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Equisetum arvense L. AS A BIOINDICATOR OF ACID SOILS

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Abstract

Bioindicator plant species are useful in deciding which species or cultivars of plants can be grown, which soil analysis should be performed and how soils with some limiting characteristics for plant growing can be improved. In agricultural practice Equisetum arvense is known as a bio-indicator species for acid soils with excess moisture. Diminution of acid soils can be achieved by liming. In such cases, the incorporation into the soil of calcium carbonate to diminish the acidity is not always justified. In order to make a correct decision, it is necessary to perform soil analysis. Equisetum arvense is frequently found on soils with a compacted plow pan. It is not justified in this case to carry out drainage works. We consider the results obtained from the studies carried out regarding the characteristics of the habitats of this species will be useful in order to take sustainable measures for the management of soil resources.

Key words*: horsetail, compacted soil, wide pH amplitude.*

INTRODUCTION

According to Wikipedia the free Encyclopedia, *Equisetum* (horsetail, snake grass, puzzlegrass, candock, scouring-rush) is the genus of plants belonging to the the living genus in *Equisetaceae*, a family of vascular plants that reproduce by spores rather than seeds of *Equisetaceae* family.

The term, *Equisetum* derives from the latin words *equus* and *seta* which means the *horse* and respectively *bristle* or *hair*, i.e. horsetail (Chifu, 2006).

In Romania, are known eight plant species belonging to the genus *Equisetum* (E): *E. arvense, E. pratense, E. palustre, E. ramosisisma, E. fluviatile, E. syilvestris, E. maxima, E. hyemale* (Grintescu et al., 1952).

The genus *Equisetum* can be considered cosmopolitan because missing in some region such as Antarctica, Australia and New Zealand (https://en.wikipedia.org/wiki/Equisetum).

The requirements of *Equisetum* species are very different from ecological factors such as light, temperature, soil moisture, soil reaction and content of nutrients.

The species *Equisetum fluviatile* with the highest requirements for soil moisture is followed by species *E. telmateia, E. variegatum* that have moderate to high requirements for soil water content (Chifu et al., 2006).

After Atland (2003) *Equisetum fluviatile*, is an emergent aquatic, rooted in water with shoots growing into the air. The stalks arise from underground rhizomes that are difficult to dig out (https://en.wikipedia.org/wiki/Equisetum).

In some publications it is mentioned that *Equisetum arvense* is a plant bioindicator of moisture excess (waterlogging) and in other more recent publications it is considered that this species has moderate water requirements.

Knowing the water regime in the soils in which horsetails are abundant is important in order to establish the correct improvement measures.

Berca (2004) noticed that *Equisetum arvense* is found in all areas of the country, on different types of soil in annual or perennial plant crops, as well as in rural places. It does not tolerate cold, frost and shade, elements that can be used in weed control.

Some species such as *Equisetum ramosissimum*, *E. telmateia* and *E. variegatum* are common on slight alkaline soil. Another species such as *E. ramosissimum* are common on a soil with a high level of acidity.

The shade sensitivity of *E. arvense* can partly be explained by its small, scale-like, non-functional leaves at the nodes (Holm et al., 1977).

E. arvense has a high potassium demand, especially at high nitrogen levels.

E. arvense is tolerant of low levels of nitrogen but will be overtopped by fast-growing species

when competing for increased supplies of nitrogen. (Andersson and Lundegårdh, 1999).
Most of the publications that address *E. arvense* mention that this plant is bioindicative to acid soils and therefore it is recommended to apply calcium carbonate amendments to reduce soil acidity and thus reduce the degree of infestation of this agricultural weed (Ionescu-Şişeşti et al., 1958; Budoi et al., 1994; Gus et al., 1998; Lăzureanu, 1994).
Studies conducted by Chifu et al. (2006), showed that *E. arvense* has a wide ecological amplitude for pH, it develops on both acidic and neutral or slightly alkaline reaction soils.
In these cases, the application of limestone to reduce soil acidity would not be justified in all habitats with *Equisetum arvense*.
Field horsetail can be very competitive in crops for light, water and nutrients as its rhizomes can form an underground dense network during the growing season, especially summer and autumn growing seasons (James and Rahman, 2010). The plant can regrow from very small pieces of rhizome remaining in the soil (Chirilă, 2001).
The correct identification of *Equisetum* species and the knowledge of the requirements for ecological factors is useful in establishing the most appropriate measures to reduce weeding.
In this paper we intend to come up with additional data on soil characteristics in which the presence of this species has been found.

MATERIALS AND METHODS

Investigations were conducted in the agricultural area from the north-eastern part of Romania.
In our investigations have been taken many pictures with digital camera and have been collected samples of biological material consisting of mature plants of *Equisetum* sp.
The obtained images in the field were stored, analysed and processed on the computer. Biological collected material was used in order to establish genus and species of plants. The binomial nomenclature of plant species was done on behalf of the rules of the International Code for Botanic Nomenclature reviewed in the latest taxonomy works (Ciocârlan et al., 2004).
Diagnosis and name of the soil was done according to new Romanian Sol Taxonomy System known as STRS 2003 (Florea & Munteanu, 2012; WRB-World Reference Base for Soil Resources, 2014).
Soil samples were taken from each pedogenetical horizon in order to conduct laboratory analysis such as particle size, calcium carbonate, pH, content of organic carbon, cation exchange capacity).
The analysis was performed according to the standard methods presented in the current methodology (Dumitru et al., 2009; Lăcătușu et al., 2017).

RESULTS AND DISCUSSIONS

In order to establish control measures of horsetail weeds, it is necessary to correctly identify the species, the knowledge of the biology and the ecological requirements for environmental factors such as light, temperature, soil moisture, content of the nutrients etc.
Many authors noted that green stems of *Equisetum arvense* may be easy mistaken with other species such as *E. pratense, E. palustre, E. sylvaticum*, *E. pratense* Ehrh. may be distinguished by the presence of long thin silica spicules on the ridges of the middle and upper internodes of the main stem (Cody & Wagner, 1981).
E. sylvaticum L. may be easy distinguished by secondary branching of the branches. *E. palustre* L. (Figure 1) may be distinguished by the first branch internode being shorter rather than longer than the subtending stem sheath.
In Romania, *E. palustre* is the most toxic species belonging to the family Equisetaceae (Anghel et al., 1972) and the Equisetum is spread over large areas, starting with the forest-steppe zone to the forest area with spruce forests. It is found in cereals, corn, potatoes, meadows and even in plastic tunnels used predominantly for growing vegetables.
Our studies conducted in poly-tunnels located in the northeastern part of Romania have highlighted the strong infestation of soils horticultural substrata with *Equisetum arvense* and *Equisetum pratense* (Figure 2).

Figure 1. Fertile shoots of *Equisetum palustre*

Figure 2. Strong infestated soil with horsetail from plastic tunnels in Targu Frumos (foto: F. Filipov, 2014)

Special attention must be paid to the weeds of *Equisetum arvense* because they may expand rapidly after they have established themselves, and may subsequently dominate for years.

Horsetail is a very competitive species, online there are images available with the asphalt traversed by plant developed from rhizomes (https://www.vc77botany.org/equisetum-species-horsetails).

Even if it seems impossible, we also noticed that asphalt path can be traversed by plant roots or runners that develop from buds on roots or rhizomes of couch grass. The land infestation with couch grass caused gradual and continuous degradation of asphalt paths around (Filipov, 2013).

Field horsetail can also expand the rhizomes that grow in the cracks resulting from drying of compacted soils.

Such a case was reported by us in the pathway in the vicinity of the plastic tunnel located on a Phaeozems with a compact under ploughed layer that can be defined as plowpan.

Following some brief analysis performed on the plowed layer, it was shown that the reaction is slightly acidic (pH = 6.4), clay loam texture (clay = 34.8%) and well supplied with humus and nutrients of nitrogen, phosphorus and potassium.

The sterile stems grown from the rhizomes in the cracks of the strongly compacted soil on the access alley in the plastic tunnel can be seen in Figure 3.

Figure 3. *Equisetum arvense* grown from rhizomes extended into cracks in compact soil

In our studies, we identified weeds of horsetail that perforated the black plastic foil (Figure 4) used as mulch in polytunnels from Dumbrava, Neamt county.

Highly heated foil during the day can be perforated by sterile growing horsetail stems.

The strong heating of the foil takes place during the summer and corresponds to the intense growth and expansion of the surfaces infested with horsetail.

Figure 4. Perforation of black plastic foil by *Equisetum arvense* (foto: F. Filipov, 2012)

We also noticed that horsetail infestation occurs on Aluviosol with slight alkaline soils (Figure 5) with pH of 7.8.

Figure 5. *Equisetum arvense* on the slight alkaline alluvial soil

Horsetail infestation was also noticed on soils with good external drainage, but with a strong hardpan (Figure 6).

Following the description in the field, soil was named as Faeoziom cambic (after Romanian Soil Taxonomy System-2012) or haplic Phaeozems (after WRB-2014).

Haplic Phaeozems (Figure 7A, Figure 8) is strong compacted in the upper part of soil profile, over the depth between 0 and 35 cm. The strong compaction of the soil is evident both in the plowed layer and in the underlying horizon (Figure 7B) and is due to poor agricultural practices.

Figure 6. Infestation with *Equisetum arvense* of sloping ground with good external drainage

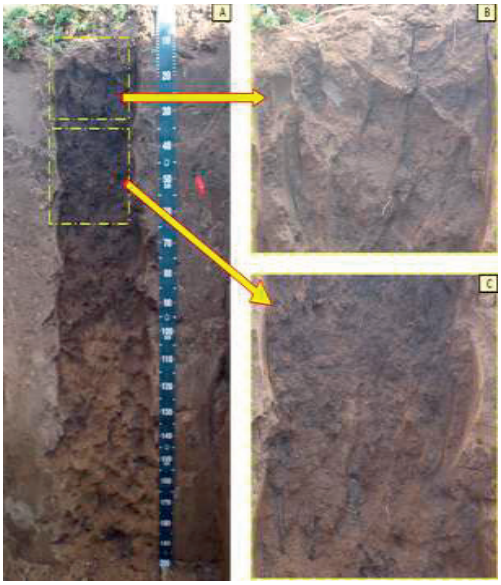

Figure 7. Soil profile of haplic Pheozems (A); Strong compacted upper part of soil (B); Frequent galleries of earthworms (C)

Strong soil compaction favors soil erosion that is easily observed in the field, especially on the tracks of farm machinery wheels.

The soil layers located at a depth higher than 35 cm is maintained loose (Figure 7C).

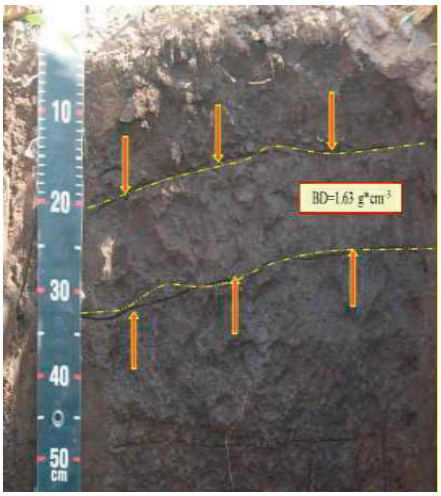

Figure 8. Soil strongly compacted on the depth of 20-32 cm

The presence of earthworm galleries indicates that in this soil the biological activity was intense. Earthworm species are a very good bio indicator of soil health. Earthworm populations have declined considerably with soil degradation through compaction and due to using high doses of the chemical fertilizers.

We consider that the compaction of the upper part of the ash, which favored the retention of a larger amount of water, the soil tillage frequencies allowed the multiplication of the horsetail and the extension of the weeding.

Some soil properties are presented in Table 1. In the ploughed horizon is registered pH value of 7.47.

Table 1. Some properties of Phaeozems infested with horsetail

Depth cm	Clay %	pH	$CaCO_3$ %	T me/100 g	OC (%)
0-30	32.50	7.47	-	19,73	1.7
30-55	33.71	6.95	-	20,3	1.5
55-75	29.58	6.61	-	19,7	--
75-115	28.93	7.58	2.63	18.38	-
115-155	28.11	823	4.61	16.31	-

OC-organic carbon; T cation exchange capacity

We mention that in our studies the most common horsetail infestations were found on acid soils. As weakly alkaline soils infested with *E. arvense* were also noticed, we recommend that the establishment of the opportunity to decrease soil acidity should be done following the laboratory analysis.

The competitiveness of horsetails to infest agricultural land is also due to its biological characteristics.

The experiment conducted by the Cody and Wagner (1981) highlighted that, in growth room, a rhizome of horsetail with length of 10 cm has produced a total of 64 m of rhizome in a year. Some biological characteristic that favor the spread of this species are summarized in Figure 9.

Several authors (James and Rahman, 2010) has noted that in the agricultural land where horsetail is well established and has an extensive root system, effective control weeds with herbicides is very difficult due to the biological characteristics of *Equisetum arvense*.

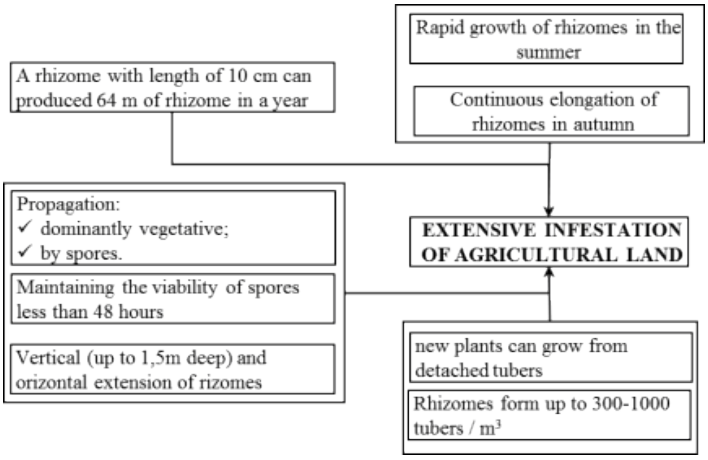

Figure 9. Diagram with some biological characteristics of *Equisetum arvense*

CONCLUSIONS

The genus *Equisetum* includes several species of plants with different ecological requirements. *Equisetum arvense* is frequently spread on soils with compacted under ploughed layer. In this case, it is necessary to loosen the soil in order to increase the draining porosity from the upper part.

Underground drainage is not justified when the soil is loose under the layer of plough pan.

Equisetum arvense is a plant species with wide ecological amplitude for soil reaction. The application of amendments containing calcium carbonate is not always justified.

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