The Effects of Irrigation Regimes and Nitrogen Rates on some Agronomic Traits of two Rapeseed Cultivars

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Introduction

Water is not the only limiting factor in arid and semiarid ecosystems. Plants often suffer from nutrient (especially N and P) deficiencies, which could be exacerbated by climate and environment changes, especially increased water stress (Wu et al., 2009) due to the close relationships between water and nutrient availabilities. Nitrogen (N) fertilizer plays a crucial role in enhancing canola yield. A high rate of N application increases leaf area development, improves leaf area duration (LAD) after flowering, number of branches per plant, the number of silique per plant and increases overall crop assimilation, thus contributing to increased seed yield (Rose et al., 2008). Amounts of N fertilizer required for maximum yield of oilseed species vary, depending on environmental conditions (Gan et al., 2007).

Material and methods

The study was conducted at Agricultural Research Station of Karaj, Tehran province, Iran.. In this study, two rapeseed cultivars, Zarfam and Modena, were used. As cultivar Zarfam is more drought-resistant than Modena. The study (a randomized complete block design with four replicates) was conducted at two years and consisted of a factorial combination of two rapeseed cultivars, four irrigation regimes and four nitrogen rates. The irrigation regimes consisted of irrigation scheduling based on maximum allowable depletion (MAD) of the total available soil water (ASW). The irrigation treatments signed by I1 to I4 as 30, 45, 60 and 75% MAD of ASW.. Nitrogen (urea) was splited as half with sowing (incorporated) and the remaining half at the beginning of stem elongation (hand broadcasted) (N45+45, N90+90, and N135+135). The target plant density was 95 plants per m2. The area of each plot was 1.8×5.3 m (9.6 m2), Maintaining a buffer of 2m between adjacent plots. The relationship between irrigation regimes and N fertilizer rates was investigated by regressing seed yield against N fertilizer rates using a segmented linear-plateau model as Eq.1.

y = a + bN if N<Ncritical (linear part) (1)

y = a + b Ncritical if N≥ Ncritical (plateau part)

a

Where y is the yield (kg ha-1), N is fertilizer rates (kg N ha-1), Ncritical is the critical point or the N fertilizer rate at which the plateau begins, a and b are model coefficients. The plateau of the regression estimated the maximum yield, and the critical point of the regression estimated the N fertilizer rate at which the maximum seed yield was achieved. These nonlinear regression coefficients were estimated using iterative optimization method by the Solver Add-ins tool (Microsoft Excell, 2003).

Results and discussion

In both years, there were effects on yield, yield components and water use efficiency due to irrigation regimes, nitrogen rates, and cultivars. Cultivars tended to respond similarly to irrigation regimes and nitrogen rate for seed yield in both years of the study. The results revealed that treatment combinations of I1*N4, I1*N3 and I2*N4 maintained significantly greater leaf area index (LAI), above-ground dry matter (DM) and seed yield of the crop than other combinations. For all irrigation levels, the seed yield was highly responsive to N fertilizer rates from zero to about 147 kg N ha−1 (N inflection), and thereafter, the rate of yield responses declined. The amount of N fertilizer required to achieve the maximum seed yield was 147 kg N ha−1 for I4, 150 kg N ha−1 for I3, 189 kg N ha−1 for I2 and 166 kg N ha−1 for I1. The present results highlight the practical importance of adequate N fertilization in yield formation in winter oilseed rape and suggest that the rate of N inflection will be about adequate for the crop to meet its N requirements. Earlier flowering, longer flowering duration, and greater tolerance to drought stress for Zarfam cultivar were detected as determinant physiological traits for successful adaptation to water deficit. .

References
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Table 1. Mean comparison some agronomic traits of rapeseed under irrigation regimes, cultivars, and nitrogen rates.

	Days to maturity (d)	Plant height (cm)	Lodging score	Silique number (no. plant^{-1})	Seed number (no. silique^{-1})	1000-Seed weight (gr)	Seed yield (kg ha^{-1})	Seed oil concentration (%)	Seed N concentration (%)	Water use efficiency (kg m-3)
Y1*										
I_1	230 a	192 a	1.44 a	191 a	25 a	3.7 a	3872 a	40.81 a	20.11a	0.54 b
I_2	229 a	189.7 b	1.41 a	188 a	24 a	3.6 a	3850 a	40.40 b	18.94 b	0.61 a
I_3	225 b	180 c	0.97 b	119 b	20 b	3.21 b	3135 b	39.8 c	16.6 c	0.53 b
I_4	220 c	173.8 d	0.78 c	83 c	18 c	3.2 b	2654 c	37 d	16.5 d	0.47 c
N_1	227 c	194 d	0.0 d	73 d	20 c	3.26 c	2312 c	41.9 a	16.01 d	0.37 c
N_2	229 b	196 c	0.84 c	105 c	22 b	3.33 b	3124 b	39.6 b	18.07 c	0.41 b
N_3	229 b	199 b	1.69 b	170 b	25 a	3.44 a	3800 a	39 c	19.73 b	0.51 a
N_4	230 a	201 a	2.38 a	190 a	25 a	3.5 a	3700 a	37.74 d	21.44 a	0.5 a
Zarfam	229 a	189	1.33 a	130 a	23 a	3.51a	3250 a	40.2 a	19.37 a	0.56 a
Modena	228 b	187	1.12 b	128 b	20 b	3.2 b	3157 b	39. b	18.38 b	0.5 b
Y2										
I_1	241 a	199 a	1.81 a	210 a	28 a	3.74a	4190 a	44.9 a	21.13	0.63 b
I_2	240 a	197 b	1.5 b	207 a	27 a	3.65 a	4134 a	44.7 a	21.1	0.79 a
I_3	234 b	189.3 c	1.12 c	131 b	24 b	3.5 b	3264 b	43.8 b	20.95	0.56 c
I_4	233 b	185.9 d	0.94 d	91 c	23 b	3.47 b	2740 c	41.73 b	20.9	0.5 d
N_1	C 237	201.8 b	0.03 d	80.3 d	22 d	3.53 b	2464 d	46.17 a	17.62 d	0.4 d
N_2	C 238	203 b	0.97 c	115 c	24 c	3.59 b	3231 c	43.58 b	19.68 c	0.63 c
N_3	B 240	206 a	1.84 b	196 b	26 b	3.76 a	3830 b	42.7 c	21.47 b	0.73 b
N_4	A 242	207 a	2.22 a	210 a	27 a	3.75 a	3991 a	41.52 d	23.55 a	0.88 a
Zarfam	240 b	196.6 a	1.28 a	144 a	26 a	3.8 a	3499 a	43.74 a	21.1 a	0.6 a
Modena	238 a	194.5 b	1.25 a	141 b	24 b	3.75 b	3389 b	43.2 b	20 b	5.5 b

* Mean values in the same columns with the same letters are not significantly different (P<0.05) according to LSD.

Table 2. Summary of the nonlinear regression coefficients (a, intercept; b, linear slope coefficient; critical point, N fertilizer rate at which the plateau begins) for seed yield. Average data for two experiments (Eq. 1).

Irrigation regimes	R^2	a	b	$N_{critical}$
I_1	0.97	1999	11.11	166.5
I_2	0.97	1850	9.4	189.8
I_3	0.97	1500	9.2	150
I_4	0.98	1200	7.7	147

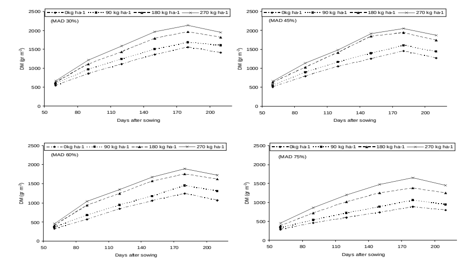

Fig. 1. Dry matter production of canola as influenced by irrigation and nitrogen application treatments, average data for two experiments

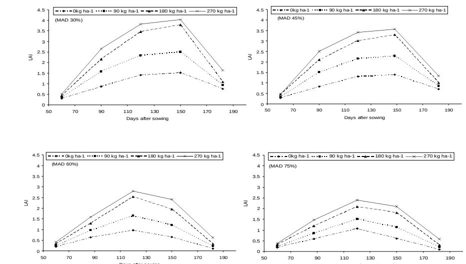

Fig. 2. Leaf area index of canola as influenced by irrigation and nitrogen application treatments, average data for two experiments

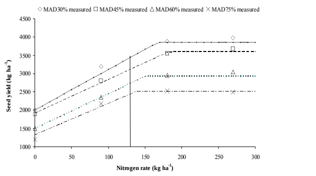

Fig. 3. Nonlinear regression output for seed yield produced under different irrigation regimes, averaged data for two experiments, the vertical solid line indicates the recommended rate of N fertilizer (130 kg N ha-1) for rapeseed production under normal growing conditions.