HEMP IN SLOVENIA – THE AREA, VARIETIES AND ITS RESPONSE TO SOME AGROTECHNICAL ARRANGEMENTS

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Abstract

Despite the long history of using hemp for fibres, seeds and oil, it was later replaced by other crops. After 2004, hemp reappeared on Slovene fields, but the growers are faced with a series of agrotechnical dilemmas in hemp production and processing. In order to solve some of them in conditions that prevail in Slovenia (small fields, transitional position between the Adriatic Sea, the Alps and the Pannonian Basin), we set up a field experiment within the targeted research project. In the paper, the first results from year 2017 are presented as well as area, sown with hemp and varieties that are grown in Slovenia.

Key words: *hemp, area sown, varieties, Cannabis sativa L., fertilization, nitrogen, sowing rate, sowing time*

1. INTRODUCTION

In the past hemp was well-known for its use for fibre and oil. Our ancestors cultivated it for centuries and the first known data on its cultivation in Slovenia are from the second half of the 18th century. Despite the long history of its use for fibres, seeds and oil, it was later replaced by other crops. After 2004, hemp reappeared on Slovene fields, but the growers are faced with a series of agrotechnical dilemmas in hemp production and processing. The reason lies in the lack of experiences, since most of the existing practices from the past base on manual work; most of the work in the cultivation and processing of hemp at that time was done manually, while today mechanized cultivation should be implemented. In addition, in literature various data on hemp cultivation can be found; for example, the recommendable crop density for fiber production is very wide; from 30 to 500 plants/m^2 [1]. This information is not useful for practical purposes, since the range is too wide. It is therefore very important to know how a particular variety responds to a particular agrotechnic and as well as on the environment.

Hemp is a specific plant and differs from the dominant crops on Slovenian fields. It requires a specific agrotechnical measures and the adaptation of mechanization. The biggest problem in the seed production is harvest. When the seeds become mature, the stems of hemp are already woody and during harvest the stem fibres are winding around the machine parts. This leads to a constant need to clean the machine, that not only prolongs and aggravates the harvest, but it can also cause damage to machinery. Varieties of hemp are mainly breed for fibre namely, which means that they ideally should be harvested much before the seeds are mature. However, in Slovenia, hemp is cultivated mostly for usage of seed. Therefore, problems with harvest are present.

In addition, hemp plants at the same field are often very unevenly high, causing a presence of significant impurities in machine harvested seeds or loss of yield if the combine header is set too high. If plants grow higher than 2 m, machine seed harvesting is not possible. However, the average area of hemp field in 2015, for example, was only 0.5 ha, which allows manual harvesting in case of sufficient labour.

The height of the plants is the most dependent on the variety and weather conditions in a particular season, but we can also influence it with agrotechnic. There is no uniform agricultural practice for the cultivation of hemp among growers; there are considerable differences. In the literature, many different information exist, about e.g. the date of sowing and the amount of seed used for different purposes (fibre, oil, cannabinoids, combine usage). It is therefore necessary to adapt the production technology to our growing conditions, which will enable, on the one hand high yield and on the other

hand mechanized cultivation. Usually, hemp for fiber production is sown dense, which influence the higher growth and hinders stem branching and with that number of inflorescences, and hence lead to higher yield of fiber. In contrary, for the seed production, where the diversification of stem and more inflorescences are desirable, the sowing density is lower.

The first experimental data we have are from 2016 [2]. It was indicated that among the studied amounts of seed for sowing (20 kg/ha, 30 kg ha, 40 kg/ha and 50 kg/ha) the most suitable was 40 kg/ha at variety USO 31 and 20 kg/ha at variety Fedora 17 to reach the highest yield of inflorescences, but the differences among treatments were not significant. There were in fact significant differences among the blocks because of the pigeons, which ate seed from the soil right after sowing. The biggest problem for hemp seed production, beside birds that ate maturing seeds from the inflorescences, was harvest; because high variation in plants height (from 1.3 m to 3.0 m), a lot of leaves and stem biomass was present in the harvested seed. On the other hand, for the yield of stems, the most suitable amount of seed for sowing was indicated the maximum amount (50 kg/ha) for both varieties. As reported also by van der Werf et al. [3], in their experiments the proportion of stems in the total aboveground biomass (dry matter) increased by increasing the crop density (10, 30, 90 plants/m^2) up to 90 plants/m^2.

The next problem we are facing is the lack of hemp varieties that would be adapted to our agro-ecological conditions. In recent years, various foreign varieties of hemp have been introduced to Slovenian fields, so approximately 18 hemp varieties from different European countries are grown, mostly from Hungary and France. Varieties that come from different European breeding houses and from different geographical areas vary in morphological, physiological and economically important properties. Certainly some of them would thrive better in our agro-ecological conditions than others, so they must first be tested in field experiments. Such a procedure is also known in other countries; Williams and Mundell [4] wrote that local research for Kentucky, USA, will be required to provide specific information on hemp requirements, such as crop density and fertilization requirements, as well as harvesting and processing methods.

Varieties for dual or combined use are suitable for the production of seeds and fibres, but modern trends govern breeding of new varieties to be used for one specific purpose [5]. The plant is, by its nature, dioecious, while the breeding programs in Europe have focused on the obtaining of monoecious varieties [1].

In selecting varieties for seed production, their nutritional value should also be adequately evaluated, as varieties, especially in combination with environmental factors, can vary greatly in nutrient content. In addition, certain varieties can have different THC (tetrahydrocannabinol) content when placed in foreign agro-ecological conditions, compared to the area of origin. Therefore, when choosing varieties for introduction into new growing conditions, attention of hemp research should be given to THC concentration as well.

Varieties of hemp react differently to agro-technical arrangements. Those that are grown for fiber are grown differently compared to varieties for seed, dual purpose or for cannabinoids [5].

In order to solve some agrotechnical dilemmas in the hemp production in conditions that prevail in Slovenia (small fields, transitional position between the Adriatic Sea, the Alps and the Pannonian Basin), we set up a field experiment within the targeted research project V4-1611. In the paper, the first results from year 2017 are presented as well as area, sown with hemp in Slovenia and varieties that are grown.

2. MATERIALS AND METHODS

2.1. Area sown with hemp in Slovenia related to variety and year of production

Data on area sown with different hemp varieties in Slovenia in the period between 2015 and 2017 was collected from the Ministry of Agriculture, Forestry and Food. Data was compared across varieties and years of production.

2.2. A preliminary variety field trial

On May 3, 2017, at the experimental field of the Slovenian Institute of Hop Research and Brewing (IHPS), a preliminary variety field experiment with 12 hemp varieties from the EU variety list (all of them had already been grown in Slovenia) was conducted to get the first basic data on their response in the conditions that prevail in Slovenia. At sowing KAN fertilizer was applied in the amount of 70 kg/ha of nitrogen (N). Potassium and phosphorus fertilizers were not applied, because the soil was already oversupplied (36.7 mg phosphorus /100 g soil and 29.6 mg potassium /100 g soil; Al method). The pH of the soil was 6.7, cation exchange capacity was high (44.6). The sowing rate was the same for all varieties (60 kg/ha), as well as all other agrotechnical arrangements. The plots were 3x3 m. Each variety was sown only at one plot (no replications). After the sowing, the soil was covered with a cover until the emergence of hemp in order to protect seeds from birds, as we had serious problems with the pigeons in the year before. The previous crop was oil pumpkins. The experiment was not irrigated. No phytopharmaceutical products (PPP) were used. No pests or diseases were detected during the growth period. The height of plants was measured several times in the growth period.

On August 11, the above-ground parts of hemp of earlier varieties: Fedora 17, KC Dora, USO 31, Finola and Santhica 27 were harvested, and on August 18 of varieties Monoica, Tiborszallasi, Tisza, Kompolti hybrid TC, Férimon, Carmagnola and Antal. Plants were in the development phase *beginning of the seeds formation*. We cut plants manually and then separated stems and inflorescences. Stems and inflorescences were weighted to determine yield, samples for moisture content were taken immediately.

2.3. Technological field trial

The technological field experiment was conducted to study the impact of sowing time (S1 - May 19th and S2 - June 9th), nitrogen fertilization (N1 - 80 kg/ha at sowing, N2 - 80 kg/ha at the time when hemp had 3 pair of leaves) and sowing rate (20, 30, 40 and 50 kg/ha of seed) on the seed yield of two the most widespread hemp varieties in Slovenia, Fedora 17 and USO 31. It was conducted as a block field trial in three replications in year 2017. The size of the basic plot was 3 m x 3.2 m, there were 96 plots in total.

According to literature, varieties USO 31 and Fedora 17 are monoecious, early varieties (vegetation less than 125 days), Atlantic type, in height from 200 to 250 cm, the yield of stems (dry mass) ranges between 8 and 10 t/ha. USO 31 is suitable for seeds and fiber production, Fedora 17 for seeds, fiber and cannabinoid cannabidiol (CBD) production [9].

We covered the entire surface of the experiment with a protective net fixed on columns to protect the maturing seeds from birds, which ate maturing seeds from the inflorescences in the experiment a year ago. All other agrotechnical arrangements were the same for all plots. The seed yield of hemp seed was evaluated plot by plot on September 22 (for the first sowing date) and September 28 (the second sowing date). The seeds were weighted, samples for moisture content (Analytica EBC 7.2. /1998/) were taken immediately. Statistical analysis was done with analysis of variance, using Duncan multiple test to detect differences (p=0.05).

2.4. The weather conditions in year 2017 at the experimental location

During winter, there was relatively low precipitation amount in Žalec (January 26 mm, February 58 mm, March 22.8 mm). From April to June there were 266 mm of precipitation (maximum in April, 126 mm, in May 38 mm, in June 102 mm). The lack of precipitation was also observed in July and August (in July 39 mm, in August 73 mm). In the three summer months, there was only 214 mm of

precipitation, which is 166 mm lower than the long-term average. The lack of precipitation in 2017 was accompanied by above long-term average temperatures (Figure 1).

The first decade of May was slightly colder than the long-term average (by 0.7°C), while the second and third decade of May were very warm (Figure 1). The average daily temperature of the second decade of May was 17.8°C, which is by 2.3°C higher than the long-term average. There was 32.2 mm precipitation. The last decade of May was even warmer, with an average daily temperature of 19.2°C and 34.3 mm of precipitation.

All three summer months (June, July and August) were significantly warmer than the long-term average. This was one of the warmest summers since year 1961. There were 34 days when the air temperature exceeded 30°C (6 days in June, 16 days in July and 12 days in August). There were five heat waves and a lack of precipitation.

Wet and cold September followed. There was 225 mm of precipitation, which is more than was recorded for all three summer months together. It rained almost every day. Unfortunately, the precipitation came too late to mitigate the effects of drought. Moreover, it had very negative impact on hemp harvest, which was delayed and many seeds were lost from the inflorescences.

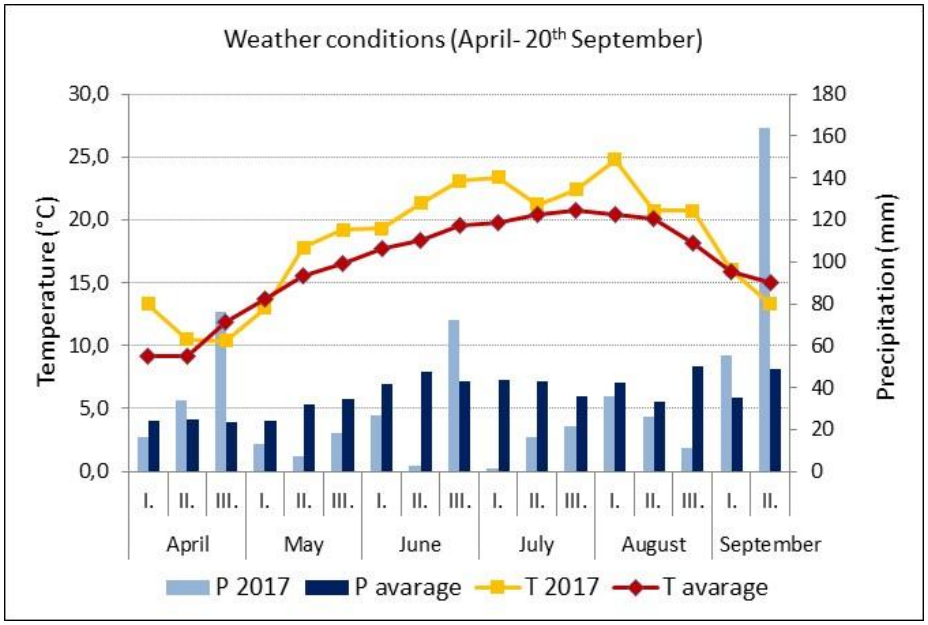


Figure 1. Temperature and precipitation in day decades of certain months in 2017 at the experimental location compared to 30-year's average

3. RESULTS AND DISCUSSION

3.1. Area of hemp with regard to variety and year of production

Fedora 17, USO 31 and KC Dora are sown on the biggest area (Figure 2). The most popular, Fedora 17, was sown on 140 ha in 2015, on 98 ha in 2016 and on 56 ha in 2017. It was variety Finola on the fourth place in 2015 and 2016, while in 2017 the fourth place was taken by variety Futura 75, which area increased the most of all from 2015 to 2017; from 6 ha to 42 ha. On the fifth place in 2017 there was variety Tiborszallasi, which area also expanded significantly – by 28 ha from 2016. Variety Finola was on the sixth place in 2017. All other varieties are sown on smaller areas, less than 20 ha or even less than 10 ha. Mentioned six varieties were sown on 260 ha in 2017, which means 88 %.

3.2. A preliminary variety field trial

The height of the plants differed greatly among varieties (Figure 3). The highest were the plants of variety Carmagnola, followed by KC Dora, which reached up to 3.4 m and 3.0 m, respectively. In addition, the majority of other varieties were too high for machine harvest; they were higher than 2 m. If we would like to grow hemp for seeds and use combine for harvesting, the plants would be too high.

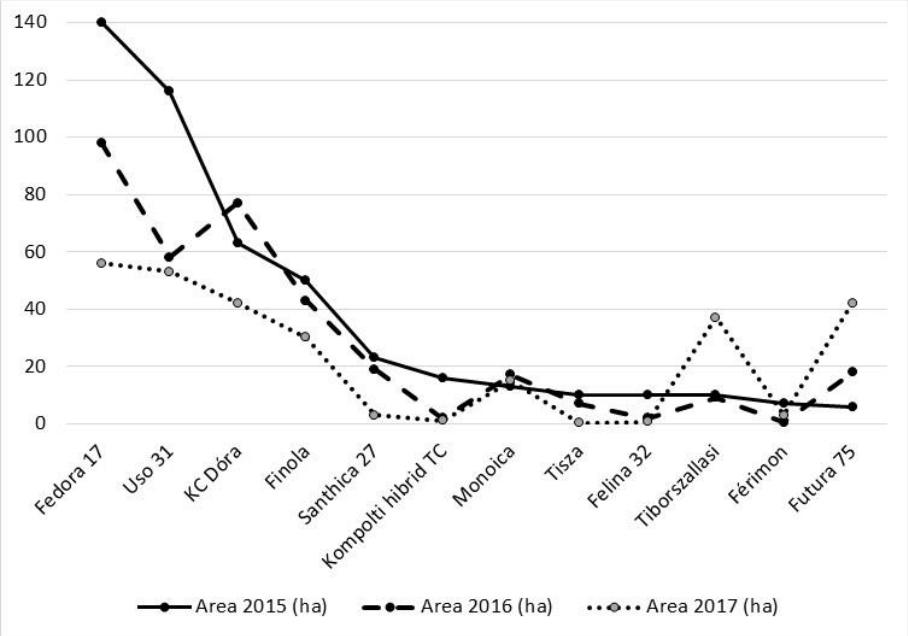


Figure 2. Hemp area (in ha) related to variety and year (2015, 2016 and 2017) in Slovenia

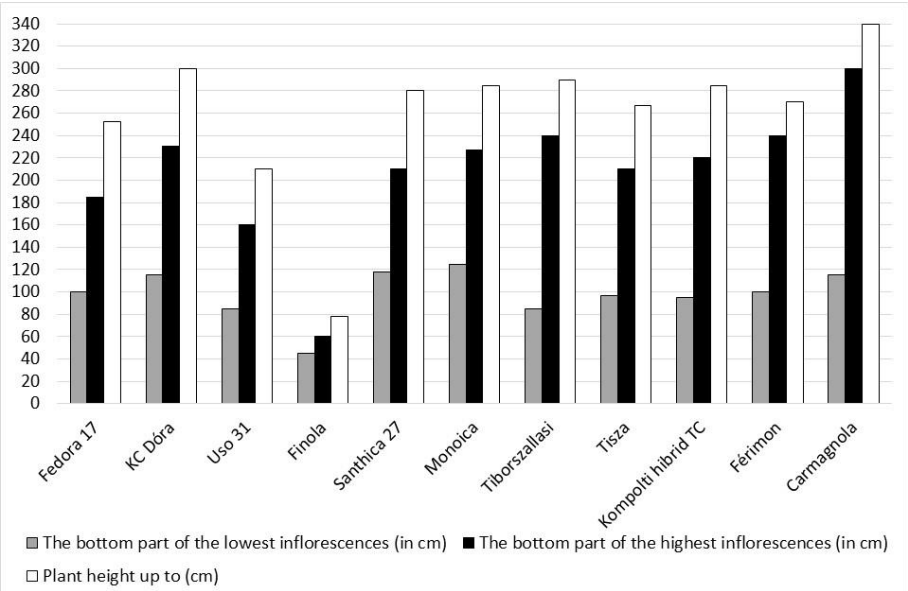


Figure 3. Hemp height and height of the lower part of the inflorescences (where they should be cut at seed harvest) related to variety in the field experiment in 2017 in Žalec (in cm)

We can avoid that in the future, maybe, by later sowing and different way of nitrogen fertilization. For seed production, it is more advisable to sow hemp later in the spring namely; this enables easier harvesting because the stems of plants are lower but flower extension is the same [6]. Varieties USO 31 and Finola grew up not too high considering this fact. USO 31 was 2.1 m high at flowering and 1.0 to 2.3 m at seed maturing, the height of the lower part of the highest inflorescences at the maturity of the seed was 1.6 m. However, the main problem with very short Finola plants, that grew up only from 55 to 80 cm (what is very good for seed harvest) was, that this was the only variety that was overgrown by weeds.

The stem yield was very high at variety Carmagnola (18 t/ha of dry matter), followed by KC Dora (14 t/ha). Kompolti Hybrid TC reached 11.5 t/ha, while all other varieties had stem yields lower than 10 t/ha. The stem yield in the experiments by Kocjan Ačko et al. [6] also significantly depended on the variety and the amount of seed for sowing. For all five investigated hemp varieties, the stem yield was higher at higher amount of seed for sowing in year 2000; at 70 to 80 kg/ha of seed for sowing it was from 6.7 to 9.4 t/ha, while at 35 to 40 kg/ha of seed for sowing it was from 4.6 to 7.5 t/ha. In 2001 (very dry summer), the yield of stems was higher at higher amounts of seed for sowing only for two varieties, while for others it was higher at lower amount of seed for sowing. Stem yield of all varieties was significantly lower compared to the year before. In the experiment by Flajšman et al. [8] with 7 hemp varieties (Fedora 17, Santhica 27, Futura 75, KC Dóra, Finola, Kompolti hybrid TC and Monoica) in 2016, the highest yields of stems (3248 kg of dry matter/ha) and seed (1573 kg /ha) reached variety Futura 75.

The yield of inflorescences in our preliminary trial was from 0.9 t/ha (variety Finola) to as high as 6.5 t/ha at variety Ferimon. Fedora 17 and USO 31 had also high inflorescences yield, reaching 4 t/ha to 5 t/ha of dry matter. They are both used a lot for herbal (hemp) tea production in Slovenia. Variety Carmagnola followed with 3 t/ha. All other varieties had lower inflorescences yields.

The lowest yield of inflorescences had variety Finola (0.9 t/ha, index 33), which was overgrown by weeds. We did not use phytopharmaceutical products against weeds, because they are not allowed for hemp namely. Therefore, this result should be understood with caution – if mechanical weed control would be included, the result would be different. For the weed control at wider distances between rows and smaller sowing densities, mechanical weed control is necessary, since no herbicides for use in hemp cultivation are approved [7].

We have to emphasize that these are only data from the preliminary field trial at one location and in one year. The purpose of this trial was to get the first impression on the response of different varieties compared to each other at the same location, so the numbers are relative. We will repeat the experiment next year to get further information.

3.3. Technological field trial

Statistical analysis showed that there was no significant difference in seed yield among the sowing rates, the nitrogen fertilization variants and the date of sowing. The significant difference in seed yield existed only between varieties; the seed yield of Fedora 17 was significantly higher compared to variety USO 31. The reason could be in the fact that variety USO 31 is earlier than variety Fedora 17, and at the time that harvest should be done, there was a constant rain, which postponed the harvest for approximately 4 weeks what reflected in falling out and loosing of mature seeds on the ground more at earlier variety USO 31. However, fallen seeds were seen also on the ground at Fedora 17; therefore, the yield at this variety was probably higher than the figures showed and the results should be taken by caution.

When we analyzed the data for variety Fedora 17 separately, we found out that the sowing rate and the nitrogen fertilization variant did not have a significant impact on seed yield, while the sowing time had - it was significantly higher at the later sowing date, i.e. on June 9 compared to the sowing on May 19. However, we need to deal with this information carefully at the moment too, because it is possible that this was also the consequence of the delayed harvest due to the excessive rain. It may have happened that more mature seeds were at the plots of the earlier sowing time and consequently more seeds were lost to the ground compared to the later sowing time.

Experiences from Canada suggest that early sowings lead to a higher fiber yield [4]. However, attention should be paid to the fact that the excessive plant density, on the other hand, results in considerable competition between the plants and, consequently, the decay of the plants, which is reflected in the smaller stalk production and reduced quality of fibers [10]. For this reason, plant distribution is also important; in experiments of van der Werf et al. (1995) [10] in the Netherlands, for example, the highest number of decayed plants was found if the distance between rows was 50 cm, compared to distances 12.5 cm and 25 cm. A distance between rows between 8 cm and 20 cm proved to be the most suitable for achieving the highest stem yield [10]. In the experiment by Čeh and Čremožnik (2016) [2] the number of plants per unit area of the variety USO 31 at harvest was higher with the increasing amount of seed for sowing, while at the variety Fedora 17 the number of plants per unit area was statistically the same at all treatments and not related to the amount of seed for sowing. The share of decayed plants increased with the increase of the amount of seed for sowing, what was more pronounced for the variety Fedora 17. The highest share of decayed plants was found at the highest seed amount for sowing (50 kg/ha) at the variety Fedora 17.

In conclusion, we have to emphasize presented results are from one location and from one year, therefore we have to look at them from this perspective. We will repeat the experiments in the following years to get further information and will be able to make conclusions.

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