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# Effects of Plant Density and Nitrogen Rates on the Competitive Ability of Canola (*Brassica napus* L.) against Weeds

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## ABSTRACT

**To study the effects of plant density and nitrogen rates on the ability of canola (Regent × Cobra; an inbred variety) to compete with weeds, an experiment was conducted as a factorial complete block design with four replications. The treatments included four levels of plant density at 150, 190, 230, and 270 plants m$^{-2}$, and four levels of nitrogen (N) fertilizer at 0, 46, 92, and 138 kg ha$^{-1}$. Results indicated that different levels of plant density and N fertilizer had significant effects on the canola's leaf area index (LAI) and dry matter accumulation, as well as on the weed's dry matter at three stages of plant growth (rosette, stem elongation, and 50% flowering). The addition of N fertilizer resulted in increasing plant LAI and decreasing weed dry matter. Densities of 150 and 270 plants m$^{-2}$, along with 138 kg ha$^{-1}$ nitrogen showed the highest LAI at the rosette and stem elongation stages. The LAI at different plant growth stages was an important factor in enhancing canola's competitiveness with weeds. There were significant differences between different plant density and N fertilizer levels for traits such as plant height, pod bearing stem length, biomass and seed yield. An increase in plant density significantly decreased the pod bearing stem length and total pod numbers per plant (i.e. pod numbers in main branches and sub-branches), but increased plant height. The highest seed yield was obtained with 190 plants m$^{-2}$ along with 138 kg N ha$^{-1}$. This study revealed that optimum plant density as well as N fertilizer may increase the competitive ability of canola against weeds.**

**Key words**: Canola, Cultural weed control, LAI, Nitrogen rate, Plant density.



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## INTRODUCTION

Since 1996 the production of oilseed crops such as soybean, canola, sunflower, safflower, sesame and cottonseed has increased in Iran. However, the growing conditions suggest that only a limited amount of canola can be produced due to certain constraints including the need for improved sowing seeds, optimum stands, proper seeding dates, weed and fertilizer management and proper harvesting machinery. Among these constraints, weeds are one of the important factors in limiting canola production in many countries. Weeds have a direct effect on seed yield and the quality of seed oil. The other factor is the quality of crop stands that can affect seedling establishment, canopy development and total dry matter accumulation during the canola growing season. Crop stands can also affect the weed population and its growth.

Weed competition with canola has reduced crop growth, leaf area and subsequently increased infertile flowers and pods (Tomass, 1992). Moreover, weed competition and crop loss in winter-sown canola will be more severe as compared with the spring-sown variety. Therefore, weed control at initial growth stages is indispensable for gaining a higher seed yield of canola (Blackshaw *et al.*, 2002). The most notorious weed species in winter-sown canola include wild mustard (*Brassica kaber*), foxtail (*Setaria media*),

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bedstraw (*Galium tricornutum*) and lamb-squarters (*Chenopodium album*) (Tomass, 1992). In an experiment Esser *et al*. (1999) examined the weed competition effects on canola and showed that white mustard (*Brassica hirta*) had the greatest affect in all treatments. Similarly, the competitive ability of weeds on canola was measured by weed biomass. Davis *et al*. (1999) studied the effect of weed seeds of the Brassica family, including wild mustard (*Brassica kaber*), black mustard (*Brassica nigra*), birdrape mustard (*Brassica rapa*), shepherd's purse (*Capsulla bursa – pastoris*), flix weed (*Descurainia sophia*), thumble mustard (*Sisymbrium altissimum*) and fieldpenny cress (*Thlaspi arvensis*), on the quality of canola oil and seed cake. They concluded that the presence of two percent weed seeds in canola seed would considerably reduce the quality of oil and seed cake.

Fathi *et al*. (2002) reported that increasing nitrogen fertilizer and plant density caused a boost in seed yield in canola and the highest yield per hectare resulted from 225 kg N ha$^{-1}$ and a plant density of 90 plants per square meter. Salehian *et al*. (2002) showed that plant density significantly affected the number of pods, secondary branches and seeds per plant. The maximum and minimum number of pods and seeds per plant were obtained at 110 and 50 plants m$^{-2}$, respectively. However, the maximum and minimum number of secondary branches were achieved at 50 and 110 plants m$^{-2}$. Leach *et al*. (1998) stated that increasing the plant population to 110 plants m$^{-2}$ decreased the number of pods and branches significantly. Prasad and Shakla (1991) concluded that canola seed yield was affected by the interaction between plant density and nitrogen fertilizer, whereby the optimal seed yield could be achieved by increasing plant density and nitrogen levels.

The aim of this study was to study the effects of plant population density and N fertilizer rates on the ability of canola to compete with weeds.

## MATERIALS AND METHODS

The experiment was conducted at Karaj, Iran (Lat. 35°48′N; Long. 50°57′E; Alt. 1313m). Climatically, the area is in the semi–arid temperate zone with a cool winter and hot summer. Average rainfall is about 243 mm, mostly falling between November to February. The soil was loam with 0.05% total nitrogen, 7.4 and 180 ppm available phosphorus (P) and potassium (K), respectively. Soil samples were taken for analysis before land preparation and were fertilized on the basis of a soil test recommendation with the basal dose of P (70 kg ha$^{-1}$ $P_2O_5$) and K (75 kg ha$^{-1}$ $K_2O$).

Plant density treatments comprised of 150 ($d_1$), 190 ($d_2$), 230($d_3$) and 270($d_4$) plants m$^{-2}$ and these were maintained by using the seed rates of 6, 8, 10 and 12 kg ha$^{-1}$, respectively. Nitrogen fertilizer that included zero ($n_0$), 46 ($n_1$), 92 ($n_2$) and 138 ($n_3$) kg N ha$^{-1}$ was applied in the form of urea (46%N) in three splits at planting, stem elongation and flowering stages. The type of design was based on a randomized complete block in a factorial arrangement with four replications per treatment. Sowing was performed on 29 September 2001 and the harvesting date was 14 June 2002. The size of plots were 5m × 3m with row spacings of 60 cm apart, separated by two fallow ridges as a border on each side to avoid nutrient leakage. A regent × cobra inbred variety was used in this experiment.

After land leveling and furrow preparation, the plots were irrigated using the furrow irrigation method (with a siphon) and subsequent irrigation was applied every 10 days before the rosette appeared in autumn and every 7-8 days during spring. No insect pests and diseases were observed during the growing season. The data were collected separately for plants and weeds. Traits such as plant height (cm), pods per plant and seeds per pod measured by selecting 10 plants at random in a given plot. A 3.0 m long a harvest sample was taken from the two middle rows for measuring total dry matter, seed yield and other yield attributes. To measure leaf area (LAI) and total above-ground dry matter (DM), plant samples were taken from the two center rows of each plot by a quad rate of 0.25 m at three growth stages (rosette, stem elongation and flowering). Similarly, for weed count, identification and dry matter accumulation samples were taken at these plant stages. Analysis of variance was performed using the MSTAT-C computer software package. The main effects and interactions were tested using the Duncan's multiple range tests.

## RESULTS AND DISCUSSION

The analysis of variance for canola seed yield and other traits (Table 1) at different levels of plant density and nitrogen rates indicated that these two agronomic factors could enhance canola yield and yield attributes significantly (except oil percentage). The interaction effects of plant density and nitrogen were also significant except for pods per plant and oil percentage (Table 1).

Similarly, increased plant density and nitrogen levels rendered a significant increase in DM accumulation and the LAI of canola at three growth stages (Table 2). The highest DM accumulation at rosette stage (Figure 1) was recorded at a density of 270 plants m$^{-2}$ for 92 kg N ha$^{-1}$ ($d_4n_2$) with 343.4 g m$^{-2}$. This trend was generally observed for stem elongation and the 50% flowering stages (Figures 2 and 3). The lower densities of 150 ($d_1$) and 190 ($d_2$) plants m$^{-2}$ with no nitrogen application (i.e. $d_1n_0$ and $d_2n_0$) had the lowest DM accumulations at these growth stages. The increased DM accumulation in canola given the addition of plant density and nitrogen levels has resulted from rapid canopy development, especially during the stem elongation (vegetative growth) stage. The LAI at this stage as compared to the 50% flowering stage was greater at higher plant density and nitrogen levels (Figure 5), which might be due to a closer canopy, more light intercept prevention and low leaf senescence at higher plant densities. The treatment combination of 150 plants m$^{-2}$ along with no nitrogen ($d_1n_0$) produced the lowest LAI at all growth stages, whereas the addition of plant density ($d_3$ and $d_4$) and nitrogen levels ($n_2$ and $n_3$) led to a higher LAI. The increased LAI in $d_1n_3$ at the rosette (Figure 4) and 50% flowering stages (Figure 6) possibly resulted from the nitrogen level ($n_3$) whereas, under the $d_4n_3$ treatment, the increased LAI at all these growth stages could be due to higher plant densities ($d_4$) (Figures 4, 5 and 6). Cheema *et al*. (2001) reported that increasing the application of N from 90 to 120 kg ha$^{-1}$ resulted in a higher LAI compared to the control with no fertilizer and lower levels of nitrogen. Salehian *et al*. (2002) showed that the highest plant density (i.e. 110 plants m$^{-2}$) produced the highest DM and LAI. Linqisted and Mortensen (1998) measured the LAI and photosynthetic photon flux density (PPFD) in two old and two new corn hybrids and reviewed the suppression ability of these hybrids on velvetleaf (*Abutilon theophrasti*). The hybrids that produced a higher PPFD had good suppression effects on velvetleaf growth and development. Therefore, they suggested that optimum LAI and PPFD could be utilized in integrated weed management programs.

Analysis of the variance of weed dry weight (g m$^{-2}$) at different canola growth stages (Table 1) revealed significant ($p \leq 0.01$) effects of plant density and nitrogen fertilizer. The most effective treatments at these crop stages caused reduction in weed dry weight ($p \leq 0.01$) due to increase in plant density and addition of nitrogen fertilizer. This reduction in weed dry weight could be from the increased competitive ability of canola plants, due to more and rapid canopy development, such that a density of 270 plants m$^{-2}$ and the application of 138 kg N ha$^{-1}$ ($d_4n_3$) rendered the lowest weed dry weight and the treatment of 150 plants m$^{-2}$ with no nitrogen fertilizer ($d_1n_0$) resulted in the highest weed dry weight accumulations (Figures 7-9). Donovan (1994) reported that a canola density of 300 plants m$^{-2}$ significantly reduced the adverse weed effects on yield, and further decreased weed





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**Table 1.** Analysis of variances showing the effects of plant density and nitrogen treatments on canola traits and weed dry matter accumulation at three plant growth stages.

| | | Mean square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Plant height | Pods per plant | 1000 seed weight | Seed yield | Oil percentage | weed dry matter accumulation at different plant growth stages | | |
| S. O. V | d. f. | | | | | | Rosette | Stem elongation | 50% flowering |
| Replication | 3 | 6.17 $^{ns}$ | 359.7 $^{ns}$ | 0.004 $^{ns}$ | 27790.7 $^{ns}$ | 2.7 $^{ns}$ | 0.001$^{ns}$ | 0.001 $^{ns}$ | 0.004 $^{ns}$ |
| Plant density (D) | 3 | 517.4 $^{**}$ | 11200.7 $^{**}$ | 0.156 $^{**}$ | 433316.0 $^{**}$ | 3.6 $^{ns}$ | 0.009$^{**}$ | 0.078$^{**}$ | 0.234$^{**}$ |
| Nitrogen rate (N) | 3 | 806.5 $^{**}$ | 592.7 $^{*}$ | 0.211 ** | 716825.2 $^{**}$ | 5.5 $^{ns}$ | 0.006$^{**}$ | 0.007$^{**}$ | 0.026$^{**}$ |
| Interaction (D*N) | 9 | 268.3 $^{**}$ | 310.9 $^{ns}$ | 0.051 $^{**}$ | 205970.1 $^{**}$ | 5.0 $^{ns}$ | 0.002$^{**}$ | 0.002$^{**}$ | 0.006 $^{ns}$ |
| Errors | 45 | 7.5 | 174.9 | 0.009 | 26160.8 | 2.8 | 0.001 | 0.001 | 0.003 |
| Mean | | 173.7 | 179.4 | 22.2 | 3109.3 | 45.1 | 0.164 | 0.221 | 0.423 |
| C.V. % | | 106 | 7.3 | 2.3 | 5.2 | 3.7 | 70.8 | 68.0 | 74.0 |
| S.E. | | 2.74 | 13.22 | 0.045 | 161.74 | 1.67 | 0.032 | 0.032 | 0.055 |

Ns, * and ** are non – significant and significant at %5 and %1 percent level, respectively.

**Table 2.** Analysis of variances indicating the effects of plant density and nitrogen treatments on canola leaf area index and total dry matter (g $m^{-2}$) at three growth stages.

| | | Mean square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Rosette stage | | Stem elongation stage | | 50% Flowering stage | |
| S.O.V. | d. f. | LAI | D.M. | LAI | D.M. | LAI | D.M. |
| Replication | 3 | 0.02 $^{ns}$ | 4.26 $^{ns}$ | 0.02 $^{ns}$ | 8. 95 $^{ns}$ | 0.02 $^{ns}$ | 26.44 $^{ns}$ |
| Plant density (D) | 3 | 2.25 $^{**}$ | 55.48 $^{**}$ | 7.09 $^{**}$ | 497.57 $^{**}$ | 3.58 $^{**}$ | 1499.83 $^{**}$ |
| Nitrogen rate (N) | 3 | 1.62 $^{**}$ | 35.81 $^{**}$ | 1.48 $^{**}$ | 43.71 $^{**}$ | 1.71 $^{**}$ | 163.60 $^{**}$ |
| Interaction (D× N) | 9 | 0.43 $^{**}$ | 15.17 $^{*}$ | 0.19 $^{*}$ | 15.24 $^{**}$ | 0.64 $^{**}$ | 39.56 $^{*}$ |
| Errors | 45 | 0.03 | 4.04 | 0.07 | 5.28 | 0.05 | 20.75 |
| Mean | | 3.03 | 262.0 | 3.87 | 406.3 | 3.41 | 2349.8 |
| C. V. % | | 6.1 | 15.3 | 7.1 | 13.0 | 6.7 | 13.5 |
| S.E. | | 0.173 | 2.001 | 0.264 | 2.298 | 0.224 | 4.55 |

Ns, * and ** are non – significant and significant at %5 and %1 percent level, respectively.

DM. Figure 9 revealed that weed DM at later stages of canola growth (e.g. flowering stage) would have been higher compared with the earlier stages (Figures 7 and 8); consequently, early weed control measures taken in the field would curtail yield loss.

In this experiment, with the help of these cultural practices such as increasing plant density and nitrogen levels, the weed DM was drastically reduced. In particular, at the 50% flowering stage the weed DM reduction was two-fold with $d_4n_3$ treatment as compared to $d_1n_0$ (Figure 9).

Paolini *et al.* (1999) stated that if certain weed control methods in growing canola are not possible, then the application of N could bring about effective weed control due to rapid crop growth and enhanced canopy development. They also stated that the competitive ability of sunflower with weeds depended on the crop biomass at different growth stages. Similarly, narrow crop spacing (higher plant density) in canola could suppress weeds and their growth (Donovan, 1994). In the present experiment, the following weed species such as wild oats (*Avena fatua*), lambsquarters (*Chenopodium album*), wild mustard (*Brassica kaber*), flix weed (*Descurainia sophia*), shepherd's purse (*Capsulla bursa – pastoris*), foxtail (Se*taria media*), sowthistle (*Sonchus arvensis*), bedstraw (*Galium tricornutum*), red root amaranth (*Amaranthus retloflexus*) and running mallow (*Malva rotundifolia*) were identified in the field. Of these species the wild oats, running mallow, bedstraw and sowthistle had more density and kept their competitiveness with canola plants. At three growth stages, increasing plant density reduced the relative density of garlic mustard, running mallow and sow thistle significantly (the data are not given); however, the relative density of wild oats was not affected. The effect of nitrogen fertilizer and the interaction effects of plant density and nitrogen levels on relative density of these weeds was not significant.

The effects of treatment on canola height revealed that the combination of 270 plants $m^{-2}$ with 138 kg N $ha^{-1}$ ($d_4n_3$) resulted in the highest plant height, mainly due to plant competition and higher nitrogen levels ($p \leq 0.01$). In contrast the lowest plant density with no fertilizer ($d_1n_0$ = 150 plants $m^{-2}$ with zero N) produced the shortest plant stature (data are not presented). Norris *et al.* (2001) studied the effects of tomato spatial arrangement and population density on barnyard grass (*Echinochloa cruss-galli*) and concluded that the high shading capacity of tall tomato plants reduced the height and growth of barnyard grass. Our study also showed that the weed dry weight (Figures 8-10) was reduced due to competition and the shading effects of tall stature plants at higher density and nitrogen levels.

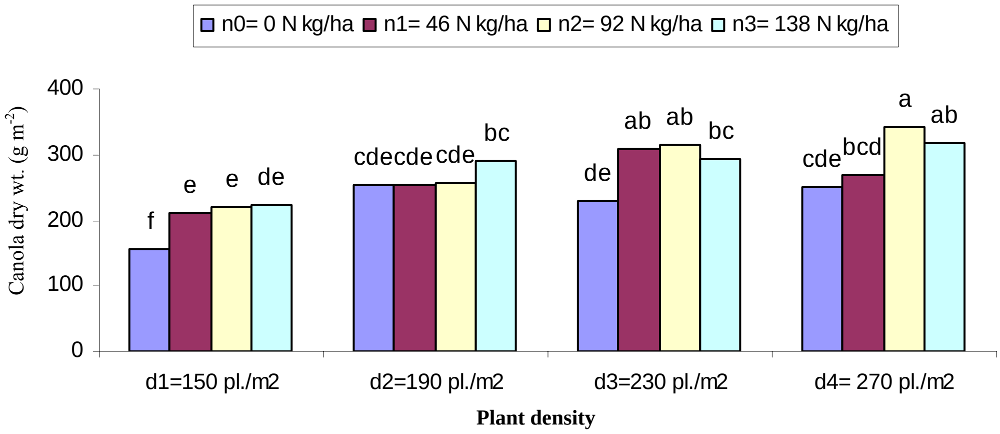


**Figure 1.** The interaction between plant density and nitrogen levels on canola dry weight at the rosette stage.

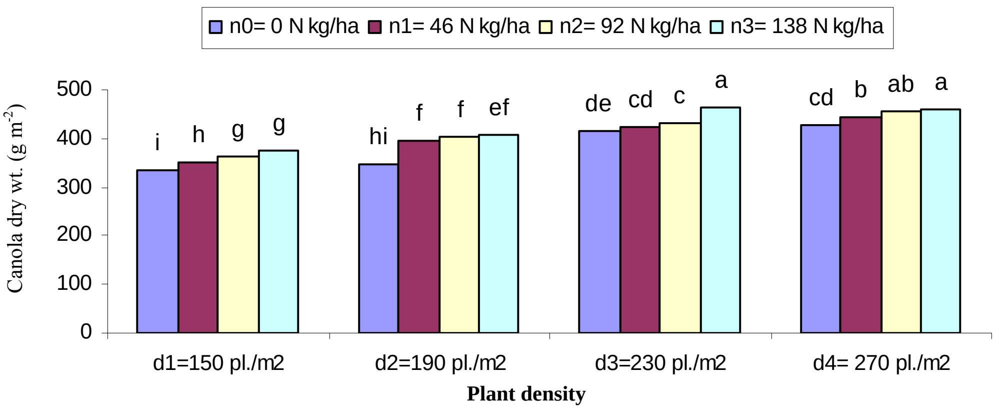


**Figure 2**. The interaction between plant density and nitrogen levels on canola dry weight at stem elongation stage.

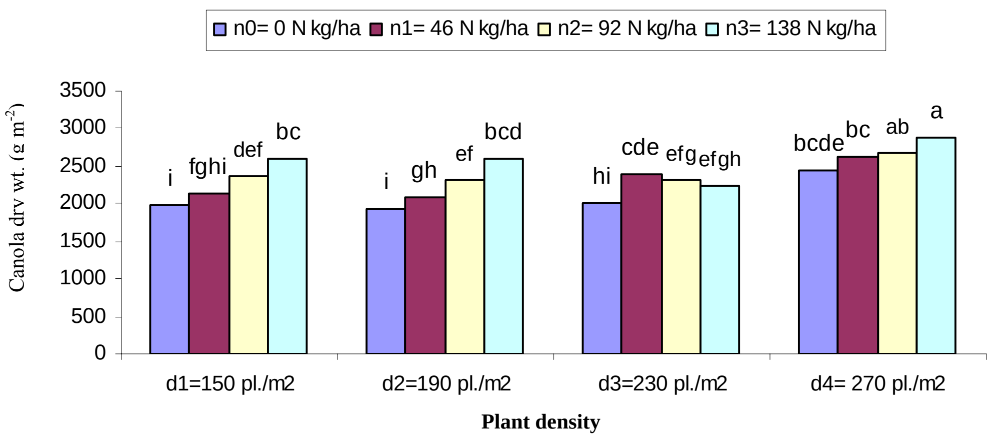


**Figure 3**. The interaction between plant density and nitrogen levels on canola dry weight at the 50% flowering stage.





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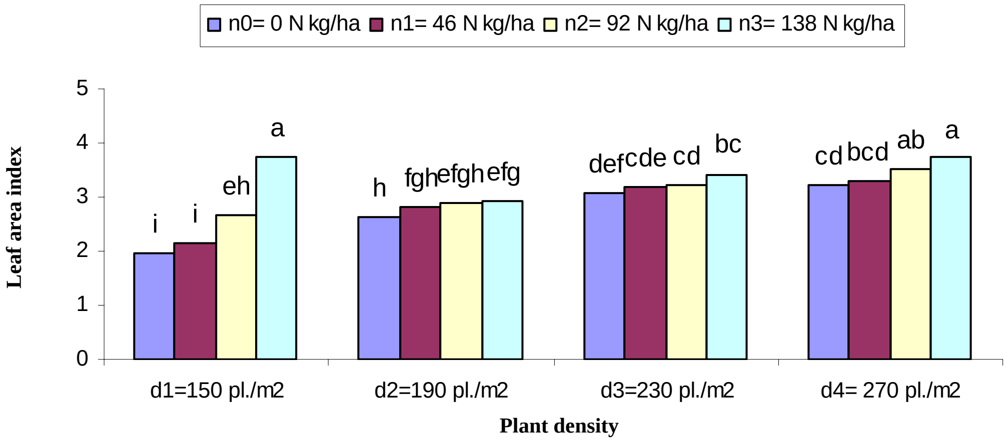


**Figure 4**. The interaction between plant density and nitrogen levels on canola left area index at the rosette stage.

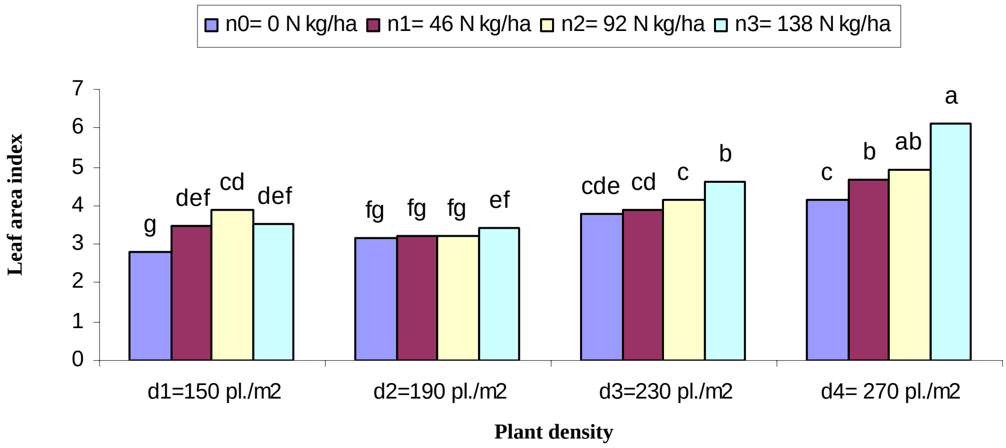


**Figure 5**. The interaction between plant density and nitrogen levels on canola leaf area index at stem elongation the stage.

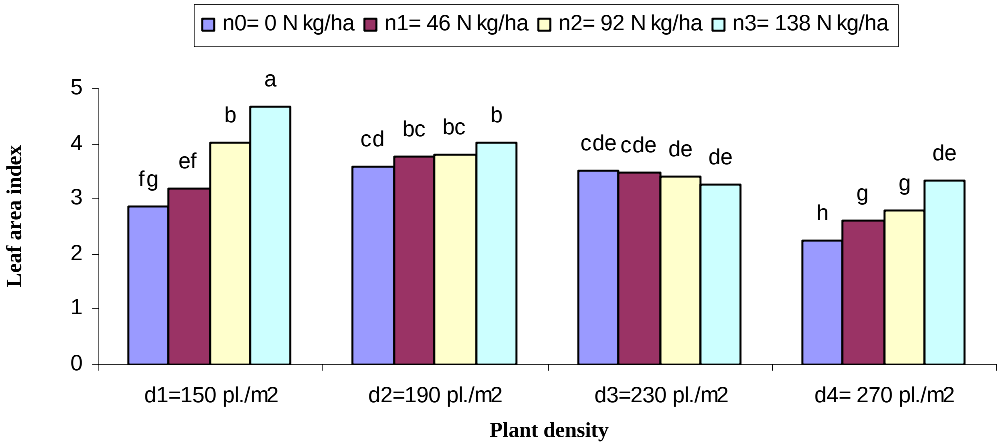


**Figure 6**. The interaction between plant density and nitrogen levels on canola leaf area index at the 50% flowering stage.





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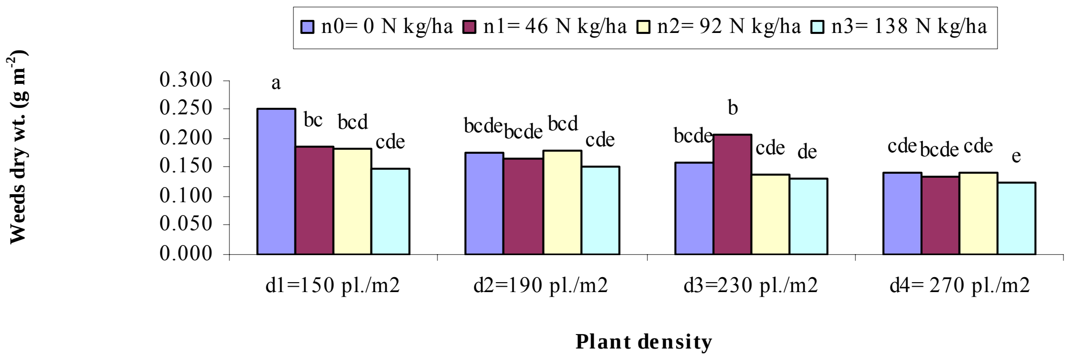


**Figure 7**. The interaction between plant density and nitrogen levels on weeds dry weight at the rosette stage.

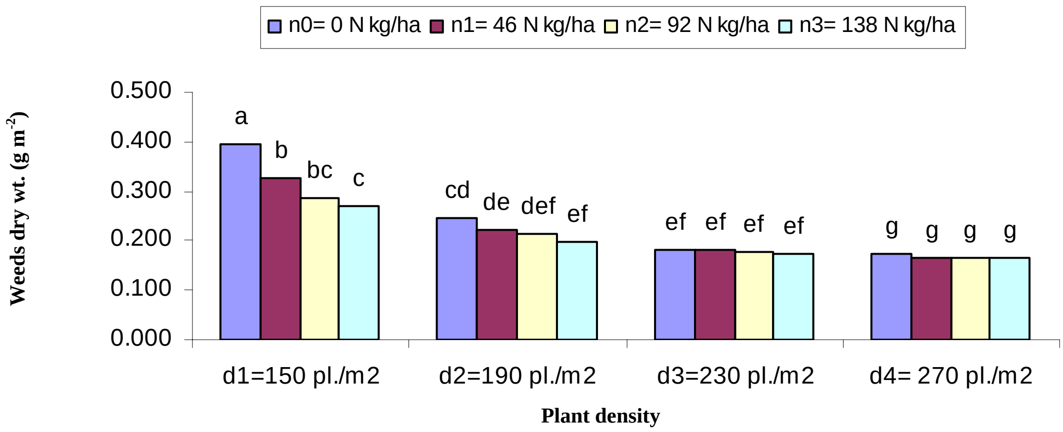


**Figure 8**. The interaction between plant density and nitrogen levels on weeds dry weight at the stem elongation stage.

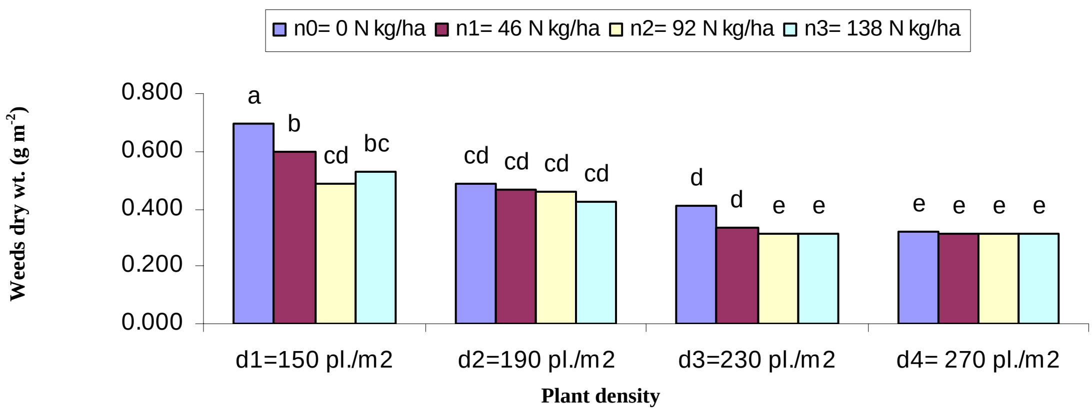


**Figure 9**. The interaction between plant density and nitrogen levels on weeds dry weight at the 50% flowering stage.

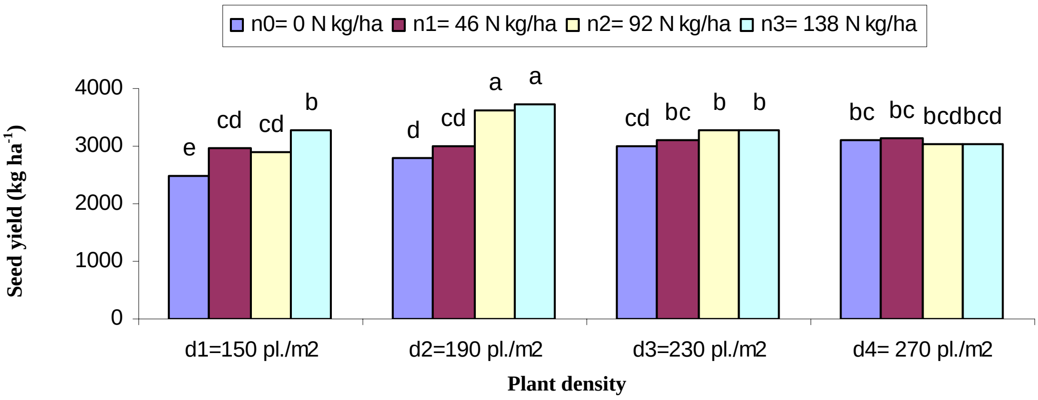


**Figure 10**. Interaction effects of plant density and nitrogen levels on canola seed yield.

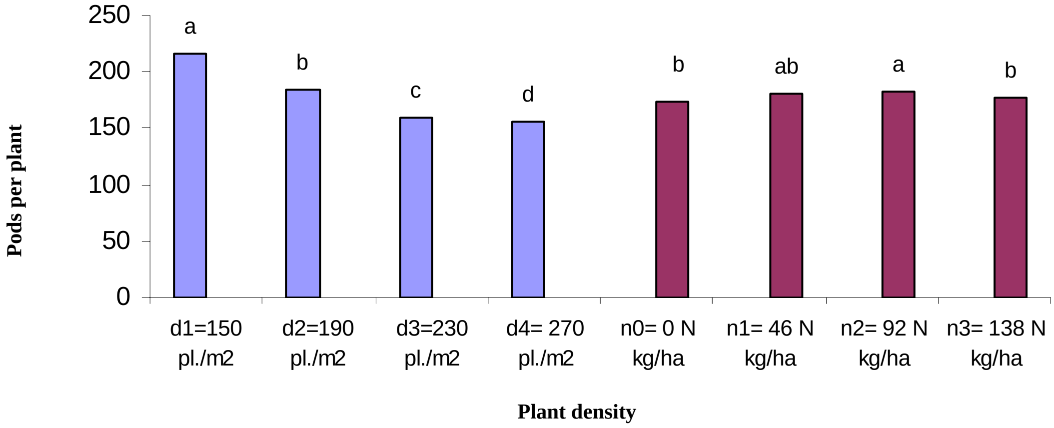


**Figure 11**. Main effects of plant density and nitrogen levels on canola pods number per plant.



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With increasing plant density along with nitrogen levels the canola seed yield increased (Figure 10), but it was maximized at $d_2n_3$ (190 plants $m^{-2}$ + 138 kg N $ha^{-1}$) and minimized at $d_1n_0$ (150 plants $m^{-2}$ + zero N). Fathi *et al.* (2002) have reported a highercanola seed yield with the addition of plant density at 90 plants $m^{-2}$ + 225 kg N $ha^{-1}$. Here, the higher seed yield was achieved (Figure 10) at 190 plants + 138 kg N $ha^{-1}$ ($d_2n_3$) and this was not significantly different with 190 plants $m^{-2}$ + 92 kg N $ha^{-1}$($d_2n_2$).

Increasing plant density reduced the number of pods per plant ($p \leq 0.01$), whereas the addition of nitrogen increased the number of pods per plant ($p \leq 0.05$) (Figure 11). Cheema *et al*. (2001) have reported that the increased canola seed yield was mainly due to increasing the number of pods per plant; in contrast to this result, here the higher densities resulted in lower pods per plant (Figure 11) but gave a higher seed yield (Figure 10). Further more, the increased canola seed yield was not correlated with pods per plant.

On the whole, the results revealed that higher plant density and the addition of nitrogen could enhance canola seed yield and its attributes; however, it seems that the canola crop is sensitive to higher plant densities. Granted that the LAI and DM increased along with increased plant density at different plant growth stages and resulted in reduced weed dry matter accumulation, yet maximum canola seed yield in this study was achieved at 190 plants $m^{-2}$.

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# اثرات تراکم بوته و کود نیتروژن بر قابلیت رقابت کلزا (*Brassica napus* L.) با علفهای هرز

**ن. مجنون حسینی, ح. م. علیزاده و ح. مالک احمدی**

## چکیده

برای مطالعه اثرات تراکم بوته و میزان نیتروژن بر قابلیت رقابت محصول کلزا (رقم ریجنت × کبرا) در کنترل علفهای هرز، آزمایشی بصورت فاکتوریل در قالب طرح بلوکهای کاملا" تصادفی در ۴ تکرار به اجرا درآمد. تیمارها شامل چهار تراکم بوته :۱۵۰، ۱۹۰، ۲۳۰ و ۲۷۰ بوته / متر مربع و چهار سطح نیتروژن : صفر، ۴۶، ۹۲ و ۱۳۸ کیلوگرم (نیتروژن خالص) در هکتار بود. نتایج نشان داد که سطوح مختلف تراکم و نیتروژن اثرات معنی داری برشاخص سطح برگ و تجمع ماده خشک کلزا، همچنین بر ماده خشک علفهای هرز طی سه مرحله رشد گیاه یعنی روزت، رشد طولی ساقه و ۵۰ درصد گلدهی داشت. افزاش نیتروژن باعث افزایش شاخص سطح برگ کلزا و کاهش ماده خشک علفهای هرز گردید. تیمارهای ۱۵۰ و ۲۷۰ بوته در متر مربع به همراه ۱۳۸ کیلوگرم نیتروژن در هکتار بیشترین شاخص سطح برگ طی مراحل روزت و رشد طولی ساقه داشتند و ثابت نمودند که شاخص سطح برگ را کلزا طی مراحل رشد و نمو بهترین عامل افزایش رقابت گیاه با علفهای هرز است. صفات ارتفاع بوته، طول ساقه غلاف دهنده، بیوماس کل و عملکرد بذر کلزا در سطوح مختلف تراکم و کود نیتروژن تفاوت معنی داری نشان دادند. افزایش تراکم بوته بطور معنی داری طول ساقه غلاف دهنده و تعداد کل غلاف در بوته را کاهش ولی ارتفاع گیاه افزایش یافت. بیشترین عملکرد بذر در تراکم ۱۹۰/۰۰۰ بوته به همراه ۱۳۸ کیلوگرم نیتروژن در هکتار حاصل گردید. نتیجه اینکه، تراکم بوته و کود نیتروژن ممکن است قابلیت رقابت کلزا در کنترل علفهای هرز مزرعه را افزایش دهد.



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