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Effect of Nitrogen Rates and Plant Density on the Agronomic Traits of Canola (*Brassica napus* L.) in Paddy Field

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Abstract: In order to investigate the effect of nitrogen rate and plant density on agronomic characteristics and yield of canola an experiment was carried out at the Iran Rice Research Institute in 2006 to 2007. The experiment was laid out as a split plot, Randomized Block Design with three replications. Main factor was nitrogen in four levels (0, 46, 92 and 138 kg N m^{-2}) and sub factor was plant density in three levels (65, 85 and 95 plant m^{-2}). Results showed that nitrogen had significant effect on plant height, minor stem number, stem diameter, pod length, grain number per pod, biologic yield and grain yield. The most and least grain yield were produced in 138 and 0 kg N ha^{-1} treatments, respectively. Plant density had significant effect on minor stem number, stem diameter, pod number per plant, pod length and grain yield. The most grain yield were produced in 80 plant m^{-2} plant density. According to results apply 138 kg N ha^{-1} and 80 plant m^{-2} plant density for the best plant attributes were recommended.

Key words: Canola, nitrogen, population, yield

INTRODUCTION

The canola plant has indeterminate growth characteristic. Generally, canola requires more nitrogen compared to the other essential plant nutrients. Canola assimilates nitrogen in NO_3^- form. Noorullah Khan and Amunaullah Jan (2002) showed that maximum pod number per plant were produced with use of 120 kg N ha^{-1}. Ali *et al*. (1990) reported that with increase in nitrogen fertilizer, pod number would be increased. Holmes (1980) indicated that nitrogen had significant effect on pod number which has a strong role in increasing grain yield. Some experiments showed that the most biologic yield and straw yield were produced with increase in use of nitrogen fertilizer (Leng *et al*., 1997). Radenovich (1987) showed that the highest grain yield was produced by applying of 210 kg N ha^{-1}. Lewis and Knight (1986) reported that in order to obtain maximum canola yield, nitrogen fertilizer in the range of 193 to 209 kg ha^{-1} was necessary. Patel and Mieishern (1996) indicated that applying nitrogen fertilizer up to 120 kg ha^{-1} would increase canola yield. Increase in nitrogen fertilizer would increase canola yield (Karpen and Schultz, 1998). Canola has good stem ability and in low density can compensate low plant density with increase in minor stem. Canola stem height would increase with increase in planting density. Leng *et al*. (1997) indicated that with increase in nitrogen amount the stem biomass would increase. Mhali and Ullah (1989) suggested that with decrease in planting space and use of nitrogen fertilizer the plant height would increase. Chid *et al*. (1998) indicated that with increase in planting density in canola, the plant competition would increase and stem diameter would decrease. Canola in low plant density had low yield because of low plant population (Menham and Scott, 1981). Ali and Zaman (1999) indicated that in plant density (10, 40, 70 and 100 plant m^{-2}), the most straw yield were produced in 70 plant m^{-2} plant density. Heikkinen and Auld (1991) recommended that in planting density of 40 plant m^{-2} would achieve high yield. Wielebski and Wojtowiccz (1998) showed that 70 to 60 plant m^{-2} planting density had the most grain yield. Ali and Zaman (1999) suggested that between 10, 40, 70 and 100 plant m^{-2}, the maximum harvest index was related to 70 plant m^{-2} plant density.

MATERIALS AND METHODS

In order to investigating the effect of nitrogen and plant density on the agronomic characteristic and yield of

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canola, an experiment was carried out at the Iran Rice Research Institute in 2006 to 2007. The experiment was arranged as a split plot in Randomized Complete Blocks with three replications. Main factor was nitrogen at four levels (0, 46, 92 and 138 kg N ha^{-1}). Sub factor was plant density at three levels (65, 80 and 95 plant m^{-2}). Canola variety Hayola 401 was used in this experiment. 5 kg P, 5 kg K and 2.5 kg S were used in each plots. The plot size was 250 m^2 Standards cultural practices like irrigation and weeding were carried out until the crop was mature. For measure of yield component, six samples were selected and plant height, minor stems number, stem diameter, pod number per plant and pod length were measured at physiological maturity stage. Grain yield was determined from harvest area of five m^2. All statistical tests were done using the Statistical Analysis System package (SAS, 1996) and mean values were compared by Duncan Multiple Rang Test.

RESULTS AND DISCUSSION

Plant height: Nitrogen application had significant effect on plant height at p = 0.01 probability level (Table 1). Plant density had significant effect on plant height and interaction effect of nitrogen and density had significant effect on plant height at p = 0.01 probability level (Table 1). Mean comparison of simple effect showed that with different nitrogen amounts, the tallest plant height (105.4 cm) were produced with application of 138 kg N ha^{-1}. Among different planting spaces the tallest plant height (95.6 cm) was produced in 65 plants m^{-2} planting density (Table 2). Interaction effect of nitrogen and density showed that the tallest plant height (110.9 cm) was obtained with 138 kg N ha^{-1} in 65 plants m^{-2} planting density. At the same time, the shortest plant height (77 cm) was produced in the 0 kg N ha^{-1} plot with 95 plants m^{-2} (Table 3). Qayyum and Kakai (1999) obtained almost the similar results. They reported that with increase in use of nitrogen plant height increased. Yousaf and Ahmad (2002) suggested that the maximum plant height would be obtained in maximum plant density.

Branch number: Results showed that nitrogen amount and density had significant effect on branch number at p = 0.01 probability level (Table 1). Interaction effect of nitrogen and density had significant effect on branch number at p = 0.05. Mean comparison of morphological characteristics showed that with different nitrogen rates, the highest count of branch number (3) were produced with 138 kg N ha^{-1} application. Also in different planting density the most (4.7) and least (2.4) branch number were obtained in 65 and 95 plant m^{-2}, respectively (Table 2). Interaction effect of nitrogen and density showed that the most branch number (3.5) were produced in 138 kg N ha^{-1} in case of 65 plant density and the least branch number (1.1) were obtained with 0 kg N ha^{-1} and 95 plant m^{-2} plant density (Table 3). Patll *et al*. (1996) suggested that increased N application would increase the branch number would be increased. Because of nitrogen role to stimulate vegetative organs.

Stem diameter: Results showed that main stem diameter was influenced significantly by nitrogen rate and density at %1 probability level (Table 1). Mean comparison of morphological characteristics showed that in different rate of nitrogen the most (6.8 cm) and least stem diameter (4.8 cm) were obtained in 138 and 0 kg N ha^{-1}, respectively (Table 2). Interaction effect of nitrogen and density showed that the most stem diameter (7.5 cm) were produced in 138 kg N ha^{-1} in case of 65 plants m^{-2} planting density also the least stem diameter (3.8 cm) was obtained in not use of nitrogen in case of 95 plants m^{-2} planting density (Table 3). Chid *et al*. (1998) indicated with increase in plant density the stem diameter would decrease.

Pod number per plant: Results showed that nitrogen rate, density and interaction of nitrogen and density had significant effect on pod number per plant at p = 0.01 (Table 1). Mean comparison of morphological characteristics showed that with different nitrogen rate the most pod number per plant (89.2) were produced in 138 kg N ha^{-1} and in different planting density the most

Table 1: Mean squares of canola morphological characteristics under different treatments

SOV	Planting height	Branch (No.)	Stem diameter (cm)	Pod per plant (No.)	Pod length in minor stem	Biological yield	Grain yield
Rep	21.04^{ns}	0.036^{ns}	0.020^{ns}	39.290^{ns}	0.290^{ns}	1793233.30^{ns}	40732.90^{ns}
Nitrogen	1068.49**	3.73**	0.060**	7469.470**	039.000**	9029386.03**	11088506.60**
Error	37.21	0.23	0.003	118.860	0.020	9240459.50	33567.90
Density	192.38**	1.46**	0.070**	1266.770**	0.047^{ns}	179672.11^{ns}	2180413.70**
Nitrogen density	41.29**	0.16*	0.001^{ns}	313.270**	0.140*	2716034.90**	76297.67 **
Total	6.57	0.06	0.001	44.040	0.053	478913.59	7895.72
CV	2.81	10.60	5.970	10.900	3.940	8.34	3.18

*, **, ^{ns}: significant at 5% and 1% probability levels and non-significant, respectively

Table 2: Mean comparison of canola agronomical characteristics in different treatments

Treatments ($kg\ ha^{-1}$)		Plant height (cm)	Branch (No.)	Stem diameter (cm)	Pod per plant (No.)	Pod length in minor stem	Biological yield ($kg\ ha^{-1}$)	Grain yield ($kg\ ha^{-1}$)
Nitrogen	9	80.0^{c}	1.6^{c}	4.8^{c}	25.7^{c}	5.6^{c}	4945^{b}	1553^{d}
	46	86.0^{c}	2.1^{b}	5.1^{c}	49.6^{b}	5.7^{bc}	6314^{b}	2262^{c}
	92	93.4^{b}	2.7^{a}	5.8^{b}	79.0^{a}	5.9^{b}	10380^{a}	3304^{b}
	138	105.4^{a}	3.0^{a}	6.8^{a}	89.2^{a}	6.1^{a}	11550^{a}	4065^{a}
Density	95	87.7^{c}	4.7^{c}	4.7^{c}	50.3^{c}	5.7^{a}	8361^{a}	2317^{c}
	80	90.3^{b}	2.4^{b}	5.7^{b}	61.6^{b}	5.8^{a}	8375^{a}	3134^{a}
	65	95.6^{a}	2.7^{a}	6.3^{a}	70.8^{a}	5.9^{a}	8157^{a}	2936^{b}

Mean with similar letter(s) in each column are not significantly different at the 0.05 probability level to DMRT

Table 3: Mean comparison of interaction effect of canola agronomical characteristics in different treatments

Treatments	Density	Plant height (cm)	Branch (No.)	Stem diameter (cm)	Pod per plant (No.)	Pod length in minor stem	Biological yield ($kg\ ha^{-1}$)	Grain yield ($kg\ ha^{-1}$)
0	95	77.0^{f}	1.1^{e}	3.8^{h}	18.4^{f}	5.3^{c}	4699^{e}	1191^{i}
	80	81.3^{ef}	1.8^{d}	5.0^{efg}	28.0^{ef}	5.5^{bc}	4947^{e}	1884^{g}
	65	81.9^{de}	1.9^{cd}	5.5^{cde}	30.9^{e}	5.9^{ab}	5191^{e}	1586^{h}
46	95	85.0^{de}	1.9^{cd}	4.5^{g}	35.4^{e}	5.9^{ab}	6710^{d}	1914^{g}
	80	86.7^{cd}	2.2^{bcd}	5.2^{ef}	51.6^{d}	5.7^{abc}	6637^{d}	2484^{ef}
	65	86.5^{cd}	2.3^{bc}	5.7^{cd}	61.7^{d}	5.5^{bc}	5596^{de}	2388^{f}
92	95	86.7^{cd}	2.4^{b}	4.7^{fg}	58.4^{d}	5.7^{abc}	9325^{c}	2572^{e}
	80	90.3^{c}	3.1^{a}	6.0^{c}	85.9^{d}	5.8^{ab}	11420^{ab}	3761^{c}
	65	103.2^{b}	3.2^{a}	6.7^{b}	92.6^{ab}	6.0^{a}	10390^{bc}	3579^{d}
138	95	102.3^{b}	2.6^{b}	6.0c	75.8^{c}	6.0^{a}	12710^{a}	3592^{d}
	80	103.1^{b}	2.4^{b}	6.6^{b}	87.7^{b}	6.0^{a}	10500^{bc}	4410^{a}
	65	110.9^{a}	3.5^{a}	7.5^{a}	104.0^{a}	6.1^{a}	11450^{ab}	4192^{b}

Mean with similar letter(s) in each column are not significantly different at the 0.05 probability level to DMRT

pod number were obtained (70.8) in 65 plant m^{-2} plant density (Table 2). Interaction of nitrogen and density showed that the most pod per plant (104.0) were obtained in 138 kg N ha^{-1} in case of 65 planting density also the least pod per plant (18.4) was obtained with 0 kg N ha^{-1} in case of 95 plant per m^2 plant density (Table 3). Ali *et al.* (1990) got almost similar results. They showed that pod number per plant would be increased with increases in nitrogen application.

Pod length in minor stem: Results showed nitrogen rate and interaction of nitrogen and density had significant effect on pod length in minor stems at $p = 0.01$ and $p = 0.05$, respectively (Table 1). Mean comparison results showed that the most pod length (6.1 cm) per minor stem in different nitrogen rate were produced in 138 kg N ha^{-1} and the least pod length in minor stem (5.6 cm) were obtained in not apply of nitrogen. In different planting density the most pod length (5.9 cm) was produced in 65 plant m^{-2} plant density (Table 2). Interaction effect of nitrogen and density on pod length in minor stem showed that the most pod length (6.1 cm) was produced in 138 kg N ha^{-1} in case of 65 plants m^{-2} planting density and the least pod length (5.3 cm) was produced in not use of nitrogen application in case of 95 plant per m^2 plant density (Table 3).

Biological yield: Results showed that nitrogen amount and interaction of nitrogen and density had significant effect on biological yield at 1% probability level (Table 1). Mean comparison results showed that the most biological yield (11550) and the least biologic yield (4945) were produce in 138 kg N ha^{-1} and not use of nitrogen applied, respectively (Table 2). Interaction effect of nitrogen and density showed the most biologic yield (11450 kg ha^{-1}) was produced in 138 kg N ha^{-1} in case of 65 plant m^{-2}planting density. The least biologic yield (4699 kg ha^{-1}) were produced in 0 kg N ha^{-1} application in case of 95 plant m^{-2} planting density (Table 3).

Grain yield: Results showed that nitrogen rate, density and interaction of nitrogen and density had significant effect on grain yield at %1 probability level (Table 1). Mean comparison of morphological characteristics showed that the most (4065 kg ha^{-1}) and least grain yield (1553 kg ha^{-1}) were produced in 138 and not used of nitrogen, respectively. The most grain yield (3134) in different plant density and the least grain yield (2317) were produced in 80 and 95 plant m^{-2} planting density, respectively (Table 2). Interaction effect of nitrogen and plant density results showed that the most grain yield (4410 kg ha^{-1}) was produced in 138 kg N ha^{-1} in case of 80 plants m^{-2}plant density. And the least grain yield (1191 kg ha^{-1}) was obtained in not use of nitrogen in case of 95 plant m^{-2} plant density. Ali *et al.* (1990) showed that use of nitrogen could increase canola grain yield. Yousaf and Ahmad (2002) indicated that in 80 plant m^{-2} planting density the most canola yield would be obtained.

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