *Mentha* as a potential candidate for isolation and identification of allelochemicals, which were used as a natural herbicides. Sardashti and Adhami (2013) analyzed oils of *Mentha pulegium* L. using gas chromatography/mass spectrometry technique. They recognized 35 constituents of total essential oil, where the pulegone, cineole, isopulegone and beta-pinene were the major ones representing 99.52% of the total essential oil mass from which 29 compounds were elucidated. In other studies (Boukhebt et al. 2011), the major components for *Mentha pulegium* were: pulegone, menthone, pipériténone, pipéritone and isomenthone, limonene and octaan-3-ol. Dias et al. (2013) compared chemical composition of wild and commercial *Achillea millefolium* and they found their profiles similar, but

commercial yarrow have higher content of fat and saturated fatty acids, proteins, ash, energy value, sugars and flavonoids. Bimbiraite et al. (2008) observed the highest content of flavonoids in deep pink morphotype while the highest content of essential oil was found in white morphotype. Literature regarding allelopathy provides examples of plant species characterized by great allelopathic potential towards cultivated species. Some authors emphasize the fact of a change in pH of soil with allelopathic compounds (Khalid et al., 2002). Bhatia et al. (1982) named *Chenopodium album* as a plant specially involved in stimulating wheat germination, and *Chenopodium murale* as a plant stimulating mustard growth. On the other hand, Kossanel et al. (1977) considered *Chenopodium album* as a plant inhabiting germination and growth of corn. Bhowmic and Doll (1984) in their study obtained a positive effect of extracts of *Chenopodium album*, *Amaranthus retroflexus*, *Artemisia artemisifolia*, *Abutilon theophrasti* and *Setaria glauca* on soy and corn. Elmore et al. (1985) stated that *Cyperus rotundus* caused a decrease in yield of cotton, corn, sorghum and tobacco. Plants with a strong inhibitory effect on germination, seedling growth and on an increase in fresh matter of many cultivated plants include also: *Lolium multiflorum*, *Diachanthium annulatum*, *Euphorbia granulata* (Hussain, 1980), *Datura innoxia*, *Citrullis colocynthis*, *Stachys parviflora* (Hussain et al., 1986). Among medicinal plants, strong allelopathic properties can be observed for example, in *Rheum emodi*, *Saussurea lappa* and *Potentilla fulgens*. Nazir et al. (2007) indicated that the plants reduced germination of such cultivated plants as: love-lies-bleeding (*Amaranthus caudatus*), mung bean (*Phaseolus mungo*), common bean (*Phaseolus vulgaris*), finger millet (*Elusine coracana*), common wheat (*Triticum aestivum*) and common buckwheat (*Fagopyrum esculentum*).

CONCLUSION

This study gives a general outlook of the allelopathic effects of popular medicinal plants on some crops. It has been observed that increase of common buckwheat seeds germination is strongly enhanced by *Urtica sp.* whereas *Matricaria sp.*, *Euphrasia sp.*, and *Viola sp.* have inhibitory effects on that process. The studies revealed that later growth of common buckwheat was positively stimulated by such herbs as *Urtica sp.*, *Viola sp.*, *Foeniculi sp.*, *Colendula sp.* and *Equisetum sp.* Significant increase of opium poppy germination capacity was recorded in the presence of *Hypericum sp.*, even though, *Crataegus sp.* and *Equisetum sp.* have also given positive results. However seed germination of opium poppy was suppressed by *Euphrasia sp.* The maximum stimulatory effect on the traditional cultivar of oilseed rape germination was caused by *Mentha sp.* but

the most tested medicinal plants rape enhanced that process whereas germination capacity of semi-dwarf oilseed rape cultivar increased as a result of *Foeniculi sp.* presence. Further growth and development of traditional oilseed rape was significantly and positively affected by *Mentha sp.*, *Crataegus sp.* and *Foeniculi sp.* but extremely positive results were obtained in the presence of *Achillea sp.* In case of semi-dwarf oilseed rape cultivar, later growth was stimulated by *Achillea sp.*, *Crataegus sp.*, *Foeniculi sp.*, *Mentha sp.* and *Calendula sp.* This paper confirms different response of popular crops on the presence of some medicinal plants. These experiments can be valuable in agronomical practice because some of tested herbs are frequently present on fields and they can significantly reduce yield, and on the other hand some of them can be used as alleloherbicides or natural bio-stimulants in crops.

Conflict of Interest

We declare that we have no conflict of competing interest.

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