INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 6, No. 1, p. 179-184, 2015

RESEARCH PAPER OPEN ACCESS

Investigation of some qualitative traits of six spring and autumn rapeseed cultivars under different sowing dates

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Key words: Rapeseed, glucosinolate, oleic acid.

http://dx.doi.org/10.12692/ijb/6.1.179-184 Article published on January 10, 2015

Abstract

In order to comparison of six spring and autumn cultivars of rapeseed regarding to some qualitative attributes under different sowing dates, a split plot experiment as base of randomized complete block design was conducted in Qazvin, Iran during 2012-2013. Sowing date in five levels included: 1, 10, 20, 30 Oct and 10 Nov as main plots and cultivar consist of: RGS003, Sarigol, Option 500, Zarfam, Opera and Modena as sub plots were considered. Results showed that cultivar effect was significant on grain oil content, oleic acid, erucic acid and glucosinolate. However, effect of sowing date and its interaction with cultivar was not significant on oil content. The obtained values of grain oil content of studied cultivars were 38.18-40.45%. The mean comparison of sowing date and cultivar interaction demonstrated that RGS003 at all sowing dates had the most grain oil content and oleic acid. These results also showed that the lowest grain oil content and oleic acid belonged to cultivar Opera in all sowing dates. Adversely, the most amounts of erucic acid and glucosinolate observed in Opera and RGS003 had the least amounts.

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Introduction

Rapeseed (*Brassica napus* L.), an annual oilseeds, has been grown agriculturally for many centuries for its oil and meal. Rapeseed cultivars, low in erucic acid and glucosinolates, are very different from high erucic acid rapeseed oil in chemical, physical and nutritional properties. Rapeseed oil contains a low content of saturated fatty acids (5–7%) and high content of polyunsaturated fatty acids with about 7–10% alpha-linolenic and 17– 21% linoleic acids. It is therefore considered as a healthy edible oil (Baux *et al*., 2008). Experiments conducted by Modares Sanavi and Daneshgar (2004) showed that, with the considerable amounts of unsaturated fatty acids in the seed oil of the studied rapeseed varieties and also their less than 1% erucic acid content taken into account, the obtained oil can be a good replacement for animal fat or even other herbal oils in the human diet. Usually, the qualitative properties of each oil type depends on its fatty acid compounds and one of the main breeding objectives regarding rapeseed besides the oil quantity is to increase its oil quality (Azizi *et al*.,1999). During the past fifteen years, most of the breeding programs for rapeseed were focused on oleic and erucic unsaturated fatty acids as well as medium-chain fatty acids (Piazza and Foglia, 2001). Mainly, the quality of rapeseed oil is determined based on its oleic, linoleic and erucic fatty acid contents and is highly affected by the variety type (Lee *et al*, 1998; Nasr *et al*, 2006; Javidfar *et al*, 2007). Previous studies have been made by a number of workers showed that erucic acid content (Liu and Liu, 1990; Qi *et al*., 2001), oleic acid content (Schierhoft and Becker, 2001), and glucosinolate content (Dong *et al*., 2007) were heritable characters with different kinds of gene actions and levels of heritability depending on the materials used in their studies. Therefore, there is significant difference among rapeseed cultivars according to qualitative traits of grain and meal. Glucosinolates, commonly referred to as goitrogens, are uniform class of naturally occurring compounds found exclusively in the plant kingdom, and only in limited number of dicotyledonous families (Underhill, 1980). All members of the cruciferae family, including rapeseed, contain glucosinolates (Fenwick and Curtis, 1980). Rapeseed meal is unsuitable for livestock feed due to its high glucosinolate content and is a hindrance to domestic rapeseed production. Because low glucosinolate meal can be used for livestock feed, and high glucosinolate meal for potential pest control (Bhardwaj *et al*., 1996), either a reduction or an enhancement in glucosinolate content might be helpful in developing rapeseed as a renewable-domestic source of erucic acid. Thus, the aim of this research was investigated the effect of sowing date and cultivar on qualitative characteristics of rapeseed.

Material and method

Study area and trial procedure

This experiment was conducted in Qazvin area during 2012-2013 where the latitude is 36N and longitude 16E with an elevation of 1285 m above the sea level. Mean precipitation per year was 320-310 mm and Mean temperature per year was 9.13 ° C. The experimental units were designed as a split plot based on randomized complete block design (RCBD) with 3 replications and 30 treatment combinations. The factors examined were five sowing dates (1 October, 10 October, 20 October, 30 October and10 November) as main plots and six cultivars (RGS003, Sarigol, Option 500, Zarfam, Opera and Modena) as sub plots.

Agronomical operations

Total amount of nitrogen recommended (150 kg/ha), and phosphorus (100 kg/ha) fertilizers based on soil physic-chemical test. Fertilizers were broadcasted and incorporated to the experimental soil prior to canola cultivation. Nitrogen fertilizer was added in three times: 1.3rd at cultivation time as basal fertilization, 1.3rd at stem initiation stage and the remaining1.3rd applied at flowering initiation.

Measurement of studied traits

The studied traits included oil content, erucic acid and oleic acid of grain and glocosinolate of meal. To measure the grain oil content, about 3 grams of grain was prepared and using an NMR apparatus, the oil percentage was measured. The said apparatus works based on the magnetic induction of hydrogen nucleus

which is a spectrometry method.The fatty acid compositions were determined by gas spectroscopy method. Initially, to methyl ester the fatty acids, normal heptane and 2mol/l potassium hydroxide methanol solution (2 N) was used (Khan *et al*, 1985; Franzens, 2000). Then, the obtained methyl esters were injected to Gas Chromatography apparatus (Agilent 6890 N, USA) for determining the type and percentages of fatty acids. Column temperature was 175°C, while the detector and injection port temperature was 250°C. The capillary column was 60 meters long with the polar silica thickness being 0.32 micrometers. The applied detector was of the Flame Ionization type with hydrogen fuel and its air oxidation, nitrogen carrier gas, hydrogen pressure and compressed air measure were 15 millimeters per minute. Identification of methyl esters in fatty acids was done by comparing the peaks' retention times with those of the methyl esters of standard fatty acids. The percentage of each fatty acid was measured based on the calculation of the area below the curve by computer stability. Glucosinolate content in rapseed meal was determined by using High Performance Liquid Chromatography (HPLC). The glucosinolates were separated using a type C18 column (CAPCELL PAK C18 Type: C18 AG 120 A Size 4.6 mm × 150 mm, 5 µm) with a flow rate of 0.5 ml/min at 30° C. Elution of glucosinolates from HPLC was performed by a gradient system of water (A) and acetonitrile/water (25:75, v/v, B). The total running time was 45 min with a gradient as follows: 100% A and 0% B for 5 min, then in 35 min to 0% A and 100% B and in 5 min back to 100%A and 0%B. An UV detector was used at a wavelength of 229 nm. Total glucosinolate amount was accomplished using the response factors as published in the ISO protocol (ISO Method, 1992). Total glucosinolate was expressed as mg. g^{-1} DM of meal.

Statistical Analysis

Data were subjected to analysis of variance (ANOVA) using the Statistical Analysis System SAS software computer software at $P<0.01$ (SAS, 2001) and significant treatment means were separated by DMRT ($p<0.05$). Correlation coefficients between studied traits were calculated by SPSS software.

Results and discussion

The results of variance analysis revealed that the effect of cultivar was significant on content of grain oil, erucic acid, oleic acid and glocosinolate at 0.01 probability level. However, effect of sowing date and interaction of sowing date and cultivar was not significant effect on mention traits (Table 1).

Table 1. The variance analysis of studied characteristics.

S.O.V	d.f	Grain oil content	Oleic acid content	Erucic acid content	Glocosinolate content
Replication	2	10.743 ns	0.062 ns	1.344 ns	4.675 ns
Sowing date	4	0.615 ns	0.01 ns	0.24 ns	0.782 ns
Error	8	13.162	0.7	3.718	88.7
Cultivar	5	7.665 **	1.584 **	3.011 **	81.062 **
Sowing date × cultivar	20	7.178 ns	0.004 ns	0.046 ns	2.414 ns
Error	50	0.208	0.021	0.076	2.486
CV%	-	3.16	7.92	4.43	7.69

**significant at 1%, ns non significant.

These findings are in conformity with the results by Nasr *et al.* (2006) and Javidfar *et al.* (2007) who found a salient diversity among selected varieties of *Brassica napus*. Oil content is one of the important components, which play a crucial role in the rapeseed seed quality (Jensen, *et al.*, 1996). In this experiment the values of grain oil content of studied cultivars were 38.18-40.45%. The mean comparison of sowing date and cultivar interaction demonstrated that RGS003 at all sowing dates had the most oil content

of grain that with Zarfam were a common statistically group. These results also showed that the lowest oil content of grain belonged to cultivar Opera in all sowing dates (table 2). The difference in the oil content of rapeseed varieties might be due to genetic variations which existed among them (Naeemi *et al*., 2007). The obtained results showed that there was significant difference among present studied cultivars in terms of their oleic acid content. The mean comparison of sowing date and cultivar interaction on oleic acid content revealed that RGS003 had the highest oleic acid content and Opera had the lowest amount (table 2). On the other hand, result of present experiment showed a significant positive correlation (r= 0.845) between oleic acid and oil content (table 2).

Table 2. The mean comparison of sowing date × cultivar interaction on studied characteristics.

Sowing date	Cultivar	Grain oil content (%)	Oleic acid content (%)	Erucic acid content (%)	Glocosinolate content ($mg.g^{-1}$ DM of meal)
1 Oct	RGS003	39.97 a-e	64.27 abc	0.4825 ij	18.1 ij
	Sarigol	38.77 ghi	63.2 f-i	1.092 bcd	21.03 c-i
	Option500	39.57 b-e	63.83 b-e	0.6112 hij	19.17 e-j
	Zarfam	40.02 a-e	63.87 b-e	0.5996 hij	19.43 e-j
	Opera	38.22 i	63 ghi	1.326 ab	23.87 abc
	Modena	38.95 ghi	63.57 def	0.7618 f-i	21.6 b-j
10 Oct	RGS003	40.4 abc	63.97 a-e	0.4817 ij	18.07 ij
	Sarigol	38.18 i	63.2 f-i	0.9835 c-f	22 b-e
	Option500	39.36 d-h	63.83 b-e	0.6365 hij	18.3 hij
	Zarfam	39.55 c-g	63.97 a-e	0.5974 hij	18.47 hij
	Opera	38.88 hi	62.97 hi	1.245 abc	25.87 a
	Modena	39.96 d-h	63.2 f-i	0.8114 e-h	21.07 c-i
20 Oct	RGS003	40.29 abc	64.37 ab	0.4813 ij	18.67 g-j
	Sarigol	39.04 f-i	63.43 e-h	1.116 a-d	20.9 c-i
	Option500	39.89 a-f	63. 63 def	0.6348 hij	19 e-j
	Zarfam	39.64 a-g	63.8 cde	0.5708 hij	18.57 g-j
	Opera	38.18 i	63 ghi	1.364 a	24.57 ab
	Modena	39.13 e-h	63.53 def	0.7461 f-j	19.83 d-j
30 Oct	RGS003	40.48 a	64.33 abc	0.4667 j	16.83 j
	Sarigol	39.04 f-i	63.23 f-i	0.9534 d-g	23.77 abc
	Option500	39.57 b-g	63.53 def	0.5588 hij	19.63 e-j
	Zarfam	40.04 a-d	63.9 b-e	0.5549 hij	19.8 e-j
	Opera	38.22 i	62.9 i	1.335 ab	23.8 abc
	Modena	38.91 ghi	63.57 def	0.6987 g-j	21.33 c-h
10 Nov	RGS003	40.32 abc	64.47 a	0.4588 j	17.67 j
	Sarigol	39.20 d-h	63.5 d-g	1.058 cde	21.17 c-i
	Option500	39.95 a-e	63.9 b-e	0.6187 hij	18.73 f-j
	Zarfam	40.45 ab	64.03 a-d	0.5973 hij	19.6 e-j
	Opera	38.86 ghi	63.2 f-i	1.376 a	22.8 cbd
	Modena	39.26 d-h	63.87 b-e	0.7603 f-i	21.83 b-f

Means within the same column and rows and factors, followed by the same letter are not significantly difference ($P < 0.05$).

In further experiment a positive correlation between oleic acid and oil content was found (Schierhoft and Becker, 2001; Mollers and Schierhoft, 2002). From nutritional viewpoint, the presence of oleic acid in diet is very useful. It has been shown that oleic acid is effective in lowering LDL content and LDL cholesterol content (Grundy, 1989). Generally, the type and amount of fatty acids in the studied varieties' oils is an indication of the oil quality. The grain oil of the tested rapeseed varieties in this study had a desirable amount of oleic acid as the most important unsaturated fatty acid (62.9-64.47%). Investigation of mean comparison of data indicated that erusic acid content was significantly influenced by cultivar effect. So that rapeseed cultivar RGS003 had the least erusic acid content in all sowing dates and the most value

was observed in Opera (table 2). The result of correlation analysis demonstrated there was a significant positive correlation (r= -0.848) between erucic acid and oil content (table 2). This 22-carbon fatty acid is usually harmful to the human health; thus, those varieties, which do not have it, are nutritionally, placed at the highest level (Siavash *et al.*, 2005). The obtained grain oil of rapeseed cultivars of this experiment had the least erucic acid (0.4813 - 1.376%) that they have a desirable quality oil. The results of this experiment showed that the glocosinolate content was significantly difference among tested cultivars (table 1). The mean comparison indicated RGS003 had the lowest glocosinolate content in meal which was very desirable and the most value of this acid belonged to Opera (table 2). The cultivar RGS003 might be considered a useful rapeseed to include in the diet as it contains low specific glucosinolate. According to the canola council, all present cultivars are low glucosinolate because they contained 16.83- 25.87 $mg.g^{-1}$ DM of meal. The analysis of correlation coefficient revealed that glocosinolate content had a highly negative correlation with grain oil, oleic acid and erucic acid contents (table 3).

Table 3. Correlation coefficients between grain oil parameters.

Traits	Grain oil content	Oleic acid content	Erucic acid content	Glocosinolate content
Grain oil content	1			
Oleic acid content	0.845 **	1		
Erucic acid content	-0.848 **	- 0.885 **	1	
Glocosinolate content	-0.809 **	-0.874 **	-0.883 **	1

**. Correlation is significant at the 0.01 (2-tailed).

Turhan *et al.* (2010) also found the presence of negative correlation between glocosinolate and oleic acid content. In general, the present study can be helpful in developing 00-rapeseed cultivars (zero erucic, low glucosinolate content).

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