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Plant Extracts and their Influence on Some Properties of Seeds of Cultivated Plants – Grain Plants

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1. Introduction

Plants are one of the oldest inhabitants of the planet. Among 400 thousands of plant species occurring in the world, about 10% show a therapeutic action. Only a small part from those is exactly described and investigated in respect of their chemical composition. In a process of synthesis these plants produce organic compounds with a different composition and action.

In order to use their exceptional properties broad investigations should be carried out. It will indicate a proper preparation and application and the factors influenced a therapeutic value of these plants.

It has a special significance in view of an increased need of an environment protection and the use of plant extracts means taking of advantage of that what is created by nature. They could be used as preventive or therapeutic means in protection of cultivated plants. But before their use in a practice, for instance as alternative seed dressing, their toxicity in relation to the protected plant should be examined.

The aim of presented experiments was the examination of an antibiotic action of the plant extracts determined by seed vitality and plant sprouts development, as well as their impact on plant healthiness.

Results of investigations carried out may be useful for selection of some "producers" of chemical compounds which may find its application in decreasing of harmfulness of some phytopathogens and replace in some extent fungicides used in plant protection.

2. Material and methods

The material used in investigations was as follows:

- Water extracts (maceration, infusion) made from different parts of 20 plant species: 1. ***Sambucus nigra*** L. (flowers); 2. ***Betula verrucosa*** Ehrh. (leaves); 3. ***Artemisia vulgaris*** L. (green parts); 4. ***Allium sativum*** L. (bulbs); 5. ***Aesculus hippocastanum*** L. (bark); 6. ***A. hippocastanum*** L. (flowers); 7. ***Mentha piperita*** L. (leaves); 8. ***Saponaria officinalis*** L. (roots); 9. ***Urtica dioica*** L. (leaves); 10. ***Equisetum arvense*** L. (green parts); 11. ***Marrubium vulgare*** L. (green parts); 12. ***Acorus calamus*** L. (rhizomes); 13. ***Crataegus oxyacantha*** L. (inflorescence); 14. ***Frangula alnus*** Mill. (bark); 15. ***Zea mays*** L. (stigmas); 16. ***Melissa officinalis*** L. (leaves); 17. ***Taraxacum officinale*** Web. (roots); 18. ***Inula helenium*** L. (roots); 19. ***Matricaria chamomilla*** L. (head); 20. ***Rosa canina*** L. (fruit). The dried plant material was derived from Zakład Zielarski „Kawon-Hurt". Water extracts were prepared as follows:
  - Maceration: to 5 g of plant dried material a 100 ml of sterile, cold water was added and it was set aside for 24 hours in a temperature of 20^{o}C under cover;
  - Infusion: to 5 g of plant dried material a 250 ml of boiling water was added and it was set aside for 30 min under cover.

    The received after filtration extracts were used to a seed dressing of grain plants.
- Non-disinfected seeds of three grain plants: ***Triticum aestivum*** L. (cv. Almary); ***Secale cereale*** L. (cv. Dańkowskie Złote) and ***Triticosecale*** Wittm. (cv. Marko) were wet dressed by inundation in the extracts and shaken out for 10 min in a dressing device and then set aside for 20 hours in an ambient temperature. As a control the treated by distilled water seeds of the grain plants were used.

The experiment was carried out as a filter paper test according to requirements of Polish Standard (PN-94R-6595) in order to determine:

- a germination viability, carried out after 4 days for all seeds (I time);
- a germination capacity, carried out after 7 days for rye and after 8 days for wheat and triticale (II time).

In the above mentioned periods the evaluation criteria were: a number of normally germinated seeds; not normally germinated; not germinated and natural infected seeds. In the presented work only an impact of the extracts on a number of normally germinated and emerging seeds as well as their healthiness was examined.

The results obtained were statistically elaborated with a method of a single variance analysis (P=95%), separately for each cultivated plant, an evaluation criterion and a feature to be observed. The response of the grain plants on the extract tested were compared using the method of linear correlation and of variability coefficients (V%).

3. Research results

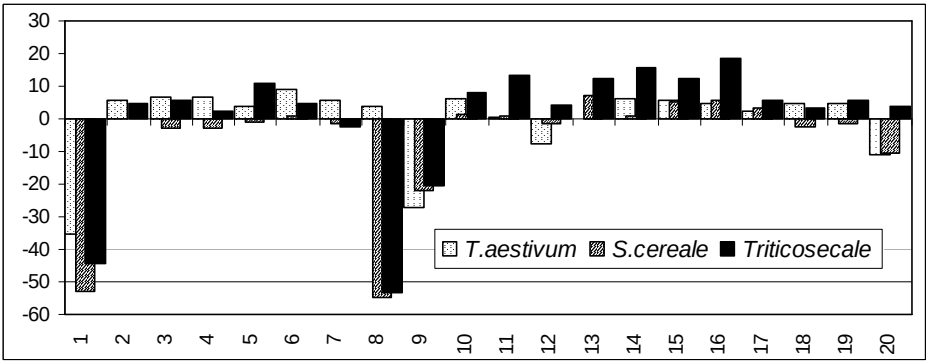
The extracts made from individual plant species and prepared according to different procedures significantly differentiated (P=95%) a germination viability and capacity as well as seeds healthiness of *Triticum aestivum, Secale cereale* and *Triticosecale.*

Regardless of a mode of an extract preparation, the germination viability of grain plants was most strongly inhibited by an extract from a flower of *S.nigra* (Fig. 1A). A percent of normally germinated seeds expressed as a deviation from a control amounted -35,4% for *T.aestivum*; -53,0% for *S.cereale* and -44,5% for *Triticosecale*. Furthermore the germination viability was negatively influenced by an extract from leaves of *U.dioica* (wheat -27,0, rye -21,8, triticale -20,5%) and from roots of *S.officinalis* (rye -54,5%; triticale -53,3%).
A seed germination was however stimulated by extracts from flowers of *A.hippocastanum* (wheat), from inflorescences of *C.oxycantha* (rye) and from leaves of *M.officinalis* (triticale*).*

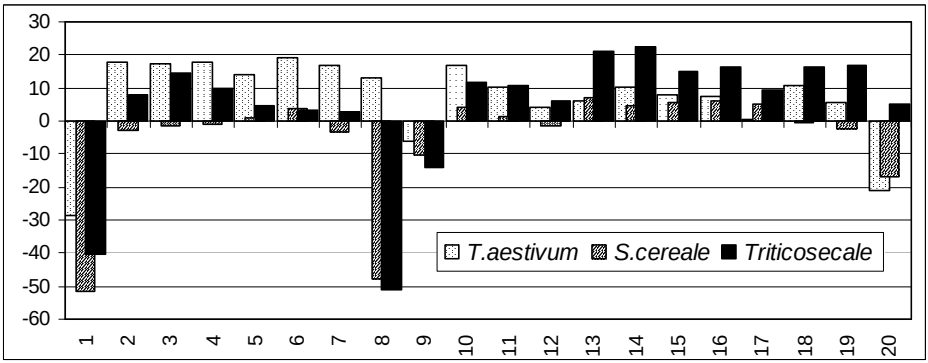
Regardless of an extract source (plant), the germination viability of seeds of *T.aestivum* and *Triticosecale* was inhibited by maceration when an infusion had a stimulating effect. A germination of *S.cereale* seeds was inhibited by an infusion as well as by maceration.

Significant was also an interaction between source x preparation mode of the extracts, as well as conformity of response of investigated grain plants on the extracts used (wheat x rye r= 0,613**; wheat x triticale r = 0,557*; rye x triticale r= 0,970**, r critical = 0,443). It indicates that a interaction significance resulted rather from an extent of reaction of grain plants on used extracts than from its direction.

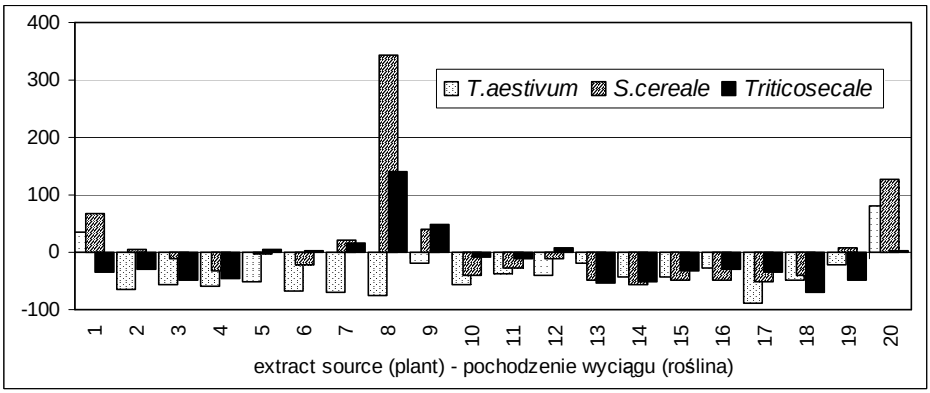
So, the germination viability of *T.aestivum* seeds was most strongly inhibited by maceration from flowers of *S.nigra* (-73,9%), from leaves of *U.dioica* (-32,5%) and from rhizomes *A.calamus* (-22,2%); of *S.cereale* – by maceration from flowers of *S.nigra* (-98,9%), roots of *S.officinalis* (-70,9%), leaves of *U.dioica* (-43,7%) and infusion from roots of *S.officinalis* (-38,2%); of *Triticosecale* – by maceration from flowers of *S.nigra* (-92,4%), roots of *S. officinalis* (-51,7%), leaves of *U.dioica* (-45,2%) and infusion from roots *S.officinalis* (-54,8%; Fig. 2).



A. Germination viability – energia kiełkowania



B. Germination capacity – zdolność kiełkowania



C. Infected seeds – porażenie nasion

Fig. 1. A mean influence of the extracts on a seeds vitality and healthiness (deviation from control in %)

Rys. 1. Przeciętne oddziaływanie wyciągów na żywotność i zdrowotność nasion (odchylenie od kontroli w %)

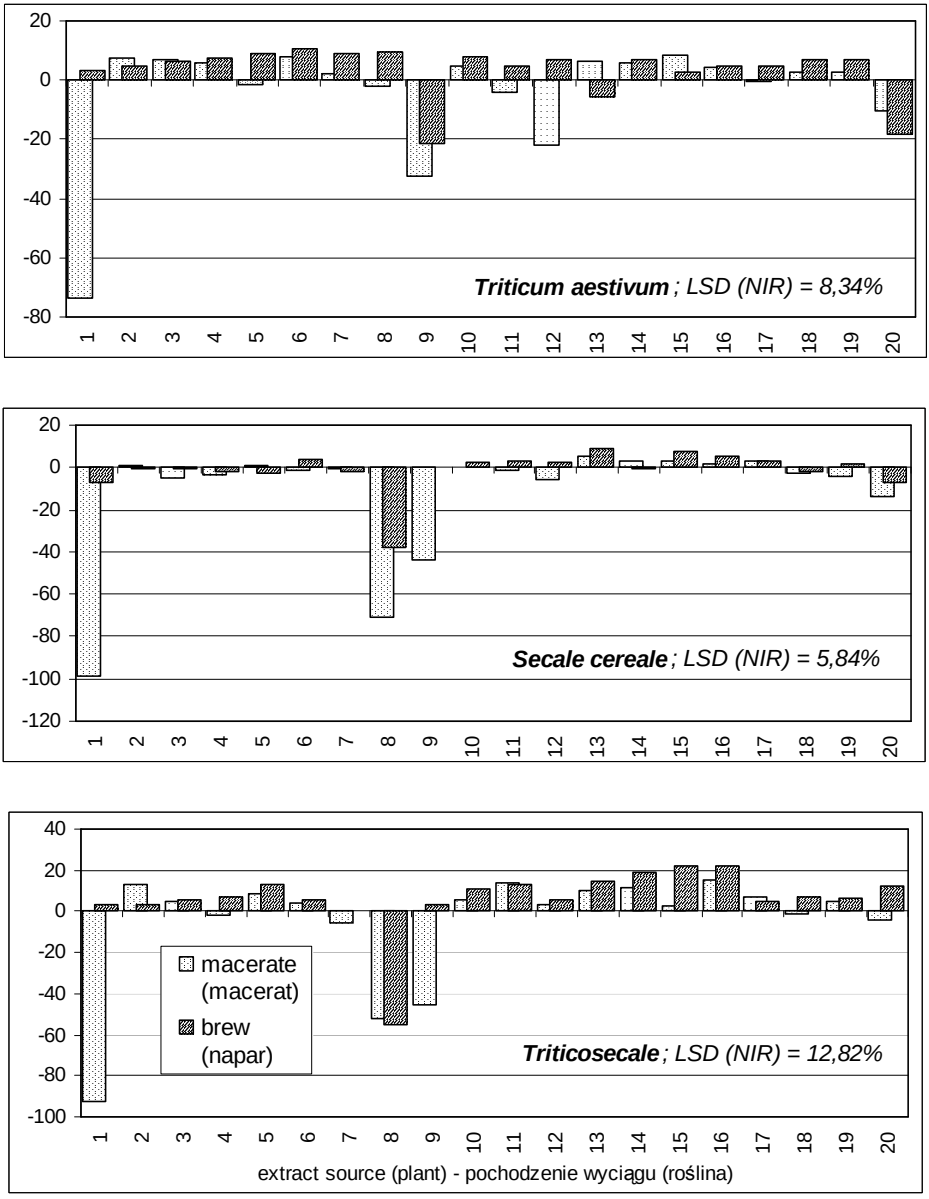


Fig. 2. A seeds vitality depending on a source and a preparation mode of the extracts (I time; number of normally germinated seeds – deviation from control in %)

Rys. 2. Żywotność nasion w zależności od pochodzenia i sposobu przygotowania wyciągów (I termin; liczba nasion normalnie kiełkujących – odchylenie od kontroli w %)

The germination viability of *T.aestivum* seeds was stimulated however by infusions from flowers of *A.hippocastanum* (+10,6%), from roots of *S. officinalis* (+9,4%) and from leaves of *M.piperita* (+9,1%); of *S.cereale* – by infusions from inflorescence of *C.oxycantha* (+8,7%) and from stigmas of *Z. mays* (+7,3%); of *Triticosecale* – by infusions from stigmas of *Z.mays* and from leaves of *M.officinalis* (both +22,1%) and from bark of *F.alnus* (+19,3%).

The impact of used extracts on germination viability and capacity of grain seeds was reciprocally positively correlated. Values of correlation coefficients amounted 0,919** for *T.aestivum;* 0,975** for *S.cereale* and 0,902** for *Triticosecale*. Also a variability (V%) of grain plant reaction on the investigated extracts was slight and very similar (from 15,2% to 22,5%).

As regards the germination capacity of the seeds a negative impact (regardles of preparation mode) of extracts from flowers of *S.nigra* and from fruits of *R.canina* was revealed, which inhibited a germination of *T.aestivum* (-28,5 and -21,0% respectively) and of extracts from flowers of *S.nigra* and from roots of *S.officinalis* inhibited a germination of *S.cereale* (-51,4 and -47,8 respectively) and of *Triticosecale* (-40,2 and -51,1% respectively; Fig. 1B).

A stimulating effect on germination capacity of *T.aestivum* showed however extracts from flowers of *A.hippocastanum* (+19,4%) and from leaves of *B. verrucosa* (+17,8%); of *S.cereale* – extracts from inflorescence of *C. oxycantha* (+7,1%) and leaves of *M.officinalis* (+6,0%); of *Triticosecale* – extracts from bark of *F.alnus* (+22,6%) and from inflorescence of *C.oxycantha* (+21,1%).

It was noticed that both kinds of water extracts (regardles of a source) has stimulated a germination and emergence of seeds of wheat and triticale, but on the other hand they inhibited this process in the case of rye.

The analysis carried out revealed that beside of a proved interaction between a source of an extract x preparation mode, a significantly consistent reaction was observed only between *S.cereale* and *Triticosecale* (r=0,930**) and *T.aestivum* (r=0,544*). The impact of extracts on germination capacity of wheat and triticale was different, both in respect of intensity and a direction of response.

Negatively on germination capacity of *T.aestivum* influenced macerations from flowers of *S.nigra* (-69,6%), maceration and infusion from fruits of *R.canina* (-22,1; -20,1%); of *S.cereale* – maceration from flowers of *S. nigra* (-98,9; -26,5%), maceration and infusion from roots of *S.officinalis* (-68,9; -26,5%), of *Triticosecale* – maceration from flowers of *S.nigra* (-91,6%) and from leaves of *U.dioica* (-28,2%), maceration and infusion from roots of *S.officinalis* (-50,7; -51,5%; Fig. 3).

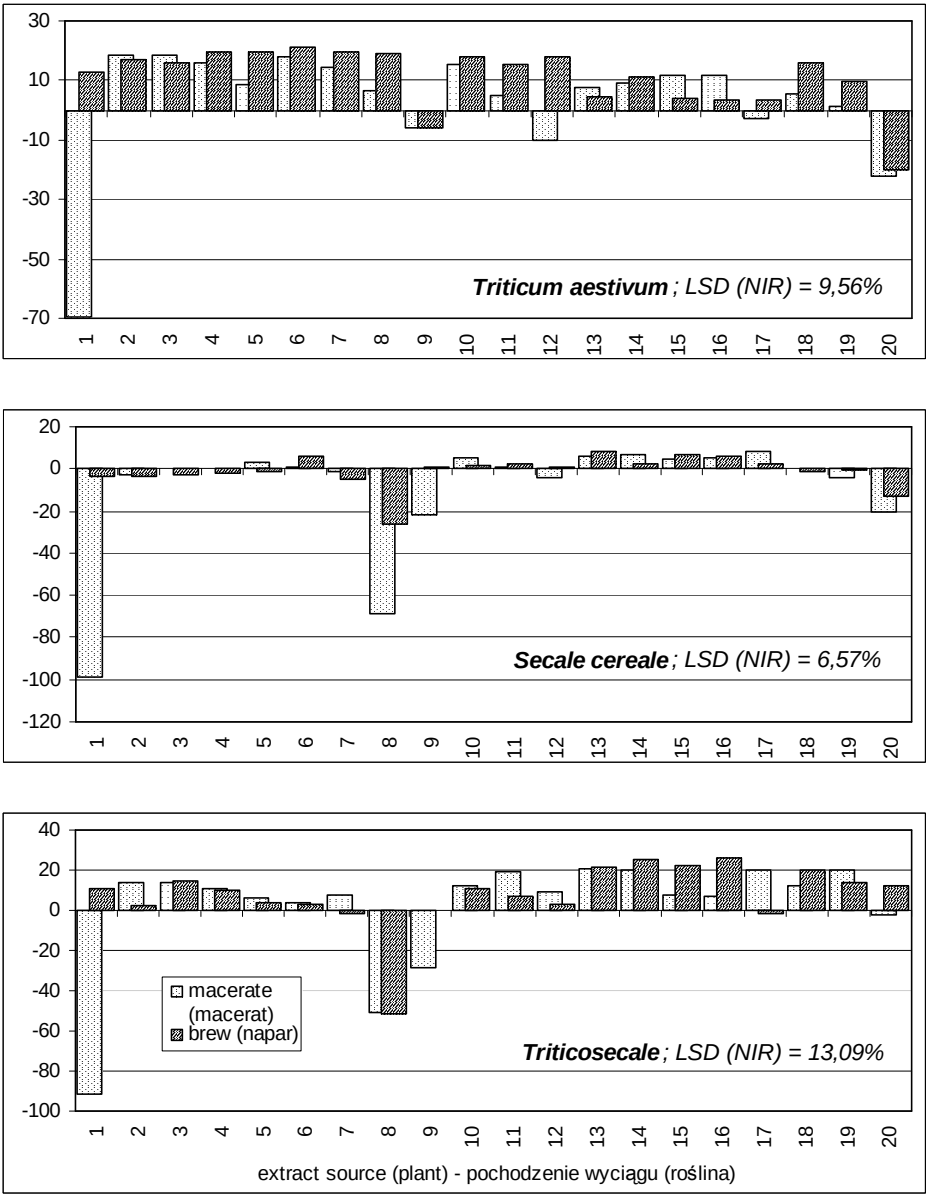


Fig. 3. A seeds vitality depending on a source and a preparation mode of the extracts (II time; a number of normally germinated seeds – deviation from control in %)

Rys. 3. Żywotność nasion w zależności od pochodzenia i sposobu przygotowania wyciągów (II termin; liczba nasion normalnie kiełkujących – odchylenie od kontroli w %)

Most favourably influenced the germination capacity of seeds of *T.aestivum* infusions from a flower and a bark of *A.hippocastanum* (+21,0; +19,4%), from bulbs of *A.sativum* (+19,4%) and from leaves of *M.piperita* (+19,4%), while in a case of *Triticosecale* it was infusions from leaves of *M.officinalis* (+26,1%) and from bark of *F.alnus* (+25,3%). The germination of seeds of *S. cereale* was stimulated by a maceration from roots of *T.officinale* (+8,1%), infusion from inflorescence of *C.oxyacanta* (+8,1%) and an infusion from inflorescence of *C.oxycantha* (+8,1%) and a maceration from a bark of *F. alnus* (+7,0%) and an infusion from stigmas of *Z.mays* (+7,0%).

The influence of infusions upon healthiness of grain seeds was more differentiated than on germination viability and capacity. The variability coefficients (V%) amounted 65,7% (wheat); 91,1% (rye) and 58,5% (triticale). Furthermore their impact on a number of infected seeds and on germination viability and capacity (number of normally germinated seeds) was negatively correlated. The correlation coefficients amounted respectively -0,720** and -0,907** for *T.aestivum;* -0,774** and -0,771** for *S.cereale* and -0,572** and -0,528** for *Triticosecale*. It means that, the more the investigated extracts reduced a number of infected by microorganismes seeds of grain plants, the better was their vitality and a number of normally germinated seeds.

Regardless of a preparation mode an increase of a number of infected seeds of *T.aestivum* was caused by extracts from fruits of *R.canina* (+81,0%) and from flowers of *S. nigra* (+35,0%). In a case of *S.cereale* it was extracts from roots of *S.officinalis* (+342,2%) and from fruits of *R.canina* (+127,3%) and of *Triticosecale* – from roots of *S.officinalis* (+140,4%) and from leaves of *U.dioica* (+49,0%; Fig. 1C).

The number of infected seeds of *T.aestivum* was reduced however most strongly by extracts from roots of *T.officinale* (-90,1%) and of *S.officinalis* (-76,5%), from leaves of *M.piperita* (-69,0%); of *S.cereale* – from bark of *F. alnus* (-55,6%), from roots of *T.officinale* (-51,5%) and leaves of *M. officinalis* (-49,4%); and of *Triticosecale* – from roots of *I.helenium* (-68,9%), from inflorescence of *C.oxycantha* (-54,3%) and from bark of *F.alnus* (-52,5%).

In a case of wheat and triticale both a maceration and an infusion (regardless of a source) reduced a number of infested seeds, while an infection of seeds of rye was increased be maceration and reduced by infusions.

It was proved also a diverse influence of the extracts upon a healthiness of seeds of grain plants depending on a source and preparation mode of the extracts. The significantly consistent response was observed only in a case of rye and triticale ($r = 0,818^{**} > 0,443$).

It was accompanied by that fact (Fig. 4) that the maceration from flowers of *S.nigra* (+117,2%), maceration and infusion from fruits of *R.canina* (+85,1; +77,0%) influenced negatively on healthiness of seeds of *T.aestivum*, while in a case of *S.cereale* it was macerations and infusions from roots of *S. officinalis* (+501,2; +183,1%) and from fruits of *R.canina* (+147,9; +106,6%) and of *Triticosecale* – a maceration and infusion from roots of *S. officinalis* (+143,1; +137,7%) and maceration from leaves of *U.dioica* (+86,5%).

Similarly a number of infested seeds was reduced by infusions from roots of *S.officinalis* (-83,9%) and from flowers of *A.hippocastanum* (-71,3%), macerations from leaves of *M.piperita* (-70,1%) and *B.verrucosa* (-66,7%), while in a case of *S. cereale* it was a maceration from roots of *T.officinale* (-81,4%) and an infusion from a bark of *F.alnus* (-56,6%), and of *Triticosecale* – macerations from roots of *T.officinale* (-82,6%) and from inflorescence of *C.oxyacanta* (-68,0%), maceration and infusion from roots of *I.helenium* (-74,4; -63,4%).

4. Discussion

During last years a clear tendency for a discovering and using of medicines obtained from natural sources is observed (Ożarowski, Jaroniewski 1987). In many countries (Japan, USA) intensive phytochemical and pharmacological researches on herbs being earlier eliminated by synthetic substances are conducted (Kużnicka, Dziak 1987).

Similarly, in plant protection against pests the examinations on a possibility of using of bioproducts in order to diminish an environmental pollution with synthetic pesticides are undertaken. On this possibility pointed out among others Nawrot (1984), Łakota and others (1993). These researches concerned both microbiological bioproducts (Misato, Yamaguchii 1977, Piotrowski 1984, Martyniuk 1988), and those of a vegetable origin (Achremowicz, Cież 1988, Piotrowski and others 1995).

As a result of the in many scientific centers carried out researches was a registration of the safe for environment bioproducts, for instance Polagrocyna (*Agrobacterium radiobacter)*, Novodor or Bacillan (*Bacillus thuringiensis)*, Amistar (synthetic analogues of azoxystrobin produced by forest fungi from genera *Strobilurus* and *Oudemansiella)*, Bancol (bensultap from a marine worm *Lumbrineris heteropoda*), Bioczos and Aldarep (*Allium sativum)*, smoke candles Norniko (alkaloid *Nicotiana tabacum)*.

In the presented own paper an influence of active substances contained in plant extracts on healthiness and vitality of cereal seeds were evaluated.

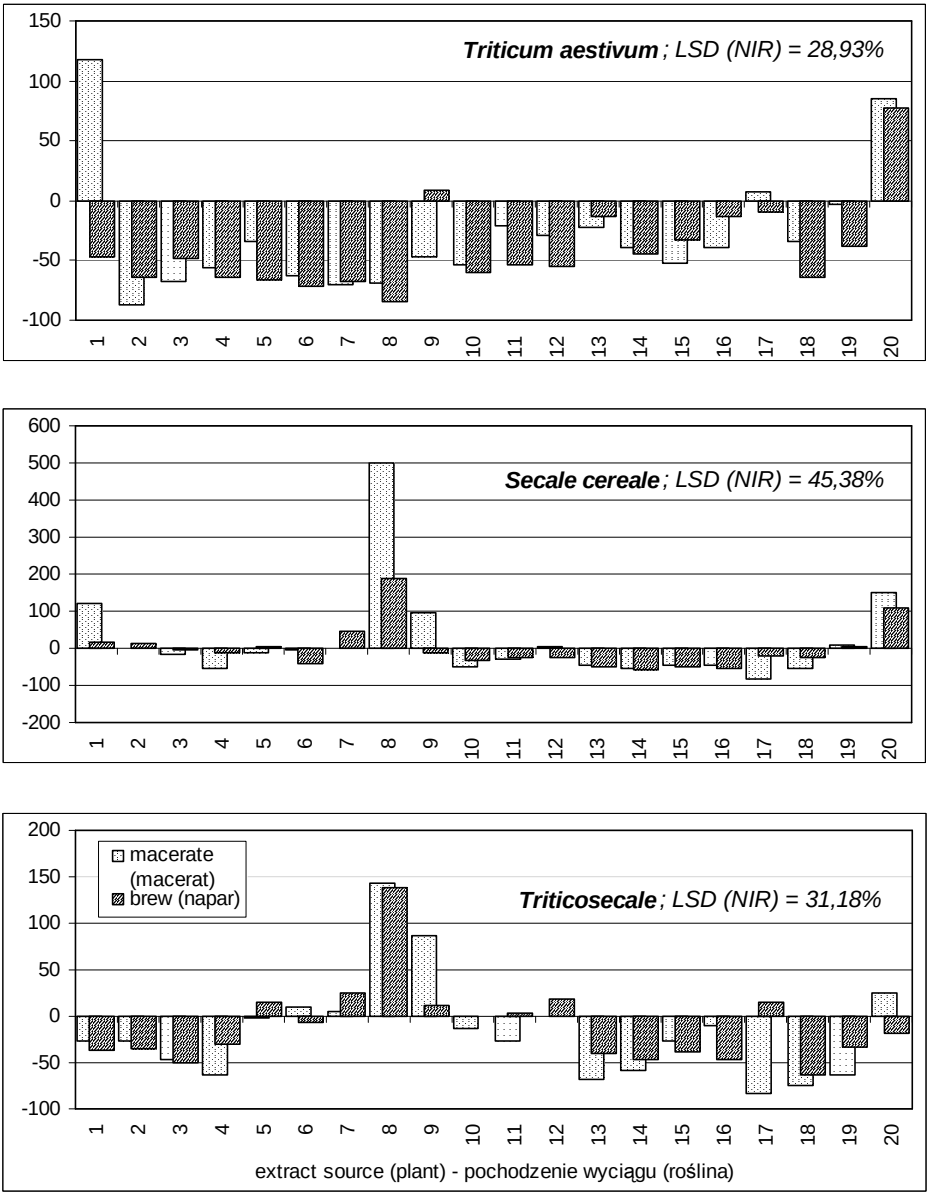


Fig. 4. A seeds healthiness depending on a source and a preparation mode of the extracts (number of infested seeds – deviation from control in %)

Rys. 4. Zdrowotność nasion w zależności od pochodzenia i sposobu przygotowania wyciągów (liczba nasion porażonych – odchylenie od kontroli w %)

It was stated, that similarly as in researches of other authors (Boligłowa, Znój 2002) an activity of the extracts prepared from various plant species in relation to microorganisms was different. Some of them stimulated and the others inhibited a growth and development of pathogens, what can be considered as a confirmation of previous researches (Piotrowski and others 1995). In the present paper the healthiness as well as vitality of seeds of *T. aestivum* were increased by infusions from *A.hippocastanum* and *S.officinalis*, maceration from *B.verrucosa*, *A.vulgaris* and *A.hippocastanum*; of *S.cereale* – by maceration from *T.officinale*, maceration and infusion from *C.oxyacantha* and *F.alnus*; of *Triticosecale* – by macerations from *T. officinale*, *I.helenium* and *C.oxyacantha*, while the macerations from *S.nigra* and *R.canina* influenced negatively the healthiness and vitality of the seeds.

The observed differences in effectiveness of the extracts should be connected with a content in the plants of specific substances and their different solubility in water or in organic solvents used for extraction. It was stated, that the effectiveness of alcohol or acetone extracts was in general higher than of water extracts (Sas-Piotrowska, Piotrowski 1997a and b; Krupiński, Sobiczewski 2001).

However taking into account possible costs, in the present work only water extracts (macerations and infusions) were prepared. So, a factor differentiating their effectiveness was a solubility of active substances in water. Among those plant substances with favorable action on healthiness and vitality of the seeds may be mentioned: tannins, anthocyanins, phenolglucosides, organic acids saponins, gallic acid, bitter substances, quinones and coumarins (Kohlmunzer 1984, Ożarowski 1980). It should be emphasized that the mentioned substances play a significant role in arising of a resistance of the given plants against specific active agents (Trzebiński 1970; Whitehead, Bowers 1985).

5. Conclusions

1. A vitality and a healthiness of the seeds depended both from a species of a grain plant and from an extract source and its mode of preparation.
2. A vitality of seeds of *T.aestivum* was stimulated by infusions from *A. hippocastanum*, *S.officinalis*, *A.sativum* and *M.piperita*, of *S.cereale* – by infusions from *C.oxycantha* and *Z.mays* and macerations from *T.officinale* and *F.alnus* and of *Triticosecale* – by infusions from *Z.mays*, *M.officinalis* and *F.alnus.*
3. A healthiness of seeds and emerging plants of wheat was improved in general by the same extracts which influenced positively on vitality of the seeds. There were in a case of *T.aestivum* infusions from *A. hippocastanum* and *S.officinalis*, maceration from *B.verrucosa*; of *S.cereale* – maceration

from *T.officinale*, infusion from *C.oxyacantha and F.alnus*; and of *Triticosecale* – macerations from *T. officinale, I.helenium* and *C. oxyacantha.*

4. Negatively on a vitality and healthiness of seeds of investigated grain plants influenced macerations from *S.nigra* and *R canina.*

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Wyciągi roślinne i ich oddziaływanie na niektóre cechy nasion roślin uprawnych – rośliny zbożowe

Streszczenie

W pracy analizowano wpływ wyciągów wodnych sporządzonych z 20 gatunków roślin: *Sambucus nigra* L.; *Betula verrucosa* Ehrh.; *Artemisia vulgaris* L.; *Allium sativum* L.; *Aesculus hippocastanum* L.; *A. hippocastanum* L.; *Mentha piperita* L.; *Saponaria officinalis* L.; *Urtica dioica* L.; *Equisetum arvense* L.; *Marrubium vulgare* L.; *Acorus calamus* L.; *Crataegus oxyacantha* L.; *Frangula alnus* Mill.; *Zea mays* L.; *Melissa officinalis* L.; *Taraxacum officinale* Web.; *Inula helenium* L.; *Matricaria chamomilla* L.; *Rosa canina* L. na zdrowotność i żywotność nasion: *Triticum aestivum* L; *Secale cereale* L; *Triticosecale* Wittm.

Wykazano, że wyciągi sporządzone z poszczególnych gatunków roślin, a także przygotowane wg odmiennych procedur, istotnie różnicowały energię i zdolność kiełkowania oraz zdrowotność nasion *Triticum aestivum*, *Secale cereale* i *Triticosecale.*

Energię kiełkowania nasion *T.aestivum* stymulowały najsilniej napary z kwiatów *A.hippocastanum* (+10,6%), korzeni *S.officinalis* (+9,4%) i liści *M.piperita* (+9,1%); *S. cereale* – napary z kwiatostanu *C.oxyacantha* (+8,7%) i znamion *Z.mays* (+7,3%); *Triticosecale* – napary ze znamion *Z.mays* i liści *M.officinalis* (po +22,1%) oraz kory *F.alnus* (+19,3%).

Wpływ wyciągów na energię i zdolność kiełkowania nasion zbóż był ze sobą pozytywnie skorelowany. Wartości współczynników korelacji wynosiły 0,919** dla *T.aestivum*; 0,975** – *S.cereale* i 0,902** – *Triticosecale*. Również zmienność (V%) reakcji roślin zbożowych na testowane wyciągi była niewielka i do siebie zbliżona (od 15,2% do 22,5%).

Najkorzystniej na zdolność kiełkowania nasion *T.aestivum* działały napary z kwiatu i kory *A.hippocastanum* (+21,0; +19,4%), cebul *A.sativum* (+19,4%) i liści *M.piperita* (+19,4%), podczas gdy w przypadku *Triticosecale* były to napary z liści *M.officinalis* (+26,1%) i z kory *F.alnus* (+25,3%). Kiełkowanie nasion *S.cereale* stymulowały natomiast macerat z korzenia *T.officinale* (+8,1%), napar z kwiatostanu *C.oxyacantha* (+8,1%) oraz macerat z kory *F. alnus* (+7,0%) i napar ze znamion *Z.mays* (+7,0%).

Oddziaływanie wyciągów na zdrowotność nasion zbóż było bardziej zróżnicowane aniżeli na energię i zdolność kiełkowania. Współczynniki zmienności (V%) wynosiły 65,7% (pszenica); 91,1% (żyto) i 58,5% (pszenżyto). Ich wpływ na liczbę porażonych nasion oraz na energię i zdolność kiełkowania był ujemnie skorelowany. Współczynniki korelacji wynosiły -0,720** i -0,907** dla *T.aestivum*; -0,774** i -0,771** dla *S.cereale* oraz -0,572** i -0,528** dla *Triticosecale*. Oznacza to, że im silniej badane wyciągi ograniczały porażenie nasion roślin zbożowych przez mikroorganizmy, tym większa była ich żywotność.

Liczbę chorych nasion *T.aestivum* ograniczały zatem napary z korzeni *S.officinalis* (-83,9%) i kwiatu *A.hippocastanum* (-71,3%), macerat z liści *M. piperita* (-70,1%) i *B.verrucosa* (-66,7%), podczas gdy w przypadku *S. cereale* był to macerat z korzenia *T.officinale* (-81,4%) i napar kory *F.alnus* (-56,6%); a *Triticosecale* - maceraty z korzeni *T.officinale* (-82,6%), kwiatostanu *C. oxyacantha* (-68,0%), macerat i napar z korzeni *I.helenium* (-74,4; -63,4%).