Effect of different levels of plant density and time of nitrogen application on Canola oil quality and quantity (cultivar Hyola 401) in Ahvaz conditions

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Abstract

In order to study the effects of plant density and time of nitrogen application on Canola oil quality and quantity in Ahvaz conditions, an experiment was conducted at Agricultural College of Shahid Chamran University of Ahvaz. The experiment design was split plot in completely randomized block basis with 4 replications. In this study main plots and sub plots were consisted of 3 levels of plant density (60, 80 and 100 plants per m^2) and 3 times of nitrogen fertilizer application (T_1: application of nitrogen in 3 times, 1/3 at sowing date, 1/3 at stem elongation stage and 1/3 at the beginning of flowering. T_2: application of nitrogen in 2 times: 1/3 at sowing date and 2/3 at stem elongation stage. T_3: application of nitrogen in 2 times: 1/2 at sowing date and 1/2 at stem elongation) respectively. The results showed that different levels of treatments and interaction of them had no significant effects on percents of Palmitic acid, Palmitoleic acid, Stearic acid, Linolenic acid and Arashitic acid. But use of nitrogen in tree times decreased the oil percent, erosic acid percent, ratio of erosic acid to oleic acid, saturated to unsaturated fatty acids and polyunsaturated to monounsaturated fatty acids. Use of nitrogen in tree times, especially at higher plant densities, increased the percent of oleic acid. Increasing in level of plant densities from D_1 to D_2 lead to decrease of Linoleic acid. Minimum ratio of polyunsaturated fatty acids to monounsaturated fatty acids obtained from 80 plants/m2 and any changes (decrease or increase of plant density), can increase this ratio and oil quality will be decreased. According to these results at Ahvaz conditions, Canola planting at 80 plants/m^2 and use of nitrogen at tree times (D_2T_1) lead to Higher oil quality.

Key words: Plant density, Nitrogen, Gas chromatography, Fatty acid, Canola, Hayola

Introduction

Canola (*Brassica napus* L.) is the third most important source of plant oil in the world after soybean and palm oil (Sovero, 1997). There are agricultural opportunities to increase canola production and the expansion of canola in Iran has been dramatic. Among many of others, the effects of agricultural practice on quality of crop oil are considered to be most important. Triglyceride analyses have become very important in recent years since health conscious consumers are concerned with minimizing their dietary intake of saturated fats to reduce the risk of heart disease (Anonymous. 2006). During the past decade, one major goal in oilseed rape quality breeding has been to increase oleate at the expense of polyunsaturated fatty acids linoleate and linolenate (Moller and Schierholt, 2002). The seed oil of modern oilseed rape cultivars contains ≈60% oleate (C18:1), 20% linoleate (C18:2), 10% linolenate (C18:3), and small amounts of palmitate (C16:0, 4%) and stearate (C18:0, 2%) (Muller and Schierholt 2002). Previous reports showed that canola oil content was not affected by plant density (Noreldin et al., 1993; Cheema et al., 2001; Starner et al., 1999). Ahmad and Abdin (2000) reported that rapid accumulation of lipids started at 7 days after flowering (DAF) and continued until 35 DAF. Moreover they showed that the fatty acid composition of the oil changed substantially during seed development and S application in three portions increased the oleic acid (18:1) content, and decreased the erucic acid (22:1) content over other treatments. Starner et al., 1999 showed that planting date did not affect the oil content and the content of saturated or unsaturated fatty acids and contents of 14:0, 16:0, 18:0, 20:0, 18:1, 18:2, 18:3, 20:1 and 22:1 fatty acids but planting delay from either Sept. 13 or 28 to Oct. 7 increased the content of 22:0 by almost 3 and 7 times, respectively. They also reported that an increase in seeding rate from 1.8 to 3.6 kg/ha resulted in higher contents of 16:0 fatty acid. Jackson, 2000 and Brennan, 2003 showed that the percentage oil tended to decline with N application. This is probably due to N delaying plant maturity. Cheema, et al., 2001 reported that the time of nitrogen application did not affected the oil content, but the rate of fertilizer application significantly affected oil contents.

Materials and Methods

A field experiment was conducted in 2003-2004 at Agronomic Research Area, college of Agriculture, Shahid Chamran University of Ahvaz ($31^0$19'N, $48^0$41'E), Iran. This area is situated at an elevation of 22 m above sea level. During conduction of experiment it has average minimum and maximum temperature 13.6 and 25.6 respectively. The soil at the experimental site (0-30 cm soil layers) was a silty clay loam; the pH and EC were 7.95 and 2.9 mmohs, respectively. The experiment was split-plot designs, with plant densities as the main plots and the time of nitrogen application as subplots randomized within

them. The experiment was replicate 3 times. The area of each sub plot was 10 m^2 consisting of eight rows, 4 m long and 30 cm apart. N fertilizer applied (180 kgN ha^{-1}) as urea form. All plots received phosphorus at 110 kg ha^{-1} as phosphate de ammonium and potassium at 100 kg ha^{-1} as potassium sulfate at sowing. The crop (*Brassica napus* L var. Hyola 401) was sowing at a 25-mm seeding depth on 18 November 2003. Plots were thinned to final plant density of about 100 plants m^2 at seedling stage. A 0.8-m alley was left around each plot to avoid plot to plot N contamination during irrigation. Seeds were taken at maturity by harvesting the center two rows of each plot on Apr. 16. Seed oil content was determined by the Soxhlet apparatus. The fatty acid composition of the seed oil was determined by simultaneous oil extraction and methyl esterification (Garce and Mancha, 1993) followed by gas chromatography of fatty acid methyl esters (Table 1). Fatty acids percentages were arcsine-transformed before statistical analysis (Steel and Torrie 1980). Data were analyzed with the GLM procedure using the SAS package (SAS Institute, 1996).

Table 1 Chromatograph characteristics

GC System: Unicom 4600	Detector type: FID
Column type: Capillary, BPX70	Split ratio: 1/10
ID: 0.25mm, 0.22µm, 30m	Plait program: Opened after 0.2 min
Detector Temp: 300°C	Oven Temp: 140°C for 3 Min.
Injector Temp: 250°C	By 2.5^0C/min to 90°C for 8 Min.
Carrier: Helium	

Result and discussion

The different levels of plant density and time of nitrogen application did not affect the oil content (Table 2). Means comparison of interactions on oil content by Duncan indicated that there was significant difference among different treatments ($P<0.05$). In general use of nitrogen at the beginning of flowering (T_1) led to decreasing of oil content. This results was not surprising as similar effects have been reported by Noreldin et al., 1993; Cheema et al., 2001. According to Table 4, there was a negative correlation between linoleic and linolenic acids with oil percent. These results are consistent with those reported by Muller and Schierholt, 2002. In general statistical analysis showed that the effects of plant densities, time of nitrogen applications and their interactions on percentages of palmitic, palmitoleic, stearic, linolenic and arashitic acids was not significant (Table 2). Significant differences in percent of oleic acid (OA %) were observed among the different levels of plant densities (Table 2). The OA % increased with increasing the number of plants per m^2 to the 80 plants m^{-2} thereafter it declined at higher plant density. (Table 3). Time of nitrogen application has significant effects on the OA % (Table 2) and use of nitrogen at 3 times can significantly increase the OA %. The interactions of treatments significantly influence the OA %. In general at highest plant densities (D_2 and D_3, 80 and 100 plants per m^2, respectively) use of nitrogen at 3 times increased OA %. The highest OA % was obtained from 80 plants per m^2 and use of nitrogen at 3 times (D_2T_1).

Percent of linoleic acid (LLA %) was affected by different levels of plant densities, however times of nitrogen application had no significant effects on it (Table 2). highest and lowest LLA % was obtained at 60 and 80 plant per m^2, respectively (Table 2). There was a negative correlation between OA % with LLA % (Table 4). This result is consistent with those reported by Muller and Schierholt, 2002. The effects of interactions on the LLA % were significant. (Table 3). However the LLA % decreased with increasing the number of plants per m^2, use of nitrogen at two times (T_2), 1/3 at sowing date and 2/3, can increased the LLA % significantly (Table 3). The different levels of plant densities and times of nitrogen application did not affect the erosic acid percent (EA %), but the effects of interactions on it were significant. Generally in each plant density, application of nitrogen at 3 and two times significantly decreased and increased the EA %, respectively (Table 4). The highest EA % was approximately 0.51% that obtained from 80 plants per m2 and application of nitrogen at 2 times (D_2T_2).

Erocic acid/oleic acid ratio (EA/OA) is one of the canola oil quality indexes (Ahmad and Abdin 2000) and there is a negative relationship between this ratio and oil quality. Results showed that this ratio was affected by times of nitrogen application and interactions of treatments (Table 2). Ahmad and Abdin (2000) showed that this ratio is closely related to the N:S ratio in the seed. As show in table 3, use of nitrogen at 3 times decreased this ratio. The highest EA/OA was obtained by 80 plant per m^2 and use of nitrogen at 2 times (D_2T_2). This ratio has positive correlation with EA % (Table 4). The study showed that the main effect of plant densities and time of nitrogen applications and their interaction on saturated fatty acids/unsaturated fatty acids ratio (Sa/UnS) were significant (Tables 2). The highest and lowest Sa/UnS was obtained at 60 and 80 plant per m^2, respectively (Table 3).

Table 2. Summary of variance analysis of characters

S.O.V	df	Oil%	Palmitic acid	Palmitoleic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid	Arashitic acid	Erosic acid	EA/OA	Sa/ UnS	PUnS/ MUnS
R	2	$4.47^{n.s}$	0.0002*	$0.00007^{n.s}$	$0.0027^{n.s}$	$0.00064^{n.s}$	$0.00003^{n.s}$	$0.00003^{n.s}$	$0.000028^{n.s}$	$0.000171^{n.s}$	0.000002*	0.0000008n.s	$0.0000006^{n.s}$
D	2	$6.05^{n.s}$	$0.00003^{n.s}$	$0.000002^{n.s}$	$0.0012^{n.s}$	0.0129*	0.00035*	$0.000007^{n.s}$	$0.000023^{n.s}$	$0.000171^{n.s}$	$0.000001^{n.s}$	0.0000035*	0.000031*
E(a)	4	2.002	0.000015	0.00018	0.00018	0.0025	0.00008	0.00005	0.000012	0.000042	0.0000009	0.0000004	0.0000056
T	2	$3.66^{n.s}$	$0.000021^{n.s}$	$0.000042^{n.s}$	$0.000185^{n.s}$	0.0106*	$0.00007^{n.s}$	$0.000029^{n.s}$	$0.000031^{n.s}$	$0.00006^{n.s}$	0.000001*	0.0000042*	0.000015*
D*T	4	$2.52^{n.s}$	$0.00002^{n.s}$	$0.000045^{n.s}$	$0.00015^{n.s}$	0.0087*	0.00022**	$0.000011^{n.s}$	$0.000043^{n.s}$	0.00002**	0.000003**	0.0000026*	0.000016*
E(b)	12	1.82	0.000012	0.000046	0.000091	0.00255	0.000036	0.000028	$0.000035^{n.s}$	0.000042	0.0000005	0.000001	0.0000039
cv	-	3.2	1.6	12.0	5.8	5.3	1.3	1.67	5.8	12.4	11.9	3.3	3.1

*.** and $^{n.s}$ significant at the 5 and 1% and Non significant, respectively

Table 3. Means comparison of characters

Treatment	Oil%	Palmitic acid	Palmitoleic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid	Arashitic acid	Erosic acid	EA/OA	Sa/ UnS	PUnS/ MUnS
Plant Density												
D1	40.5 a	4.55 a	0.32 a	2.79 a	63.79 b	18.26 a	8.88 a	1.04 a	0.24 a	0.003 a	0.091 a	0.42 a
D2	41.9 a	4.44 a	0.32 a	2.63 a	69.64 a	17.3 b	8.93 a	1.05 a	0.34 a	0.005 a	0.084 b	0.38 b
D3	41.3 a	4.61 a	0.33 a	2.57 a	64.09ab	17.74ab	8.82 a	1.03 a	0.26 a	0.004 a	0.090 ab	0.41 ab
Time of nitrogen aplication												
T1	40.6 a	4.47 a	0.30 a	2.52 a	69.23 a	17.56 a	8.96 a	1.08 a	0.25 a	0.003 b	0.084 b	0.38 b
T2	41.4 a	4.54 a	0.35 a	2.81 a	63.85 b	18.00 a	8.76 a	1.04 a	0.32 a	0.005 a	0.092 a	0.41 a
T3	41.7 a	4.60 a	0.31 a	2.65 a	64.45 b	17.73 a	8.91 a	1.00 a	0.26 a	0.004ab	0.090ab	0.41 ab
Density* Time of nitrogen application												
D1T1	38.9 b	4.46 a	0.35 a	2.92 a	63.12 b	18.66 a	9.03 a	1.16 a	0.25 b	0.003 b	0.093 a	0.43 a
D1T2	41.3 a	4.49 a	0.32 a	2.91 a	64.14 b	17.64ab	8.81 a	1.05 a	0.26 b	0.004 b	0.092 a	0.41 a
D1T3	41.4 a	4.72 a	0.28 a	2.55 a	64.11 b	18.48 a	8.80 a	0.93 a	0.21 b	0.003 b	0.089 a	0.42 a
D2T1	41.8 a	4.37 a	0.28 a	2.34 a	78.99 a	16.87 b	8.98 a	1.08 a	0.25 b	0.003 b	0.074 b	0.33 b
D2T2	42.03a	4.57 a	0.37 a	2.91 a	64.98 b	17.85ab	8.72 a	1.00 a	0.51 a	0.007 a	0.091 a	0.40 a
D2T3	42.05a	4.40 a	0.30 a	2.65 a	64.96 b	17.17 b	9.09 a	1.06 a	0.26 b	0.004 b	0.088 a	0.40 a
D3T1	41.2 a	4.58 a	0.28 a	2.32 a	65.57 b	17.16 b	8.87 a	1.00 a	0.25 b	0.003 b	0.085 a	0.39 a
D3T2	40.9 ab	4.57 a	0.35 a	2.63 a	62.42 b	18.51 a	8.76 a	1.06 a	0.21 b	0.003 b	0.091 a	0.43 a
D3T3	41.7 a	4.68 a	0.36 a	2.76 a	64.28 b	17.56 ab	8.83 a	1.02 a	0.32ab	0.005ab	0.092 a	0.40 a

Difference of means having similar letter in each column is not significantly different (Duncan)

Use of nitrogen at 3 times significantly decreased this ratio. So lowest Sa/UnS obtained from D_2T_1 (80 plant per m^2 and use of nitrogen at 3 times). This ratio had negative and positive correlation with oleic acid and stearic acid, respectively (Table 4). Statistical analysis showed that the main effect of plant densities and time of nitrogen applications and their interaction on polyunsaturated fatty acids/monounsaturated fatty acids ratio (PUnS/MUnS) were significant (Tables 2). The lowest PUnSa/MUnSa obtained at 80 plants per m^2 and use of nitrogen at 3 times (D_2T_1).

Conclusions

Canola oil quality was generally affected by production practice investigated (plant density and time of nitrogen application). According to this study at Ahvaz conditions highest canola oil quality obtained at 80 plants per m^2 and use of nitrogen at 2 times, 1/3 at sowing date and 2/3 at stem elongation stage.

Table 4. Correlation coefficients between measured fatty acids

Treats	PA	PLO	SA	OA	LLA	LA	AA	EA	EA/ OA	Sa/ UnS	PUnS/ MUnS
Palmitic acid (PA)	1	*0.40	-0.21	-0.14	0.23	-0.09	-0.18	-0.33	-0.29	0.25	0.16
Palmitoleic acid (PLO)		1	0.38*	-0.27	0.22	-0.02	0.31	0.07	0.13	0.56*	0.29
Stearic acid (SA)			1	-0.24	0.17	-0.04	0.16	0.14	0.19	0.66**	0.26
Oleic acid (OA)				1	-0.39*	-0.06	-0.03	-0.01	-0.21	-0.81**	-0.93**
Linoleic acid (LLA)					1	-0.06	0.13	-0.10	-0.01	0.37	0.64**
Linolenic acid (LA)						1	0.42*	-0.06	-0.06	0.02	0.16
Arashitic acid (AA)							1	-0.11	-0.10	0.19	0.14
Erosic acid (EA)								1	0.97**	-0.05	-0.04
EA/OA									1	0.11	0.14
Sa/ UnS										1	0.79**
PUnS/ MUnS											1

*and** significant at the 5 and 1%, respectively

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