INDUSTRIAL HEMP (*CANNABIS SATIVA* L.) PRODUCTIVITY AND RISK ASSESSMENT IN HEMP PRODUCTION

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Abstract. *The sector of hemp growing and processing is subjected to significant changes through the past decades, historically hemp growing was widespread and in Latvia hemp was broadly used in everyday life – in the local cuisine, for feeding animals and also as a building and textile material. It had lost its popularity but following the global tendencies in agriculture, growing and processing of hemp (cannabis sativa L.) is slowly regaining its positions mainly due to the versatile possibilities of using hemp. Though the total number of hemp growers is significantly smaller nowadays as it has been historically, the use of hemp is expanding and during recent years several enterprises have introduced new products that includes using hemp in food production, production of ecological construction materials, paper, production of textiles, biodegradable plastics and as mentioned, renewable energy production. Agriculture, including hemp production and processing, is one of the industries subject to risks due to changing weather conditions, diseases and pests and volatile market prices on inputs and products produced. This article aims to reflect the results of the risk evaluation in hemp production and processing, for the evaluation purposes the hemp production is divided in five stages – preparation of soil and sowing of hemp; growing of hemp; hemp harvesting; hemp processing; and realisation of the produced output. The evaluation of risks was made within a system of 18 risks, divided in 6 main groups – agro-meteorological; technological and production; personnel; environment; legislative; economical and market risks. The results reviles, that the highest risk level in the entire hemp production and processing process was specific to the group of personnel risks, whereas the lowest – to the group of environmental risks. However, some risks were assessed as the highest for the group of technological and production risks, for instance, the unavailability of machinery during hemp harvesting and processing.*

Key words: *risk management, hemp production, hemp processing, risk evaluation.*

INTRODUCTION

Growing of hemp in Europe has a history of several hundred years. And it has been an important crop in many European countries as UK, France, the Netherlands, Germany, Spain and Italy. Most important applications for the strong fibre were canvas for sails, sacks, canvas water hoses, fabrics and ropes [1].

Nowadays hemp is a niche crop, cultivated on 10,000 to 15,000 ha in the European Union, but the largest hemp producing countries in the world are China, North Korea, and Canada. In China and North Korea, hemp is annually sown within approximately 80 000 hectares, in Canada − about 10 000 hectares. Among the European Union countries, most hemp is grown in France, Germany, the United Kingdom, and the Netherlands. Overall, in Europe 22,000 to 24,000 tons of hemp fibre and 44,000 to 48,000 tons of hemp sheaves are produced annually [2],[3].

Because of its unique properties, particularly its environmental benefits and the high yield of natural technical fibres, hemp is a valuable crop for the bio-based economy. According to the data of the European Industrial Hemp Association, the dynamics of hemp production has been unsteady − it has increased significantly in 2009, but then decreased in 2011 and now again a tendency to increase the area in which the hemp is grown can be observed [1].

As the hemp growing in Latvia increases, there have been several research projects in Latvia University of Agriculture and Riga Technical University funded by EU structural funds researching the properties of the hemp fibre and its use for building materials [4],[5] and heating thus highlighting the multifunctionality of the crop and the various use of it. Also this paper is based on the empirical data obtained within a nationally funded project ,,The elaboration of growing and processing technologies for the use of Industrial hemp (*Cannabis sativa*) in development of products with a high added value'' which aimed to investigate the productivity of several hemp varieties and the risks involved in the production and processing of hemp.

MATERIALS AND METHODS

Field trials were carried out in 2012-2014, in Research and Study farm 'Pēterlauki' that is supervised by the Latvia University of Agriculture. 10 industrial hemp (*Cannabis sativa* L.) cultivars – 'Bialobrzeskie', 'Futura 75', 'Fedora 17', 'Santhica 27', 'Beniko', 'Ferimon', 'Epsilon 68', 'Tygra', 'Wojko' and 'Uso 31' were sown in the sod calcareous soil (pHKCl 6.7, containing available P 52 mg kg $^{-1}$, K 128 mg kg $^{-1}$, organic matter content in the soil from 21 to 25g kg^{-1}). Total seeding rate comprised 50 kg ha^{-1}. The plots were fertilised as follows: N-120, P2O5- 90, K2O- 150 kg ha^{-1}. Hemp was sown by using Wintersteiger plot sowing machine in the middle of May, in 10 m^2 plots, triplicate. Hemp was harvested by a small mower 'MF-70' when first matured seeds appeared. Biometrical indices of the hemp seedlings, height and stem diameter in the middle thereof at harvesting time, amount of green and dry over ground mass, and fibre content were evaluated.
Besides the growing of hemp in the trial fields a classification of risks was performed by analysing risk management researches in agriculture and in the field of production of renewable energy [6]-[9]. To obtain the preliminary risk evaluation results, 3 experts were questioned all of them were involved in hemp production or research of hemp production. These experts determined the probability of occurrence of each risk and the potential severity of losses from the occurrence of it. Based on the results, a risk level was calculated for each risk assessed by the experts; from it, in its turn, the average risk level was calculated for all the three experts' assessments, as well as the average risk group level for the 6 basic groups of risks and for each phase of the production and processing process.

RESEARCH RESULTS AND DISCUSSION

The results obtained from the field trials indicate that yield of hemp dry matter acquired within the field trials under agro-climatic conditions of Latvia on average comprised 15.06 (13.32-17.78 t ha^{-1}, depending on the variety. Cultivation year and selected variety notably affected hemp biomass yield (Table 1). In 2012, notably higher yield of dry biomass was produced by cultivars 'Futura 75' (21.33 t ha^{-1}) and 'Tygra' (20.87 t ha^{-1}), while the lowest – by cultivar 'Bialobrzeskie' (11.95 t ha^{-1}. Average significantly higher yield of dry biomass was obtained from cultivars 'Futura 75' (17.76 t ha^{-1}), 'Tygra' (16.31. t ha^{-1}), 'Wojko' (15.51 t ha^{-1}) and 'Epsilon 68' (15.28.26 t ha^{-1}), whereas the lowest – from cultivar 'Bialobrzeskie' and 'Uso 31' (13.53 t ha^{-1}). Statistical assessment showed that meteorological conditions present during the growing season influence total volume of the dry biomass yielded.

Table 1

Biomass yield from different industrial hemp varieties, 2012-2014

Hemp variety	Dry biomass, t ha^{-1}			
	2012	2013	2014	Average
Bialobrzeskie	11.95	12,91	15.56	**13.47**
Futura 75	21.33	17.14	14.81	**17.76**
Fedora 17	18.23	13.32	12.78	**14.78**
Santhica 27	17.39	11.57	13.47	**14.14**
Beniko	19.27	13.30	11.96	**14.84**
Ferimon	18.59	13.09	12.93	**14.87**
Epsilon 68	12.89	18.47	14.47	**15.28**
Tygra	20.87	14.66	13.40	**16.31**
Wojko	19.91	14.83	11.79	**15.51**
Uso 31	17.38	11,40	11.98	**13,59**
Average	**17.78**	**14.07**	**13.32**	**15.06**
LDS0.05 variety		3.15		
LDS0.05 year		1.92		
LDS0.05 interaction between variety and year		4.03		

Source: made by the authors

The influence of the growing conditions was also included in the risk assessment for the hemp production and processing performed by the experts. In general, agriculture, including hemp production and processing, is one of the industries subject to risks due to changing weather conditions, sicknesses and pests and volatile market prices on inputs and products produced. However, the use of risk assessment methodologies in agriculture is not widespread, after analysing the term risk in scientific literature [10]-[15] and the principles in risk definition set by German sociologist Ortwin Renn [16], risks within the present research were defined as follows: *risk is a combination of the probability of occurrence of an event and the severity level of negative effects caused by it*. This definition includes two components: probability of occurrence of a risk and severity of losses from the occurrence of the risk.

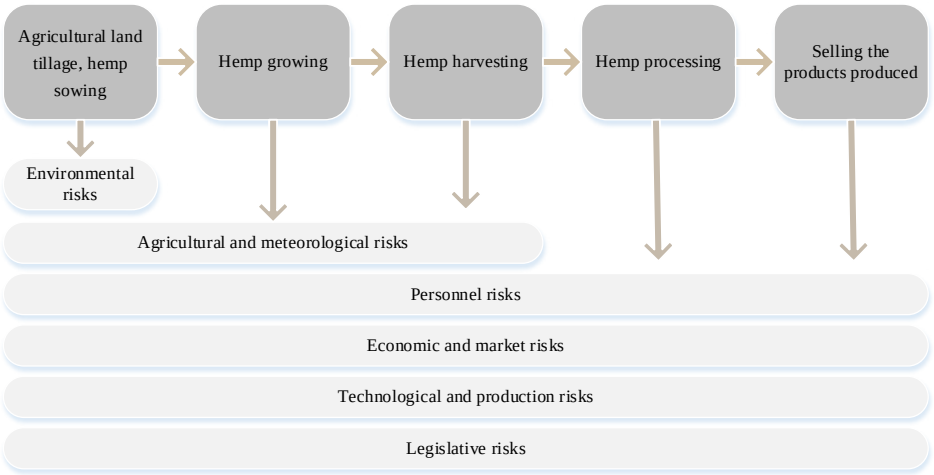

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Figure 1. **Classification of risks for assessing the risks in hemp production and processing**

Table 2

Characteristics of the risks in hemp production and processing and their distribution by group of risks

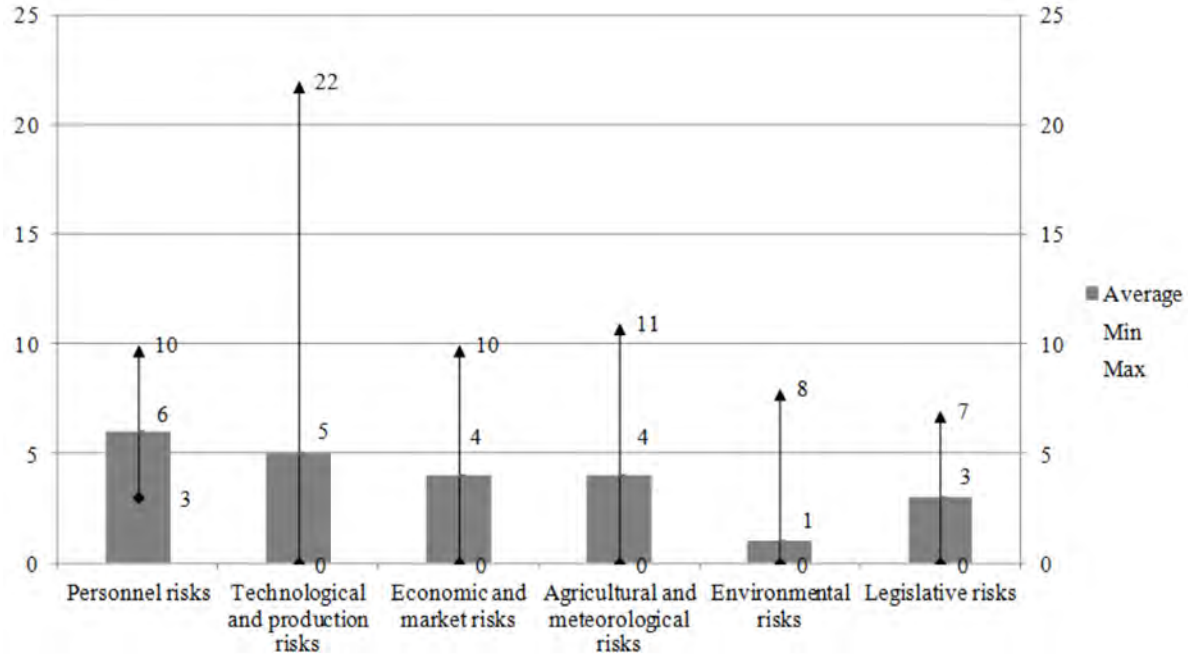
Characteristics of risks	Group of risks
Low qualification of personnel and the lack of their responsibility	Personnel risks
Violations of occupational safety rules	
Low quality of seed	Technological and production risks
Unavailability of machinery	
Machinery operational problems	
Low quality of agricultural and technological operations	
Delayed deliveries of spare parts for equipment and delayed maintenance services	
Changes in sale prices on products	Economic and market risks
Changes in purchase prices on inputs (seed, plant protection chemicals, fertilisers, etc.)	
Changes in other fixed and variable costs	
Effects of meteorological conditions	Agricultural and meteorological risks
Effects of pests and birds	
Inadequacy of agricultural land for growing hemp	
Environmental risks when fertilising fields	Environmental risks
Environmental risks when processing hemp	
Limitations of receiving direct payments	Legislative risks
Changes in the tax policy	
Changes in the quality and safety standards for the products produced	

Source: made by the authors

Given the above-mentioned, a risk assessment system was developed to assess risks in hemp production and processing; the risks in it were classified into 6 basic groups: technological and production, personnel, environmental, economic and market, and agricultural and meteorological risks. Within the basic groups of risks, a detailed classification of the specific risks affecting the production process was developed based on the analysis of specific scientific literature [17]-[20].

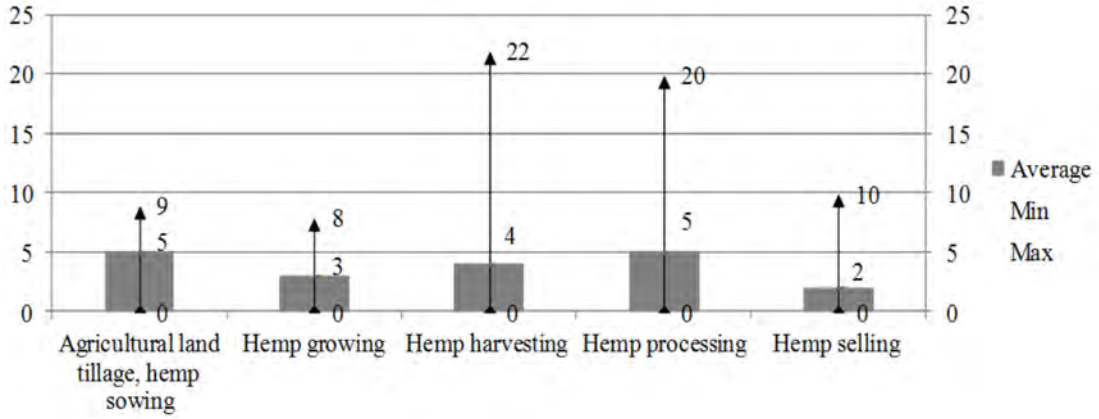
The process of hemp production and processing is divided into five phases: agricultural land tillage and hemp sowing; hemp growing, hemp harvesting, hemp processing and selling of the production (Fig. 1). To assess the risks, the mentioned six groups of risks were divided into 18 particular factors (Table 2). A specific effect area and a risk level were determined for each of these factors.

To assess the risks, the mentioned six groups of risks were divided into 18 particular factors. For each of these factors, a specific effect area and a risk level were determined using a scale of 1 to 25, where 1-3 points meant acceptable risks, 4-9: moderate risks, 10-19: significant risks and 20-25: extreme risks [21].



Source: made by the authors

Figure 2. **Dispersion of the significance of risks for the groups of risks for all the phases of hemp production and processing**



Source: made by the authors

Figure 3. Dispersion of the significance of risks for the phases of hemp production and processing

The results obtained from the experts' risk assessment showed (Fig. 2) that, on average, the highest risk level in the entire hemp production and processing process was specific to the group of personnel risks (6), whereas the lowest – to the group of environmental risks (1). The group of personnel risks was the only group of risks that was homogenously assessed by the experts as moderately significant for all the phases of hemp production and processing. However, some risks were assessed as the highest for the group of technological and production risks, for instance, the unavailability of machinery during hemp harvesting and processing.

After analysing the results for each phase of hemp production and processing (Fig. 3), one can find that, on average, the risk effects were assessed as the highest for agricultural land tillage and hemp sowing, while some very significant risks were specific to hemp harvesting and processing, at 22 and 20 points, respectively, and, as mentioned before, this was the risk of unavailability of machinery.

After analysing individual risks for each phase of hemp production and processing, one can find that the experts' assessments for agricultural land tillage and hemp sowing were quite different – on average, the most significant were the risk of changes in purchase prices on inputs (seed, plant protection chemicals, fertilisers, etc.) (9), the risk of low quality of seed (7) and the risk of changes in the tax policy (7). For the phase of hemp growing, the most significant were agricultural and meteorological risks, especially effects of pests and birds, with the maximum of 20, and the inadequacy of agricultural land for growing hemp; however, this phase does not involve several risks associated with hemp sowing and processing. For the phase of hemp harvesting, the risk of unavailability of machinery was extremely significant, 22 points; therefore, this was the most significant risk not only for a particular phase but for the entire risk assessment. The following risks, for the same phase, were also significant: effects of meteorological conditions, low quality of agricultural and technological operations and low qualification of personnel and the lack of their responsibility, while machinery operational problems were a moderately significant risk. For the phase of hemp processing, too, the most significant risks were unavailability of machinery (20) and machinery operational problems (11); two personnel risks, with 10 points, were also significant. As regards the phase of sales of products, the risk effects were comparatively lower; on average, significant risks were: changes in sale prices on products (10) and low qualification of personnel and the lack of their responsibility (7). On the whole, the lowest assessments were given to the groups of environmental and legislative risks – environmental risks quite insignificantly affect all phases, while legislative risks can affect several phases more; yet, since presently no changes are expected regarding legal provisions, standards or taxes, the effects of these risks are small.

This preliminary risk determination and assessment allowed to test the risk evaluation methodology and obtain the first results, and further, the research will focus on the differences in risk effects depending on the ways of using hemp. Since the present results show the distribution of significance of risks for hemp production and processing, but the experts, when doing their assessments, admitted that this was a quite complicated and time-consuming activity, the further research will omit insignificant risks and will focus only on those presently having moderately significant and significant effects.

CONCLUSIONS

The field trials show that the industrial hemp cultivars 'Bialobrzeskie', 'Futura 75', 'Fedora 17', 'Santhica 27', 'Beniko', 'Ferimon', 'Epsilon 68', 'Tygra', 'Wojko' and 'Uso 31' could be successfully grown in Latvia for biomass and fiber production. The highest biomass yield, during both trial years, was obtained from cultivar 'Futura 75'. According to the data we can conclude that the growing season and the selected industrial hemp variety had a significant ($p<0.05$) effect on hemp yield.

The obtained results from risk evaluation showed that, on average, the highest risk level in the entire hemp production and processing process was specific to the group of personnel risks, whereas the lowest – to the group of environmental risks. Indicating that the actions and the decisions made by the employees are the one that affect the hemp growing and processing process the most. However, some risks were assessed as the highest for the group of technological and production risks, for instance, the unavailability of machinery during hemp harvesting and processing.

The significance of risk groups and also individual risks differed among the risk groups, for example, for the phase of hemp growing, the most significant were agricultural and meteorological risks, especially effects of pests and birds, with the maximum of 20, and the inadequacy of agricultural land for growing hemp, but for the phase of hemp harvesting, the risk of unavailability of machinery was extremely significant, and reaching 22 points.

ACKNOWLEDGEMENTS

The article is based on the empirical data obtained within the project ,,The elaboration of growing and processing technologies for the use of Industrial hemp (*Cannabis sativa*) in development of products with a high added value'' no. 160413/S99

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