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Agropyrum repens IN THE FUNCTION OF PHYTOREMEDIATION AND SOIL PROTECTION

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Abstract

Agropyrum repens is a perennial plant from the grass family (*Poaceae*). In this paper, the use of *Agropyrum repens* in soil protection and phytoremediation of degraded areas, and as a medicinal and decorative plant is analyzed. The fact that *Agropyrum repens* can be grown even in marginal agro-ecological conditions gives us the opportunity to establish perennial grass areas on unused and degraded areas. Thanks to the development of new technologies for the processing of biological waste into energy products, the rate of increase in the use of alternative fuels is growing significantly, and tall mash, thanks to its modest requirements for water and heat, can be classified as a desirable energy crop. *Agropyrum repens* is one of the best crops for soil protection against all types of erosion, then for phytoremediation, absorption of harmful gases from the atmosphere, and it is valued as a decorative and ornamental plant. In order to ensure security in the supply of necessary energy sources, most countries in the world direct their research in the direction of finding the most rational way of using renewable energy sources. In folk medicine, pyrethrum is used in the prevention of gout, rheumatism, and inflammation of the urinary tract and renal stones.

Key words: *Biological waste, biofuels, Agropyrum repens, renewable resources, phytoremediation, medicine*.

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Introduction

Grasses have been around since the beginning of civilization had a significant role in human society. According to archaeobotanists, man has been growing and using a large number of annual and perennial grasses for more than ten thousand years. From the very beginnings of civilization (Paleolithic and Neolithic), people have used single-grain and double-grain wheat, then millet, maize and sorghum to prepare food, and harvest residues to feed domesticated animals. The biomass of deforested trees was used for the construction of residential buildings, in home crafts or as firewood. As concluded by Lord et al. (2015) tall perennial grasses have higher net calorific value productivity and greater ecological benefits than annual crops, because they have a reduced negative impact on the environment. Soil cultivation is performed once during the long life cycle of plants. Thus, its negative impact on physical and chemical properties is reduced, on erosion, as well as on the loss of carbon from the soil. During photosynthesis, these plants absorb large amounts of carbon dioxide, reducing the greenhouse effect as a result of global warming of the planet. The possibility of growing tall grasses on degraded or neglected agricultural lands increases their economic importance. If these lands are grown as cover crops

have a very positive impact on the ecosystem. They turn sunlight into organic matter with which they enrich the soil (phytoremediation). During the year, they consume large amounts of carbon dioxide and release oxygen into the atmosphere, which is of particular importance if the crops are located next to major environmental pollutants. *Agropyrum repens* are an excellent habitat for noble game, which provide food and peaceful shelter. In the middle of the 20th century, tall sorghum was transferred to other agro-ecological regions from its area of origin as an interesting one for introduction into agricultural production. Scientists, studying the great potential of this wild plant species, discovered the great potential of high sorghum. During the complex breeding work, a large number of genotypes for different ways of use were obtained by the selection of the most suitable forms and mutual and interspecies crossings. In the past decades evident climate changes in large geographical areas have increased the interest of primary agricultural producers in growing high sorghum, especially in marginal agroecological conditions. *Agropyrum repens* plants make excellent use of available water and collect salts from their rhizosphere, which are stored in underground bodies and prevent them from dissolving during the rainy season and reaching underground watercourses. Strong root system and with a solid hip bind the surface layer of the soil and prevent erosion caused by wind and water torrents (Liu and Wang, 2010). *Agropyrum repens* is one of the best crops for soil protection against all types of erosion, as well as for phytoremediation, absorption of harmful gases from the atmosphere, and it is also valued as an ornamental plant. It is rich in carbohydrates, which can be used in many ways, including for obtaining biofuel. Due to these properties, as well as the fact that it has negligible nutritional value, today it is mainly used to obtain biofuels and is considered one of the most important energy crops of the third generation, and it is also used as a medicinal plant.

Material and methods

This paper analyzes the use of high rennet in: - Soil protection and phytoremediation of degraded areas; -As a medicinal plant; and -As a decorative plant.
In recent times, it is one of the best crops for soil protection against all types of erosion, then for phytoremediation, absorption of harmful gases from the atmosphere, and it is also valued as an ornamental plant. Many years of work on the breeding of this species resulted in a number of different forms, which served as the basic material for the creation of high puree varieties.

Results and discussion

Soil protection and phytoremediation of degraded areas

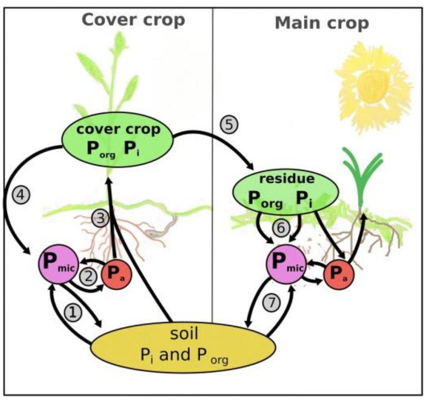
Previous research has shown that *Agropyrum repens* is an excellent cover crop, suitable for establishment on dry highly saline soils poor in plant assimilatives then on sloping terrains subject to water and aeolian erosion. The best way to use the biomass produced on these areas is by grazing domestic animals, which keep the lawn free of weeds and encourage the regeneration of above-ground biomass. The effectiveness of cover crops depends on many factors, from agroecological conditions to the applied production technology in establishing and maintaining these plant communities. In the formation of a strong vegetative cover on land under reclamation or on surfaces exposed to erosion, it is very important to adequately protect the newly formed perennial crop from weeds, Picture 1a-d.

Picture 1. *Agropyrum repens crops (a.), rhizome (b.)*, Flower spike (c)

Milchunas et al. (2011) point out that weed protection with the use of herbicides is not suitable, especially in the grass-leguminous mixture, but neither is biomass mowing. As the most effective measure of weed protection in order to form a solid grassland, these authors suggest the selection of species for cultivation with pronounced allelopathic interactions and planned grazing of these grasslands, especially in the first three years of the life cycle. On highly alkaline soil, tall sedge plants with their roots prevent the capillary rise of salt and thus affect the reduction of its salinity in the rhizosphere layer. Soils that are partially freed from excess salt ions absorb water better, and this prevents silting and freezing of grass-leguminous mixtures on these meadows and pastures. In recent times, in many agricultural areas, both in the world and in our country, increased soil salinity is a major problem in environmental protection. In the soil phytoremediation system, the cultivation of *Agropyrum repens* , in order to release excess salt in the arable layer, can be applied as a supplement to basic desalination methods. on saline and devastated lands.

Cover crop

Cover cropping is the practice of growing plants, usually in the off-season, leaving their biomass on the field to provide various benefits for the agroecosystem, including erosion reduction, soil organic matter (SOM) build-up, weed and pathogen control, and nutrient management. Cover crops are also used to improve the P efficiency of added organic or mineral fertilizers by increasing soil biological activity or uptake and protection of soluble mineral P in strongly P-fixing soils (Kamh et al. 1998; Kuo et al. 2005; Hallama et al., 2019), Picture 2.



Picture 2. The roles of cover crops and soil microorganisms in phosphorus cycling through agroecosystems

Source: https://link.springer.com/article/10.1007/s11104-018-3810-7/figures/2

Pathways of phosphorus (P) transfer and plant-microbial processes affecting P availability by cover cropping. 1) Soil P pools of varying degrees of availability are solubilized and/or mineralized and are immobilized in the microbial biomass. 2) The microbial biomass releases P into the soil solution which 3) ends up in the plant via root or mycorrhizal uptake. Cover crops may additionally possess the capacity to mine P from poorly-available P pools or to produce biochemical rhizosphere modifications to increase P availability. 4) The roots release rhizodeposits that shape the microbial community, eventually leading to increased P mining. 5) The P stored

in the cover crop biomass is transferred to the main crop via cover crop residues, which are decomposed by the soil microbial community (6). The soil microbial community (i.e. mycorrhizal fungi) in the main crop phase, enhanced by the cover crops, may possess an increased capacity to mine P for the main crop (7).
In principle, most plant species could be used for these purposes, and the list of plant species that can be used as cover crops is rapidly expanding. Agronomic requirements of the cover crops (e.g., rapid growth and high biomass production, weed suppression, easy termination) impose some restrictions (Hallama et al., 2019).

Medicinal plant

Agropyron repens (L.) P. Beauv. or *Elymus repens* (L.) Gould (couch grass, quack grass) is a well-known perennial rhizomatous plant, native from Europe and Central Asia, but wide spread in the world. Its notoriety is mainly due to its infesting action in crops (Touchette et al., 1988), and to a quite minor extent of its use as a traditional medicinal plant for urinary problems (Alosy, et al., 2019; Tsubanova, et al. 2019; Kasote et al., 2017). Ellagic acid (EA), Catechin (Ca), Hesperidin (He) structure is shown in Fig. 1.

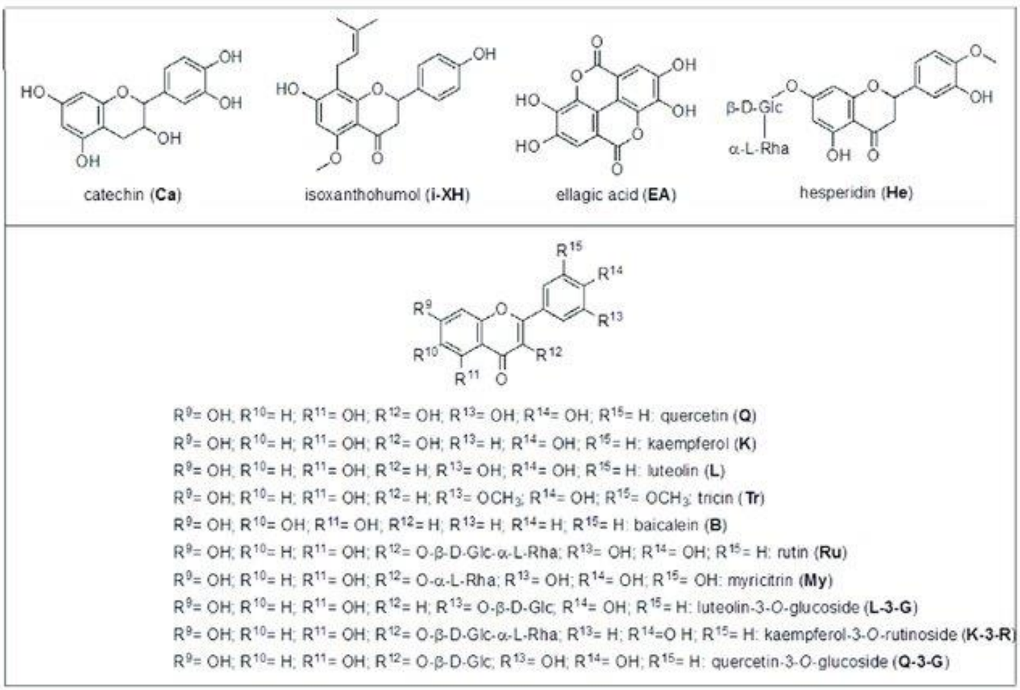


Figure 1. Flavonoids (Fs) structures

The traditional medicinal use in urinary calculus disease has received scientific confirmation, including for its other pharmacological effects (Al-Snafi, 2015), Fig. 3. Among the pharmacological actions, there are the hypoglycemic (Eddouks et al., 2005), antiinflammatory (Petrova et al., 2009), and antidiabetic activities (Neagu et al., 2019), effects on motility (Kiesewette & Möller, 1958), and beneficial effects in urinary tract infections (Hautmann & Scheithe, 2000).

Chemical constituents

The plant contained carbohydrates (fructose, glucose, inositol, mannitol), mucilaginous substances (10%), pectin, triticin, cyanogenetic glycosides, flavonoids, soponins, volatile oils 0.05%, essential oil (0.01-0.02%), 25% monoterpens (carvacrol, carvon, trans-anethole, thymol and menthol, among others) and 0.85% sesquiterpenes, 25% monoterpens (carvacrol, carvon, trans-anethole, thymol and menthol, among others) and 0.85% sesquiterpenes. Other constituents included vanillin glucoside, ironand other minerals, and large quantities of silica (Al-Snafi, 2015). The plant contained carbohydrates, mucilaginous substances, pectin, triticin, cyanogenetic glycosides, phenol compounds, flavonoids, soponins, volatile oils, essential oil, vanillin glucoside, iron and other minerals, and large quantities of silica. It possessed hypoglycemic, hypolipidemic, anti-inflammatory and diuretic effects (Al-Snafi 2015). The rhizomes, as well as the fresh above-ground biomass (young leaves), have medicinal properties, Picture 3.

Picture 3. “Pirevina” Rhizome tea

The peoples of Europe and the Middle East have been using juices, obtained by squeezing the rhizomes and leaves of ”pirevina” (and other species of the grass family), as well as teas, in folk medicine since ancient times (Husain et al., 2017). The juice squeezed from the rhizome is rich in vitamins A, E, S, K and V6, then calcium, magnesium, selenium and iron salts, as well as antioxidants (Das et al., 2012). The juice has a sweet taste and fresh juice serves as an auxiliary medicinal tool for the treatment of many diseases, for example: anemia, and diseases that occur due to the low supply of vitamins and mineral salts in the body. It is used against the occurrence of rickets, anemia, eczema, purulent inflammations, rheumatism, diseases of the bile, liver, intestines and jaundice. Teas made from dry rhizomes are used in a similar way. A wide range of health benefits is attributed to juices extracted from fresh above-ground biomass, as they contain significant amounts of chlorophyll, flavonoids and vitamins (S and E).

Preparations in the form of powder, tablets, fresh juice, as well as frozen juice are in use, they are used equally in the pharmaceutical and cosmetic industry as an important additive in numerous preparations for treatment and care (Burić et al., 2024a; 2024b; Filipović et al., 2024; Popović et al., 2024). As stated by Bar-Selaet al., (2008), preparations based on juices from leaves and sprouts serve in the prevention of cancerous diseases, then rheumatic arthritis, diabetes, against obesity, as well as for mitigating the side effects of chemotherapy, oxidative stress, etc. These studies are ongoing in many countries, but the use of these preparations is increasing.

Decorative plant

Many years of work on the breeding of this species resulted in a number of different forms, which served as the basic material for the creation of high puree varieties. Forms with lower trees covered with leaves in different shades of color are separated into a separate group. These decorative varieties can be grown both in pots, on terraces, and on larger park areas, covering the entire area, or in the form of decorative bushes next to paths and around tall flower beds. Tall sedge can also be a dangerous weed, if seeds from mature plants reach the surrounding arable land. Therefore, regular mowing and properly balanced grazing, which keeps the plants at a height of about 10 cm, are the best ways to prevent the spread of this species outside the area where it is grown. In order to prevent the spread of seeds, the areas under high heather should be fenced off (Glamočlija et al., 2012; 2015; 2022).

Agropyron repens is a Allelopathic potential

The *Poaceae* family plants generally express their allelopathic activity which commonly occur in both cultivated and wild *Gramineae* (Sánchez-Moreiras et al., 2003). It is an important weed of field crops, which seriously impacts yield of maize and potato by interfering uptake of nitrogen and potassium by maize and releasing ethylene in its rhizomes due to microbial activity in soil,which is responsible for allelopathic effects, resulting in decrease uptake of mineral by associated crops (Hasanuzzaman, 2015). that reduces the yield of alfalfa (Touchette et al., 1988).

Rhizomes of *E. repens* contain an inhibitor of *Medicago sativa* germination, highly active at 10-6 mg/ml that after isolation appeared to be indole-3-acetic acid (IAA) (Henk et al., 1997). It was noted that at the age of 54 days, this weed start exuding phytotoxic compounds and reduces the growth of cress seedlings and its impact reduces with the advancement its own growth. It was also reported that dicot species are more sensitive than the monocots (Margot et al., 1994)

Agropyron repens is a weedy species in crops, is one of the major weeds, spoiling the crop and its yield parameters. Reduced tillage encourages its growth pattern and this weed significantly reduces crop yield. Its alleopathic potential has also been observed in potato. On the other side, it is being considered as good palatable fodder but not enough to feed the animals under barren ecosystem. It is used traditionally as medicines for curing many human related health problems. As it has pharmacological action as soothing mild diuretic, demulcent, antimicrobial, antioxidant and for calming pain and spasm in the urinary tract. It is also used as demulcent and tonic (Raghuvanshi et al., 2021). In Table 1 shows the exploitation of cover cropping for allelopathic management of weeds, (Scavo&Mauromicale, 2021).

Table 1. Exploitation of cover cropping for the allelopathic management of weeds.

Cover Cropping Type	**Allelopathic Cover Crop**	**Main Crop**	**Target Weeds**	**References**
Dead mulching	*Helianthus annuus* L., *Zea mays* L., *Oryza sativa* L., *Sorghum bicolor* L.	Wheat	*Phalaris minor* Retz.	Abbas et al., 2018
	Trifolium subterraneum L.	Apricot	Several monocots and dicots	Scavo et ak., 2020
	Fagopyrum esculentum Moench., *Sinapis alba* L., *T. subterraneum*, *H. annuus*, *Linum usitatissimum* L., *Raphanus sativus* L., *Vicia sativa* L., *Avena strigosa* Schreb., *Cannabis sativa* L. and mixtures	Sugar beet	*Stellaria media* (L.) Vill., *Chenopodium album* L., *Matricaria chamomilla* L.	Sturm et al., 2016
Green manuring	*Eucalyptus globulus* Labill.	Maize	*Digitaria sanguinalis* (L.) Scop., *C. album*	Puig et al., 2019
	S. *alba* and *S. alba* + *Fagopyrum esculentum*	Red clover, wheat, pea, barley rotation with red clover as a undersown crop	*Cirsium arvense* (L.) Scop., *Sonchus arvensis* L., *Galium aparine* L., *Lamium purpureum* L., *Fallopia convolvulus* (L.) Á. Löve, *C. album*, *S. media*	Masilionyte et al., 2017
	V. faba	Maize	A. *retroflexus*, *C. album*, *Solanumnigrum*, *D.sanguinalis*, *Cyperus rotundus* L.	Álvarez-Iglesias et al., 2018
	Hordeum vulgare L., *V. sativa*	Maize, sunflower	*Xanthium spinosum* L. and other broadleaf species	Alonso-Ayuso et al., 2018

Cover Cropping Type	Allelopathic Cover Crop	Main Crop	Target Weeds	References
Inter-cropping	*Crotalaria juncea* L.	Cotton	*C.rotundus*, *Alternanthera paronychioides* A. St.-Hil.	Blaise et al., 2020
	Trigonella foenum-graecum L.	Coriander	Several monocots and dicots	Pouryousef et al., 2015
	F. esculentum, *Lens culinaris* Medik., *S.bicolor*, *H. annuus*	Soybean	*C. album*, *Polygonum persicaria* L.	Cheriere et al., 2020
	T. repens	Wheat	*A. fatua*, *S. media*, *M. recutica*	Vrignon-Brenas et al., 2018

As observed for crop rotation, cover cropping is commonly adopted in low-input agriculture and organic farming, to control the soil weed seedbank and prevent weed emergence (Scavo, Mauromicale, 2020). The weed-suppressive ability of cover crops is a result of physical and allelopathic effects, which in the field often act in synergism (Lemessa, Wakjira, 2014).

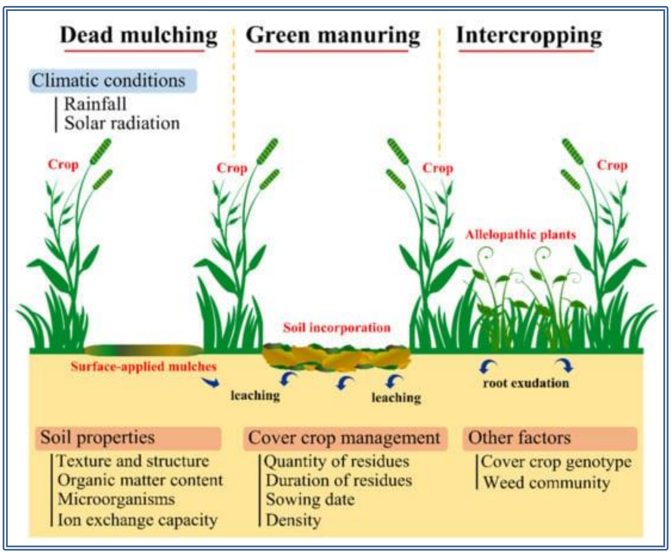


Figure 2. Practical applications of allelopathic cover cropping by intercropping, surface-application (dead mulching) and soil incorporation (green manuring) of crop residues

Root development, rapid growth, length of biological cycle and biomass production are factors determining the competitive capacity of cover crops for light, water, nutrients and space. Generally, the greater the biomass production and biological length, the higher the cover crop phytotoxicity (Restuccia et al. 2020). Both cover crops and mulches can indirectly affect weed density by favouring predators that eat seeds (Westerman et al., 2011). The efficacy of allelopathic weed suppression is mediated by climatic conditions, soil properties, cover crop genotype, quantity, duration and placement of cover crop residues, and biological characteristics of the weed communities (Scavo & Mauromicale, 2021), Figure 2.

Allelopathic effects are due to the release of active allelochemicals into the soil through root exudation from living mulches and leaching from decomposing residues. The level of phytotoxicity is closely influenced by climatic conditions (rainfall, solar radiation), soil properties (texture, structure, organic matter content, pH, cation exchange capacity and microorganisms), characteristics of the weed community, cover crop genotype and management (quantity and duration of residues, sowing date and density).

Conclusion

- The fact that *Agropyron repens* can be grown even in marginal agroecological conditions gives us the opportunity to establish perennial grass areas on unused and degraded areas.
- *Agropyron repens* is one of the best crops for soil protection against all types of erosion, then for phytoremediation, absorption of harmful gases from the atmosphere, and it is valued as a decorative and decorative plant.
- In recent times, in many agricultural areas, both in the world and in our country, the increased salinity of the soil represents a major problem in environmental protection. In the soil phytoremediation system, the cultivation of tall peat, in order to release excess salt in the arable layer, can be applied as a supplement to basic desalination methods.
- In a system of sustainable production, *Agropyron repens*could be grown as a cover crop or for grazing domestic animals in semi-arid regions of Serbia, on saline and devastated lands.
- In a separate group, the forms of *Agropyron repens,* which have lower trees overgrown with leaves in different shades of color, are separated. These decorative varieties can be grown both in pots, on terraces, and on larger park areas, covering the entire area, or in the form of decorative bushes next to paths and around tall flower beds.
- *Agropyron repens* can be a dangerous weed, if the seeds from mature plants reach the surrounding arable land. Therefore, regular mowing and properly balanced grazing, which keeps the plants at a height of about 10 cm, are the best ways to prevent the spread of this species outside the area where it is grown. In order to prevent the spread of seeds, the areas under high heather should be fenced off.

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