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Assessment of Terminal Heat Stress and Nitrogen on Grain Yield and Yield Components of Canola

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ABSTRACT
In order to study the effects of terminal heat stress and nitrogen on morphophysiological characteristics, ANUE (Agronomical Nitrogen Use Efficiency) and yield of canola, an experiment was conducted at research farm of Ramin Agricultural Sciences and Natural Resources university. The experiment was arranged in split plots based on randomized complete block design with four replications. Main plots included three N fertilizer levels consisted of 90, 180, and 270 $kg.ha^{-1}$ nitrogen and control. Sub plots were considered as two sowing dates, Nov.11 (optimum condition) and Jan.26 (terminal heat stress condition). Results showed that terminal heat stress and nitrogen had significantly effect on all measured parameters while effect of nitrogen on ANUE was not significant. The two levels of 180 and 270 $kg.ha^{-1}$ nitrogen had no significantly different effects on plant height, leaf number, sub branch number, LAI and ANUE. In addition, interaction effects between terminal heat stress and nitrogen was significant on some parameters. In both of optimum and terminal heat stress conditions, increase in used nitrogen led to significantly more yield. Nitrogen had no significant effect on ANUE. Decrease in nitrogen levels caused decrease of final grain yield. Also, terminal heat stress decreased grain yield about 59 percent. Our result suggested that increased nitrogen could have a positive effect on terminal heat stress tolerance of canola.
Keywords*:* *Brassica napus, Nitrogen Fertilizer, Stress, Yield.*

INTRODUCTION
Canola is one of the most important oil crop that play an essential role in supplying edible oil and its cultivation is going up (Dehghanzadeh and Azarpanah, 2013). As canola needs temperate the climates during growing period, early heat in late growing season could affect on the yield quantity and quality of canola (Malhi *et al*., 2007). Using effective factors on yield, especially on the environment stresses and nutrients an essentially effective ways to increasing productivity and improve quantitative and qualitative yield of canola (Robertson and Holland, 2004).

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To reach these goals, must be found out agricultural management such as optimum sowing date and nutrition application. (Si and Walton, 2004) in assessment of canola phenology and yield reaction to sowing date in west Australia reported that reduction in yield per week sowing delay led to 1-7% which could because of limited growth period due to terminal heat. Taylor and Smith (1992) reported that sowing date affected on yield and yield component significantly and optimum sowing date depends on variety and climate factors especially latitude. Robertson and Holland (2004) reported that late sowing in canola led to flowering and filling stage face to terminal heat which result in grain and oil yield reduction. Later sowing decrease yield owing to growth and leaf area reduction and faster maturity (Ozer, 2003). Morison (1993) reported that heat stress during flowering stage of canola in comparison to vegetative or pod stage would result in larger losses. For instance, in Saskatchewan, Canada, early sowing date of canola would diminish risk of heat stress at the flowering stage in July. Late sowing date could cause decrease in grain yield due to coincidence the flowering stage with high temperature and heat stress (Sharghi *et al*., 2011). Nitrogen is the most effective nutrition influencing on yield, crop quality and one of the most important factors determining productions (Mendham *et al.*, 1990, Yasari and Patwardhan, 2006). Goldoust Khorshidi *et al*. (2013) reported that nitrogen would effect on grain yield due to increasing number of plant branches and buds. Also, Malhi and Gill (2007) found that nitrogen reduction in leaves would lead to decline dry matter yield. Svecnjak and Rengel (2006) by investigating of sowing date on dry matter yield and critical nitrogen concentration in canola found that critical nitrogen concentration for dry matter production in late sowing date was 50% less than early sowing date at rosette and stem elongation stage. The objective of this research is investigation effect of late sowing date and different levels of nitrogen manure on morphophysiological characteristics, ANUE and yield of canola.

MATERIALS AND METHODS

Field and treatment information

This research was conducted in research farm of Ramin Agricultural Sciences and Natural Resources University, Islamic Republic of Iran, during 2011-2012. The experimental site is located at 31°36´ N, 48°70´ E and an altitude of 30 m. The experiment was laid out in split plot arrangement based randomized complete block design with and four replications. The main plot consisted of 90, 180, and 270 kg.ha^{-1} nitrogen and control (no nitrogen application) to computation of ANUE (Agronomical Nitrogen Use Efficiency). Main physical and chemical properties of soil are listed in Table (1).

Table 1. Main physic-chemical properties of soil

Depth (cm)	Clay (%)	Silt (%)	Sand (%)	Organic Matter (%)	pH (1:5)	EC (ds.m^{-1})	P (ppm)	K (ppm)	N (%)
0-30	44	41	15	0.8	7.0	2.5	8.5	180	0.07
30-60	44	38	18	0.4	7.5	1.5	6.5	115	0.04

Sowing date was assigned to the subplots which included Nov.11 (optimum conditions) and Jan.26 (terminal heat stress condition).

Crop Management

Urea and single super phosphate were used as sources of N and P, respectively. After experiment design, canola seeds planted manually on 4m long and 3m width plots consisted of 10 rows of plants and distances between plants and rows of 3 and 30 cm, respectively into1 to 2 cm depth number of pod per plant. For this study, Hyola401 hybrid (spring and early maturity) was used that obtained from Ahvaz Agricultural Research Center.

Traits measure

Plants were harvested at physiological maturity and different traits were evaluated including plant height, leaf number per plant, sub branch number per plant, leaf area index, chlorophyll content and grain yield ($Kg.ha^{-1}$). Chlorophyll content was determined by SPAD502 Chlorophyll meter (ten samples for each replication), and ANUE ($kg. kg^{-1}$) was calculated by follow formula (Timsina *et al*., 2001):

Formula. 1. ANUE= GY (N_X) - GY (N_0)/N_X

Where GY (N_X) grain yield at X nitrogen fertilizer level and GY (N_0) grain yield at no nitrogen fertilizer. Data for abnormal germination percentage were subjected to arcsine transformation before analysis of variance.

Statistical analysis

Statistical analysis was carried out using SAS software (Ver. 8). Mean comparison was performed with Duncan's Multiple Range Test at the 1% level of significance.

RESULTS AND DISCUSSION

Analysis of variance showed that the effect of nitrogen on plant height was significant at 5% probability level (Table 2). Regarding to results, the highest and lowest plant height were obtained from the use of 270 and 90 $kg.ha^{-1}$ nitrogen levels with 120 and 109 cm height respectively. Terminal heat stress condition on plant height was significant at 5% probability level, and led to significantly decrease plant height from 133.5 cm in optimum condition to 96 cm (Table 3). Interactions effects between both factors (Terminal heat stress and nitrogen) on plant height were not significant. Effect of nitrogen on leaf number was significant (P<0.01) (Table 2). The highest leaf number (10.75 leaf. $plant^{-1}$) was achieved under the use of 270 $kg.ha^{-1}$ N. Pinkerton (1998) reported that decrease on leaf number because of nitrogen deficiency. Terminal heat stress on this attribute was significant at 5% probability level (Table 2). Highest leaf number was obtained from the optimum condition (13.1) and decrease to 7.41 leaves in terminal heat stress condition (Table 3).

Table 2. ANOVA result of nitrogen and date sowing treatments on all studied traits

S.O.V	df	Plant height	Leaf number	Sub Branch	LAI	Chlorophyll content	ANUE	Grain yield
Replication	3	131.5*	190.2*	217.8*	91.9*	109.2*	88.5**	145.5**
Nitrogen	2	237.7*	2.7**	13.5**	127**	8986**	0.82^{ns}	70855**
Error a	6	22.5	029	0.652	0.01	6.79	0.32	20047
Heat Stress	1	8475**	198**	210**	8.3*	177**	36.7**	19863481**
N * H.S.	2	28.2^{ns}	0.12^{ns}	6.29^{ns}	0.02^{ns}	4.6^{ns}	5.47^{ns}	324985^{ns}
Error b	9	32.2	0.31	0.98	0.018	4.9	1.34	13981
CV (%)	-	6.30	6.17	17.91	12.56	5.11	20.00	16.09

ns,* and**, non significant and significant at 5% and 1% probability levels respectively.
N: Nitrogen, HS: Heat Stress

Table 3. Means comparison of nitrogen and date sowing treatments on all studied traits

Treatments	Plant height (cm)	Leaf number (plant)	Sub Branch (plant)	LAI	Chlorophyll (SPAD)	ANUE ($Kg.kg^{-1}$)	Grain yield ($Kg.ha^{-1}$)
Optimum Condition	133.5 [a]	13.1 [a]	8.6 [a]	3.71 [a]	45.8 [a]	3.7 [a]	3079.5 [a]
Heat stress Condition	96 [b]	7.41 [b]	2.75 [b]	2.5 [b]	41.3 [b]	1.2 [b]	1260 [b]
N= 270	120 [a]	10.75 [a]	6.75 [a]	3.23 [a]	46.87 [a]	2.8 [a]	2407 [a]
N= 180	115 [ab]	10.5 [a]	6.12 [a]	3.1 [a]	43.7 [b]	2.6 [a]	2254 [b]
N= 90	109 [b]	9.62 [b]	4.25 [b]	2.9 [b]	40.1 [c]	1.9 [a]	1847 [c]

Duncan's test: means within each column, followed by similar letter indicates no significant difference between treatments ($P < 0.01$).

In addition interactions effects of terminal heat stress and nitrogen on leaf number was not significant. Effects of nitrogen and terminal heat stress on Sub-Branch number were significant at 1% probability level and interactions effects of those was non significant at 5% probability level (Table 2). The highest and the lowest sub branch number (6.75 and 4.25) were achieved under the use of 270 and 90 $kg.ha^{-1}$ N respectively (Table 3). Terminal heat stress decreased sub branch number from 8.6 branches in optimum condition to 2.75 Similar results were reported by Brennan and Bolland (2007) who found that delay sowing date led to decrease number of sub branch and number of pod per plant and result in decline grain yield. Increasing nitrogen level from 180 to 270 $kg.ha^{-1}$ under both optimum and terminal heat stress conditions were not significantly effect on this mentioned trait. Effects of nitrogen levels, terminal heat stress and interactions effects of those factors were significant at 1% and 5% probability level and no significant on leaf area index respectively (Table 2). Terminal heat stress led to decrease of LAI from 3.71 in optimum condition to 2.5 (Table 3). Similar results were reported by Rathke *et al.* (2005) who concluded that delay sowing date decrease growth, leaf area, rather maturity and led to decrease grain yield. Effects of nitrogen and terminal heat stress on chlorophyll content was significant (P <0.01) (Table 2). The highest and least chlorophyll content (46.87 and 40.1 SPAD) were achieved under the use of 270 and 90 $kg.ha^{-1}$ N respectively (Table 3) and interaction effects of nitrogen and terminal heat stress on chlorophyll content were not significant. Similar results were revealed by Walker (2001) who found that whatever the nitrogen concentration in leaves increased, the carboxylation is more, because in addition of plant protein, nitrogen is a main element of chlorophylls and plays important role in carboxylation. The presented data in (Table 2) showed that effect of nitrogen on ANUE was not significant, but influence of terminal heat stress on ANUE was significant (at 1% level). The effect of terminal heat stress led to decrease ANUE from 3.7 in optimum condition to 1.2 $kg.kg^{-1}$ (Table 3). The results are in line with Aminpanah (2013) who reported that late sowing date would cause confront filling stage with heat stress, in addition made root development and plant nitrogen uptake efficiency restricted. Effects of nitrogen, terminal heat stress factors were significant at 1% probability level on grain yield (Table 2). Least grain yield (1847 $kg.ha^{-1}$) was achieved under application 90 $kg.ha^{-1}$ N and highest grain yield (2407 $kg.ha^{-1}$) was achieved under application 270 $kg.ha^{-1}$ N.

In addition increasing of nitrogen level from 180 to 270 kg.ha^{-1} was no significant effect on this attribute (Table 3). Terminal heat stress decreased grain yield 59 percent. Same results were reported by Whitfield (1992), who said higher temperature at grain filling stage would increase pod respiration quickly. In optimum condition, increasing of nitrogen from 90 to 180 kg.ha^{-1} grain yield was increased from 2524.5 to 3271.5 kg.ha^{-1} but increasing of nitrogen at 270 kg.ha^{-1} was no significant effect on this attribute. In terminal heat stress condition, increasing of nitrogen from 90 to 270 kg.ha^{-1}grain yield was significantly increased (Table 3).

Correlation

Correlation coefficients between the traits were presented in Table (4). Grain yield revealed positive and highly significant correlation with the plant height (r=0.975**), chlorophyll content (r=0.642**), leaf number per plant (r=0.963**), sub branch number per plant (r=0.975**) and the ANUE (r=0.835**). According to the Aminpanah (2013) ANUE had positive correlation with canola grain yield. Brennan and Bolland (2007) found a positive correlation between sub branch number and grain yield.

Table 4. Correlation coefficients between traits in rape seed

Traits	Plant height (cm)	Chlorophyll Content (SPAD)	Leaf Number (plant)	LAI	Sub Branch number (plant)	ANUE (Kg.kg^{-1})
Plant height (cm)						
Chlorophyll content (SPAD)	0.94**					
Leaf number (plant)	0.97**	0.60**				
LAI	0.98**	0.59**	0.97**			
Sub Branch Number (plant)	0.96**	0.67**	0.92**	0.95**		
ANUE (Kg.kg^{-1})	0.81**	0.43*	0.76**	0.78**	0.81**	
Grain yield (Kg.ha^{-1})	0.97**	0.64**	0.96**	0.97**	0.97**	0.83**

ns,* and**, non significant and significant at 5% and 1% probability levels respectively.

CONCLUSION

In optimum condition with increasing of nitrogen levels grain yield was increased. But with increasing of nitrogen level from 180 to 270 kg.ha^{-1} was no significantly effect on this attribute. In terminal heat stress condition grain yield of canola did not change with increasing of nitrogen from 90 to 180 kg.ha^{-1}. Increasing of nitrogen at 270 kg.ha^{-1} just led to increase 14.8 percent grain yield of canola in comparison to 90 kg.ha^{-1} nitrogen.

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