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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Production of Hull-less Mutant of Pumpkin Seed Under Different Abiotic Conditions

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Abstract

Pumpkin seeds are crucial for both human and animal nutrition. Furthermore, the importance of pumpkin seed oil, the snack seed trade and even the medicinal uses of pumpkin seed products have been taken into account for the attempts to improve oil pumpkin seed yield, seed quality and other parameters. The climatic conditions may have a considerable effect on both the vegetative and the reproductive growth as well, and can influence the quality and quantity of the yield. Large-scale field experiment was set up to investigate the climatic sensitivity of hull-less pumpkins. Three groups of fields in different regions of Eastern-Hungary; Southern, Northern and Middle regions were involved in this study. Monthly average temperature and precipitation and soil chemical characteristics were analyzed. Based on the results, the lowest yield was achieved in the Northern region, potentially because of the higher amount of precipitation during the vegetation period. The higher precipitation can possibly increase the sensitivity of pumpkin plants to diseases. The highest amount of the seeds was achieved in the Middle region, where the distribution of the rainfall was moderate. From the investigated soil parameters, the pH had a measurable effect on the final seed yield. It could be concluded that higher precipitation and lower pH can lower pumpkin seed yield. Maximum yield might rely on continuously monitoring the soil moisture status and on the irrigation scheduling management, in addition to the nutrient availability in the soil. Further studies, however, are necessary to prove these hypotheses and to provide more useful data.

Keywords: *Cucurbita pepo*, Precipitation, Soil pH, Temperature, Yield

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1. Introduction

Pumpkin (*Cucurbita pepo* L.) is a really crucial plant species for human and animal nutrition, with more value being in the seed rather than the flesh of the pumpkins. Hull-less pumpkin (*Cucurbita pepo* L. convar. pepo var. styriaca Greb.) (Naked or Styrian Pumpkin) varieties were developed from natural mutants, integuments (seed coats) of which were very thin in contrast to the thick, hard, and close-fitting integuments (hulls) of regular pumpkin seed. The term "hull-less" is used to describe the unique seed trait; however, this is not a botanical description as the seed coat layers in hull-less cultivars still exist. The mutant hull-less seed pumpkin, originated in the Styria region of Central Europe, exposes a complete lack of lignification of the seed test. As a result, it is more desirable as a snack compared to other seed kinds. In the snack seed trade, hull-less pumpkin seeds are treated with heat and pressure in order for the oil to be extracted, and thus hull removal is not needed relative to the normal hulled-seeds (Andres, 2000; Loy, 2004).

Robinson (1981) concluded that this type of pumpkin has a potential value for people who want to set up a lifestyle based on natural and healthy food and self-sufficient food production. Hull-less pumpkin is also a potential oilseed and high-protein seed crop. Because of significant amounts of tocotrienols and other active agents, Styrian Pumpkin is also known as a medicinal crop among other cucurbits. Natural vegetable oils from various species and subspecies of pumpkins are of great interest for pharmacological and medicinal industries (Howitt and Pogson 2006, Vorobyova et al. 2014).

The snack seed trading, the importance of pumpkin seed oil and the medicinal products from the seeds of pumpkins have increased the efforts of oil pumpkin seed yield and quality enhancements (Teppner 2004). Pumpkins are especially sensitive to low temperatures (Top and Ashcroft, 2000) and drought (Seymen et al., 2020; Farzamisepehr et al., 2021).

This study focuses on measuring the yield of hull-less pumpkin seed (Gleisdorfi Classic) in different growing regions in Hungary; namely Northern, Middle and Southern regions under different climatological conditions to know more about the climate sensitivity of this crop.

2. Materials and Methods

Field experiments were set up in 2016 in the eastern part of Hungary. Three groups of fields were involved in the investigation in three different regions; Northern region, Middle region (160 km from the Northern region) and Southern region (280 km from the Northern region) of the eastern side of Hungary (*Table 1*).

Table 1. Group of the examination areas with the details: name of the plots, lot number and the size of plots

Lot number of plot	Name of plot	size of plot (ha)
Northern Region (Szászfa/Pamlény)		
Szászfa 045/5	Szászfa temető mögött	21.08
Szászfa 050/3	Szászfa háromszög	7.46
Pamlény 013/4	Pamlény013	7.79
Southern Region (Fábiánsebestyén/Nagyszénás)		
Fábiánsebestyén 0135/1	100ha-os	103.57
Nagyszénás 061/26	Laci földje	15.18
Nagyszénás 084/34	Nagyszénás kicsi	11.32
Middle Region (Hortobágy/Nagyhegyes)		
Nagyhegyes 0276/1-4	Kecskés	26.63
Hortobágy 01418	Fasor6	4.53
Hortobágy 01416/2	Fasor5	3.41
Hortobágy 01414/2	Fasor4	3.82
Nagyhegyes 0273/3-4	Kertész	10.23

The overall size of each group was at least 35 ha. All of the applied agrotechnological treatments were the same in all fields; i.e. a total fertilization rate of 110, 35 and 250 kg ha^{-1} of N, P_2O_5 and K_2O, respectively were applied in all fields in 2 occasions (prior to seeding and 45 days after). Weed management was applied when necessary. There were 3 plots (fields) in the northern region, 3 plots in the southern region and 5 plots in the middle region (*Table 1*). The row and planting distance was 100 * 50 cm, the number of plants is 12000-13000 plants ha-

1. The cultivar was Gleisdorfi Classic. This cultivar is an early maturity cultivar, tolerant to viruses, to leaf necrosis and to fruit rot with a relatively big seed size (www.saatzuchtgleisdorf.at). Sowing time was early May (8th, 4th and 5th of May in the northern, southern and middle regions, respectively), whereas the harvest was in the middle of October (15th, 9th and 12th of October in the northern, southern and middle regions, respectively).

Average monthly temperature and precipitation were collected (Országos Meterológia Szolgálat) (*Figure 1*) in order to calculate the Gaussen-Bagnouls-xerothermic index (I). The equation is I=N/2T (Gaussen and Bagnouls, 1952), the ratio of average monthly precipitation (N) and the doubled monthly average temperature (T). If the value of this index is below 1, it means ecologically dry month (*Table 2*). In addition, the average temperature, precipitation and daylight hours of the past 30 years are presented in *Table 3*.

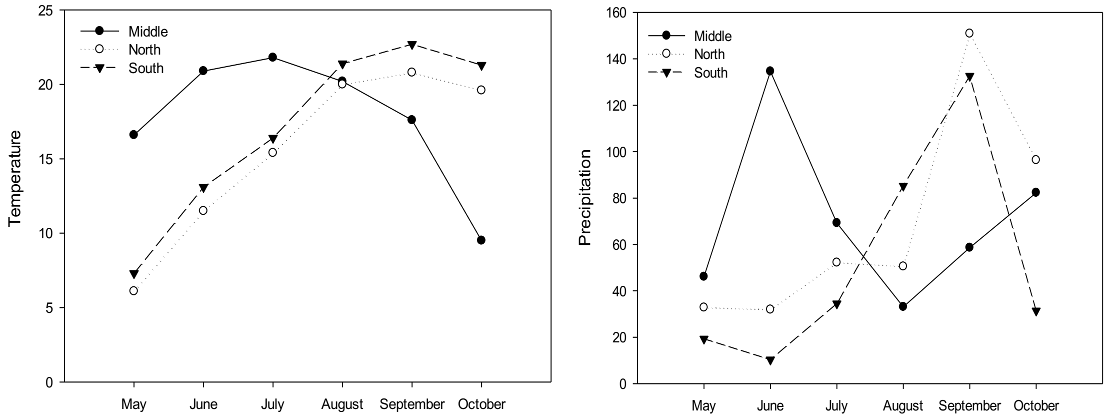

Figure 1. Monthly temperature (ºC) and precipitation (mm) in three regions of hull-less oil pumpkin production during the vegetative period of 2016, Hungary

Soil chemical analyses were performed before sowing in each of the three regions in order to find out the determinant factors that have a main role in affecting hull-less pumpkin yield (Baxter et al. 2012) (*Table 4*).

Table 2. The value of Gaussen-Bagnouls-xerothermic index (Northern, Middle, Southern) during the vegetation period. The bold numbers representing the ecologically dry months.

Region	**May**	**June**	**July**	**August**	**September**	**October**
Northern	2.689	1.387	1.695	1.2625	3.627	2.459
Middle	1.389	3.220	1.587	**0.819**	1.665	4.332
Southern	1.322	**0.393**	1.052	1.993	2.921	**0.737**

Table 3. The 30-year average temperature (T), precipitation (P) and day light hours (DL) in the Middle, Norhtern and Southern regions.

Month	**Middle Region**			**Northern Region**			**Southern Region**		
	T (°C)	**P (mm)**	**DL (hour)**	**T (°C)**	**P (mm)**	**DL (hour)**	**T (°C)**	**P (mm)**	**DL (hour)**
January	-1.3	26	59	-1.9	25	63	-0.7	28	61
February	0.3	30	91	-0.2	30	91	0.9	26	97
March	5.4	30	154	5.1	30	142	6.0	28	144
April	11.4	52	198	11.0	48	190	11.5	39	188
May	16.7	64	251	16.0	64	241	16.9	52	244
June	19.5	66	263	19.1	78	245	19.8	73	258
July	21.6	66	286	21.0	76	267	21.8	58	290
August	20.9	49	277	20.4	69	261	21.4	50	275
September	16.2	48	194	15.7	54	183	16.7	46	197
October	10.6	37	152	10.2	39	142	11.4	34	157
November	4.7	40	81	4.1	41	72	5.2	40	86
December	-0.1	40	48	-0.9	39	49	0.6	42	52

- Source: Hungarian Meteorological Service (www.met.hu)

The experiment was layed out in Complete Block Randomized Design with 3 replicates (plots) in both the Northern and the Southern regions (blocks) and 5 replicates in the Middle region. Microsoft Excel 2019 (Microsoft, USA) was used for arranging the data in proper tables, and then SigmaPlot for Windows (V.12.0) was used for statistical analysis (one-way ANOVA) at 95% probability level, followed by LSD post-hoc test to indicate the significant differences among the 3 regions.

Table 4. Main soil parameters of the investigated sites. n=3-5, ±s.e.

Region	pH	OM m/m%	Nitrite/ Nitrate-N mg kg^{-1}	P_2O_5 mg kg^{-1}	K_2O mg kg^{-1}	Mg mg kg^{-1}	Na mg kg^{-1}	Zn mg kg^{-1}	Mn mg kg^{-1}
Northern	5±0.3	1.63±0.03	7±0.29	40±7.5	147±16	202±21	42±11	1.5±0.1	315±2.8
Middle	6.5±0.3	2.8±0.2	55±30	344±93	338±40	323±60	144±30	2.9±0.5	159±59
Southern	5.4±0.1	2.9±0.3	3.2±1.6	160±33	603±32	333 ±41	76±9	1.6 ±0.3	289±1

3. Results and Discussion

Significant differences ($p \leq 0.05$) in the yield were recorded among the three regions of study. The highest yield (493 kg ha^{-1} ±0.03) was achieved in the Middle region whereas the lowest yield (408 kg ha^{-1} ±0.1) was achieved in the Northern region (*Figure 2*). In the Southern region the yield amount was 440 kg ha^{-1} ±0.1.

According to Bavec et al. (2002), seed yield of oil pumpkin cultivars grown in the traditional 'oil pumpkin' production areas of Central Europe ranges between 500 and 800 kg ha-1 seeds. In our experiment, however, neither irrigation, nor any other agricultural practice was applied, which might explain the relatively-low yields achieved in our experiment.

The Northern region had the highest precipitation amount; 382 mm in 5 months. In the Middle and Southern regions, this amount was less by approximately 100 mm during the same period. However, the distribution was more moderate in the Middle region as high amount was recorded in Southern and Northern regions in August. Water is a crucial abiotic factor during germination through fruit set (Basal and Szabó, 2020; Seymen et al., 2019). Süheri et al. (2020) concluded that the final yield of snap bean had a linear correlation with the seasonal water use. However, too much irrigation, mainly in the fruit ripening period can cause rotting (Maširević et al., 2011), which will probably cause serious yield loss.

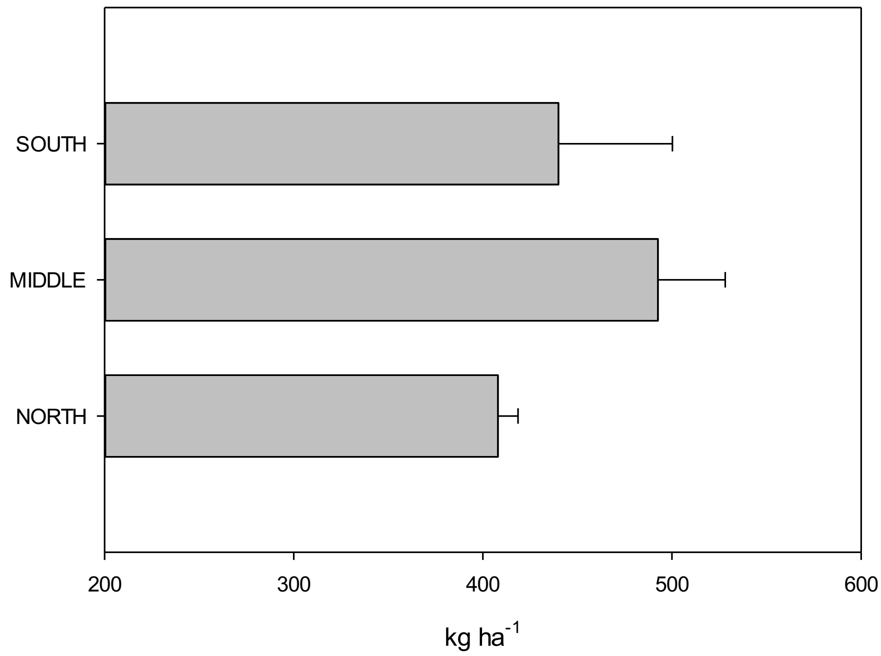

Figure 2. Yield (kg ha^{-1}) of hull-less pumpkin seeds in three different regions (Southern, Middle, Northern) in Hungary, 2016. Bars with different letters (a, b, ab) indicate significant differences at $p \leq 0.05$ level, n=3-5±s.e

Both middle and southern regions had considerably-higher soil organic matter (OM) (by about 78%) compared to the northern region (*table 3*), and that possibly had a positive influence on the yield. OM can enhance plant development with its role on soil sustainability (Marinari et al., 2000; Das et al., 2016), elevated photosynthesis (Amaya-Carpio et al., 2009; Antolín et al., 2010) and, consequently, biomass and seed yield. High organic matter levels are also routinely cited as a key determinant for high yielding pumpkin production (Dimsey, 1994). This conclusion is supported by the results of Tartoura and Youssef (2011) that the biomass of C. pepo was significantly better under enhanced OM content, concluding that the plant growth was OM-dependent. The pH seemed to be one of the main factors which influenced the amount of yield. This is in agreement with the findings of Ahmad et al. (2021) and with Napier (2009) statement that soil pH between 6.0–6.5 is preferred by pumpkin, the Middle part with pH = 6.5 ±0.3 had the highest yield. When the pH was lower with 1.5 units, it caused 1 q less yield. Berenji (2000) indicated that soil boron levels can impact seed set and seed fill in ‘oil pumpkin’ cultivars, thus we also measured elements, like potential effectively active factor for improving yield. The phosphorus, sodium, zinc and sulphur elements influenced the yield positively.

The productivity of pumpkin is highly responsive to N (Moradi et al., 2014; Ünlükara et al., 2021), phosphorus (Hamzei and Najjari, 2014) and zinc (Yousefi and Zandi, 2012).

4. Conclusions

Hull-less pumpkin seeds are gaining national and international popularity, mainly because large-scale consumption possibilities and offering a healthier life. In this experiment, the highest seed yield was recorded in the Middle region of Eastern Hungary, where the soil pH was optimum for the plants and the precipitation was moderate and well distributed over the vegetation period of the plants compared to the other two regions. Thus, it could be concluded that higher precipitation and lower pH might be the reasons of lower yields, along with the lower organic matter, mainly in the Northern region. Maximum yield seems to be dependent on continuous monitoring of the soil moisture status and the management of irrigation scheduling, in addition to the soil’s components. However, further investigations will be necessary to prove these hypotheses.

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