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Identified Resilient Flax Genotypes with Improved Agronomic Characteristics for Pre-Breeding

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Abstract. **Genetic diversity evaluation in a breeding program is essential produce robust, resilient crop varieties with improved agronomic characteristics under environmental challenges in the sustainable agro-ecosystems. Knowledge and full potential on the impact of genotypes and growing conditions on flax yield traits still incomplete. The aim of this study was to evaluated the influence of hydrothermal conditions on the development of agronomic important traits of flax, analysed agronomic characteristics and identified perspective genotypes for pre-breeding. Field investigations were carried out from 2014 to 2017 for agronomically important traits of flax. In the study was evaluated flax population with Latvian origin in 24 fibre flax genotypes and 'Vega 2' (ST) as the standard variety of Lithuanian origin under Latvian meteorological conditions. Correlation between flax genotypes of the agronomically important yield traits and years of the hydrothermal coefficients during the growth period were analysed. According to the results obtained that most of genotypes the significant higher plants stem yield, total plant height, technical plant height, number of seed vessels per plant were measured in the growing seasons with high humidity. However, the higher seed yield and 1000 seed weight were measured in the driest year. The correlation between flax fibre content, seed number per seed-vessel, oil content and humidity level differed in dependence on genotype. The coefficient of variability between years was higher for of stem yield when compared with seed yield. The flax genotypes 'S13/5-7/5-93' exhibited more stable, highest stem yield (840.0 g $m^{-2)}$ and high seed yield (162.2 g m^{-2}). The flax was identified 80% samples the short and 20% the medium vegetation period.**

Keywords: fibre flax, hydrothermal conditions, yield.

I. INTRODUCTION

Flax (*Linum usitatissimum* L.) was known mainly as a textile crop in temperate region. The importance of flax grows up, as an environmentally friendly and potential natural resource, oriented to multilateral use also in nontextile industries - for use in building, paper, furniture industries and in composite (construction or automobile industries) production etc. [1], [2]. In Europe flax is the most general fibre crop.

Divergent breeding for fibre flax and linseed flax in connection with the early dispersion of this crop resulted in a wide range of intraspecific variation [3], [4]. The availability of diverse germplasm, characterization and evaluation data is of the greatest importance to realize the

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full potential of flax in agriculture [5] – [7]. Furthermore, plant breeders are continuously challenged to develop flax cultivars adapted to changing market needs and environments [8], [9].

According to the climate classification, the territory of Latvia is located in the wet climatic zone with warm summers. Currently, flax varieties which are grown in Latvia are from foreign a country, which does not always ensure stable and high quality of stem and seed yield in local climatic conditions. Similar like in the Latvia, in the Europe the aims of new flax varieties are: resistance to lodging reaching 9 points of the grade, middle early vegetation period, yield potential of stem reaching 7 – 8 t ha^{-1}, yielding potential of the seeds reaching 1.10 – 1.30 t ha^{-1} in the trials [10]. Commercial fibre yields depend not only on bred genotype but also on resistance to biotic and abiotic stress during the growing season.

In Europe, the limiting factor that affects flax yield very often is weather conditions (precipitation) [11]. To receive high quality fibre the smooth, wet climate without sudden changes in temperature and humidity and in the soil condition is required [12]. The optimum growing conditions for fibre flax could be when annual precipitation is at least 600 – 650 mm, of which at least 110 – 150 mm rainfalls perform during flax vegetation period [13]. The moisture for the fibre flax in the first period of development from germination to flowering is especially important [14]. Periods of insufficient moisture have a negative effect on the quality and quantity of yield as well significantly reduced the size of the main root and the number of side roots [15]. The insufficient moisture during the intensive growth of the stems has the most negative effect on the length of the technical part of the stem, so this period in the ontogenesis of flax is critical from the point of view of fibre yield formation. Excess moisture, especially when sowing densities and nitrogen content in the soil are high, can result in lodging [16]. However, flax is characterized by wide ecological differentiation including significant polymorphism in response to moisture deficiency [15].

In recent years, it has become more difficult to breed new fibre flax varieties with a better fibre quality, increased fibre yield, and the required resistance, due to repeated use of modern cultivars as crossing parents [10]. Knowledge on the impact of genotypes and growing conditions on flax yield traits as well resistance of disease of flax are still incomplete under the impact of the environments. The aim of this study was to evaluated the influence of hydrothermal conditions on the development of agronomic important traits of flax, analysed agronomic characteristics and identified perspective genotypes for pre-breeding.

II. MATERIALS AND METHODS

The research was conducted at the Institute of Agricultural Resources and Economics, Priekuli Research Centre, Department of Plant Breeding and Agroecology at Vilani during 2014 to 2017 for agronomically important traits of flax. Experimental material for the study consisted of 24 fiber flax genotypes of the Latvian origin (Table 1) and ‘Vega 2’ (ST) as the standard variety of Lithuanian origin.

TABLE 1. ESTIMATED FIBRE FLAX GENOTYPES

Nr.	Genotype	Nr.	Genotype
P1	Altgauzen	**P13**	T29-36/10-5-94
P2	Rota 1	**P14**	T29-36/7-1-94
P3	Rota 2	**P15**	T31-40-94
P4	Rezeknes	**P16**	T36-26/4-8-94
P5	Ruda 1	**P17**	K47-17/11-1-95
P6	S13/5-7/5-93	**P18**	K47-17/11-6-95
P7	S32/4-8-93	**P19**	L2-14/6-97
P8	S53/8-3-93	**P20**	L11-11/10-97
P9	S64-17-93	**P21**	L11-11/11-97
P10	T11-6/2-15-94	**P22**	L19-6/15-97
P11	T11-13/3-1-94	**P23**	L23-26/3-97
P12	T25/5-33/12-8-94	**P24**	L26-47/1-97

Field traits. Plants were grown in standard block plots of 1 m^2 with a distance between rows 10 cm, 1700 flax seeds per 1 m^2 were sown by hand with sowing depth 1.5–2 cm at the field trial. Prior to sowing, germination tests were performed for all used genotypes. Seeds were sown during the first 10 days of May. Flax was grown in humi-podzolic gley soil. The main agrochemical parameters of the arable soil layer were following: humus content – 6.5%, pHK_{Cl} – 6.4–7.0, available P_2O_5 – 130–145 mg kg^{-1} and available K_2O – 118–124 mg kg^{-1} soil (by results of The Latvian State Plant Protection Service). Complex fertilizer NPK 16:16:16 – 300 kg ha^{-1} was applied after first soil cultivation. For plants’ further development a surface fertilizer - ammonium nitrate 30 kg ha^{-1} N in fir-tree like phase was applied. Insecticide (‘Fastac 50’ 0.4 L ha^{-1}, active substance: 50.0 g L^{-1} alpha-cypermethrin) was sprayed against flax flea beetles (Aphthona euphorbiae) as required by the instructions. The tractor-drawn sprayer ‘Pilmet 412’ was used for insecticide application. Fungicides for flax diseases were not used at all. Plants were pulled manually at the stage of early yellow ripeness and then left on ground for air-drying for 5–8 days. The seed-vessels were removed by “Eddi” device. Seeds were cleaned with “MLN” sample cleaner. The yield of seeds was weighed and then re-calculated to weight by 100% purity and 12% humidity. The total and technical plant heights, fibre content was determined using randomly selected most typical 20 plants in each parcel area before the harvest. The length of the vegetation period from seeding to early yellow ripening stage was evaluated [2].

Meteorological conditions. Agro-meteorological conditions were determined by ADCON installed meteorological stations connected to the computer program Dacom Plant Plus. Facility provides information directly to the nearby field trials. In this study hydrothermal coefficient (HTC) of each month was calculated during the growing season (Table 2). The calculations were performed by applying formula [17]:

$$HTC = \Sigma x / \Sigma t \times 10, \quad (1)$$

where Σ x and Σ t – sum of precipitations and temperatures in the period, when the temperature has not been lower than 10°C (1).

Ranges of values [18]: HTC ≤ 0.4 extremely dry; 0.4 < HTC ≤ 0.7 very dry; 0.7 < HTC ≤ 1.0 dry; 1.0 < HTC ≤ 1.3 relatively dry; 1.3 < HTC ≤ 1.6 optimal; 1.6 < HTC ≤ 2.0 relatively humid; 2.0 < HTC ≤ 2.5 humid; 2.5 < HTC ≤ 3.0 very humid; HTC > 3.0 extremely humid.

Statistical analysis. MS-Excel software was used for data statistical analysis. Significant differences among the measured characteristics of flax were compared by Fisher's protected least significant difference (LSD) tests ($p \leq 0.05$). The correlation coefficient was used to analyse relationship between hydrothermal coefficient (HTC) and agronomically important traits for each genotype. We used the coefficient of variability (CV) used by [19], [20] to describe of stability for each genotype as a stability parameter for stem yield and seed yield.

TABLE 2 TOTAL RAINFALL, AVERAGE OF AIR TEMPERATURE AND HYDROTHERMAL COEFFICIENTS (HTC) DURING 2014 TO 2017

Year	Month	Rainfall, mm	Temperature °C	HTC	Classifications
2014	May	99.5	7.6	2.9	very humid
	June	75.6	13.2	1.7	relatively humid
	July	25.2	13.7	0.5	very dry
	August	124.8	19.9	2.6	very humid
	May - August			**1.8**	relatively humid
2015	April	71.5	16.9	2.1	humid
	May	38.0	15.3	0.8	relatively dry
	June	89.5	16.2	1.8	relatively humid
	July	19.5	17.7	0.4	very dry
	May - August			**1.2**	relatively dry
2016	May	38.0	14.1	0.9	dry
	June	102.5	16.4	2.1	humid
	July	165.3	18.0	3.0	very humid
	August	70.7	16.2	1.4	optimal
	May - August			**1.9**	relatively humid
2017	May	15.1	10.7	0.5	very dry
	June	77.3	13.7	1.9	relatively humid
	July	129.5	15.4	2.7	very humid
	August	239.4	16.4	4.7	extremely humid
	May - August			**2.7**	very humid
Long term average	May	52.0	11.1	1.5	optimal
	June	75.0	14.8	1.8	relatively humid
	July	81.0	16.9	1.6	optimal
	August	71.0	15.5	1.5	optimal
	May - August			**1.6**	optimal

III. RESULTS AND DISCUSSION

The hydrothermal conditions during the growing stages of flax differed (Table 2). In 2014 HTC was 1.8 and in 2016 was 1.9, where it is characterized as relatively humid, in 2015 it was 1.2 what means as relatively dry. But 2017, when it was 2.7, it was very humid, when HTC in August was 317%, what is extremely higher than the long-term average.

The genotype effect on the overall statistically different stem, seed yield and yield components in different humidity conditions was quite variable during 2014 to 2017 (Table 3 and 4). The correlation confirmed significant positive relationship to the most of genotypes between stem yield, total plant height, technical plant height and level of humidity. The correlation coefficient shows that genotypes 'Altgauzen' (P1) and 'Vega 2' (ST) have been highest total plant height and technical pant height in the high humidity condition. The significant impact of the hydrothermal conditions on the fibre content between genotypes was not observed. This fact suggests that flax fibre content more dependence on genotype. According to [10], [21], is known that both additive and dominant effects of genes are involved in the heredity of fibre content and both effects are influenced by environmental conditions but it is still uncertain how many genes are involved in the heredity of fibre content and stem yield at the same time the heritability was lower. It was proved earlier [22], that the low heritability found for stem yield suggests a considerable environmental influence.

The current study showed that from all accessions, 80% of genotypes were with short (3) and 20% of genotypes with medium (5) vegetation period (Table 3). The resistance to abiotic factors as lodging of the tested accessions ranged from 3 (low) to 9 (very high). The highest resistance to lodging reached 9 of the genotypes 'Rota 1' (P2), 'T31-40-94' (P15) and 'K47-17/11-6-95' (P18) during 2014 to 2017. According to the data, between all flax accessions were identified genotypes 'L11-11/11-97' (P21), 'S13/5-7/5-93' (P6), 'T11-13/3-1-94' (P11) and 'S64-17-93' (P9) with significant ($p \leq 0.05$) higher the stem yield with the range from 755 to 840 g m^{-2}. The significant ($p \leq 0.05$) highest total plant height was observed in 13 genotypes with the range from 75.8 to 81.4 cm, the technical plant height - in 14 genotypes with the range from 61.8 to 67.1 cm and the fibre content - in 8 genotypes with the range from 29.6 to 32.0% compared with the standard 'Vega 2'(ST). According to [23], important agronomic traits such as vegetation period length, plant height, and lodging resistance may also indirectly affect yield through various physiological mechanisms, allowing crop phenology and plant architecture to be adapted to regional growing conditions, thus avoiding yield and quality losses.

TABLE 3 AGRONOMICALLY IMPORTANT STEM YIELD TRAITS OF FLAX GENOTYPES AND CORRELATION COEFFICIENT BETWEEN TRAITS AND HYDROTHERMAL COEFFICIENT (HTC)

Nr.	VP	L (range)	STY, g m^{-2}	r_{STY} /HTC	ToPH, cm	r_{ToPH} /HTC	TePH, cm	r_{TePH} /HTC	FC, %	r_{FC} /HTC
P1	3	3-9	362.5	0.14	59.4	**0.95***	43.1	0.09	24.2	-0.71
P2	3	9	650.0	0.57	**75.8**	0.83	59.1	0.42	27.2	0.29
P3	3	3-9	470.0	0.41	58.1	0.47	45.1	-0.03	27.9	-0.43
P4	3	5-9	262.5	-0.15	51.9	0.00	37.9	-0.82	25.1	0.37
P5	3	7-9	427.5	0.08	60.9	0.77	48.4	0.29	25.8	0.49
P6	3	7-9	**840.0**	0.51	**79.5**	0.90	**64.7**	0.64	26.2	0.23
P7	3	7-9	597.5	0.40	69.1	0.74	54.5	0.23	**30.1**	0.01
P8	3	7-9	665.0	0.44	77.3	0.76	**62.4**	0.48	**31.7**	-0.37
P9	5	5-9	**755.0**	0.62	77.0	0.67	**61.8**	0.53	26.9	-0.58
P10	3	3-9	665.0	0.76	72.3	0.68	58.4	0.44	**30.0**	0.31
P11	3	5-9	**815.0**	0.70	**79.2**	0.85	**64.8**	0.67	28.9	-0.22
P12	3	5-9	675.0	0.27	**80.1**	0.70	**65.2**	0.32	28.7	0.30
P13	3	5-9	660.0	0.36	**78.8**	0.47	**65.5**	0.29	**29.9**	0.61
P14	3	5-9	667.5	0.41	**78.8**	0.69	**64.2**	0.17	**29.6**	0.13
P15	3	9	617.5	0.14	**78.3**	0.87	**63.0**	0.24	25.6	-0.54
P16	3	7-9	660.0	0.33	**79.3**	0.72	**64.4**	0.27	**32.0**	-0.01
P17	5	5-9	660.0	0.19	**79.4**	0.43	**64.0**	0.00	28.7	-0.64
P18	5	9	622.5	0.30	**78.0**	0.63	**63.2**	0.26	28.1	-0.41
P19	3	5-9	542.5	0.22	73.4	0.40	59.4	0.00	27.1	-0.11
P20	3	5-9	687.5	0.36	73.3	0.44	58.2	-0.01	26.5	-0.03
P21	5	7-9	**840.0**	0.76	**80.8**	0.68	**64.2**	0.08	29.4	0.72
P22	3	5-9	664.3	0.69	74.1	0.87	60.6	-0.08	26.5	0.37
P23	3	5-9	642.5	0.66	**78.5**	0.43	**63.5**	0.03	**30.8**	-0.88
P24	5	5-9	672.5	0.55	**81.4**	0.84	**67.1**	0.60	**29.9**	0.22
ST	3	7-9	562.5	0.54	73.4	**0.98***	58.5	**0.95***	27.1	-0.28
LSD$_{0.05}$			*174.4*		*4.2*		*3.1*		*2.3*	

VP – vegetation period; L – lodging; STY - stem yield; ToPH - total plant height; TePH - technical plant height; FC - fibre content; LSD values significant at $p \leq 0.05$ are marked in bold comparing with 'Vega 2' (ST); *r* - correlation coefficient * − correlation significant at $p \leq 0.05$; ** − at $p \leq 0.01$

The correlation confirmed significant negative relationships between seed yield, seed number per seed-vessel, 1000 seed weight and level of humidity to the most genotypes (Table 4). The correlation coefficient shows that the seed yield for genotypes 'Ruda 1' (P5), 'S13/5-7/5-93' (P6), 'S32/4-8-93'(P7), 'L26-47/1-97' (P24), 'Vega 2' (ST) and seed number per seed-vessel for genotype 'T29-36/7-1-94' (P14) have been highest in the dry condition. A significant influence of the hydrothermal conditions on the 1000 seed weight for 12 genotypes was found. This fact suggests that the 1000 seed weight of identified genotypes is the highest in the dry conditions. The correlation confirmed significant positive relationships between number of seed-vessel per plant, oil contents and level of humidity to the most genotypes. The correlation coefficient shows that the number of seed-vessel per plant for genotypes 'S13/5-7/5-93' (P6), 'T36-26/4-8-94' (P16), 'K47-17/11-1-95' (P17), 'K47-17/11-6-95' (P18) have been highest in the high humidity condition. The correlation equation shows that the highest oil content was found for genotypes 'Rota 1' (P2), 'T29-36/10-5-94' (P13), 'L19-6/15-97' (P22), 'L23-26/3-97' (P23), 'Vega2'(ST) in the high humidity condition but for genotypes 'Rezeknes' (P4) and 'S13/5-7/5-93' (P6) - in the driest conditions.

Some study [24] proved that in flax yield and its components such as 1000 seed weight, seed number per seed-vessel and number of seed-vessel per plant are quantitatively inherited and controlled by many genes affected by multiple interactions with other genes and the environment.

The study [25] note, that the change in oil content depends on the genotypic differences. However, some [26], [27] note, that the range of variation not only within the genotype but also with regard to the climatic conditions of cultivation including water availability influence the oil content of flax seed. In general, similar results could find in our study.

TABLE 4 AGRONOMICALLY IMPORTANT SEED YIELD TRAITS OF FLAX GENOTYPES AND CORRELATION COEFFICIENT BETWEEN TRAITS AND HYDROTHERMAL COEFFICIENT (HTC)

	SY, g m^{-2}	$r_{SY/HTC}$	NSVP	$r_{NSVP/HTC}$	SNSV	$r_{SNSV/HTC}$	SW, g	$r_{SW/HTC}$	OC, %	$r_{OC/HTC}$
P1	100.2	-0.87	9.7	0.81	**8.4**	0.80	4.0	**-0.98***	**43.3**	0.68
P2	**163.8**	-0.34	9.8	0.79	**8.7**	0.37	5.0	-0.94	42.2	**0.96***
P3	**159.9**	-0.81	8.3	0.26	**8.5**	-0.76	5.7	**-0.97***	**43.6**	0.26
P4	121.2	-0.84	**10.0**	0.70	**8.7**	-0.50	4.4	-0.92	**43.6**	**-0.96***
P5	**165.0**	**-0.99***	9.7	0.71	**8.6**	-0.60	5.0	**-0.99****	**43.0**	0.50
P6	**162.2**	**-0.96***	8.1	**0.97***	**9.4**	-0.20	4.6	**-0.99****	42.2	**-0.99****
P7	**162.0**	**-0.98***	**10.4**	0.75	**8.6**	0.18	4.5	**-0.99****	41.9	0.03
P8	145.1	-0.84	9.9	0.67	**8.8**	-0.45	4.7	**-0.95***	43.0	0.90
P9	**158.4**	-0.84	9.6	0.92	**9.1**	0.42	4.5	**-0.96***	42.5	0.90
P10	**153.2**	-0.98	8.9	0.61	**8.8**	-0.35	**5.1**	**-0.99****	42.0	0.02
P11	**158.9**	-0.83	8.8	0.59	**8.7**	0.65	4.8	-0.78	42.2	0.20
P12	110.4	0.02	7.6	0.63	**8.5**	0.69	4.7	-0.94	**43.6**	0.84
P13	137.4	0.08	6.9	0.82	**8.8**	0.10	5.0	-0.93	42.1	**0.97***
P14	133.4	0.15	7.7	0.73	**9.0**	**-0.95***	5.0	-0.85	41.9	0.94
P15	112.2	0.13	8.6	0.90	**8.4**	-0.70	4.6	**-0.96***	**43.6**	0.59
P16	117.5	-0.31	8.8	**0.99****	**8.9**	-0.68	5.0	-0.83	**43.7**	0.76
P17	134.9	-0.60	9.1	**0.98***	**8.9**	0.68	4.8	-0.92	**43.6**	0.90
P18	135.3	-0.63	9.8	**0.95***	**8.8**	-0.63	4.6	-0.94	42.6	-0.16
P19	139.0	-0.62	9.3	0.93	**8.9**	0.50	4.5	-0.90	41.9	0.50
P20	**163.5**	-0.82	**10.4**	0.49	**8.6**	-0.56	**5.3**	**-0.99****	**43.5**	0.82
P21	**168.7**	-0.53	**10.6**	0.78	**8.9**	-0.09	4.9	**-0.95***	42.9	0.76
P22	140.1	-0.16	9.7	0.72	**9.0**	-0.82	**5.4**	-0.87	**43.7**	**0.99****
P23	108.5	0.83	8.7	0.92	**8.7**	0.41	4.6	-0.84	42.5	**0.99****
P24	141.1	**-0.98***	8.3	0.93	**9.2**	-0.34	4.6	**-0.96***	42.7	0.54
ST	126.9	**-0.97***	8.5	0.87	8.1	-0.24	4.7	-0,94	42.7	**0.99****
$LSD_{0.05}$	*19.5*		*1.4*		*0.3*		*0.4*		*0.3*	

SY - seed yield; NSVP - number of seed-vessel per plant; SNSV - seed number per seed-vessel; SW - 1000 seed weight; OC - oil contents; LSD values significant at $p \leq 0.05$ are marked in bold comparing with 'Vega 2' (ST); r - correlation coefficient * − correlation significant at $p \leq 0.05$, ** − at $p \leq 0.01$

The current study identified 10 genotypes with the significantly ($p \leqslant 0.05$) highest seed yield (the range from 153.2 to 168.7 g m^{-2}) and 4 genotypes with the number of seed-vessel per plant (the range from 10.0 to 10.6) (Table 4). The seed number per seed-vessel (in range from 8.1 to 9.4) for all accessions was significantly higher than that of the standard variety 'Vega 2'. The significantly highest 1000 seed weight was observed in 4 genotypes: 'Rota 2' (P3), 'T11-6/2-15-94' (P10), 'L11-11/10-97' (P20) and 'L19-6/15-97' (P22) with the range from 5.1 to 5.7g. The significantly highest oil content was observed in 10 genotypes with the range from 43.0 to 43.7% compared with the standard 'Vega 2' (ST).

The flax genotype 'L11-11/11-97'(P21) exhibited the highest average stem yield (840.0 g m^{-2}), seed yield (168.7 g m^{-2}) and high total plant height, technical plant height, number of seed-vessel per plant, seed number per seed-vessel than the standard variety 'Vega 2'. However, there was identified most promising genotype 'S13/5-7/5-93' (P6) with high stem yield (840.0 g m^{-2}) and lower correlation between HTC (r = 0.51) and stem yield (Table 3). This fact suggests that the identified genotype 'S13/5-7/5-93' (P6) was more resistant to dry and humidity conditions during the growing periods.

The current study according to soil analysis, agrochemical indicators have not significantly differed by years which suggested complex (genetic, environment) factors influencing the growth and development of flax. At same time finding current study showed that most of the agronomically important traits of flax are subject to productivity variation depending on the effect of various humidity conditions between years and genotypes. Furthermore, identified that each genotypes have different response at the same conditions. The results allow selecting the environment which genotype is more adapted at different hydrothermal conditions in comparison with other genotypes evaluated simultaneously in the same environments. The research needs to be continued in order to understand the specific needs of each genotype and to identify which ones are more suitable to local conditions.

The coefficient of variability (CV) between years was higher for of stem yield when compared with seed yield (Fig.1, 2). The 'S53/8-3-93' (P8) had lowest coefficient for seed yield (CV =8%) and the 'Rota 1' (P3) had the highest (CV =51%). Potential promising genotypes with highest seed yield and higher stability were identified 'L11-11/11-97' (P21), 'Rota 1' (P2), 'L11-11/10-97' (P20) and 'S13/5-7/5-93' (P6).

Between genotypes, the 'L26-47/1-97' (P24) had the lowest variability coefficient for stem yield (32%), and the 'L11-11/11-97' (P21) had the highest (CV = 60%). However, the most promising genotype with the highest seed and stem yield and lowest coefficient of variability was ‘S13/5-7/5-93’ (P6) was observed.

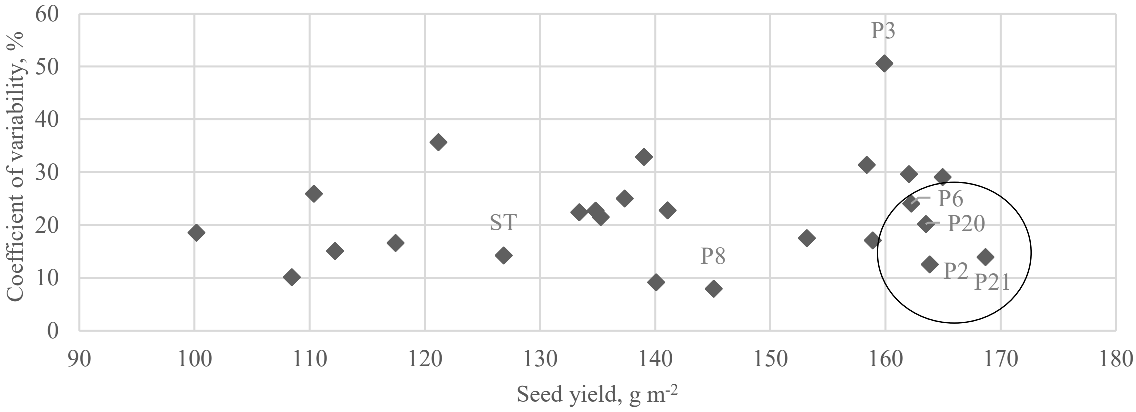

Fig. 1. The relationships between coefficient of variability (CV) of seed yield and average seed yield for each flax genotype from 2014 to 2017.

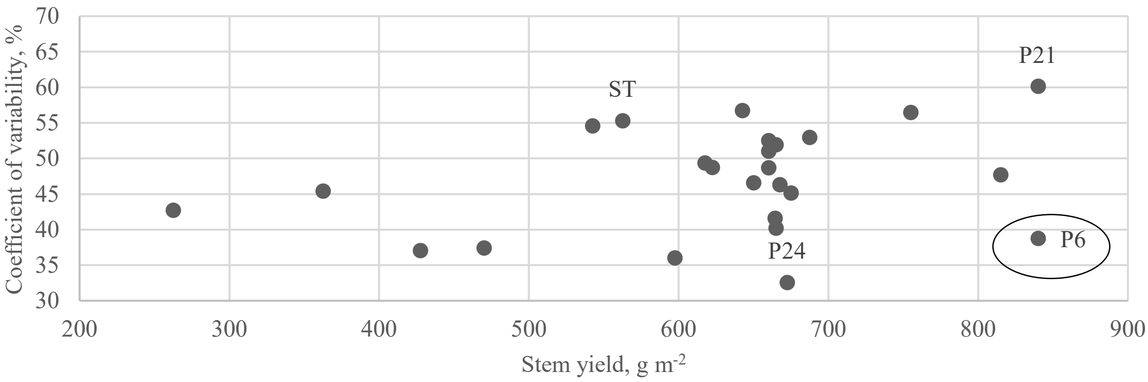

Fig. 2. The relationships between coefficient of variability (CV) of stem yield and average stem yield for each flax genotype from 2014 to 2017.

IV. CONCLUSIONS

Overall, based on the analyses of correlation, a variable influence of hydrothermal conditions on the trait of flax between years and genotypes was found. The most flax genotypes had highest total plant height, technical plant height, stem yield, a number of seed-vessel per plant and oil contents in high humidity conditions and seed yield, seed number per seed-vessel, 1000 seed weight highest in dry conditions. Furthermore, identified that each genotypes have different response at the same conditions. The flax fibre content was identified as the more heritable.

The promising genotype ‘S13/5-7/5-93’ (P6) with high stem (840.0 g m^{-2}), seed yield (162.2 g m^{-2}) and more stable stem yield performance between variable hydrothermal conditions were identified for pre-breeding.

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