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REGULAR ARTICLE

EVALUATION OF YIELD AND GROWTH INDICES OF CANOLA (*BRASSICA NAPUS* L.) CULTIVARS IN DIFFERENT NITROGEN FERTILILIZATION LEVELS

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SUMMARY

In order to evaluation of effects of different nitrogen fertilization levels on yield and growth indices of canola (*Brassica napus* L.) cultivars, an split plot experiment based on randomized complete block design was conducted in Research Farm Islamic Azad University, Ardabil branch in 2007. Factors were: nitrogen fertilizer at four levels (0 as control, 50, 100 and 150 kg N/ha) in the main plots and canola cultivars at three levels (Clover, Opera and Okape) in the sub plots. The results showed that various levels of nitrogen fertilizer affected yield and growth indices of *Brassica napus*. Means comparisons in compound of treatment cultivar x levels of nitrogen showed that maximum grain yield was obtained by the plots which was applied 150 kg nitrogen/ha with opera cultivar. Investigation of variances trend of total dry matter indicated that in all of treatment compounds, it increased slowly until 215 days after sowing with increasing of nitrogen fertilizer and then increased rapidly till 299 days after sowing. From 299 days after sowing till harvest time, it decreased due to increasing aging of leaves and decreasing of leaf area index. Increase in N levels also significantly increased the crop growth rate and the maximum of it was observed by the plots that received 150 kg N/ha with opera cultivar. In addition, in all of treatment compounds, CGR increased slowly until 243 days after sowing and then decreased slowly till 257 days after sowing. From 257 days after sowing till harvest time, it decreased due to increasing aging of leaves and decreasing of leaf area index. Thus, it can be suggested that in order to increasing of grain yield, total dry matter crop growth rate and the other of physiological indices should be applied opera cultivar with 150 kg N ha^{-1} in conditions of Ardabil Plain.

Keywords: Canola, Physiological indices, yield and yield components.

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1. Introduction

Canola is the main winter growing oilseed in Iran. Nowadays, canola (*Brassica napus L.*) cultivars are low in erucic acid and glucosinolates. Canola oil is considered healthy for human nutrition due to its lowest [1]. Canola is an important source of protein and oil for human and animal consumption. Nitrogen is the most important fertilizer applied to canola in terms of cost to growers, and inadequate or untimely N applications often restrict yields. Nitrogen deficit canola plants have fewer and smaller leaves than N-sufficient plants [2]. Deficiency of N is particularly limiting for canola because its requirement for N per unit of yield is higher than in most grain crops [3].For example, Canola requires about 25% more N than wheat [4]. Hocking et al [4] reported that the increase in pod number per plant with increasing N fertilizer was virtually the only factor responsible for the increased seed yield as seed number per pod and individual seed weight were comparatively constant over the range of N rates applied. Application of nitrogen has been reported to influence productivity of seed yield and seed oil contents [5]. Malhi and Gill [6] reported that nitrogen increased canola grain yield and thousand grain weight. Khan et al [7] reported plots that received 120 kg N /ha, had highest branch number, pod per plant, grain per pod and grain yield. Ahmad et al [8] reported that with nitrogen increase, grain yield component increase through increased LAI and branch number. Nitrogen also helps in accelerating the photosynthesis activity [9] and increase total dry matter in Indian mustard [10]. Mohan and Sharma [11] also reported that application of N increased the seed yield of Indian mustard. Shukla et al [12] reported that using nitrogen as supplementary nutrient resulted in 20.5 and 23 % increase in crop growth rate in Indian mustard. Shukla et al [12] reported that using nitrogen increased relative growth rate in initially stages and decreased in the final stage. Almost all investigations show that nitrogen fertilizer causes a substantial yield increase in spite of diverse and contrasting growing conditions of oilseed rape. However, requirement for nitrogen fertilizer can vary very much according to cultivars, soil type, climate and management [13]. In the other hand, low level of the yield is due to mistakes in agro technical principles. In addition, growth analysis is still the most simple and precise method to evaluate the contribution of different physiological processes in plant development. The aim of this study was to evaluate the influence of nitrogen fertilization on grain yield and the some of physiological indices of canola in conditions of Ardabil Plain.

2. Materials and methods

A split plot experiment based on randomized complete block design with three replications was conducted in 2007 at the Research Farm of Islamic Azad University, Ardabil Branch , (lat 38̊ 15' N; long 48̊ 15' E; Alt 1350m). Climatically, the area placed in the semi-arid temperate zone with cold winter and hot summer. Average rainfall is about 368 mm that most rainfall concentrated between winter and spring. Soil properties were presented in Table 1.

Table 1. Physical and chemical properties of experimental soil

Sampling depth	Avaluable N (ppm)	Avaluable P (ppm)	Avaluable K (ppm)	pH	Organic matter (%)	texture
(0-40 cm)	5.2	3.4	54	7.2	.12	loamy salty

The field was prepared well before sowing by plowing twice with tractor followed planking to make a fine seed bed. Treatments were arranged in a split plot design with three replicates. Nitrogen fertilizer in four levels (0 as control, 50,100 and 150 kg N /ha) as urea in the main plots, while canola cultivars in three levels (Clover, Opera and Okape) were allocated at random in the sub-plots. Row spacing was 25 cm, respectively. In each sub plot there were 5 rows 5m long. Plots and blocks were separated by 1m unplanted distances. Canola seeds were planted in the third week of September.

Nitrogen fertilizer was applied as 1/3th at sowing, 1/3th at leaf rosette and 1/3 at flowering. Seeds were sown with density of 8 kg ha^{-1}. Fertilizer basic dose of P.K at the rate of 70-70 kg ha^{-1} were applied in the form of triple super phosphate and nitrate potassium. All of phosphor and potassium were applied at the time of sowing. The field was immediately irrigated after planting. Weeds were controlled manually. All other agronomic operations except those under study were kept normal and uniform for all treatments. For estimation of growth analysis, five plants were sampled randomly in each treatments and average for recording the change in dry weight in shoots (above ground), interval at different stages of the canola growth 215,229, 243, 257, 271, 285, 299 and 313 days after sowing. For dry weight determination, samples were oven dried at 70° C to constant weight. Leaf area index was determined by dividing leaf area over ground area. The growth indices such as total dry matter (TDM), crop growth rate (CGR), relative growth rate (RGR) and leaf area index (LAI) were determined following Acuqaah [14] and Gupta and Gupta [15].

Grain yield obtained from 1 m^2 long from the three middle rows in each sub plot. In order to measurement of yield components such as pod per plant and grain per pod, ten plants were selected randomly from 3 m long from the three middle rows of sub plots and then their average was calculated. Analysis of variance and regression were performed using SAS computer software packages. The main effects and interactions were tested using the LSD test.

3. Results and Discussion

Grain yield and yield attribute**:** the grain yield, pod per plant and grain per pod were influenced significantly by nitrogen levels, cultivar and interaction of nitrogen levels ×canola cultivar.

Number of pod per plant

Data regarding number of pod per plant of canola cultivars as affected by N levels are presented in Table 2. Means comparison in treatment compound of canola cultivar x various levels of nitrogen indicated that the maximum (96.1) number of pod per plant was recorded for opera cultivar in application of 150 kg N ha^{-1} and minimum of it was recorded for Okape cultivar (65.1) in zero kg N ha^{-1} (Table 3). Similar observation was made by Ozer (16) and Hocking et al (4) suggesting seed yield increase with enhancement in N rate was mostely due to increase in pod per plant.

Grain per pod

Means comparison indicated that maximum grain per pod (23.5) was observed for opera cultivar in application of 150 kg N/ha, while minimum (12) of it was recorded for Okape cultivar in application of zero kg N/ha (Table 3).Kumar et al [7] reported that number of pod per plant in some genotype of *Brassica napus* and *Brassica juncea* increased with higher rates of N, which is also observed at the present study.

Plant height

Plant height is function of genetic as well as environmental conditions. It is considered as vegetative growth potential of a crop. Data regarding the effect of canola cultivars and nitrogen fertilizer on plant height are given in Table1. The tallest plants were observed in the plots, which received the maximum dose of nitrogen fertilizer (Table 2). In the other hand, the maximum plant height (110.17 cm) was obtained with the highest nitrogen levels (150 kg N ha^{-1}),while the least value (93.8 cm) was recorded at the lowest nitrogen level (0 kg N ha^{-1}). Holmes [3] reported that due to N deficiency in rapeseed the growth is checked and the plant height is reduced subsequently. Mean comparison of treatment compound cultivar x levels of nitrogen showed that maximum plant height was obtained by the plots which was applied 150 kg N/ha with opera cultivar, while the least value was recorded at the lowest nitrogen level (0 kg N ha^{-1}) with clover cultivar. Our findings are in agreement with observations made by Ahmad et al [8] and Takure et al [18].

Grain yield

Grain yield is the main target of crop production. The grain yield was significantly affected by both canola cultivars and various levels of nitrogen fertilizer. Nitrogen fertilizer significantly increased the grain yield. The grain yield varied between .81 ton/ha in zero level of nitrogen fertilizer and 1.167 ton/ha in

150 kg N ha^{-1} (Table 2). Means comparison in treatment compound of canola cultivar x various levels of nitrogen indicated that the maximum (1.26) grain yield was recorded for opera cultivar in application of 150 kg N ha^{-1} and minimum of it was recorded for Okape cultivar (.68) in zero kg N ha^{-1} (Table 3). This might be related to the favorable response of canola cultivars to nitrogen fertilizer. Haneklaus et al. [19] reported an 88% rise in the canola yield by application of nitrogen fertilizer. The results obtained in the present study are reported by Santonoceto et al [20] suggesting that increase in the rate of N resulted in a higher seed yield. Our findings are in agreement with observations made by Zhaohui and Shengxiu [21].

Table 2-Effects of various levels of nitrogen fertilizer on grain yield and the some of characteristics of canola

Characteristic		Grain yield (ton/ha)	Plant hieght	Number of pod per plant	Number of grain per pod
Canola cultivars	Opera	1.18 b	107.43 a	79.1 c	24.19 a
	Clover	.9 c	104.81b	75.81 b	24.7 a
	Okape	.78 a	95.04c	74.9 a	20.33 b
Nitrogen levels (kg/ha)	zero	.81 d	93.84d	70.4 b	-
	50	.96 c	102.22c	73.4 b	–
	100	1.017 b	103.48b	77.9 ab	–
	150	1.167 a	110.17a	84.95 a	–

Means with similar letters in each column are not significantly different

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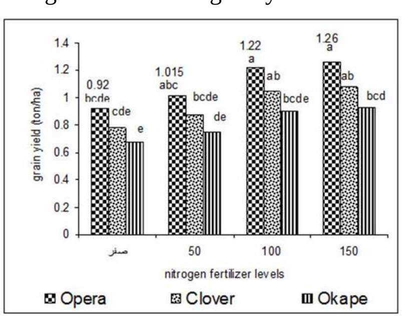
Table 3- Mean comparisons of treatment compound of various levels of nitrogen fertilizer on some of characteristics in canola cultivars

Characteristics		Number of grain per pod			Number of pod per plant			Plant hieght		
Canola cultivars		Opera	Okape	Clover	Opera	Okape	Clover	Opera	Okape	Clover
levels of nitrogen fertilizer (Kg/ha)	0	16.55c	12 e	16 c	96.1 a	67.4 e	65.1 ef	89.7 d	87.9 d	83.3 d
	50	19 b	14 d	18 bc	75.6 e	70.5 d	72.5cd	95 c	93.4 c	94.7 c
	100	22.3 a	21 ab	21 ab	81.07 c	78.62 c	73.2 cd	124 a	103.75 b	98.29 bc
	150	23.5 a	23 a	22 ab	92.2 a	85.12 b	88.7 b	126 a	122 ab	103.3 b

Means with similar letters in each column are not significantly different

Means with similar letters in each column are not significantly different

Fig 1- Mean comparison of treatment compound of various levels of nitrogen fertilizer on grain yield of canola cultivars



Total Dry matter

Study of trend of variances total dry matter in treatment compounds canola cultivars x various levels of nitrogen fertilizer (Table 4) showed that in all of cultivars, total dry matter increased during plant growth with increasing nitrogen fertilizer and reached to a maximum level at 286-299 days after planting, then showed a declining trend at maturity (300-313 DAS). Wysocki et al [2] have also reported such a decline in dry matter after reaching a climax in full bloom. The increase in total dry matter with the increasing rate of nitrogen fertilizer indicates the favorable response of canola cultivars to nitrogen fertilizer. It is perhaps related to accelerating the photosynthesis activity [23]. and activity photosynthesizing tissues which grow during this period of growth. Similar observations were also made by Singh and Singh [24]. Study of total dry matter trends of opera cultivar in various levels of nitrogen fertilizer shows that dry matter increased slowly until 215 days after sowing and then increased rapidly till 299 days after sowing. From 300 days after sowing till harvest time, accumulated dry matter decreased due to increasing aging of leaves, decreasing of leaf area rate (Table 4). On the other hand, total dry matter in unit of area increased with increasing levels of nitrogen fertilizer, as the maximum and the minimum biomass in unit of area obtained from 0 and 150 kg ha^{-1}, respectively (Table 4). Study the total dry matter in other cultivars (clover and okape) indicated that in all of cultivars increased with increasing of nitrogen fertilizer (Table 4) and trend of variances were similar to dry matter remobilization in opera cultivar.

Crop growth rate

Study of trend of variances crop growth rate showed that in all of cultivars, the crop growth rate was low in the beginning, increased thereafter considerably up to 243 days after planting with a peak during 243-244 days after planting (Table 5), then showed a declining trend at 245-313 days after planting. The increase in CGR with the increasing rate of N may be due to the positive response of canola to S fertilizer. Similar results were also reported by Holmes [3]. The decrease in crop growth rate towards maturity is due to senescence of lower leaves and decrease of leaf area index (Table 7). Similar results were reported by Shukla et al [12]. They reported that application of nitrogen increased 23% in CGR value of Indian mustard.

Relative growth rate

In the initial stages of the plant growth the ratio between alive and dead tissues is high and almost the entire cells of productive organs are activity engaged in vegetative matter production. In conclusion, the relative growth rate of plant crops is high. In all of treatment compounds, RGR decreased during plant growth with decreasing nitrogen fertilizer and reached to a minimum level at 244-257 days after planting, then showed a negative value at maturity (258-313 DAS). The reason of such negative value in RGR at the final stage can be related to increasing of the dead and woody tissues comparing to the alive and active texture. Similar observations have been reported by Shukla et al (12) in Indian mustard.

Table 4-Effects of various levels of nitrogen fertilizer on variances trend of total dry matter (TDM)

Treatment compounds \ Days after planting	0-215	216-229	230-243	244-257	258-271	272-285	286-299	300-313
Opera × Zero kg N/ha	68	109.07	151	190	239	268	290	281
Opera × 50 kg N/ha	80	125.4	170	230	278	315	335	316
Opera × 100 kg N/ha	88	138	186	255	300	346	374	361
Opera × 150 kg N/ha	89	141	205	262	322	362	396	380
Okape × Zero kg N/ha	79.59	122.55	170	220	265	298	319	305
Okape × 50 kg N/ha	89	140.9	196	256	303	348	389	370
Okape × 100 kg N/ha	91.41	145.86	200	265	319	358	390	379
Okape × 150 kg N/ha	94.21	150.47	206	269	325	360	400	390
Clover× Zero kg N/ha	60	100	125	174	201	210	224	207
Clover × 50 kg N/ha	70	118	140	190	220	244	251	242
Clover × 100 kg N/ha	80	130	170	210	260	295	308	295.3
Clover × 150 kg N/ha	85	135.8	183.14	223.84	271.33	306	321	310

Table 5-Effects of various levels of nitrogen fertilizer on variances trend of crop growth rate(CGR)

Treatment compounds \ Days after planting	0-215	216-229	230-243	244-257	258-271	272-285	286-299	300-313
Opera × Zero kg N/ha	2.76	3.42	3.74	3.58	2.94	1.94	.802	-.27
Opera × 50 kg N/ha	3.207	3.92	4.195	3.87	2.95	1.62	.138	-1.23
Opera × 100 kg N/ha	3.205	3.98	4.37	4.22	3.51	2.404	1.12	-.94
Opera × 150 kg N/ha	3.411	4.22	4.62	4.22	3.62	2.39	.98	-.45
Okape × Zero kg N/ha	2.69	3.31	3.54	3.28	2.62	1.76	.91	.257
Okape × 50 kg N/ha	2.36	2.705	2.61	2.088	1.253	.334	-.464	-1.023
Okape × 100 kg N/ha	2.51	3.064	3.33	3.174	2.534	1.484	.204	-1.065
Okape × 150 kg N/ha	2.311	2.739	2.84	2.53	1.83	.856	-.191	-1.118
Clover× Zero kg N/ha	2.11	2.51	2.57	2.19	1.41	.36	-.74	-1.72
Clover × 50 kg N/ha	2.57	3.18	3.48	3.33	2.73	1.8	.74	-.253
Clover × 100 kg N/ha	3.21	3.98	4.35	4.75	3.41	2.58	.93	-.31
Clover × 150 kg N/ha	3.53	4.37	4.78	3.58	3.75	2.48	1.02	-.348

Table 6. Effects of various levels of nitrogen fertilizer on variances trend of relative growth rate (RGR)

Treatment compounds \ Days after planting	0-215	216-229	230-243	244-257	258-271	272-285	286-299	300-313
Opera × Zero kg N/ha	.034	.027	.021	.015	.0107	.0063	.0024	-.000827
Opera × 50 kg N/ha	.034	.027	.0218	.016	.0112	.0068	.00298	-.00025
Opera × 100 kg N/ha	.0333	.0264	.02007	.0412	.009	.0044	.00036	-.00313
Opera × 150 kg N/ha	.034	.027	.021	.0158	.0107	.00632	.00245	-.000827
Okape × Zero kg N/ha	.0365	.028	.021	.0154	.0103	.0061	.00301	.000824
Okape × 50 kg N/ha	.0335	.0254	.0181	.0117	.00623	.00157	-.002201	-.005102
Okape × 100 kg N/ha	.0307	.025	.02002	.0149	.01009	.00527	.000629	-.0037
Okape × 150 kg N/ha	.031	.025	.0191	.0135	.0087	.0036	-.000792	-.00481
Clover× Zero kg N/ha	.029	.022	.016	.0108	.0057	.00132	-.00254	-.00582
Clover × 50 kg N/ha	.0249	.0176	.0108	.00466	-.00093	-.0059	-.01038	-.0142
Clover × 100 kg N/ha	.0344	.027	.021	.0158	.0107	.0063	.002458	-.000827
Clover × 150 kg N/ha	.344	.0276	.021	.015	.0107	.006329	.00245	-.000827

Leaf area index

Leaf area index increased during plant growth with increasing nitrogen fertilizer and reached to a maximum level at 257 days after planting. From 258 days after sowing till harvest time, leaf area index decreased due to increasing aging of leaves, shading and competition between plants for light and other resources. Photosynthetic efficiency and growth in the crop plants are strongly related to the effect of canopy architecture on the vertical distribution of light within the canopy [25]. Increasing leaf area index is one of the ways of increasing the capture of solar radiation within the canopy and production of dry matter. Hence, the efficiency of the conversion of intercepted solar radiation in to dry matter decreases with decreasing of leaf area index. In the present study, trend of variances leaf area index in treatment compounds of canola cultivars× various levels of nitrogen fertilizer was according to crop growth rate. These results are in agreement with trend of variances total dry matter.Similar results have also been reported by Shulka et al [12].

Table 7-Effects of various levels of nitrogen fertilizer on variances trend of leaf area index (LAI)

Treatment compounds \ Days after planting	0-215	216-229	230-243	244-257	258-271	272-285	286-299	300-313
Opera × Zero kg N/ha	.071	1.07	1.36	1.91	1.64	1.33	.86	.263
Opera × 50 kg N/ha	.082	1.25	1.806	2.304	1.974	1.745	1.031	.403
Opera × 100 kg N/ha	.089	1.28	2.056	2.56	2.25	1.904	1.229	.539
Opera × 150 kg N/ha	.0966	1.32	2.511	2.97	2.606	2.21	1.472	.662
Okape×Zero kg N /ha	.0714	.936	1.37	1.75	1.43	1.141	.774	.2109
Okape × 50 kg N/ha	.0829	1.081	1.708	2.0203	1.655	1.39	.89	.289
Okape × 100 kg N/ha	.0895	1.131	1.904	2.2015	1.86	1.53	1.041	.3916
Okape × 150 kg N/ha	.0966	1.22	2.056	2.377	2.01	1.65	1.095	.422
Clover× Zero kg N/ha	.082	1.077	1.22	1.9	1.7	1.4	.87	.3
Clover × 50 kg N/ha	.0936	1.25	1.6	2.2	1.96	1.8	1	.45
Clover × 100 kg N/ha	.104	1.28	1.8	2.42	2.2	1.9	1.2	.58
Clover ×150 kg N/ha	.104	1.32	2.2	2.67	2.4	2.1	1.4	.7

Conclusion

In this experiment, nitrogen fertilizer showed significant effects on canola cultivars yield, yield components and physiological indices of canola such as total dry matter, crop growth rate, relative growth rate and leaf area index. The highest grain yield and physiological indices of canola recorded at 75kg S ha^{-1} application. In conclusion, it can be suggested that opera cultivar should be applied to 75kg S ha^{-1} in conditions of Ardabil Plain.

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