Effects of Irrigation Regimes and Nitrogen Management on Oil Content and Composition of Rapeseed (Brassica napus L. Var. Hayola 401)

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Abstract

The fatty acid composition of vegetative oil determines its commercial value. In order to evaluation the effects of irrigation regimes and nitrogen management on oil content and composition of rapeseed (Brassica napus L. Var. Hayola 401) a field experiment was conducted in a split plot at base of randomized complete block design with four replications in experimental field of agricultural and natural resource of Ramin during 2005-2006. Irrigation regimes at three levels: without stress (S_1), moderate (S_2) and severe (S_3) water stress (irrigation after depletion of 25, 50 and 75 % field capacity (FC), respectively) established as main plots and four N fertilizer rates: 90, 140, 190 and 240 kg N/ha were consider as sub plots. Drought stress treatment was implement from flowering stage and continued after maturity. The results showed that seed qualitative traits were affected by treatments. Percents of oleic, linoleic and linolenic acids and seed oil content adverse to arashitic acid and seed protein and glucosinolate content with increasing the severity of water stress was decreased, significantly. Increase in nitrogen led to increase in Oleic acid and protein content, but stearic and arashitic acids and oil content was decreased. According to these results water stress through augmentation in Saturated to Unsaturated ratio and seed glucosinolate content lead to reduction in canola seed quality.

Key words: Brassica napus, Irrigation regime, Nitrogen, Seed quality, Gas chromatography, Fatty acid

Introduction

Canola (Brassica napus L.) is an important oil crop in most parts of Iran; it is cultivated for its edible oil content. Both genotypic and environmental parameters determine the seed FA profiles and consequently amount and quality of canola oil (Aslam, et al., 2009). In Khuzestan province (southwestern of Iran) as one of the opportunity regions to increase rapeseed production in Iran (Danesh-Shahraki et al., 2007), the reproductive growth of rapeseed is exposed to low rainfall and drought stress. Water stress during the flowering stage has a severe impact both in seed yield and seed oil content (Champolivier and Merrien. 1996). Because of soil fertility improves the water use efficiency of plants (Buttar et al., 2006), rapeseed production management in arid and semi-arid regions such as Khuzestan province conditions include nitrogen application beside of irrigation management. According to Andersen et al. (1996) optimal rapeseed seed yield could be harvested if sufficient water is accompanied by proper nitrogen fertilization. Nitrogen rate not only affected crop yield (Danesh-Shahraki et al., 2008) but also affected the oil quality. The general trend is for oil content of seed to decline as N supply to the rape plant is increased (Ogunlela et al., 1990). Steer and Seiler (1990) showed that N supply rates before floret initiation affected the percent of FA composition of sunflower mature seeds; the percentage of palmitic (PA) and linoleic acid (LiA) responded positively to increases in N supply whereas stearic (SA) and OA acids responded negatively. According to earlier reports, the objective of this study was evaluation the effect of irrigation regimes and nitrogen management on oil content and composition of rapeseed simultaneously.

Materials and Methods

A field experiment was conducted at the Agronomic Research Area, College of Agricultural and Natural Resource University of Ramin (31^{0}36'N, 48^{0}53'E), Mollasani, Ahvaz, Iran during 2006-2007. During conduction of experiment it has average minimum and maximum temperature 3.0 and 29.2 respectively. The soil at the experimental site (0-30 cm soil layer) was silty clay; the pH and EC were 7.0 and 2.6 dS.m^{-1}, respectively. The experiment, split plot at base of randomized complete block design (RCB) with four replications, was conducted. Irrigation regimes at three levels: without stress (S_1), moderate (S_2) and severe (S_3) water stress (irrigation after depletion of 25, 50 and 75 % field capacity (FC), respectively) established as main-plots and four N fertilizer rates: 90, 140, 190 and 240 kg N.ha^{-1} were considered as sub-plots. FC was measured by pressure plate (Tan, 2005). Drought stress treatment was implement from flowering stage and continued after maturity. 2 and 1-m alleys were left around each main and sub plots, respectively to avoid plot to plot water and N contamination during irrigations. Nitrogen was applied as split in two applications; one third with sowing and the remaining at the beginning of stem elongation. N fertilizer applied as urea form. All plots received P:K fertilizers in the rates of 60:50 kg.ha^{-1} at sowing. Cultivar (Brassica napus L var. Hyola 401) was sowing at a 20-mm seeding depth on 20 November 2006. Seeds were taken at maturity by harvesting the 1.8 m^2 area of the two inner rows of each plot at the end of April. Seed oil content was determined by the Soxhlet apparatus. The FA composition of the seed oil was determined by simultaneous oil extraction and methyl esterification (Garce and Mancha, 1993) followed by gas chromatography of FA methyl esters (Table 1). FA percentages were arcsine-transformed before statistical analysis. Data were analyzed with the GLM procedure using the SAS package.

Table 1- chromatograph characteristics

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

Result and discussion

The results showed that experimental treatments affected the oil content and it's Composition, significantly (Table 2). Highest oil content (45.2 %) was taken from no water stress conditions. Moderate and severe drought stress, compared to no stress conditions, reduced the oil content. These results were not surprising, as similar effects have been reported (Champolivier and Merrien, 1996). As see at table 2, the oil content decreased with increasing the N rate up to 190 kg N.ha^{-1} (N_3), significantly. The next highest rate (N_4) had no significant decreasing effect on oil content. The mechanism for this, simplistically, is that N supply increases N-containing protein precursors so that protein formation competes strongly for photosynthates; as a result, less of the latter are available for lipid biosynthesis (Rathke et al., 2005). Evaluation the effect of Irrigation regime on FA profile showed that with increasing in drought stress severity, the percent of saturated FA (SaFA) such as PA and Arashitic acid (AA) were increased. So the highest PA and AA % respectively by 7.2 and 9.3% increase compared to no stress condition, was taken from severe drought stress (table 2). This result is consistent with those reported by Flagella et al. (2002). However Ashrafi and Razmjoo (2010) find that drought stress in Safflower lead to reduction in PA %. SaFA % (PA, Stearic acid (SA) and AA %) were affected by nitrogen rate, significantly. Interactions of irrigation regimes and nitrogen on SA and AA % were significant too (Table 2). SaFA % decreased with increasing in N rate, so the highest content of PA, SA and AA by 4.7, 2.6 and .66 %, respectively was obtained with application of 90 kg N.ha^{-1}. Evaluation the interactions showed that the reduction trend in SA and AA % because of increasing in N rate, affected by irrigation regime. This rate in no stress and moderate drought stress condition was higher, compared to severe drought stress conditions. Unsaturated FA (USaFA) content, such as OA, LiA and linolenic acid (LnA) adverse to SaFA % with increasing the severity of drought stress were decreased. The negative correlation between USaFA and SaFA is well established (Flagella, et al., 2002). Highest OA, LiA and LnA % by 66.6, 17.6 and 7.9 %, respectively were taken from no stress conditions. In severe drought stress, compared to no stress conditions, these parameters reduced by 2, 4.5 and 5.6 %, respectively. This result is consistent with those reported by Champolivier and Merrien (1996). N had significant effect on USaFA % too. OA % increased with increasing in N, significantly. LiA and LnA % increased with increasing the N rate up to 190 kg N.ha^{-1} (N_3), significantly. The next highest rate (N_4) reduced these parameters. However this reduction for LnA was not significant. This result consistent with those reported by Joshi et al. (1998) in mustard.

Cunnae (1995) stated that relative proportion of different FA determines the quality of edible oil. A diet containing a high content of OA can reduce the content of the undesirable low-density lipoprotein cholesterol in blood plasma and monounsaturated FA more effectively prevent arteriosclerosis than polyunsaturated FA. So SA and PA are unhealthy SaFA, whereas OA and LiA are both unsaturated healthy FA. According to importance of SaFA and USaFA in oil quality, SaFA/USaFA ratio (Sa/USa) and C_{16}/C_{18} FA ratio were evaluated as canola oil quality indexes (Mollers and Schierholt, 2002; Danesh-Shahraki et al., 2007). Results showed that with increasing in water stress severity and because of increase in SaFA (PA and AA %) and reduction in USaFA (OA, LiA and LnA), Sa/USa ratio was increased, significantly. Increase in Sa/USa ratio showed that terminal drought stress not only decreased oil content (oil quantity) but also reduced oil quality. Dakhma et al. (1995) showed that water stress tends to reduce the degree of unsaturation of rape leaf lipids. With increasing in N application and because of reduction in PA and AA % and increase in OA, LiA and LnA %, Sa/USa ratio was decreased, significantly. However according to treatments interaction, this trend was affected by water availability and this reduction trend in moderate drought stress and no stress conditions was higher, compared to severe drought stress condition.

Table 2: Mean value comparisons of the seed Oil content (Oil%), Palmitic acid (PA%), Stearic acid (SA%), Oleic acid (OA%), Linoleic acid (LiA%), Linolenic acid (LnA%), Arashitic acid (AA%), saturated to unsaturated fatty acids ratio (Sa/ USa) and C_{16} to C_{18} fatty acid ratio (C_{16}/C_{18}).

Treatment	Oil%	PA%	SA%	OA%	LiA%	LnA%	AA%	Sa/ USa	C_{16}/C_{18}
Irrigation management									
S_1	45.25 a	4.46 c	2.33 b	66.64 a	17.67 a	7.93 a	0.589 b	0.080 b	0.047 c
S_2	44.71 ab	4.63 b	2.46 a	66.07 b	17.04 b	7.83 a	0.599 b	0.084 a	0.049 b
S_3	43.34 b	4.78 a	2.40 ab	65.46 c	16.91 b	7.52 b	0.644 a	0.087 a	0.052 a
Nitrogen rate									
N_1	45.90 a	4.76 a	2.60 a	65.43 c	16.93 c	7.56 c	0.658 a	0.089 a	0.051 a
N_2	44.51 ab	4.96 b	2.42 b	65.77 bc	17.21 b	7.73 b	0.627 b	0.085 b	0.050 b
N_3	43.71 b	4.64 b	2.36 b	66.12 b	17.42 a	7.89 a	0.608 c	0.083 c	0.049 c
N_4	43.61 b	4.40 c	2.21 c	66.91 a	17.27 b	7.87 a	0.550 d	0.077 d	0.046 d
Interactions									
S_1N_1	46.79	4.56	2.52 b	66.04	17.42 abc	7.78 bcde	0.637 bc	0.084 de	0.048 cd
S_1N_2	45.12	4.52	2.44 bc	66.43	17.68 a	7.87 abcd	0.588 e	0.082 efg	0.047 cde
S_1N_3	44.69	4.53	2.37 bc	66.81	17.85 a	8.06 a	0.599 de	0.080 fg	0.047 de
S_1N_4	44.39	4.22	1.97 d	67.26	17.73 a	8.02 ab	0.532 f	0.072 h	0.044 f
S_2N_1	46.15	4.81	2.79 a	65.37	16.58 e	7.54 efg	0.655 ab	0.092 a	0.052 ab
S_2N_2	44.89	4.75	2.38 bc	65.92	17.08 bcd	7.72 cdef	0.626 cd	0.085 cde	0.051 b
S_2N_3	43.70	4.59	2.36 bc	66.33	17.47 ab	7.94 abc	0.593 e	0.082 ef	0.048 cd
S_2N_4	44.11	4.38	2.33 c	66.66	17.02 bcde	8.11 a	0.522 f	0.078 g	0.046 e
S_3N_1	44.76	4.90	2.48 bc	64.87	16.79 de	7.36 g	0.682 a	0.090 ab	0.053 a
S_3N_2	43.53	4.80	2.44 bc	64.96	16.86 de	7.61 efg	0.668 a	0.088 bc	0.052 ab
S_3N_3	43.74	4.79	2.35 bc	64.21	16.95 cde	7.67def	0.632 bc	0.086 cd	0.051 b
S_3N_4	42.32	4.62	2.33 c	66.81	17.05 bcde	7.47 fg	0.596 b	0.082 ef	0.049 c

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

Lowest C_{16}/C_{18} FA ratio was taken from control treatment. With increasing in drought stress severity because of increase in PA % (as C_{16} FA) and reduction in OA, LiA and LnA % (as C_{18} FA), C_{16}/C_{18} ratio compared to no stress conditions was increased by 10 %. This 10 % increased was associated with 7.2 % reduction in oil content. Mollers and Schierholt (2002) also found that there is a negative correlation between seed oil and C_{16}/C_{18} ratio. Considering the importance and role of C_{18} FA in seed oil quality, increase in C_{16}/C_{18} ratio showed that terminal drought stress reduced oil quality. C_{16}/C_{18} ratio was affected by N rate. Highest C_{16}/C_{18} ratio was obtained with application of 90 kg N.ha^{-1}. With increasing in N application and because of reduction in PA % and increase in OA, LiA and LnA %, C_{16}/C_{18} ratio was decreased, significantly. This trend was affected by water availability and this reduction trend was more severein moderate drought stress.

Conclusions

Canola oil quality and quantity was generally affected by irrigation regime and N management. According to these results water stress through augmentation in Saturated to Unsaturated ratio and seed glucosinolate content lead to reduction in canola seed quality.

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