Journal of Agricultural Sciences
Vol. 51, No 1, 2006
Pages 7-13

UDC: 582.741
Original scientific paper

VARIABILTY OF SOME TRAITS OF FLAX SEED IN RESPECT TO GENOTYPE AND CLIMATIC CONDITIONS

Radojka Maletić[1] and R. Jevdjović[2]

Abstract: Beside its multiple use in oil producing and feed industry, flax seed is used also in pharmaceutical industry as additional medicinal component, whether as mono component or in tea mixtures.

Results of a two-year cultivation of several flax genotypes are analyzed. The highest yield of seed in both study years was achieved in genotype "Z" and the lowest in standard cultivar "Mira". In regard to germination energy and total germination, the best value was determined for genotype "B" and the lowest for standard cultivar "Mira". The greatest swelling of flax seeds was established for genotype "B", and the least in the case of genotype "Z".

Climatic conditions in the year of cultivation had effects on yield and quality of flax seed. During 2001, the year with high rainfall, higher yields were produced in all tested genotypes, and better germination energy, total germination and mass of 100 seeds established. In seed obtained in 2002, when average temperatures were higher, number of swollen seeds was higher.

Key words: flax, genotype, yield, quality, swelling of seed.

Introduction

Flax (*Linum usitatisimun L.*) is annual herbaceous plant from the family *Linaceae*. The most significant genus of this family *Linum* (flax) includes approx 300 species (Kojić and Pekić, 1995). It is possible that flax originates from wild flax *Linum angustifolium* (Martin and Leonard, 1967). Central Asia is considered to be its place of origin, the Mediterranean region and Ethiopia (Milošević, 1997). It is mostly cultivated in Russia, India, South America and

[1] Radojka Maletić, PhD, Professor, Faculty of Agriculture, 11081 Belgrade-Zemun, Nemanjina 6, Serbia and Montenegro

[2] Radoslav Jevdjević, MSc, Medicinal Plants Research Institute «Dr Josif Pančić» 11000 Belgrade, Tadeuša Košćuška 1, Serbia and Montenegro

Canada (Tucakov, 1996). Also, USA has significant production of flax (Davidson and Laude,1938; Hill, 1939; Klages, 1938; Reddy and Burnett, 1936). It is cultivated for production of fibres and seeds for further production of oil (Djordjević , 1961; Dillman, 1928; Johnson, 1932; Abramov, 1944; Potočanec, 1950; Pasković, 1966). In our conditions it is cultivated as summer culture but it can also be winter culture (Potočanec, 1952). Predominantly, cultivars with seed of brown colour are cultivated, but there are also cultivars with yellow seed created by plant breeders (Dijanović et al., 2002). Flax seed is also widely used in medicine, scientific and folk medicine, primarily because of abundance of very useful and important substances which it contains. Recently, it is also used in human nutrition (as substitute for sesame in production of bread and other bakery products) and predominantly cultivars with yellow seed are used for this purpose (Stanković and Petrović, 1998). In mature flax seed there is 5-10% of mucilage, 25-40% of fatty oil, vitamin F (linoleic and linolenic acid), approx. 25% of proteins (which makes this seed very nutritious).

The aim of the research was to demonstrate if and to what extent genotypes influence the quantity and quality traits of flax seed and if climatic conditions in the year of study (primarily precipitation and temperature) have certain effect on mentioned traits.

Material and Methods

In this research seed of plant species of flax (*Linum usitatisimun L.)* was used, which was cultivated and multiplied in the Institute of Medicinal Plant Research "Dr Josif Pančić", Belgrade. Two genotypes marked as "B" and "Z" were tested and cultivar "Mira" was used as a control.

Research was carried out during 2001 and 2002. Experiments were set on locations of South Banat on the soil type of marsh dark soil at 70 m above sea level. Soil was of poor acid reaction (pH=6.2), content of humus 3.5%, phosphorus 5.5 mg per 100 g of soil and potassium 42 mg per100 g of soil.

Tab. 1.- Distribution of temperature and mean daily temperature during vegetation season of 2001 and 2002

Month	DECADES I		II		III		Average daily temperature ^{0}C	
	2001	2002	2001	2002	2001	2002	2001	2002
IV	11.4	8.7	10.3	12.9	15.0	15.8	12.2	12.5
V	13.2	19.8	17.8	21.4	20.3	22.7	19.2	20.7
VI	17.8	20.2	22.0	24.5	21.4	25.7	20.4	23.5
VII	22.7	26.0	26.4	26.5	22.2	23.1	23.7	25.1
VIII	27.3	24.3	23.6	21.0	25.4	22.5	24.6	22.6
IX	14.4	22.1	14.8	16.9	17.9	16.7	15.2	18.6

In both study years, trials were carried out in four repetitions for each genotype and standard cultivar surface of basic trial plot was 20 m^2. Climatic conditions (temperature and precipitation) during vegetation differed significantly in study years.

T a b. 2.- Distribution of precipitation and total precipitation during vegetation season of 2001 and 2002

Month	DECADES I		II		III		Total precipitation, mm	
	2001	2002	2001	2002	2001	2002	2001	2002
IV	44.6	4.1	14.5	26.0	78.3	6.6	137.4	36.7
V	29.0	2.4	23.7	2.8	12.6	10.3	65.3	15.5
VI	55.8	8.1	90.4	6.9	34.1	5.5	180.3	20.5
VII	3.6	5.9	6.2	22.7	14.8	12.1	24.6	40.7
VIII	10.2	49.1	32.5	36.4	9.5	2.6	52.2	88.1
IX	72.9	0.0	98.8	7.2	16.7	64.2	188.5	71.4

Direct sowing of flax was carried out for all genotypes and standard cultivar in both study years in the second decade of April in continuing rows with distance between rows of 50 cm and depth of 3 cm. During vegetation standard cultivation measures have been applied, weed plants were destroyed mechanically without the use of herbicides. Presence of diseases and harmful insects was not registered in flax plants. Harvest in both study years was carried out in the first decade of August. Seed was dried naturally to 9% moisture and cleaned and subsequently yield from all repetitions was determined. Samples were taken for analysis of quality.On a precise scales mass of seed was determined, and using usual method (in Petri dishes on filter paper at 20^0C) germination energy and total germination were established. In the laboratory of the Institute also number of swollen seeds was determined.

Obtained experimental data were processed using mathematical-statistical procedure. Testing of the significance of differences between calculated mean values of investigated factors (genotype and year) was carried out using model of variance analysis of the following mathematical form:

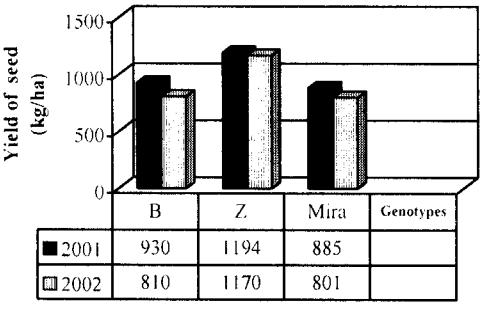
$$y_{ij} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk} \qquad (i=1,2,3;\ j=1,2;\ k=1,2,3,4)$$

Evaluation of significance was carried out based on F-test and LSD-test for threshold of significance of 5% and 1%.

Results and Discussion

Average yields of flax seed of investigated genotypes and cultivars, obtained from four repetitions and in both study years are presented in graph 1.

Considerably higher yield of flax seed in all genotypes was realized in the first study year (graph. 1), which is probably the result of considerably higher precipitation and more rainy days compared to the next year - 2002 (table 2). Flax genotype "B" had approx by 14% higher yield in the first study year, whereas the flax genotype "Z" had the least reactions to change of climatic conditions (precipitation and temperature) and realized by only 2% higher yield in 2001.



Graph. 1. - Average yield of flax seed different genotypes (kg/ha)

LSD	Genotype	Year	Genotype x Year
0.05	36.0553	29.4390	50.9898
0.01	49.3894	40.3262	69.8470

The highest yield of flax seed in both analyzed years was established for genotype "Z" (1194 kg/ha in 2001 and 1170 kg/ha in the year 2002), and the lowest for cultivar "Mira" (885 kg/ha in 2001 and 801 kg/ha in the year 2002) Yield of seed of genotype "Z" was statistically significantly higher than yield of other genotype ("B") and cultivar "Mira", $P<0.01$ (graph. 1). Difference in yields of genotype "B" and cultivar "Mira" was not statistically significant ($P>0.05$), graph. 1 Produced yields were mainly in accordance with the results of previous investigations (Dijanović et al., 2002; Stanković and Petrović,1998).

Interaction of factors also demonstrated statistical significance ($P<0.05$), which indicated that they were mutually determined.

Average values of germination energy of flax seed demonstrated great differences between investigated genotypes (table 3). The greatest germination energy was determined in flax genotype "B" (92% in 2001 and 90.25% in the year 2002) and the lowest for cultivar "Mira" (79.25% and 78.50%, respectively). Determined differences in germination energy of flax seed genotype "B" and other genotype and cultivar are statistically very significant ($P<0.01$), whereas the

difference in germination energy of flax seed genotype "Z" and cultivar "Mira" was not statistically significant (P>0.05). Difference in germination energy in different study years also was not statistically significant (F_{exp}=0.1646) as well as interaction of factors (F_{exp}=0.2553).

T a b. 3. - Quality of seed flax

Genotype flax	Year	Germination energy	Total germination	Mass of 100 seeds	Number swell
"B"	2001	92.00	96.00	0.392	6.40
	2002	90.25	91.50	0.367	6.50
"Z"	2001	88.25	94.25	0.588	5.25
	2002	89.00	90.50	0.559	5.50
"Mira"	2001	79.25	83.75	0.569	5.75
	2002	78.50	80.50	0.554	6.00
LSD test					
0.05	Genotype	3.6996	3.8239	0.0129	0.2053
0.05		5.0678	5.2380	0.0176	0.2812
0.05	Year	3.0207	3.1222	0.0105	0.1676
0.01		4.1378	4.2768	0.0144	0.2296
0.05	Interection	5.2320	5.4078	0.0182	0.2903
0.01		7.1670	7.4077	0.0249	0.3977

Varying of average value of total germination of flax seed has, as expected, similar tendency as previous trait, germination energy (table 3). Flax genotype "B" demonstrated the highest germination (96% in 2001 and 91.5% in the year 2002), whereas the cultivar "Mira" in both study years demonstrated the lowest degree of germination (83.75% and 80.50% respectively). Total germination of seed of genotype "B" was statistically considerably higher compared to germination of other flax genotype "Z" and cultivar "Mira", P<0.01. Germination of cultivar and genotype "Z" demonstrated no statistically significant differences. Difference in total germination between two sdudy years was statistically significant (P<0.05) in favour of the first experimental year (2001). Interaction of investigated factors showed no statistical significance.

Results of the investigation of the flax seed quality do not deviate significantly from results of previous investigations (Potočanec, 1952; Dijanović et al., 2002; Stanković and Petrović, 1998).

Obtained results for realized average flax seed mass indicate that genotype "B" had the seed of lowest mass (0.392 and 0.367 g respectively), whereas the other genotype "Z" and cultivar "Mira" had higher and approximately similar seed mass (from 0.554 g to 0.588 g of 100 seeds), therefore established difference in regard to seed mass between genotype "B" and other genotypes was statistically highly significant. There is also statistically significant difference

between study years in regard to seed mass. In 2001 considerably higher seed mass was determined in all genotypes. Interaction of investigated factors showed no statistical significance.

Parameter relating to swelling of seed had the highest value in flax genotype "B" in both study years. Established difference in number of swollen seeds between investigated genotypes and cultivar was $P<0.01$, and between study years $P<0.05$. In the year 2002, when temperatures were higher (table 1), number of swollen seeds was higher in all genotypes (table 3).

Conclusion

Based on carried out investigation and analysis of obtained results, the following can be concluded:

Higher precipitation during vegetation has positive effects on flax cultivation.

Higher temperatures also have positive effects on number of swollen seeds.

Genotypes "B" and "Z" demonstrated better quantitative traits than standard cultivar and should be introduced into production with additional investigations.

Flax genotype "Z" had the highest yield and mass of 100 seeds.

These investigations should be continued with different sizes of vegetation space and new genotypes.

REFERENCES

1. Kojić, M., Pekić, S. (1995): Botanika, "Nauka", Beograd.
2. Martin, J.H. and Leonard, W.H.(1967): Princlipes of field crop production, The Mac Millan Company-New York.
3. Milošević, D. (1997): Posebno ratarstvo, Zavod za izdavanje udžbenika, SR Srbija, Beograd.
4. Tucakov, J.(1996): Lečenje biljem, "Rad", Beograd.
5. Davidson, F.E. and Laude, H.H. (1938): Flax production in Kansas, Kans. Agr. Exp. Sta. Bul. 191, pl-14.
6. Hill, D.D.(1939): Seed-flax production in Oregon, Ore. Agr. Exp. Sta. Cir. 133.
7. Klages, K.H.W.(1938): Flax –production in Idaho, Idaho Agr. Exp. Sta. Bul. 224.
8. Reddy, C.S. and Burnett, L.C. (1936): Flax as an Iowa crop, Iowa Agr. Exp. Sta. Bul. 344.
9. Djordjević, V. (1961): Posebno ratarstvo, "Naučna knjiga", Beograd.
10. Dillman, A.C. (1928): Daily growth and oil content of flaxseeds, Jour. Agr. Res. 37(6):357-377.
11. Johnson, I.J.(1932): The relation of agronomic practices to the quantity and quality of the oil in flax seed, Jour. Agr. Res. 45:329-355.
12. Abramov, V.A.(1944): Len dolunec.
13. Potočanec, J. (1950): Problemi proizvodnje lana za vlakno, Biljna proizvodnja br. 1. Zagreb.
14. Paskvić, F. (1966): Predivo bilje-konoplja, lan pamuk, Zagreb.

15. Potočanec, J. (1952): Naše sorte ozimog lana i njihovo oplemenjivanje, Arhiv za poljoprivredne nauke, cv. 7, Beograd.
16. Dijanović, D., Mihajlović, I., Stanković, V. i Stanojević, D. (2002): Produktivne karakteristike zaječarskih selekcija uljanih kultura, Agoinovacije, str. 67-72, Soko Banja.
17. Stanković, V., Petrović, R. (1998): Biološka i produktivna svojstva perspektivnih linija konzumnog i uljanog lana, Zbornik radova 39, Savetovanja industrije

Received October 21, 2005
Accepted May 18, 2006.

VARIRANJE NEKIH OSOBINA SEMENA LANA U ODNOSU NA GENOTIP I KLIMATSKE USLOVE

Radojka Maletić[1] i R. Jevdjović[2]

Rezime

U ovim istraživanjima korišćeno je seme biljne vrste lana (*Linum usitatisimun L.)* koje se gaji i umnožava u Institutu za proučavanje lekovitog bilja "Dr Josif Pančić", Beograd. Testirana su dva genotipa označena kao "B" i "Z" i sorta "Mira" koja je služila kao kontrola.

Najveći prinos semena u obe godine istraživanja ostvario je genotip "Z" a najmanji standardna sorta "Mira". U pogledu energije klijanja i ukupnog klijanja najbolju vrednost je ispoljio genotip "B", a najlošiju standardna sorta "Mira". Najveći broj bubrenja semena lana ostvario je genotip "B", a najmanji genotip "Z".

Klimatski uslovi u godini gajenja imali su uticaj na prinos i kvalitet semena lana. U toku 2001 godine, koja je imala znatno više vodenog taloga, ostvareni su veći prinosi kod svih testiranih genotipova, kao i bolja energija klijanja, ukupna klijavost i masa 100 semena. Samo je broj bubrenja bio bolji kod semena dobijenog u 2002. godini u kojoj su prosečne temperature bile više.

Primljeno 21. oktobra 2005.
Odobreno 18. maja 2006.

[1] Dr Radojka Maletić, vanredni profesor, Poljoprivredni fakultet, 11081 Beograd-Zemun, Nemanjina br. 6, Srbija i Crna Gora
[2] Mr Radosav Jevdjović, Institut za proučavanje lekovitog bilja "Dr Josif Pančić", Tadeuša Košćuška br.1, 11000 Beograd, Srbija i Crna Gora