INTERRELATIONSHIP BETWEEN OIL YIELD AND OTHER QUANTITATIVE TRAITS IN RAPESEED (*Brassica napus* L.)

POVEZANOST PRINOSA ULJA I DRUGIH KVANTITATIVNIH SVOJSTAVA ULJANE REPICE (*Brassica napus* L.)

Ana MARJANOVIĆ-JEROMELA[1], Radovan MARINKOVIĆ[1], Anto MIJIĆ*[2], Mirjana JANKULOVSKA[3], Zvonimir ZDUNIĆ[2]

1Institute of Field and Vegetable Crops, Maksima Gorkog 30, 21 000 Novi Sad, Serbia

2The Agricultural institute Osijek, Južno predgrađe 17, 31000 Osijek, Croatia

3Faculty for Agricultural Sciences and Food, blvd. "Aleksandar Makedonski" BB 1000 Skopje, Macedonia

*E- mail: anto.mijic@poljinos.hr

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ABSTRACT

The objective of the investigation was to estimate interrelationship among rapeseed quantitative traits using simple regression coefficients, as well as to assess direct and indirect effects of specific traits to oil yield/ha via path analysis. Three year investigation was carried out including thirty rapeseed genotypes. The following traits were investigated: number of pods per plant, oil content, 1000 seed weight, pre-anthesis duration, post-anthesis duration, seed yield/ha and oil yield/ha. Almost complete correlation was determined between seed yield/ha and oil yield/ha and strong between oil content and oil yield/ha. The strongest direct effects to oil yield/ha was estimated for seed yield/ha, whereas other investigated traits showed low or no effect to oil yield/ha.

KEY WORDS: rapeseed, oil yield/ha, correlation, path analysis

SAŽETAK

Cilj istraživanja je bio procijeniti povezanost kvantitativnih svojstava uljane repice međusobno putem jednostavnih koeficijenata korelacije, te direktne i indirektne učinke pojedinih svojstava na prinos ulja putem path analize. Istraživanje je obuhvatilo 30 genotipova uljane repice tijekom tri godine. Analizirana su svojstva broj komuški po biljci, sadržaj ulja, masa 1000 sjemena, vrijeme do cvatnje, vrijeme poslije cvatnje, prinos sjemena i prinos ulja. Potpuna korelacija utvrđena je između prinosa sjemena i prinosa ulja, a jaka između sadržaja ulja i prinosa ulja. Najveće direktne učinke na prinos ulja/ha imao je prinos sjemena/ha, dok je direktan utjecaj ostalih svojstava bio manji ili neznatan.

KLJUČNE RIJEČI: uljana repica, prinos ulja/ha, korelacija, path analiza

DETAILED ABSTRACT

Oplemenjivački programi na uljanoj repici (Brassica napus L.) su uglavnom usmjereni na stvaranje kultivara poboljšanog prinosa sjemena i ulja po jedinici površine. Istraživanje je imalo za cilj procijeniti odnose između pojedinih svojstava međusobno, kao i direktne i indirektne učinke pojedinih svojstava na prinos ulja/ha. Pokus je postavljen prema slučajnom bloknom rasporedu tijekom tri godine (1997- 2000) na lokalitetu Rimski Šančevi, Novi Sad. Obuhvatio je trideset genotipova uljane repice (trinaest podrijetlom iz Srbije, deset iz Njemačke, četiri iz Francuske, dva iz Mađarske i jedan iz Švedske). Analizirana su svojstva broj komuški po biljci, sadržaj ulja, masa 1000 sjemena, vrijeme do cvatnje, vrijeme poslije cvatnje, prinos sjemena/ha i prinos ulja/ha. Prinos ulja/ha je dobiven kao rezulat prinosa sjemena/ha i sadržaja ulja u sjemenu. Procijenjene su visokoznačajne korelacije između svih istraživanih svojstava. Između prinosa sjemena i prinosa ulja je postojala potpuna, a između sadržaja ulja i prinosa ulja jaka korelativna veza. Najveće direktne učinke na prinos ulja imao je prinos sjemena, te bi ga trebalo uzeti u obzir kao važan selekcijski kriterij za poboljšanje prinosa ulja/ha. Direktan utjecaj ostalih svojstava u istraživanju (broj komuški po biljci, sadržaj ulja, masa 1000 sjemena, vrijeme do cvatnje i vrijeme poslije cvatnje) na prinos ulja bio je manji ili neznatan, što nije u skladu sa jednostavnim koeficijentima korelacije. Njihovo djelovanje je bilo zamaskirano uglavnom indirektnim utjecajem u prvom redu prinosa sjemena. Koeficijent determinacije (R^2) je iznosio 0,997.

INTRODUCTION

Correlation studies are of interest to plant breeders because traits that are correlated with main breeding objectives may be useful for indirect selection and, when the selection is simultaneous for various traits, the correlation between them may restrict the response to selection [6].

But, the use of simple correlation analysis could not fully explain the relationship between traits. Therefore, the associations between traits should be further on analyzed by the path coefficient technique. This technique splits the correlation coefficients into direct and indirect effects via alternative traits or pathways and thus permits a critical examination of components that influence a given correlation and can be helpful in formulating an efficient selection strategy [24, 16, 17]. This approach is based on a priori assumptions which traits are to be included in the analysis. Such assumptions are somewhat subjective, but path coefficients may allow a better understanding of the interrelationships between traits than correlation tables with all possible combinations between all traits measured [2]. The proportion of variance in the response variable explained by the variance in the predictor variable (partial coefficient of determination) is the square of the path coefficient [5].

Many researchers reported correlations between different traits in rapeseed in order to identify traits that could serve as selection criteria for yield improvement [13, 21, 22, 4, 20, 6, 10, 14, 1, 11, and 12]. But, such studies for oil yield/ha are lacking.

The seed oil content, a key quality trait, has not been emphasized by most of rapeseed breeders because of the demanding need of reducing the contents of glucosinolate and erucic acid in the seeds. In fact, breeding for higher oil content is an important way to increase rapeseed economic value and farmer's income by increasing oil production in their limited land [9]. The higher the oil content, the higher is not only the oil yield/ha but also the effectiveness of the oil crushing process, the payment to the farmer, the competitiveness of the local oil crop compared to oil imports, the value of the crop for the non food (e.g. bio fuel) sector, and the lower is the price for the consumer [8].

Considering that oil content is one of the imperatives in rapeseed breeding [6, 11, 18], the following study was undertaken in order to estimate interrelationships between oil yield/ha and some related traits. The required data will further on be implemented in the breeding program for rapeseed oil yield/ha improvement.

MATERIALS AND METHODS

Thirty Brassica napus L. cultivars were sown for three years at the Institute of Field and Vegetable Crops, Novi Sad. Thirteen genotypes were originated from Serbia, ten from Germany, two from Hungary, four from France and one cultivar from Sweden. Those genotypes presented both commercial and experimental rapeseed cultivars.

The field trial was arranged in a randomized complete block design with three replications during three growing seasons (from 1997 to 2000). The seed was sown by hand in 4 rows, 4 meters long, 25 cm apart. Thinning at HB 3 stage [7] provided 5 cm distance between plants within a row. The trial was set up at chernozem type of soil, according to pedodinamic classification [23], with 2.8% humus content, moderate content of phosphorus and potassium and pH 6.92. Optimal agricultural practices were carried out in all investigated seasons.

Pre-anthesis duration and post-anthesis duration and oil content were determined on a plot basis. Pre-anthesis duration represented days from emergency (HB1) to first flower (recorded when 50% of the plants had first flower

open- HB4.1). Post-anthesis duration is a period from HB4.1 to HB5.4 (recorded when 50% of the plants had brown seeds in lower pods of the main raceme). Seed yield/ha was calculated after the harvest. Oil content was determined by magnetic resonance analyzer (Newport 4000 NMR analyzer). Oil yield/ha is a function of seed yield/ha and oil content.

Phenotypic correlations and path coefficient analyses were calculated as described by Singh and Chaundhary [19] and Williams at al. [24].

RESULTS AND DISCUSSION

Phenotypic correlations between studied traits are given in Table 1. The correlations between all traits were positive. Oil yield/ha showed highly significant association with all traits included in the study. The highest correlation (r=0,994) was estimated between oil yield/ha and seed yield/ha. Strong correlation was also determined between pre-anthesis duration and number of pods per plant, then pre-anthesis duration and oil content and finally between seed yield/ha and all the other investigated traits. Engqvist and Becker [6] in segregating families of spring oilseed rape found highly significant correlations between oil yield/ha and seed yield/ha. Oil content in the same study had significant association with oil yield/ha, which corresponds with results in this study. Ozer et al. [14] reported positive correlations between oil content and seed yield/ha, days to flowering and 1000 seed weight. Significant positive correlation between 1000 seed weight and seed yield/ha has been reported by Thurling [21], Ozer et al. [14] and Ali et al. [1], which is not in relation with the findings of Pospišil and Mustapić [15].

Path coefficient analysis was applied in order to obtain and interpret information on the nature of interrelationships between oil yield/ha and related traits (Table 2). Direct effects of certain traits on oil yield/ha are not corresponding to the simple correlation coefficients. Seed yield/ha showed highly significant direct effect to oil yield/ha. Oil content and post-anthesis duration had significant positive effect, unlike pre-anthesis duration, number of pods per plant, as well as 1000 seed weight, that showed negative direct effect to oil yield/ha. It can not be seen from the simple correlation coefficient calculation because it was strongly masked by the positive effect of seed yield/ha. Si and Walton

Table 1 Phenotypic correlations between related traits
Tablica 1. Fenotipske korelacije između istraživanih svojstava

Trait Svojstvo	Oil yield/ha Prinos ulja/ha	Pods/ plant Komuški/biljci	Oil content Sadržaj ulja	1000 seed weight Masa 1000 sjemena	Pre-anthesis duration Vrijeme do cvatnje	Post-anthesis duration Vrijeme nakon cvatnje
Pods/plant Komuški/biljci	0.701**					
Oil content Sadržaj ulja	0.673**	0.466**				
1000 seed weight Masa 1000 sjemena	0.500**	0.337**	0.299**			
Pre-anthesis duration Vrijeme do cvatnje	0.642**	0.523**	0.659**	0.365**		
Post-anthesis duration Vrijeme nakon cvatnje	0.556**	0.402**	0.112^{ns}	0.375**	0.116^{ns}	
Seed yield/ha Prinos sjemena/ha	0.994**	0.705**	0.606**	0.504**	0.625**	0.577**

ns, ** - non significant and significant at 0.01 level, respectively
ns, ** - nesignifikantno i signifikantno na razini 0,01

Table 2 Path analysis results for oil yield
Tablica 2. Rezultati path analize za prinos ulja

Trait Svojstvo	Direct effect Direktan utjecaj	Indirect effect via Indirektni utjecaj putem						r^1
		Pods/ plant Komušk i /biljci	Oil content Sadržaj ulja	1000 seed weight Masa 1000 sjemena	Pre-anthesis duration Vrijeme do cvatnje	Post-anthesis duration Vrijeme nakon cvatnje	Seed yield/ha Prinos sjemena/h a	
Pods/plant Komuški /biljci	-0.006 ns		0.0576	-0.0004	-0.0096	0.0047	0.6547	0.701**
Oil content Sadržaj ulja	0.124**	-0.0028		-0.0004	-0.0121	0.0013	0.5631	0.673**
1000 seed weight Masa 1000 sjemena	-0.001 ns	-0.0021	0.0369		-0.0067	0.0044	0.4684	0.500**
Pre-anthesis duration Vrijeme do cvatnje	-0.018**	-0.0032	0.0815	-0.0004		0.0014	0.5808	0.642**
Post-anthesis duration Vrijeme nakon cvatnje	0.012*	-0.0024	0.0139	-0.0005	-0.0021		0.5358	0.556**
Seed yield/ha Prinos sjemena/ha	0.929**	-0.0043	0.0750	-0.0006	-0.0115	0.0067		0.994**

ns, *, ** - non significant, significant at 0.05 and 0.01 level, respectively
ns, *, ** - nesignifikantno i signifikantno na razini 0,05 i 0,01
[1]- simple correlation coefficient
[1]- jednostavni koeficijent korelacije

[18] found positive association between oil content and post-anthesis duration and negative correlation with pre-anthesis duration. Oil content in rape seed has been found to be highly heritable [3, 25]. Although the absolute oil content may vary considerably due to environment, the relative oil content, i.e., the range of different cultivars to each other will be highly stable [8].

The coefficient of determination (R^2=0.997) represents the influence of traits involved in the investigation on total variability of oil yield/ha. The remaining 0.003% could be attributed to factors that are not included in this study.

CONCLUSIONS

Based on the results of the investigation, the following conclusions can be reached:

- Almost complete correlation was estimated between seed yield/ha and oil yield/ha, which was expected considering that oil yield/ha is directly derived from the seed yield/ha.
- Strong correlation was determined between seed yield/ ha and the following traits: number of pods per plant, oil content, 1000 seed weight, pre-anthesis duration, and post-anthesis duration.
- Strong correlation was also estimated between pre-anthesis duration and number of pods, as well as between pre-anthesis duration and oil content.
- The strongest direct effect to oil yield/ha was estimated for seed yield/ha, while the influence of the other investigated traits to oil yield/ha was quite low. This indicates that none of these traits could serve as an

indirect selection criteria for improving oil yield/ha.

- Increasing the seed yield/ha and oil content in the seed will lead to higher oil yield/ha.

- The coefficient of determination (R^2=0.997) represents the influence of the traits involved in the study on total variability of oil yield/ha.

REFERENCES

[1] Ali N., Javidfar, F., Elmira J.Y., Mirza M.Y., Relationship among yield components and selection criteria for yield improvement in winter rapeseed (Brassica napus L.), Pak. J. Bot. (2003) 35 2: 167-174.

[2] Baye T., Becker C.H., Genetic variability and interrelationship of traits in the industrial oil crop Vernonia galamensis. Euphytica (2005) 142: 119–129.

[3] Becker H.C., Loptien H., Robbelen G., Breeding: an overview, in: Gomez-Campo C. (Ed), Biology of Brassica coenospecies, Elsevier, Amsterdam, 1999: pp. 413-460.

[4] Degenhart D. F., Kondra Z. P., Relationships between seed yield/ha and growth traits, yield components and seed quality of summer-type oilseed rape (Brassica napus L.), Euphytica (1984) 33: 885-889, 2.

[5] Dewey D.R., Lu K.H., A correlation and path-coefficient analysis of components of crested wheatgrass seed production, Agron. J. (1959) 51: 515-518.

[6] Engqvist M. G., Becker H.C., Correlation studies for agronomic traits in segregating families of spring oilseed rape (Brassica napus), Hereditas (1993) 118: 211-216.

[7] Harper F.R., Berkenkamp B., Revised growth-stage key for Brassica campestris and B. napus, Can. J. Plant Sci. (1975) 55: 657-658.

[8] Hauska D., Oertel C., Alpmann L., Stelling D., Busch H., Breeding progress towards high oil content in oilseed rape (Brassica napus L.) – essential innovations to meet current and future market needs, Proc. 12th International Rapeseed Congress Wuhan China (2007) 1: 159-162.

[9] Li J., Li G., Zhang G., Chen W., Dong Y., Zhang M., Wang J. (2007) Research on creating new germplasm of high oil content in B. napus, Proc. of the 12th International Rapeseed Congress Wuhan China (2007) 1: 152- 154.

[10] Marinković R., Marjanović-Jeromela A., Genotipic and phenotipic correlations of some traits of oilrape (Brassica napus L.), Proc. of the Eucarpia - Symposium on breeding of oil and protein crops Zaporozhye Ukraina (1996): 127-130.

[11] Marinković R., Marjanović-Jeromela A., Crnobarac J., Lazarević J., Path-coefficient analysis of yield components of rapeseed (Brassica napus L.), Proc. of the 11th Inter. Rapeseed Congres, Copenhagen, Denmark (2003) 3: AP5 15.

[12] Ogrodowczyk M., Wawrzyniak M., Adoption and path- coefficient analysis for assesment of relationship and interrelationship of yield and yield parameters of winter oilseed rape, Rosliny Oleiste, (2004) 25 2: 479-491.

[13] Olsson G., Some relations between number of seeds per pod, seed size and oil content and the effect of selection for these traits in Brassica and Sinapis, Hereditas (1960) 46: 29-70.

[14] Ozer H., Oral E., Dogru U., Relationship between yield and yield components on currently improved spring rapeseed cultivars, Turk. J. Agric. For. (1999) 23: 603-607.

[15] Pospišil M., Mustapić Z., Evaluacija novih 00-kultivara uljane repice, Sjemenarstvo (1995.) 12 4-5: 273- 282.

[16] Scheiner S.M., Mitchell R.J., Callahan H.S., Using path analysis to measure natural selection, J.Evol. Biol. (2000) 13: 423–433.

[17] Shipley B., Exploratory path analysis with applications in ecology and evolution, Am.Nat. (1997) 149: 1113–1138.

[18] Si P., Walton G. H., Determinants of oil concentration and seed yield/ha in canola and Indian mustard in the lower rainfall areas of Western Australia, Aust. J. Agric. Res. (2004) 55: 367-377.

[19] Singh, R.K., Chaudhary B.D., Biometrical methods in quantitative genetic analysis, Kalyani Publishers, NewDelhi, 1985.

[20] Taylor A.J., Smith C.J., Effect of sowing date and seeding rate on yield and yield components of irrigated canola (Brassica napus L.) grown on a red-brown earth in south-eastern Australia, Aust. J. Agric. Res. (1992) 43: 1629-1641.

[21] Thurling N., Morphophysiological determinants of yield in rapeseed (Brassica campestris and Brassica napus), II Yield Components, Aust. J. Agric. Res. (1974) 25: 711-721.

[22] Thurling N., Vijendra Das L.D., The relationship between pre-anthesis development and seed yield/ha of spring rape (Brassica napus L.), Aust. J. Agric. Res. (1979) 31: 25-36.

[23] Vasin J., Sekulić P., Belić M., Traitistics of the chernozem soil at Rimski Šančevi experiments field of Institute of Field and Vegetable crops, Sesiunea anuala

omagiala de comunicari si referate stiintifice " 80 de ani de la nasterea prof. dr. Iulian Dracea" Temisoara Romania (2002): 153-160.

[24] Williams W.A., Jones M.B., Demment M.W., A concise table for path analysis statistics, Agron. J. (1990) 82: 1022-1024.

[25] Wu J.G., Shi C.H., Zhang H.Z. Partitioning genetic effects due to embryo, cytoplasm and maternal parent for oil content in oilseed rape (Brassica napus L.). Genet. Mol. Biol. (2006) 29: 533-538.