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IMPACT OF THE AGRO-ENVIRONMENTAL FACTORS ON THE SEED YIELD AND YIELDS COMPONENTS PRODUCTIVITY OF LATVIAN ORIGINAL HEMP

Summary

In the European Union, including Latvia there is an increasing interest in cultivation and production of industrial hemp (Cannabis sativa L.) fibres as well as seeds. The aim of the investigation was to evaluate N fertilization and sowing rate suitable for seed yield productivity of hemp cultivar 'Purini' in Latvian environmental conditions. Research was carried out to study the effect of the environmental factors in the cultivation years 2012 – 2013 and 2015, genotype ('Purini'), nitrogen fertilizer doses (0, 30, 60 and 90 kg · ha^{-1}), seeding density (50, 70, 90 and 110 kg · ha^{-1}) in one vegetation period on hemp seed yield. In this case agronomically important traits, such as seed yield, 1000 seed mass and seed oil contents also were taken into account. Investigation has been conducted in the Agricultural Scientific Centre of Latgale in field trials. Yield parameters of hemp varied both by years and by treatments. Correlations showed statistically positive significant relationships between seed yield and nitrogen rate increasing in all years. Seed yield of hemp ranged from 0.83 to 2.39 t · ha^{-1}. In 2015 optimal plant seed density rate of 50 kg · ha^{-1} by seed yield 2.05 t · ha^{-1}.
***Key words**: hemp, seed yield, nitrogen fertilizer, seeding density*

WPŁYW CZYNNIKÓW AGROŚRODOWISKOWYCH NA PLON NASION I PRODUKTYWNOŚĆ KOMPONENTÓW PLONU ORYGINALNYCH ŁOTEWSKICH KONOPI

Streszczenie

W Unii Europejskiej, w tym na Łotwie wzrasta zainteresowanie uprawą i produkcją włókna i nasion z przemysłowych konopi (Cannabis sativa L.). Celem badań była ocena wpływu nawożenia azotem i normy wysiewu odpowiedniej dla produktywności uprawy odmiany konopi 'Puriņi' w łotewskich warunkach środowiskowych. Badania zostały przeprowadzone, by zbadać oddziaływanie czynników środowiskowych w latach uprawy 2012-2013 i 2015, genotyp ('Purini'), dawki nawozu azotowego (0, 30, 60 i 90 kg · ha^{-1}), gęstość siewu (50, 70, 90 i 110 kg· ha^{-1}) na plon nasion konopi w jednym okresie wegetacyjnym. W tym przypadku agronomicznie ważne cechy, takie jak: plon nasion, masa 1000 nasion i zawartość oleju w nasionach zostały również uwzględnione. Badania polowe przeprowadzono w Rolniczym Centrum Naukowym w Łatgalia. Parametry plonu konopi różniły się zarówno w poszczególnych latach jak i przeprowadzonymi zabiegami. Korelacje pokazały statystycznie pozytywne znaczące związki pomiędzy plonem nasion a normą nawożenia azotem (wzrost we wszystkich latach). Plon nasion konopi wynosił od 0.83 do 2.39 t · ha^{-1}. W 2015 optymalny wskaźnik gęstości siewu wyniósł 50 kg · ha^{-1} a plon nasion 2.05 t · ha^{-1}.
***Słowa kluczowe**: konopie, plon nasion, nawóz azotowy, gęstość siewu*

1. Introduction

Industrial hemp (*Cannabis sativa* L.) is one of the world's foremost renewable resources. In China and in other hemp growing areas in Asia, hemp seeds are used as traditional food. In Europe and North America, hemp seeds for food were rediscovered in the mid-1990s – currently with the reintroduction of hemp as a source of technical fibre [10]. The versatility of the seed lends itself to the development of numerous products for the food, cosmetic, therapeutic, functional food and nutraceutical industries [16].

Hempseed contains more than 30% oil of which polyunsaturated fatty acids constitute more than 80% [5]. Hempseed oil is especially rich in two essential fatty acids-linoleic acid (18:2, omega-6) and *alpha*-linolenic acid (18:3, omega-3). They are present in a ratio of about 3:1, considered optimal in healthy human adipose tissue [19], and apparently unique among common plant oils [11]. There are various benefits attributed to omega-3 and include anti-cancer, anti-inflammatory and anti-thrombosis properties, stimulation of general metabolism and promotion of burning fat [6, 19]. HSM is a rich source of protein and energy and can represent a nutritious feed supplement for livestock or used for production of high-protein flour [18].

Hemp is a valuable crop also because of its biological pesticidal, repellent and allelopathic properties [14]. It can effectively compete with weeds not only by outgrowing them [17, 24] but also by allelopathic interactions [3, 8]. Moreover, the ability of rooting deeply makes hemp a low nitrogen- and irrigation-demanding crop, leading to significant environmental benefits compared to other competing arable crops, such as cotton [25].

Hemp fertilization methodology badly varies in different countries. For example, in Canada quoted nitrogen doses range from 60 to 90 kg · ha^{-1} [20], while in EU countries doses vary between 80-160 kg · ha^{-1}, depending on soil composition [1]. To avoid loss of nitrogen, it is recommended to divide nitrogen fertilizer into several portions [15].

Economic efficiency of planting a crop such as industrial hemp consists in sowing at differing density depending on the purpose of the crop: whether it is for fibre or grain. Recommended seed rate for the latter (a seed crop) is often around 30 kg · ha^{-1} or between 100-150 plants m^{-2} [4]. The appropriate density of planting varies with variety, season, soil type and range of other agronomic practices adopted for the crop. Hence, seeding density for any variety should be optimised for the particular location of interest [7].

The research presented in this manuscript was carried out to determine the effect for seed yield and yield components productivity of hemp cultivar 'Purini' by nitrogen fertilizer impact in variable environmental conditions as well as seed density. Hemp cultivar of 'Purini' has grown since 1936 in Piksars district of Rujiena region in Latvia.
Investigation of hemp (*Cannabis sativa* L.) morphological parameters as influenced by seed rate and genotype.

2. Materials and methods

2.1. Field experiments

Investigation has been carried out over the growing seasons 2011 – 2013 and 2015 in the Agricultural Science Centre of Latgale in Latvia out at the field trial. Experimental material for the present study consisted of Latvian origin cultivar hemp 'Purini'. Plants were grown in random block plots in three replications.

Hemp was grown in humi-podzolic gley soil. Soil agrochemical characteristics of the four experimental years were not significantly different: organic matter content of the soil is 6.5%, pH - 7.0, phosphorus contents P_20_5 - 145 mg · kg^{-1} soil, potassium K_2O - 118 mg · kg^{-1} soil (by results of State Plant Protection Service). Complex fertilizer applied after first soil cultivation (NPK kg · ha^{-1}) of 16:16:16 300 kg · ha^{-1}. Three nitrogen fertilizer doses were used: N_{+0} – control, N_{+30} – 30 kg · ha^{-1}, N_{+60} – 60 kg · ha^{-1} and N_{+90} – 90 kg · ha^{-1}. The seeds density was 70 kg · ha^{-1}. Oil content in hemp seeds was determined with a grain quality analyzer Infratec-1241 (Foss Analytical, Denmark) using a special device for oil content determination. In 2015 four seed densities: 50 kg · ha^{-1}, 70 kg · ha^{-1}, 90 kg · ha^{-1} and 110 kg · ha^{-1} were used.
Agro-meteorological conditions were determined by ADCON installed meteorological stations which are connected to the computer program Dacom Plant Plus. Facility provides information in direct nearby field trials.

Precipitation in 2011 growing period was by 58% lower, in 2013 was by 22% lower and in 2015 by 6% lower in comparison to the long-term average of 311 mm (by 1. Fig.). However, rainfall in 2012 was by 50% higher than the long-term average.

2.2. Data analysis

MS-Excel software was used for data statistical analysis [2]. Data analysis tools Descriptive Statistics, Correlation analysis. According to 4 years results using correlation was to establish the nature of relation between seed yield and nitrogen fertilizer supply as well as seed yield and precipitation.

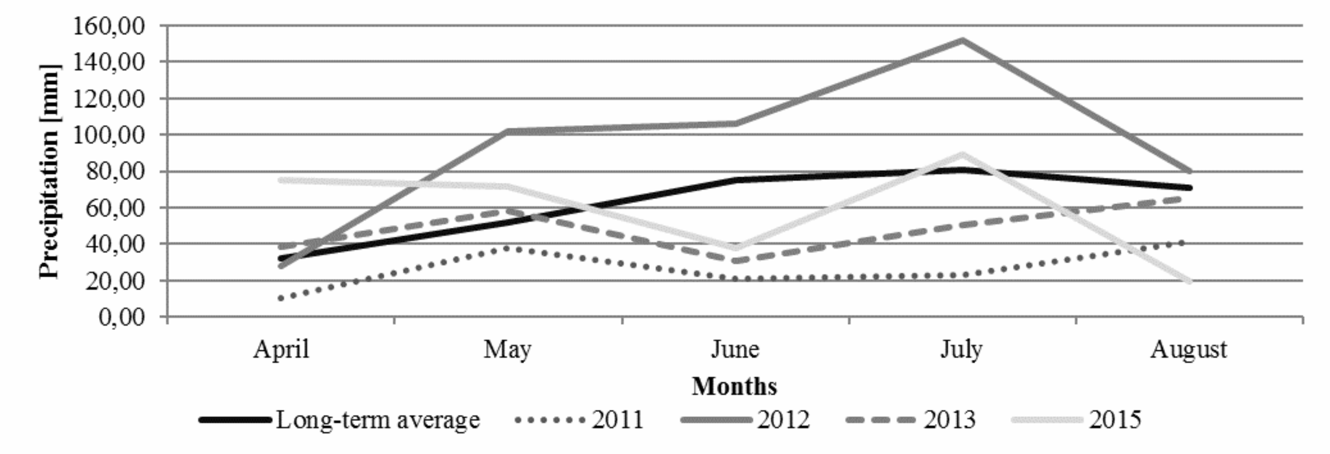

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Fig. 1. Precipitation (mm) value in vegetation period of hemp in 2012-2015

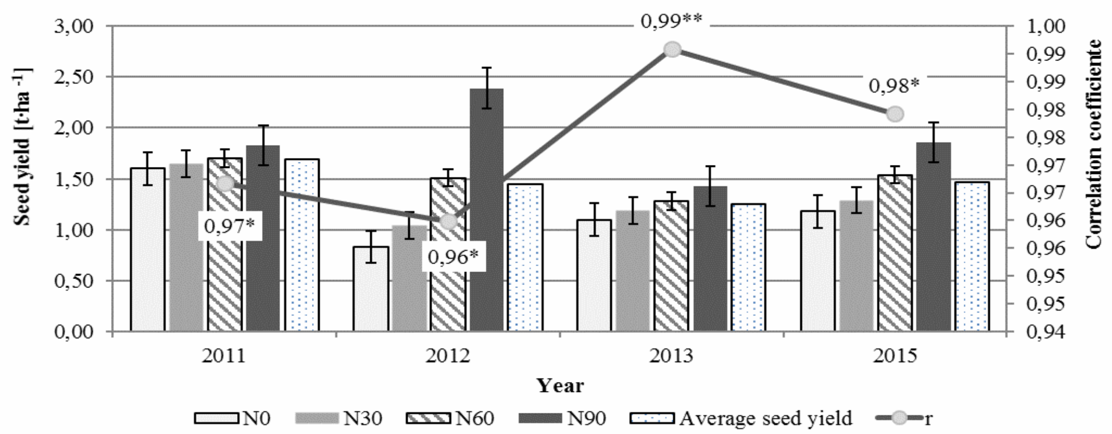

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Fig. 2. Seed yield (t · ha^{-1}) under different nitrogen fertilizer supply and correlation coefficiente between seed yield and nitrogen fertilizer doses (- correlation significant at p≤0.05, ** − correlation significant at p≤0.01)*

3. Results and discussion

Weather conditions in 2011-2013 and 2015 seasons of vegetation periods were different (presented in Fig. 1.) and varied impact on growth and development of seed yield and yield components of hemp cultivar ‘Purini’. According to [12, 13] significant effect of genotype on seed yield has been widely reported. Results showed that in four vegetation periods the highest average seed yield (1.70 t · ha^{-1}) was obtained in 2011. This vegetation period was characterized by low precipitation level (lower than 58% from long-term average) in growing period. The results showed after seed yields productivity genetical effect of hemp cultivar ‘Purini’ suitable for dry environmental conditions.

Taking into account the rate of additional fertilization the seed yield of hemp ranged from 0.83 to 2.39 t · ha^{-1}. Correlations between nitrogen fertilizer rates and adequate seed yield are displayed in Fig. 2. Positive and significant relationships were found in all vegetation periods, which proved that seed yield varies increasing, depending on nitrogen fertilizer level. According to results, highest seed yield was obtained by N_{+90} especially in 2012 by higher (50% from long-term average) precipitation level. The effect of applied nitrogen on hemp seed yield has already been researched in a number of studies [23]. The most extensive investigation to date was conducted by Struik *et al*., (2000) who found a gradual increase in stem dry matter over a range of 100 kg N · ha^{-1} – 220 kg N · ha^{-1} (soil N plus applied N) in Northern Europe. In contrast, there was a limited response to nitrogen in the nitrogen rich soils of Northern Italy [22, 23] found that yield was greater at a soil nitrogen level of 200 kg N · ha^{-1} compared with a soil nitrogen level of 80 kg N · ha^{-1} and concluded that the 80 kg N · ha^{-1} treatment was deficient in nitrogen.

Evaluating seed variability over the year’s correlation showed variable results in terms of precipitation relationships between different nitrogen fertilizer rates (in Fig. 3.). The result revealed a negative correlation transition to a positive correlation in relation by precipitation level and N rate. In this case, yield increased positive significantly in years when precipitation levels were higher by N_{+90} rate. Example: in 2012.

Like the seed yield and 1000 seed weight significant increases by higher nitrogen rate (in Fig. 4.). On average, it ranges from 10.6 to 14.59 g including changing weather conditions. Hemp seed oil content was not significantly affected by additional nitrogen fertilization. Maļceva, Vikmane, & Stramkale (2011) working with hemp cultivar ‘Purini’ also found similar results. The hemp cultivar ‘Purini’ seeds contained average 41.2% of oil. According Kriese *et al*., (2004) among the highest oil producing hemp genotypes, with an average oil content top level of 37.5%.

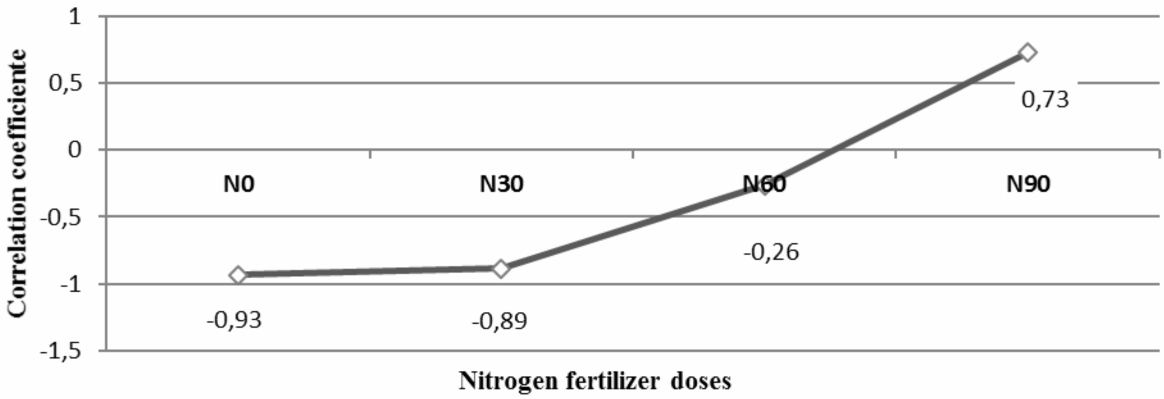

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Fig. 3. Correlation coefficient between precipitation and seed yield in four vegetation periods under different nitrogen fertilizer supply (- correlation significant at p≤0.05)*

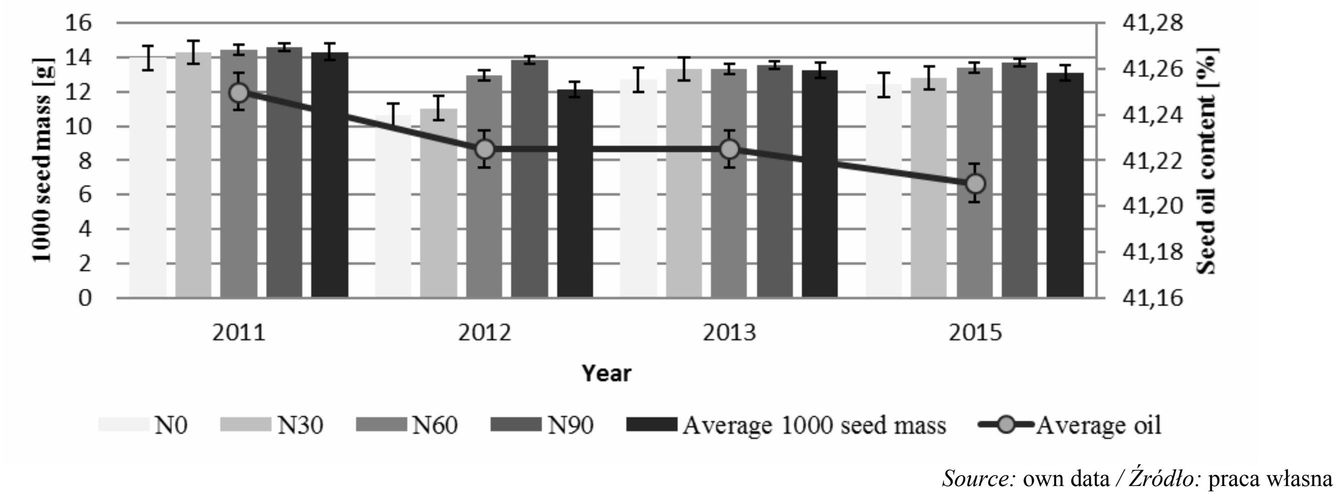

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Fig. 4. 1000 seed mass under different nitrogen fertilizer supply and average oil contents

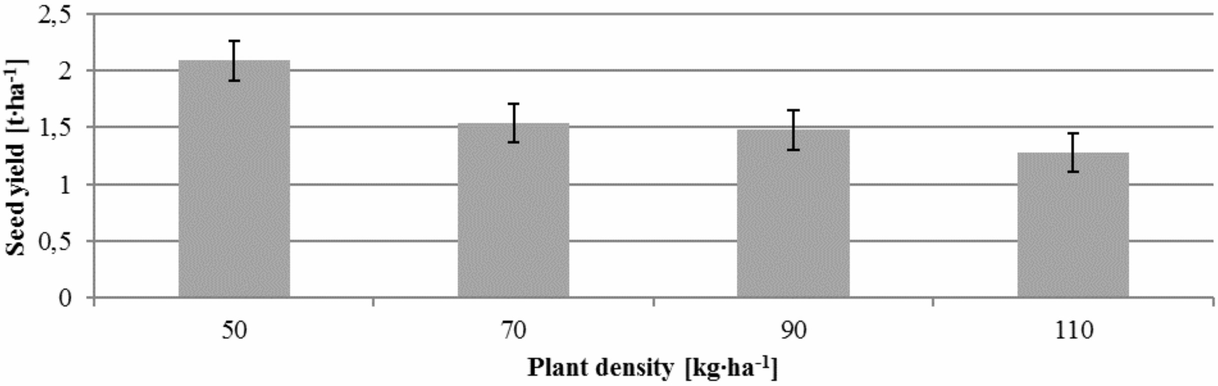

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Fig. 5. In 2015 seed yield with different plants density

Evaluating seed density in 2015 result revealed the suitable seed rate: 50 kg · ha^{-1} with significant highest seed yield of 2.09 t · ha^{-1} (by Fig. 5). In order to evaluate the optimal plant seed rate it is necessary to continue the study, which takes into account the variable environmental conditions. Furthermore, by nitrogen fertilizer supply, seeding rate of 70 kg · ha^{-1} was used which is relatively high. Low seeding density for a seed crop allows for greater branching, shorter plant height and heavy individual plant weight compared to fibre crops sown at higher density. The latter suppresses branching, induces taller and lighter individual plants. By excessive planting densities in hemp crops result in increased self-thinning and a slowing down of crop growth rate in later stages of development [7].

4. Conclusions

Hemp cultivar of 'Purini' of seed yield range from 0.83 to 2.39 t · ha^{-1} (by average 41.2% seed oil contents) depends both on climatic conditions and fertilization rate. The optimum nitrogen dose for high seed yield productivity ranges from 60 - 90 kg · ha^{-1} which may vary depending on the weather. In 2015 tendencies of higher seed yield (2.09 t · ha^{-1}) were noticed in the plots with lower density (50 kg · ha^{-1}). Hemp cultivar of 'Purini' has a good potential for seed production in temperate conditions.

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