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OPTIMAL AND SUITABLE CONDITIONS FOR PROSPECTIVE SPRING CAMELINA CULTIVATION IN SLOVAKIA – SCREENING BY THE SYSTEM OF SOIL CLIMATIC UNITS

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Camelina [*Camelina sativa* (L.) Crantz], a recently rediscovered oil crop is becoming of interest to both industry and farmers due to its relatively wide use. The amount of camelina seed production is / will be influenced both by the demand from the industry and by the suitable conditions that allow its profitable cultivation. A preliminary insight on optimal part of the used arable land in Slovakia suitable for growing this crop was based on available information on the environmental requirements of camelina and the system of land evaluation units of agricultural soils. These data have been acquired from database managed and continuously updated by National Agriculture and Food Centre – Soil Science and Conservation Research Institute Bratislava. From this database information concerning the climatic region, slope, soil texture, soil depth, and skeleton content were used. The obtained results show that approximately 27% of the acreage of utilised arable land has optimal quality for spring camelina cultivation in Slovakia. If camelina will be used for the production of various biobased materials, on a smaller scale (several thousand hectares) it is possible to grow this crop without a significant restriction of the cultivation of other crops, especially those intended for food and feed production. In case of camelina utilisation as a feedstock for conventional biofuels production, it is necessary to take into account its competitiveness compared to oilseed rape, which is currently the main raw material for FAME (fatty acid methyl ester) production, both in terms of profitability of cultivation and CO_2 emissions per tonne of oilseed yield.

Key words: *Camelina sativa* (L.) Crantz, climate conditions, soil conditions, suitability of cultivation

Camelina [*Camelina sativa* (L.) Crantz] represents the recently rediscovered oil crop which has the potential to be used as a feedstock in biofuel production and also as the raw material for the production of various bio-based materials. In addition, the camelina meal (a by-product of oil extraction) can serve as a protein feed for farm animals (Eynck & Falk 2013; Berti *et al.* 2016; Murphy *et al.* 2016). The aim of the paper was to obtain a preliminary insight of which part of the used arable land in Slovakia is optimal and suitable for growing this crop.

The selection of soil and climatic conditions affects the profitability of any crop cultivation. Recently, due attention has been paid to investigate the suitability of crop cultivation on agricultural land has been given due attention by research (e.g. Bowen & Hollinger 2004; Vilček & Bedrna, 2007; Holzkämper *et al.* 2010; Koco *et al.* 2020). Reference papers related to screening soil-climatic conditions suitable for camellia cultivation have been pub-

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lished by Falasca *et al.* (2014) and Román-Figueroa *et al.* (2017).

The screening of optimal and sustainable soil-climatic conditions for spring camelina cultivation witjhin used arable land of Slovakia was – based on available information on camelina's environmental requirements (Putnam *et al.* 1993; Zubr 1997; Crowley & Fröhlich 1998; Strašil 2008; Falasca *et al.* 2014; George *et al.* 2015; Román-Figueroa *et al.* 2017) and the system of land evaluation units – referred to as BPEJ – (Džatko, Sobocká *et al.* 2009), registered in the database managed and continuously updated by the National Agriculture and Food Centre – Soil Science and Conservation Research Institute in Bratislava.

Camelina is well adapted to the areas where flax is grown (Putnam *et al.* 1993) and for this reason, it is also referred to as "false flax". This information is the starting point when defining the suitable conditions for growing this crop. In this regard, according to Vilček & Bedrna (2007) the best conditions for flax cultivation are locations with an altitude of more than 400 m and the sum of annual total rainfall greater than 600 mm. As for soils, the most suitable are sandy loam and loam soils with a neutral to slightly acidic soil reaction. Unsuitable are clay soils prone to crusting, stony soils, dry or, conversely, wet, and land on slopes above 7°.

Although camelina is often considered as a less demanding crop to site conditions and inputs (e.g. Putnam *et al.* 1993; Zubr 1997; Strašil 2008), compared to marginal areas, in optimal conditions with mild temperatures and adequate soil moisture are achieved higher yields (Aiken *et al.* 2015). In addition, in conditions where the area of arable land is constantly declining and its expansion at the expense of grassland or forest land is out of the question, regulated conventional intensification of crop production (as defined by Heaton *et al.* 2013) is important. This fact was considered during the projection of optimal and suitable conditions for the cultivation of this crop in Slovakia where temporal intensification of crop production is limited.

The setting of the optimal and suitable range of climatic indicators and soil properties for the cultivation of spring camelina in Slovakia is indicated in Table 1. The unsuitable category has not been considered. Unlike the authors Vilček & Bedrna (2007), who used a 4-level classification of land suitability for growing crops (very suitable, suitable, less suitable, and unsuitable), our attention was focused on the first two, while very suitable conditions are perceived as optimal.

Regarding climatic conditions, the most important are temperature and moisture. The temperature is important both in terms of the sum of vegetatively active temperatures (above 5°C) also expressed as growing degree days (Miller *et al.* 2001; Krzyżaniak *et al.* 2019), and thus in terms of the length of the growing season, as well as in terms of the occurrence of temperature extremes (especially tropical days with temperature over 30°C). Moisture is primarily related to the sum of precipitation, especially during the growing period. As stated by Holzkämper *et al.* (2010), while the sufficient moisture is important mainly for the vegetative phase of growth, the

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Definition of optimal and suitable environmental conditions for spring camelina cultivation from view of seed yield

Indicator	Optimal conditions	Suitable conditions	
		Dry	Wet
Climatic region*	02, 05, 06, 07	01, 03, 04	08
Slope	< 3°	< 7°	1 – 7°
Soil texture**	SL, L	SL, L	LS, SL, L
Soil depth	> 0.6 m	> 0.31 m	> 0.31 m
Skeleton content	< 10%	< 10%	< 25%

*by Džatko, Sobocká *et al.* (2009); **LS – loamy sand; SL – sandy loam; L – loam occurrence of tropical days affects the generative phase of crop growth.

Because spring camelina has a short vegetation period (up to 100 days), its cultivation in Slovakia is practically not limited by the sum of physiologically active temperature. Temperature extremes, especially temperatures above 30°C during the ripening phase, can reduce the seed yields significantly (Aiken *et al.* 2015). Due to the elimination of the rainfall excess in humid and cold areas (BPEJ climate region codes 9 and 10) and due to the occurrence of hot days in the warmest climatic region (climate region code 0), areas corresponding with mentioned climates are not included in the definition of suitable areas for camelina cultivation (Table 1).

As additional site indicators, the slope, soil texture, soil depth, and skeleton content were taken into account. To some extent, soil texture corresponds with moisture (its retention and availability for root system). Loamy and sandy-loam soils are considered optimal for spring camelina cultivation. Suitable are also loamy-sand soils, but their production potential tends to be lower. Clearly unsuitable are clay and wet soils due to delays in entering the land for early seeding (Sintim *et al.* 2016) which can affect the use of winter moisture in the soil and subsequently also increase the likelihood of tropical days occurrence during ripening as a consequence of a shift in sowing time. Therefore, extreme soil texture categories were primarily excluded from optimal and suitable conditions for camelina cultivation.

As the most part of the camelina root system occurs in the layer 0 – 0.6 m (Putnam *et al.* 1993; Obour *et al.* 2015; Gesch & Johnson 2015), only deep (> 0.6 m) and medium-deep (0.31 – 0.6 m) soils were considered as suitable for camelina cultivation. Because increased stone/gravel content, as well as slope over 7°, can reduce the crop yields (Vilček & Bedrna 2007), lands on the slope of up to 7° without skeleton (< 10%) and weakly skeletal soils (10 – 25%) were classified as suitable (Table 1).

Based on the parameters listed in Table 1, approximately 27% of the acreage of utilised arable land can be considered as optimal and suitable for spring camelina cultivation in Slovakia. The spatial distribution of these areas is shown in Figure 1. The remaining area of utilised arable land is considered as less suitable and unsuitable for camelina cultivation.

As stated by Neupane *et al.* (2018), the main advantage of camelina as a feedstock for biofuel production, in comparison to oilseed rape, is its cultivation in conditions that are no more suitable for rapeseed. The areas, where camelina could be competitive to oilseed rape, which is currently the main raw material for FAME (fatty acid methyl ester)

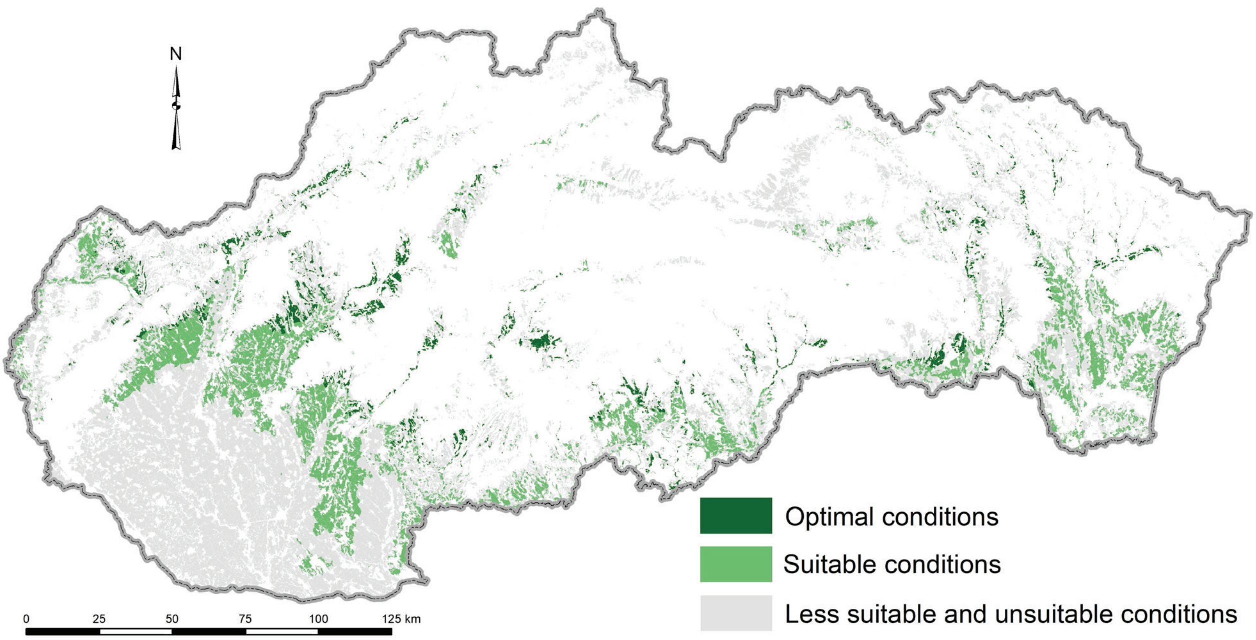

Figure 1. Optimal and suitable areas for spring camelina cultivation within the utilised arable land of Slovakia

production, were detected by overlapping of GIS layer of optimal & suitable areas for camelina cultivation (Figure 1) with a GIS layer of less suitable & non-suitable areas for oilseed rape (developed by Vilček & Bedrna 2007). These areas, scattered especially in the central and eastern part of Slovakia, account for 15,000 ha.

It is reasonable to assume that in terms of cropping area the camelina may belong to the supplementary oilseeds. Its cultivation for the production of bio-based materials is practically possible within all areas defined in Figure 1. It's just obvious that the economics of camelina cultivation as well as its competitiveness to other oil crops with similar use is / will be primarily affected by the market price and seed yields per hectare (Chen *et al.* 2015; Li & Mupondwa 2016; Righini *et al.* 2016). In the case of biofuel production, the situation is different. As indicated by Krohl & Fripp (2012) and Bujnovský *et al.* (2020), decreasing CO_2 emissions per tonne of feedstock (which is part of the life cycle analysis of the final biofuel), is a basic precondition of success. From this point of view, it is necessary to reduce inputs (especially nitrogenous fertilisers) and increase camelina seed yields, which basically represents the increase of inputs productivity. Preference for less humid conditions in the case of reducing CO_2 emissions from cultivation is also significant in this regard.

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