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Stanje i potencijal proizvodnje industrijske konoplje u Hrvatskoj na osnovi SWOT analize

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A CURRENT STATUS AND PRODUCTION POTENTIAL OF INDUSTRIAL HEMP IN CROATIA BASED ON A SWOT ANALYSIS

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SUMMARY

In the past, Croatia had industrial hemp cultivation mainly for fiber obtainment. Recently, the interest in seed and flower production has risen worldwide. Industrial hemp is interesting in many aspects, so the study evaluates the current status and potential of production using a SWOT analysis. The average harvested area under industrial hemp in Croatia was around 1,000 ha (2014 – 2023), with a seed yield of 0.8 t ha^{-1}. In addition to the favorable agroecological conditions, a considerable number of products and the medicinal properties of the plant provide most of the strength to the production. Still, the main weakness is a lack of specialized mechanization and specific regulations that the farmers need to circumvent, which may result in a loss of interest in production. The most common products on the market are the seeds, seed oil, and the CBD oil. Stem processing has not been developed yet, even though it has much potential.

Keywords: Cannabis sativa L., strategies, recommendations, production quantity, seed, oil

INTRODUCTION

In the middle of the 19th century, industrial hemp production in Croatia was intensified to extract the fiber from the stem. During that time, the production of industrial hemp had great economic importance, since the farmers produced almost all textiles for their needs themselves. During the 20th century, the production and processing of industrial hemp in Slavonia and Baranja was present on many family farms, and many of them had a small processing factory or a station for buying the stalk. At the beginning of the 20th century, the larger factories were built in Darda, Vladislavci, Osijek, and Vukovar, while in the second half of the 20th century, the most important were the factories in Črnkovci and Viškovci, which worked up to the early 1990s (Varga et al., 2022).

Industrial hemp seeds are used in the food industry due to their high oil (25–38%) and protein (18–23 %) content, and the cakes that remain after a cold pressing are very nutritious for cattle (Klir et al., 2019; Lančaričová et al., 2021). Due to new knowledge about the value of seeds, industrial hemp production has restarted at the beginning of the 21st century.

According to the existing legal framework, the production of industrial hemp whose content is not higher than 0.2% THC (delta9-tetrahydrocannabinol) is allowed in Croatia, as is the production of varieties that are on the Common Varietal List of the European Union (*Official Gazette* 18/2012). In the USA, the THC content for industrial hemp is 0.3 %, and in Australia 1.0 % (Sunoj Valiaparambil Sebastian et al., 2023).

According to the regulation (*Official Gazette* 18/2012), there was a limited production of industrial hemp—that is, only a production for food (seeds and flowers) was allowed— while the rest of the plant had to be destroyed. Moreover, by adopting a new law on hemp cultivation to simplify the cultivation and to allow the use of the whole plant (*Official Gazette* 107/2001, 87/2002,163/2003, 141/2004, 40/2007, 149/2009, 84/2011, and 39/2019), the cultivation of industrial hemp has been simplified and made easier for the farmers. It is now possible to use the entire industrial hemp plant for industrial purposes in the construction, textile, food, and cosmetic industries, in the paper industry and automo-

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tive industry, and in the production of biofuels (Varga et al., 2024). The variety *Cannabis indica* L. is still forbidden in Croatia due to its high THC content, which is about 5 – 30 % (Colizzi and Bhattacharyya, 2017; McPartland, 2017; Start et al., 2020; Malabadi et al., 2023), but it can be grown and produced for medicinal purposes with a special approval of the Ministry and with a license of the Agency for Medicines and Medical Products (*Official Gazette* 39/2019). With an increased focus on the medicinal use of cannabis, it is very much likely that the number of countries legalizing it for medicinal purposes will also increase around the world. In recent years, a huge interest was evinced in growing the industrial hemp varieties with higher nonpsychoactive compounds present in the plant, especially the cannabidiol—CBD (Foti et al., 2019; Pospišil and Trlaja, 2023)—and cannabigerol—CBG (Visković et al., 2023). The CBD has some positive influence on the regulation of emotions, sleep, appetite, and pain and has an antidepressant effect (Sholler et al., 2020). Unlike the industrial hemp seed oil, the CBD oil is obtained from the flower, leaf, and stem. Usually, a supercritical extraction using CO_2 in applied for the CBD extraction, and the content depends on a variety and ecological conditions, but it can usually fluctuate from 5 to 20 %, and the oil is rich in terpenes (Pexová Kalinová et al., 2021; Sunoj Valiaparambil Sebastian et al., 2023). A SWOT (**s**trengths, weaknesses, opportunities, and threats) analysis is one of the key tools, and it is very important and recommended when making all strategic decisions. The TOWS matrix enables the identification of connections between the strengths, weaknesses, opportunities, and the threats and provides a basis for the definition of strategies based on these relationships. It demonstrates how external opportunities and threats facing a particular production can be contrasted with the internal strengths and weaknesses to produce four alternative strategies.

An environmental analysis implies a research in all important features in order to identify the strategic factors that can determine a market future of production. The goal of a TOWS (**t**hreats, **o**pportunities, **w**eaknesses, and **s**trengths) matrix is to generate several different strategies, some of which can be applied in the analyzed production (Gonan Božac, 2008).

A strategy represents a broad and defined plan for the achievement of long-term goals. In some organizations, the strategies are focused on different areas, such as marketing, finance, production, research and development, and public relations. A strategy is a result of strategic planning that must be in line with the organizational goals, which in turn must be in line with an organizational purpose (Certo and Certo, 2008).

The external and internal environmental factors of industrial hemp production were the aims of this study. All factors were investigated and determined through a SWOT analysis, on whose basis a TOWS matrix (threats, opportunities, weaknesses, and strengths) was created, with an aim of connecting all components and formulating a conceptual framework for the industrial hemp production's development strategy (Certo and Certo, 2008).

MATERIALS AND METHODS

In this study, a SWOT matrix analysis was applied to the industrial hemp production—that is, to its current status and the recommendation strategies. This is one of the most well-known and basic techniques of strategic analysis. With this procedure, the strengths and weaknesses were identified in a very efficient way as the opportunities and threats of industrial hemp production.

Based on an analysis of external and internal environmental factors, the TOWS matrix was developed with the aim of connecting all components and formulating a conceptual framework for the development of a strategy for industrial hemp production. The TOWS analysis enables the creation of a conceptual framework for the identification and examination of threats and opportunities in the external environment and the assessment of weaknesses and strengths that individually or synergistically act upon a specific production/product (Certo and Certo, 2008).

The data from the Croatian Bureau of Statistics (2024) were used for the harvested area (ha), seed yield (t ha^{-1}), and total production (t) analysis.

RESULTS AND DISCUSSION

Production

On a global scale, Canada is the largest producer of industrial hemp, followed by China and France, respectively (Figure 1). France has the largest agricultural area dedicated to hemp cultivation in Europe. The other large agricultural areas with industrial hemp in Europe are located in Germany, Estonia, Lithuania, and Italy.

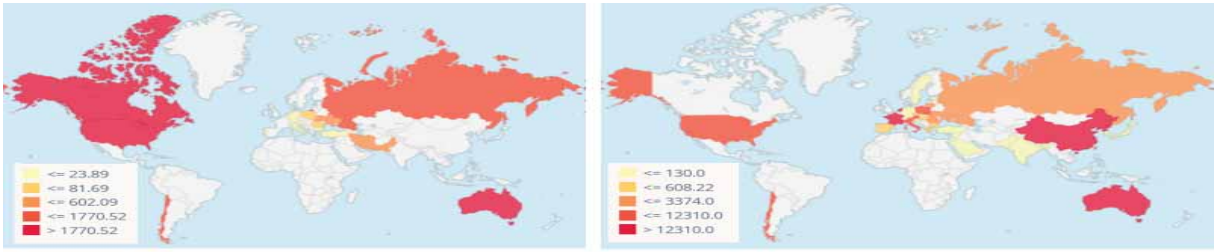

Figure 1. Hempseed production (t) (on the left) and production (t) of raw or retted hemp (on the right) the world, average 2014 – 2022 (FAOStat 2024)

Grafikon 1. Proizvodnja sjemena (t) (lijevo) industrijske konoplje i sirovoga konopljina vlakna (t) (desno) u svijetu od 2014. do 2022. godine (FAOStat 2024)

According to the Croatian Bureau of Statistics (2024), in the last ten years (2014–2023) in Croatia industrial hemp was grown on 856 ha (Table 1). The average seed yield in the analyzed period was 0.9 t ha^{-1}, and it varied from 0.4 t ha^{-1} (2014) up to 1.5 t ha^{-1} (2020 and 2023, respectively).

Table 1. The production of industrial hemp in Croatia (Croatian Bureau of Statistics, 2024)
Tablica 1. Proizvodnja industrijske konoplje u Hrvatskoj (Hrvatski zavod za statistiku, 2024)

Year / *Godina*	Harvested area (ha) / *Požnjevene površine (ha)*	Seed yield (t ha^{-1}) / *Prinos sjemena (t ha^{-1})*	Production (t) / *Proizvodnja (t)*
2014	200	0.4	71
2015	1 047	0.5	477
2016	766	0.6	490
2017	496	0.7	329
2018	1 164	1.1	1 248
2019	1 984	0.9	1 848
2020	2 055	1.5	3 105
2021	600	0.9	520
2022	133	0.5	60
2023	116	1.5	78
Average / *Prosjek*	**856**	**0.9**	**823**

Industrial hemp production chain

Most producers in Croatia grow industrial hemp according to ecological principles and register that production to sell their product more easily and to achieve a better price on the market. The farmers who plan to grow industrial hemp, or those who have already decided to sow it, should primarily know what to do with the crop yield so that they decide on the purchase and specify the price in advance. Some of the producers have their processing equipment and adequate storage warehouses, which may provide value-added products. The process flow of industrial hemp production is shown in Figure 2.

The sowing of industrial hemp in Croatia starts in the first decade of April, and it can last up to the end of May. Some producers sow industrial hemp even as a cover crop (after winter wheat) in July so that it can be harvested for flowers (tea). The farmers use sowing machines for winter wheat. During the vegetation period, appropriate pest management is required, and it depends on the organic or conventional cultivation. A seed-related harvest period depends on the maturation, weather, and seed variety, but it usually occurs at the end of September and during October and is performed by a wheat-grain harvester. In some cases, the harvest is performed manually. The harvester harvests the stem tops —namely, the tops with leaves—and then the trucks transport them to a previously agreed seed buyer, who subsequently cleans the seeds of impurities and dries them. Many producers have their own warehouses and storage facilities (e.g., those for seed or flower drying) and sell their products as seeds, seed oil, tea, and CBD oil during the sales at the fairs, as the Internet sales, or as the traditional door-to-door sales. In Croatia, stem and fiber processing is not yet a well-functioning system, but it has great potential as a renewable material. In Turkey, Ceyhan et al. (2022) stated that industrial hemp stems for a dual-purpose growing model (i.e., stem and fiber) had the highest net revenue per hectare. With regard to Turkey, the authors also stated that only a modern industrial hemp processing technology was economically viable. Giupponi et al. (2020) stated that in Italy, seeds are usually harvested mechanically by combine harvester, while inflorescences are collected manually (only one farm was found to use a trimmer and a resonator for inflorescences collection), whereas stems are collected using balers.

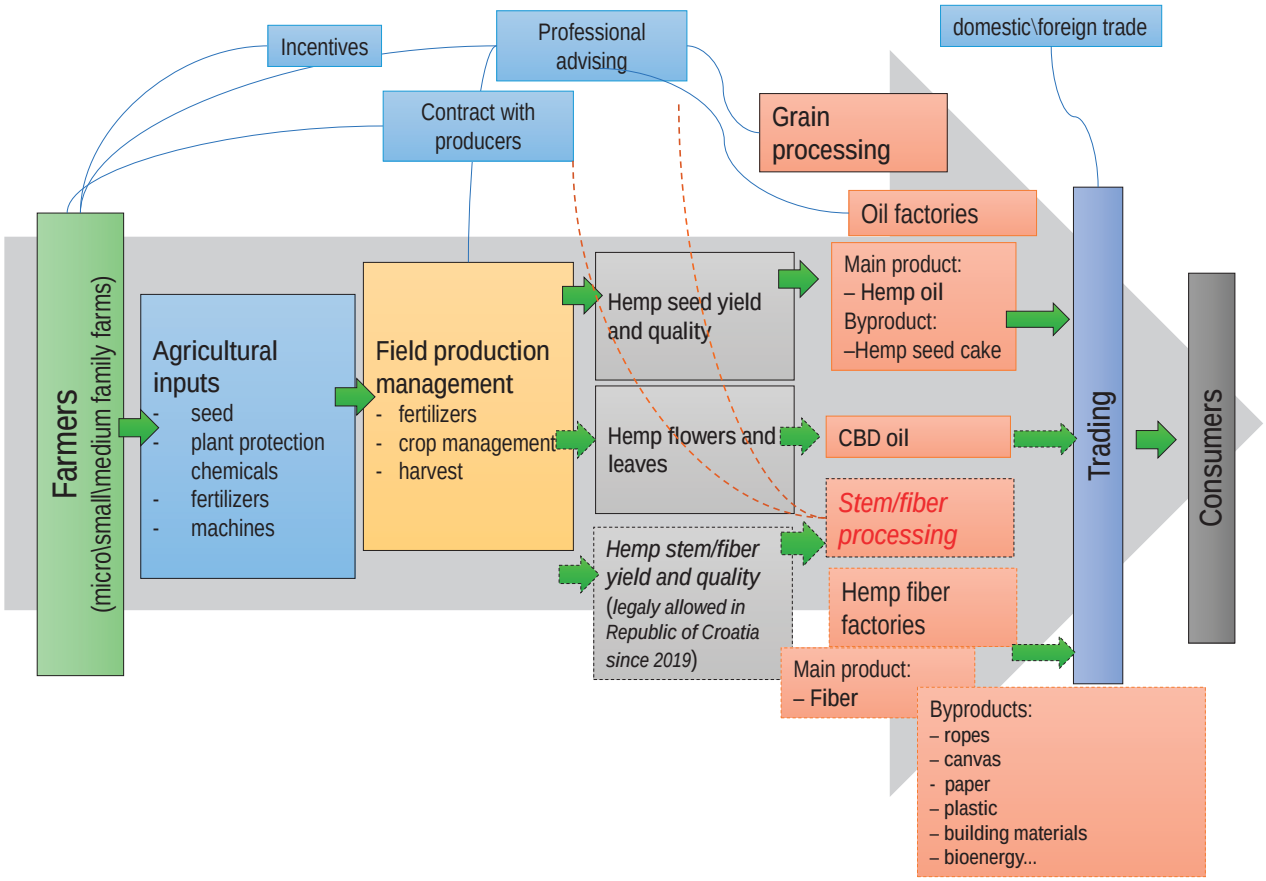

Figure 2. Flow chart of the industrial hemp production in Croatia

Grafikon 2. Tijek proizvodnje industrijske konoplje u Hrvatskoj

There are a few associations related to industrial hemp production in Croatia, such as the Udruga Konoplja and the Udruga CID (https://cid.hr/), which actively promote industrial hemp cultivation and legal entrepreneurship but also provide information and professional support for all those interested in hemp production.

The SWOT and TOWS analyses of industrial hemp production in Croatia

The internal factors of a SWOT matrix represent the strengths and weaknesses, while the opportunities and threats refer to the external factors that cannot be directly influenced, so sometimes they can only be adapted.

In this study, only the most important segments of industrial hemp production were considered in a SWOT analysis (Table 2). The main strengths of industrial hemp production in Croatia are the excellent agroecological conditions for industrial hemp cultivation, long tradition, and the farmers' know-how, which is very important for successful production.

Based on the determined external and internal environmental factors, a TOWS matrix was developed, in which the components were connected according to the four possible strategies, as shown in Table 3.

A conceptual framework of development strategy for industrial hemp production in Croatia was formulated while applying the TOWS matrix. Renewable energy sources, ecological production, and hemp's medicinal value were recognized as the most significant strengths in a strategic sense, and the category of opportunities, emphasis was placed on the possibility of opening new processing capacities and markets, which would enable greater employability. Based on the abovementioned elements, strategies were developed to overcome the weaknesses and threats.

Table 2. A SWOT analysis of industrial hemp production in Croatia

Tablica 2. SWOT analiza proizvodnje industrijske konoplje u Hrvatskoj

	Strengths / *Snage*	**Weaknesses** / *Slabosti*
Internal / *Unutarnje*	– a profitable culture – good for crop rotation – a production of renewable energy sources (bioethanol, biogas, and cellulose mass) – production on soils with low fertility – suitable for organic production – a medicinal plant – various processing options – strong fibers – possible sowing as a second crop	– inadequate specialized machinery for the harvesting of seeds and stems – there are no domestic cultivars – an insufficient knowledge about the production technology of the new genotypes – a lack of processing capacity for the stem – a competition with other oilseeds and/or products related to the cereals – a limited availability of professional literature – an abuse due to the morphological similarity with *Cannabis indica* L., which is classified as a narcotic – a small number of producers and inadequate support – a lack of human labor in the agricultural sector
	Opportunities / *Prilike*	**Threats** / *Prijetnje*
External / *Vanjske*	– ecologically acceptable plant – an increase in the share of renewable energy sources in total energy consumption – employs people in production and processing – a use of the plant for stem and oil processing – a use of the plant as a thermal insulation material – a production of bioplastics and paper – processing: edible oil, CBD oil, protein flour – applicable in the automotive industry – the number of growers is increasing – grows on soils contaminated with heavy metals – phytoremediation (if the stem is produced) – market growth: an increasing interest in alternative treatment methods	– a possibility of an increased THC content >0.2% – drought and unfavorable weather conditions for outdoor cultivation – an increased energy consumption during intensive indoor cultivation – legal regulations for industrial hemp production – a small number of researches on the genotypes in our agro-ecological conditions – an insufficiently developed local market – a large supply and demand oscillations – a limited consumer awareness – a lack of manpower for manual harvesting (flowers and seeds)

In field production, minimal agrotechnical measures can often be applied, but to achieve high yields and quality it is necessary to meet the optimal conditions. industrial hemp production is great for organic production because the soil remains clear subsequent to industrial hemp cultivation unless it has previously been weeded with perennial weeds. In phytoremediation, industrial hemp plays an important role because it absorbs the heavy metals from the soil and accumulates them so that, in this way, the soil remains clean, but this presents a problem with regard to its use in the food industry and medicine (Galić et al., 2019; Radočaj et al., 2020; Placido and Lee, 2022; Todde et al., 2022; Testa et al., 2023). Industrial hemp affects the soil's fertility, whereas the root mass extracts the heavy metals and improves the soil's aeration. Additionally, a dense number of plants per unit area plays a role in soil protection against erosion. Although industrial hemp can be grown in monoculture for two to three years on fertile soils with a greater amount of nutrients, the possibility of a disease or pest attack increases, so the best yields are achieved by growing it in a crop rotation.

Table 3. A TOWS matrix of the industrial hemp production

Tablica 3. TOWS matrica proizvodnje industrijske konoplje

Internal, external / *Unutarnje, vanjsko*	**Strengths** (S) / *Snage*	**Weaknesses** (W) / *Slabosti*
Opportunities (O) / *Prilike*	**S – O strategy: Maxi-Maxi** **Using strengths to take advantage of the opportunities.** – An ecological production method provides greater opportunities for the utilization of hemp's medicinal potential. The utilization of less fertile soils may be operationalized into the function of organic hemp cultivation. – The production of renewable energy sources (RESs) from hemp directly affects an increase in the share of RESs in total energy consumption, which is a global goal. – Various processing options increase employability.	**W – O strategy: Mini-Maxi** **Overcoming weaknesses to take advantage of the opportunities.** – A lack of processing capacity can be overcome by opening a plant for processing the seeds and stalks and by diversifying a product range. – The number of manufacturers may increase due to a growth in demand (market) because of an increased interest in alternative treatment methods.
Threats (T) / *Prijetnje*	**S – T strategy: Maxi-Mini** **Using forces to meet threats.** – Various production and processing possibilities enable a better offer on the market and its development. – Sowing hemp as a cash crop makes it possible to increase the total production of the economy and the offer on a wider market.	**W – T strategy: Mini-Mini** **Overcoming weaknesses to defend against or to avoid threats.** – Legal regulations pertaining to Indian hemp should prevent misuse due to industrial hemp's morphological similarity with Indian hemp. – A lack of domestic cultivars can be overcome by new research and adaptation of foreign genotypes to our agroecological conditions.

The other strengths are mainly effectuated due to a very wide range of industrial hemp usage. Nowadays, the seed is the main product in oil production, but the flowers and leaves are also valuable sources of cannabinoids that are used for medicinal purposes, and, in this way, the producers earn more income per unit area and do not need the large fields to grow industrial hemp. The most common industrial hemp seed product is a cold-pressed oil. One litter of oil requires an average of 3.7 kg of industrial hemp seeds. Some of the products that can be found on the local market or in the domestic Internet stores as processing options are industrial hemp protein (which remains after the seeds' cold pressing), tea, spread, cakes, seeds in chocolate, and honey. Industrial hemp seeds are available on the market, but the hulled seeds, which have a slightly higher price (ca 5 EUR/kg), have also been recently placed on the market. In Italy, Antier et al. (2019) stated that the average production of clean hemp seeds amounts to 400 kg/ha, which may be processed into 80 kg of hemp oil, 300 kg of hemp flour, and 20 kg of waste used for animal feeding. Ceyhan et al. (2022) proved that, according to a SWOT analysis of industrial hemp production in Turkey, the main issues in industrial hemp production are related to the machinery and the hemp value chain, as well as to a lack of research and regulation provision problems. According to a SWOT analysis conducted in Italy (Sicily), Colombo et al. (2020) selected an opportunity in a very large market of industrial hemp-based food products, even though a special pasta and oil represent the changes in habits. Moreover, the authors stated that a threat to the Italian production of hemp-based food products is constituted by the countries with large production (eastern Europe, Canada, and China), which are very compatible. Based on the SWOT analysis in Italy, Giupponi et al. (2020) stated that industrial hemp production is the most widespread in Campania, Lombardy, and Lazio region and is run by young entrepreneurs (57% holders under 35 years old). Sunoj Valiaparambil Sebastian et al. (2023) reported that industrial hemp producers in the US have been recently more inclined to indoor CBD production due to its popular pharmaceutical applications. Khanal and Shah (2024) accelerate that in the USA the most costs in industrial hemp production are related to the land rental cost, the price of the seeds, fertilizers, and fuel and farm labor wages.

After the regulation amendments, there has been an increased interest evinced in industrial hemp cultivation in Europe and all over the world both because of its benefits for medical, food, and cosmetic purposes and because of a growing demand for construction and textile materials that are manufactured from the ecologically renewable sources. There are many possibilities concerning industrial hemp, but most products are exported due to an insufficiently developed market. Only a small number of producers have a diversified production and process the industrial hemp seeds, flowers, leaves, or stems.

According to the regulations, industrial hemp can be cultivated, but no subsidies will be paid concerning all the parcels on which the THC is detected to exceed 0.2 percent. In some years with a lack of rainfall, as well as in cases when industrial hemp is sown in the karst regions, the THC content can be increased above that limit. A current regulation enables the cultivation of industrial hemp in areas whose size cannot objectively justify the economic purpose of its cultivation (as there is no necessity for the areas to be minimal of a 1 ha acreage). Thus, there is an increasing number of plantations on numerous micro-locations that are objectively impossible to monitor. A large number of producers reported extremely small-sized areas (amounting to approximately 0.0001 ha). These small areas can only be someone's garden or are situated in houses, farm buildings, or greenhouses as indoor production, which can be sufficient for CBD oil production (Moyer, 2021). Indoor cultivation, however, necessitates very powerful artificial lighting and climate control, which produces a giant carbon footprint, so this is an important threat to indoor cultivation as a very energy-intensive production. Outdoor cultivation is more sustainable and may be the future of the industrial hemp industry. Also, indoor cultivation can be abused for the cultivation of Indian hemp (marijuana), which can be a possible threat. The products containing CBD (oil, creams, CBD tea, dried flowers, CBD resin in the form of a spray, CBD drops, etc.) are legally available in specialized stores in Croatia or via Internet stores (Varga et al., 2021).

The industrial hemp stem usually grows about two meters high and varies depending on the type—that is, according to the varieties, soil, fertilizers, and environmental conditions. This large stem has a huge potential in the processing industry. The stem fibers are used for ropes, tent wings, cable yarn, plumbing sealants, and the like. There is a lack of studies on the fiber content of the new genotypes in Croatia. In Novi Sad (Serbia), having similar environmental conditions as Croatia, Habán et al. (2022) found that a fiber content in a two-year trial amounted to an average of $25.32 \pm 3.50\%$ for the six industrial hemp genotypes (*Fedora 17*, *Carmagnola*, *Tiborszallasi*, *Lovrin 110*, *Bialobrzeskia*, and *Novosadska*). In Croatia, Augustinović and colleagues (2016) choose six industrial hemp genotypes of (*Fedora 17*, *Futura 75*, *Felina 32*, *Ferimon*, *Santhica 27*, and *USO 31*) for an experiment resulting in an average dry-stem yield of 12.49 t ha^{-1} (Križevci) and 10.43 t ha^{-1}, respectively (Vidovec).

Although ecological materials are more expensive and less available, they become increasingly popular, and a return to nature is emphasized in many other spheres of life. Industrial hemp is an important crop in the European Green Deal goals for a sustainable European economy (Firrone and Bustinto, 2020). The industrial hemp stem has a good thermal insulation performance, so it is used in the construction industry. Recently, hempcrete became a popular construction material made of hemp mixed with lime and water. This material is good in combination with wooden construction. This material is very popular in France and Great Britain (Rhydwen, 2006; Bedlivá Isaacs, 2014; Droil et al., 2021).

CONCLUSION

This study aimed to analyze industrial hemp production in Croatia, with a special accent on the SWOT and TOWS matrix analyses. There are many advantages and opportunities for industrial hemp production in Croatia. Even though the areas with industrial hemp have decreased a bit in the last two years (2022 and 2023), industrial hemp production still enjoys an increasing interest, mainly among young farmers. Due to its great significance in pharmacological use, a major advantage is the possibility of growing industrial hemp in an organic production not only for the sake of seed but also for the sake of flowers for CBD and CBG extraction. There is still a space for the organization of local and EU markets, which will farmers a willingness to engage in industrial hemp production. The changes in the regulations regarding the use of the whole plant and not only of the seed and flowers for food will certainly open new avenues for the use of the whole plant (stem), with a whole new perspective on industrial hemp production and its use in various products.

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STANJE I POTENCIJAL PROIZVODNJE INDUSTRIJSKE KONOPLJE U HRVATSKOJ NA OSNOVI SWOT ANALIZE

SAŽETAK

Hrvatska je imala dugu tradiciju proizvodnje industrijske konoplje za vlakno. Nedavno je u svijetu porastao interes za proizvodnju sjemena i cvijeta industrijske konoplje. Industrijska konoplja je zanimljiva s više aspekata, pa stoga ovo istraživanje procjenjuje trenutačno stanje i potencijal proizvodnje koristeći se SWOT analizom i TOWS matricom. Prosječna požnjevena površina industrijske konoplje u Hrvatskoj bila je oko 1000 ha (2014. – 2023.), s prinosom sjemena od 0,8 t ha^{-1}. Osim povoljnih agroekoloških uvjeta, najveću snagu proizvodnji daje velik broj proizvoda i njezina ljekovita svojstva. Nedostatak specijalizirane mehanizacije za žetvu, kao i zakonske regulative, predstavljaju neke od glavnih problema u proizvodnji industrijske konoplje. Najčešći proizvodi na tržištu su sjemenke, ulje iz sjemenaka i CBD ulje. Premda prerada stabljike još nije razvijena, ona ima velik potencijal. Kako bi se dobile potrebne informacije za definiranje mogućih strategija proizvodnje industrijske konoplje, učinjena je identifikacija vanjskih prilika i prijetnji te unutarnjih snaga i slabosti s kojima se suočava ova proizvodnja.

Ključne riječi: Cannabis sativa L., SWOT, TOWS, preporuke, ukupna proizvodnja, sjeme, ulje

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