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Interrelationships among oilseed rape (*Brassica napus* L.) grain yield and weed growth under different nitrogen levels

R. Naderi[1*], H. Ghadiri[2], M. Edalat[2]

[1]Department of Agroecology, College of Agriculture and Natural Resources of Darab, Shiraz University, I. R. Iran
[2]Department of Crop Production and Plant Breeding, College of Agriculture, Shiraz University, Shiraz, I. R. Iran

* Corresponding Author: naderi@shirazu.ac.ir

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ABSTRACT- Management of nitrogen fertilization in crops is one of the most important components of integrated weed management. A two-year field experiment was conducted to determine the direct effects of wild mustard aboveground biomass and N content of wild mustard on oilseed rape yield. A set of factorial treatments was arranged in a randomized complete block design with four replications. Treatments were various wild mustard densities (0, 10, 20, 30, and 40 plant m^{-2}) and nitrogen (N) rates (0, 50, 100, 150, and 200 kg N ha^{-1}). Increased wild mustard densities from 10 wild mustard m^{-2} caused a decrease of 27% in oilseed rape N content of shoot. Increase in nitrogen fertilizer caused an increase in N content of oilseed rape shoot up to 150 kg N ha^{-1}, but no significant difference was found between 150 (0.88%) and 200 (0.89%) kg N ha^{-1}. Correlation analysis showed that there was a negative significant correlation between oilseed rape grain yield and weed biomass (r=-0.60, p≤0.05) and weed nitrogen content (r=-0.81, p≤0.01). Path analysis showed a highly negative significant direct effect (direct path: -0.88, p≤0.01) between weed biomass and oilseed rape grain yield. Correlation and path analyses indicated that the main factor which could cause oilseed rape yield loss was weed biomass and the second factor was N content in wild mustard.

INTRODUCTION

Oilseed rape (*Brassica napus* L.) is a broad leaved crop and can grow as a break crop for continuous run of cereals, and thus, can be considered as an important alternative for cereal-based agriculture systems (Kachaourians et al., 2001). It is a common oilseed crop in Iran, including Fars province, due to its oil quality and quantity.

Wild mustard is a dominant weed in several crop fields of Iran such as oilseed rape which can cause major yield losses as well as lower crop quality. Some traits such as persistent seed bank, competitive growth habit, and high fecundity all lead to its nature as a weed and make it a continuing problem (Warwick et al., 2000). Despite yield losses, it can reduce oilseed rape quality even at a low density (up to 5 plants m^{-2}) (Rose and Bell, 1982; Shires et al., 1982). Oilseed rape's seeds contaminated with those of wild mustard can increase linolenic and erucic acid of oil and glucosinolate content in the meal (McMullan et al., 1994). Wild mustard densities of 10 plants m^{-2} can reduce oilseed rape yield about 20%, however, 20 plants m^{-2} can reduce oilseed rape yield more than 36% (Warwick et al., 2000). With weed densities of 20-80 plants m^{-2}, oilseed rape yield in Canada was reduced up to 77% through interference from wild mustard, but only from 20 to 25% with lambsquarters (Blackshaw et al., 1987).

Since Nitrogen (N) is one of the most important nutrient elements to increase crops yield in the production of non-legume culture systems, its management is crucial (Bosnic and Swanton, 1997). It has been reported that weed-crop competitive interaction could be changed by N levels (Carlson and Hill, 1985; Ampong-Nyarko and de Datta, 1993; Santos et al., 1998; Dhima and Eleftherohorinos, 2001; Andreasen et al., 2006). Blackshaw and Brandt (2008) found that competitiveness of Persian darnel (*Lolium persicum*) and Rusian thistle (*Salsola* spp.) was not affected by N rate but the competitiveness of redroot pigweed (*Amaranthus retroflexus*) progressively improved as N rate increased.

There are some factors involved in weed crop interactions that ensure difficulty of evaluating relative priority of each (Mamolos and Kalbortji, 2001). A path coefficient is a standardized partial regression coefficient which measures the direct and indirect influence of predictor variables on the response variable (Mohammadi et al., 2003). However, it has rarely been used to study weed crop interaction (Mamolos and Calbortji, 2001). Therefore, the present study was conducted to investigate the use of path analysis to quantify the relative importance of factors involved in weed crop interactions.

MATERIALS AND METHODS

A two-year field experiment was carried out in 2004 and 2005 at Kooshkak Agricultural Research Station of Shiraz University (53.35°N/29.40°E), Iran. Soil type was a silty loam with 0.76 % organic matter (OC), 0.08 % N, 21.8 mg kg^{-1} phosphorus, 600 mg kg^{-1} potassium, pH of 7.85, and EC of 0.52 dS m^{-1}. Commercial oilseed rape seeds, cultivar Talayeh (Supplied by Oilseed Research Center of Fars province), were sown on 1 October, 2004 and 28 September, 2005 in 4×5 m plots using pneumatic planter at a depth of 2 cm. Each plot consisted of 9 rows spaced 40 cm apart expecting a plant density of 800, 000 plants ha^{-1}.

Proper weighted amounts of wild mustard seeds were hand broadcast to achieve the appropriate density. All plots were irrigated every other week in cool seasons and every 10 days in hot seasons. In both years, plots were kept free from pests, diseases, and other weeds (removed by hand) during the growing seasons. A factorial set of treatments were arranged in a randomized complete block with four replications. Treatments were different wild mustard densities (0, 10, 20, 30 and 40 plants m^{-2}) and N rates (0, 50, 100, 150 and 200 kg N ha^{-1}). One-half of the N fertilizer was hand-broadcasted at planting and the remainder was applied at bud stages. Triple Superphosphate was also applied at the rate of 200 kg before planting.

At crop maturity, the five middle rows from each plot were sampled to measure yield and yield components. Additionally, weeds were harvested from a 2 m^{-2} area per plot, oven-dried at 75 °C for 48 h and weighed. To determinate N content, three oilseed rape and wild mustard plants from each plot were separately sampled and oven-dried at 75 ºC for 72 h, finely grounded and analyzed for N content using micro Kjeldahl method (Maftoun et al., 2004).

Data collected during the 2 years of the study were combined and subjected to analysis of variance (ANOVA) and the means were compared (Duncan's multiple range test, p≤0.05) using SAS (Version 9.1, 2002). Correlation and path analysis were also performed using SAS.

RESULTS AND DISCUSSION

Several yield components were correlated (Fig. 1). Correlation analysis showed that an increase in grain yield was associated with an increase in the number of silique per plant (r=0.97**) and 1000-seed weight (r=0. 81**), respectively.

There were significant correlations between grain yield and N content in grain (r=0.92**), and N content in straw (r=0.86**). There were also significant positive correlations between the number of silique per plant and nitrogen content in grain (r=0.80**) and nitrogen content in straw (r=0.92**).

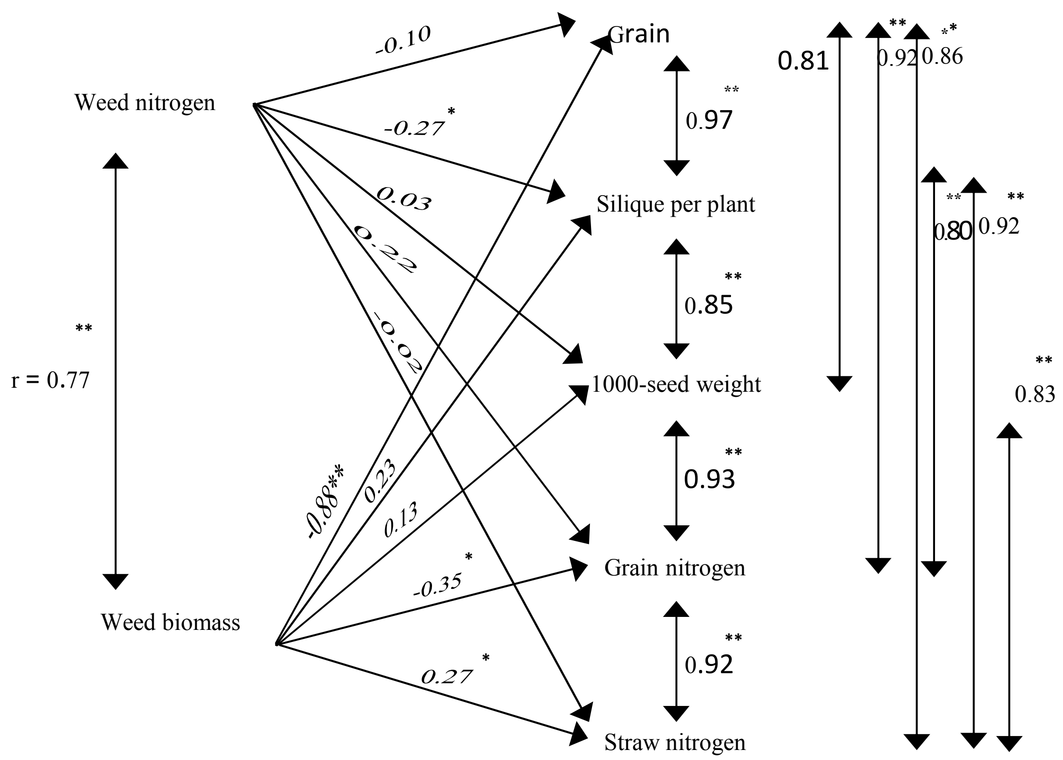

Fig. 1. Path coefficient diagram for the direct relationships of weed biomass and N content and yield and yield components of oilseed rape *One directional arrows (→) represent direct path (p) and two- directional arrow (↔) represent correlation (r)

Wild mustard aboveground biomass reduced grain yield, N content in grain and N content in straw of oilseed rape (Fig. 1). The path coefficient, direct effect, of wild mustard aboveground biomass on grain yield, N content in grain and N content in straw of oilseed rape were direct path: -0.88**, direct path: -0.35*, and direct path: -0.27*, respectively. Wild mustard N content reduced only oilseed's rape number of silique per plant (Fig. 1). The path coefficient, direct effect, of wild mustard N content on silique per plant was direct path: -0.27*. Additionally, correlation analysis showed that there was a significant negative correlation between oilseed rape grain yield and weed biomass ($r=-0.60$, $p \leq 0.05$) and weed nitrogen content ($r=-0.81$, $p \leq 0.01$).

Generally, N content in wild mustard plants was higher than that of oilseed rape plants. N content in oilseed rape decreased as wild mustard density increased but no significant difference was found between 0 and 10 plant m^{-2} (0.78 and 0.72 %, respectively) as well as between 20 and 30 plant m^{-2} (0.57 and 0.56 %, respectively) (Fig. 2). The lowest amount of N content in oilseed rape plants was achieved in 40 wild mustard m^{-2} (0.47 %) (Fig. 2).

Although application of N fertilizer caused an increase in N content in oilseed rape plants, there was no significant difference between 0 and 50 kg N ha^{-1} and between 150 and 200 kg N ha^{-1} (Fig. 3).

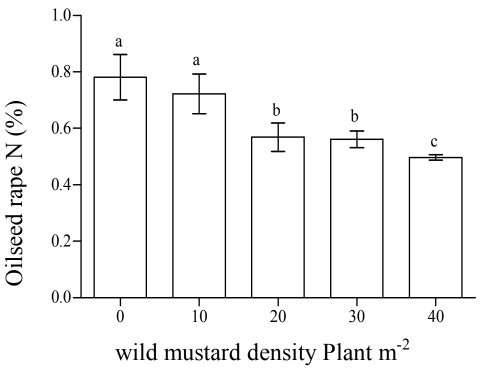

Fig. 2. The effect of wild mustard density on N content in oilseed rape plants. Error bars indicate SEs

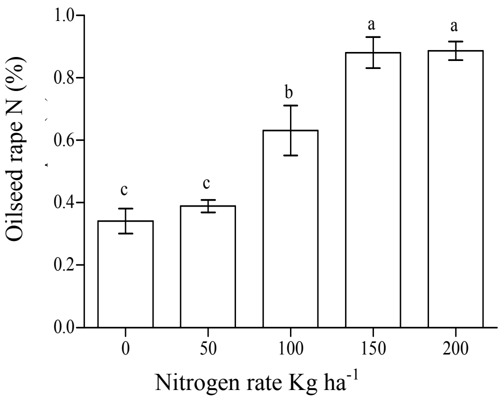

Fig. 3. The effect of N rates on N content in oilseed rape plants. Error bars indicate SEs

Increasing nitrogen rate from 50 kg N ha^{-1} to 100 kg N ha^{-1} caused an increase of 38 % in N content of oilseed rape. N content in oilseed rape in weed free plot decreased 27 % compared to 20 wild mustard m^{-2}. Application of N fertilizer increased N content in wild mustard plants significantly. Maximum amount of N content in plants was found in 200 kg N ha^{-1} (Fig. 4). N content in wild mustard plants was not significantly different among 10, 20 and 30 plant m^{-2} (1.24, 1.24 and 1.22 %, respectively) Minimum amount of N content in wild mustard plants was gained in 40 wild mustard m^{-2} (Fig. 5).

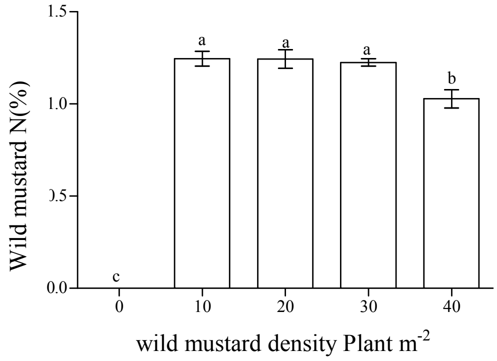

Fig. 4. The effect of wild mustard density on N content in wild mustard plants. Error bars indicate SEs

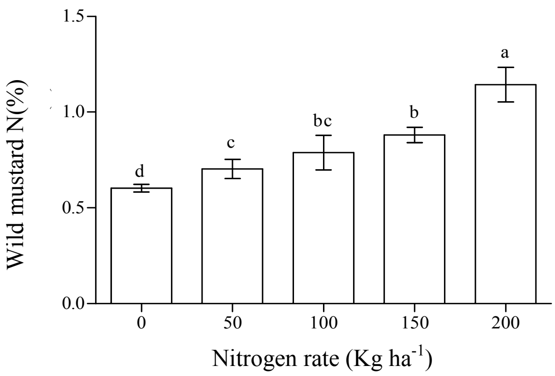

Fig. 5. The effect of N rates on N content in wild mustard plants. Error bars indicate SEs

Oil content in oilseed rape decreased as wild mustard density increased (Fig. 6.). However, there was no significant difference between 0 and 10 wild mustard m^{-2} (37 and 35 %, respectively). Maximum oil content was obtained in weed free (37 %) and minimum oil content was obtained in 40 wild mustard m^{-2} (31%) (Fig. 6).

Although increasing nitrogen rate caused a decrease in oil content of oilseed rape, no significant difference was found between 0 (40 %) and 50 kg ha^{-1} (39 %). A significant decrease occurred from 50 kg n ha^{-1}, approximately 25 % (Fig. 7).

The results of path analysis showed that the main factor leading to the reduction in oilseed rape yield was wild mustard aboveground biomass. N content in wild mustard was the second factor that affected oilseed rape yield. This is in contrast to the results obtained by Mamolos and Kalbortji (2002), who examined the competition between Canada thistle (*Cirsium arvense* L.) and winter wheat (*Triticum aestivum* L.) and found that the first factor causing wheat yield reduction was N concentration in Canada thistle. Using path analysis to study competitive ability of rice (*Oryza sativa* L.) against weeds, Ni et al. (2000) reported that path coefficient of crop biomass on weed biomass was direct path: -0.87 in the wet season and direct path: -0.81 in the dry season.

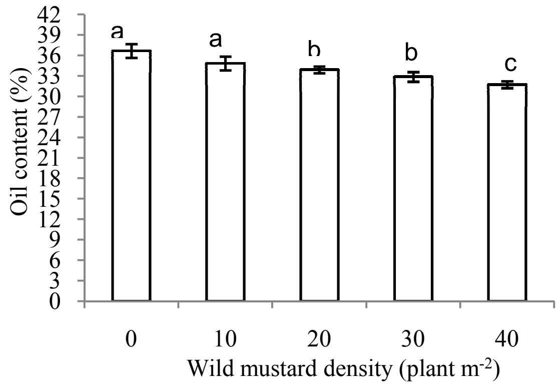

Fig. 6. The effect of wild mustard density on oil content in oilseed rape plants. Error bars indicate SEs

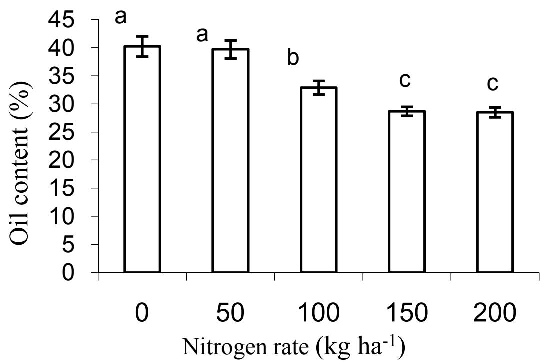

Fig. 7. The effect of N rates on oil content in oilseed rape plants. Error bars indicate SEs.

Wild mustard biomass directly affected grain yield, N in grain and straw of oilseed rape. Biomass is known as an integrated parameter which directly reflects resource capture ability (Ni et al., 2000). Plant aboveground biomass has also been found to be a suitable indicator of plant competitive ability (Gaudet and Keddy, 1988).

Wild mustard competition decreased oil content in oilseed rape. These results are in agreement with those of Bijanzadeh et al. (2010). Increasing nitrogen rates caused a significant reduction in oil content. Nartis (2010) also reported that there was a negative relationship between increasing N rates and oil content in oilseed rape.

Generally, wild mustard plants uptake higher amount of N than oilseed plants. N fertilizer application even at the rate of 200 kg N ha^{-1} caused an increase in N content in wild mustard plants, while this N rate did not increase N content in oilseed rape plants. This might mean that high N content in wild mustard plants led to less N available for oilseed rape plants. Weeds have a large nutrient demand and can absorb as much as or more than crops (Zimdhal, 2007). It has also been reported that increased N could either increase the competitiveness of weeds more than that of crops or the crop yield remained unchanged (Ampong-Nyarko and de Datta, 1993; Andreasen et al., 2006) or even decreased in some cases (Carlson and Hill, 1985, Dhima and Eleftherohorinos, 2001; Santos et al., 1998). Decreased N content in wild mustard plant as a result of increased wild mustard density revealed that there is a high intraspecific weed competition at a higher weed density.

CONCLUSIONS

Weed competition with crops can be affected by N rate application; therefore, soil fertility manipulation should be considered as an important component of integrated weed management. These results indicated that wild mustard is highly responsive to higher N rates and thus might be stronger competitors at higher N fertilizer rates. Path analysis showed that wild mustard biomass is the first factor that affected the yield of oilseed rape while the second factor is N content in wild mustard plants.

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روابط متقابل بین عملکرد کلزا و رشد علف هرز در سطوح مختلف کود نیتروژن

روح اله نادری[۱*]، حسین غدیری[۲]، محسن عدالت[۲]

[۱]بخش اگرو اکولوژی، دانشکده کشاورزی و منابع طبیعی داراب، دانشگاه شیراز، داراب، ج. ا. ایران
[۲]بخش زراعت و اصلاح نباتات، دانشکده کشاورزی دانشگاه شیراز، شیراز، ج. ا. ایران

*نویسنده مسئول

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علف هرز

چکیده- مدیریت کوددهی نیتروژن در گیاهان زراعی یکی از مهم‌ترین اجزای مدیریت تلفیقی علف های هرز می‌باشد. آزمایش مزرعه‌ای دو ساله برای بررسی اثرات مستقیم زیست‌توده و محتوای نیتروژن خردل وحشی بر عملکرد و اجزای عملکرد کلزا اجرا گردید. آزمایش به صورت فاکتوریل در قالب طرح بلوک‌های کامل تصادفی با ۴ تکرار انجام شد. تیمارهای آزمایش شامل تراکم‌های مختلف علف هرز خردل وحشی (صفر، ۱۰، ۲۰، ۳۰ و ۴۰ بوته در مترمربع) و سطوح مختلف نیتروژن (صفر، ۵۰، ۱۰۰، ۱۵۰ و ۲۰۰ کیلوگرم در هکتار) بودند. افزایش تراکم خردل وحشی از ۲۰ بوته در مترمربع باعث کاهش ۲۷ درصدی در محتوای نیتروژن شاخساره کلزا شد. افزایش کود نیتروژن تا سطح ۱۵۰ کیلوگرم در هکتار باعث افزایش محتوای شاخساره کلزا شد ولی بین تیمار ۱۵۰ کیلوگرم نیتروژن (۰/۸۸ درصد) و۲۰۰ کیلوگرم نیتروژن (۰/۸۹ درصد) تفاوت معنی‌داری وجود نداشت. نتایج تجزیه همبستگی نشان داد یک رابطه مستقیم منفی شدید بین عملکرد دانه کلزا و زیست‌توده خردل وحشی و همچنین محتوای نیتروژن علف هرز وجود داشت. تجزیه مسیر نیز نشان داد یک رابطه مستقیم و منفی شدید بین زیست‌توده علف هرز و عملکرد کلزا وجود داشت. نتایج تجزیه همبستگی و تجزیه مسیر نشان داد عامل اصلی کاهش عملکرد کلزا زیست‌توده علف هرز و عامل دوم محتوای نیتروژن در خردل وحشی بود.