Iran Agricultural Research, Vol. 28, No. 2, 2009 and Vol. 29 No. 1-2, 2010
Printed in the Islamic Republic of Iran
Shiraz University

Growth Response of Winter Wheat (*Triticum aestivum* L.) and Wild Barley (*Hordeum spontaneum* Koch) to Nitrogen

R. HAMIDI[1], D. MAZAHERI[2*] and H. RAHIMIAN[2*]**

[1] Department of Crop Production and Plant Breeding,, College of Agriculture, Shiraz University, Shiraz, I.R. Iran,
[2] Department of Crop Production and Plant Breeding, College of Agriculture, Tehran University, Karaj, I.R. Iran

ABSTRACT-A greenhouse study was conducted to investigate the effects of nitrogen (N) on wild barley (*Hordeum spontaneum* Koch) interference with winter wheat (*Triticum aestivum* var. Pishtaz) by an additive series experiment. The experiment was conducted in a split plot design with 3 replications. Wheat plant height losses were on average 30, 10, and 10% in a wild barley density of 16 plants per pot with an N supply of 40, 80, and 160 mg per kg soil, respectively. At all N application rates, wheat tillers decreased in the presence of wild barley densities of 4, 8, and 16 plants per pot. Increased N stimulated wheat tiller growth per plant but this effect was reduced by wild barley interference. The highest leaf area was observed at 80 mg N per kg soil for both species in monocultures. Significant differences were observed among wheat dry weight values in all wild barley densities and at each level of N application rate. Shoot N concentration of wild barley was greater than that of wheat. Wild barley competition always reduced shoot N concentration of wheat and this was increased with increasing wild barley density. The results of this study suggested that wild barley is more responsive to soil N levels than wheat.

Keywords: Additive series study, Competitive ability, *Hordeum spontaneum*, Nitrogen, Population density, Wheat

INTRODUCTION

Weed interference reduces crop yield, quality, and harvesting efficiency (6). The degree of interference depends on the weed and crop species (7 and 40), density (10 and 24) and distribution of weeds (14), and duration of interference (41).

The competitive relationship between plant species is highly dependent on many factors including the supply and availability of nutrients. Of all nutrients, plant response to nitrogen (N) fertilizer is most widely observed, and it is suggested that the manipulation of soil N supply offers the most important mean by which crop-weed interaction can be influenced (39). Nitrogen is the major nutrient added to increase crop yield (32), but it is not always recognized that altered soil fertility levels can markedly affect crop-weed competitive interactions. N fertilizer is known to break the dormancy of certain weed species (8) and thus may directly affect weed

---

* Assistant Professor, and Professors, respectively
** Corresponding Author

infestation densities. Depending on weed species and density, addition of N fertilizer can increase the competitive ability of weeds more than that of the crop, with little or no increase in the crop yield attained (5). In a greenhouse study, Teyker et al. (37) reported greater uptake for redroot pigweed (*Amaranthus retroflexus* L.) than corn when the addition of N was increased, suggesting that redroot pigweed interference in corn may be greater at higher levels of N. Valenti and Wicks (38) found that increasing N rates applied to winter wheat decreased annual grass weed populations and yields. Conversely, in other studies, the application of N favored *Setaria viridis* (29) and *Avena fatua* (5) over wheat. Other contrasting outcomes regarding the effects of N supplies and crop-weed competition have been presented in the literature. Forcella (12) documented in a greenhouse study that rigid ryegrass (*Lolium rigidum* Geiudin) was less competitive when N was applied before the three-leaf stage of wheat as compared with later applications.

Soil nutrient availability has also been known to influence weed-crop interactions, favoring either the crops (11, 22 and 29) or the weeds (2, 3, 6 and 20). Jornsgard et al.,1996, (19) reported that weed biomass in barley (*Hordeum vulgare* L.) and wheat could be increased, unchanged or reduced with increased soil N, depending on the weed and crop.

Not only do weeds reduce the amount of N available to crops, but also the growth of many weed species is enhanced by higher soil N levels (24). In a controlled environment study, Blackshaw et al. (3) reported that shoot and root growth of many agricultural weeds were to be more responsive to N than wheat or canola.

Information on responses of weeds to various soil fertility levels is required to develop fertilizer management strategies as components of integrated weed management programs (8). Despite studies that demonstrate the importance of dose and application method of N fertilizers on the resulting crop-weed competition, only limited information is available on how specific weed species respond to increasing soil N levels. This information is needed to further refine fertilization strategies for specific crop-weed combinations and for the overall development of more effective and economical weed management systems (3).

The design and analysis of experiments for competition studies has occupied considerable research effort in plant population biology (13). Additive series experiments are an important tool for determining yield losses resulting from weed-crop interference. In this type of experiment, crop density is kept constant, while various weed densities are allowed to compete with the crop. The additive series approach more closely resembles field conditions in measuring the effects of increasing weed density on the crops. However, it has been criticized because it does not account for increases in total plant density. In addition, species proportion varies as more weeds are added (31).

H. spontaneum is a dominant troublesome weed in most wheat fields of Fars province (18) as well as other parts of Iran (26), and its natural populations have been reported in many other parts of the world (15 and 23). This plant is a member of the Poaceae family, reproducing by seed. Seed dispersal is usually limited to the area within several meters of the mother plant; although seeds can also be carried in the fur of animals or by contaminated seeds over longer distances (42). Visual observations showed that the growth and development of wild barley is similar to that of winter wheat, often unrecognized in the field until its distinctive inflorescence is produced. Wild barley matures earlier than wheat, and its spikelets shatter easily with maturation.

Clearly, the efficacy of using agronomic practices to manage weed populations will be improved by a comprehensive understanding of the mechanisms of competition (28). Cultural control methods have been demonstrated to be effective in managing weeds and are especially important in situations where efficient herbicides are limited for a specific weed species or for certain crops (1). However, very little or no work has been done on the effect of these agronomic practices on wild barley growth and its interference with winter wheat.

The aim of this study was to evaluate the effect of nitrogen on the competitive ability of wheat in relation to different densities of wild barley.

MATERIALS AND METHODS

Experiment was conducted during 2005 in a greenhouse under a 16 h photoperiod, air temperatures of 25/15^{o}C (day/night), a relative humidity of 50 to 60%, and a light flux density of 400μ moles m^{-2} per second.

Mature seeds of wild barley were collected from the Experiment Station Farm, College of Agriculture, Shiraz University, located in Kushkak, 60 km northwest of Shiraz, Iran. The soil was silty clay loam having a pH of 6.8, 1.5% organic matter, and a total N content of 0.07%. Soil was passed through a 5-mm sieve, mixed thoroughly with well decomposed cow manure with a 50:50 ratio. Nitrogen fertilizer was applied in form of urea (0, 40, 80, and 160 mg N per kg soil, 1/3 pre-plant and 2/3 through irrigation water). Triple super phosphate (230 mg per pot, pre-plant) and potassium sulfate (115 mg per pot, pre-plant) was also added to the soil. Three kg$_{s}$ of soil was placed in each 25-cm diameter uniform plastic pot with draining holes. All pots had draining trays to prevent loss of leachates. Fifteen vernalized seeds of wheat (*Triticum aestivum* var. Pishtaz) and twenty non-dormant caryopses of wild barley were placed on the soil surface and covered with 200 g dry soil to provide an appropriate and uniform planting depth. The field capacity of the mixed soil was measured (40% w:w) and pots were maintained at 80% FC throughout the experiment. Immediately after emergence, seedlings were thinned to 10 plants per pot for wheat, and population densities of 2, 4, 8, and 16 plants per pot for wild barley. A treatment comprising of weed-free and unfertilized soil was used as control. The aboveground biomass was dried at 55^{o}C for 48 h and ground to pass through a 40-mesh screen. Total nitrogen percentage was determined by the micro-Kjeldal method (25). Wheat and wild barley were allowed to interfere for 10 weeks. Measured variables were plant height, number of tillers per plant, leaf area (LA), dry shoot biomass, and shoot total nitrogen content percentage for both plant species. The experiment was conducted in a split-plot design with three replications, the main factor being the 4 levels of nitrogen (0, 40, 80, and 160 mg N per kg soil) and the sub factor being the 5 levels of wild barley densities (0, 2, 4, 8, and 16 plants per pot). Data were analyzed by analysis of variance procedure using the MSTATC software and differences between means were subjected to Duncan's new multiple range test at the p=0.05 level.

RESULTS AND DISCUSSION

Plant height

There were significant wild barley population densities by N rate interactions on all wheat measurable variables. When wheat was grown with wild barley at the N rates of 40, 80, and 160 mg per kg soil, wheat height was not significantly affected by wild barley density of 2 plants per pot compared with control treatment (Fig. 1A). As wild barley density increased, wheat height significantly decreased at low N rates (40 mg per kg soil). At wild barley density of 16 plants per pot, wheat height losses were on average 30, 10, and 10% with an N supply of 40, 80, and 160 mg per kg soil, respectively. With no wild barley interference, wheat height was significantly higher at 80 and 160 than 40 mg N per kg soil (Fig. 1). Maximum plant height was obtained with no wild barley interference and 160 mg N per kg soil. Wild barley height increased with increasing N rates but was not significantly affected by its own densities (Fig. 1B).

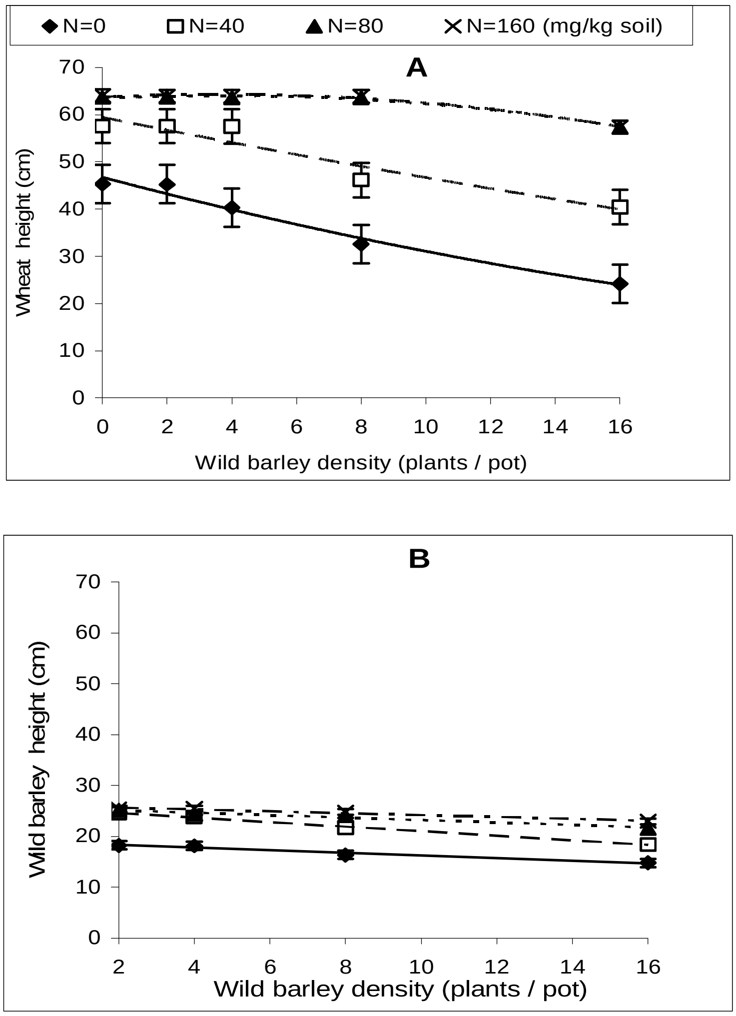

Fig. 1. Effects of wild barley densities on wheat (A) and wild barley (B) height at various nitrogen application rates

Tillers per plant

A significant decrease was observed in the number of wheat tillers per plant in the presence of wild barley densities of 4, 8, and 16 plants per pot at all N application rates compared with weed-free control treatment (Fig. 2). Generally, wheat tillers per plant did not decreased when wild barley density increased to more than 2 plants per pot at the 40, 80, and 160 mg N per kg soil. Increased N application stimulated wheat tiller per plant but this effect was reduced by wild barley interference. Storninos, Jr *et al.* (36) reported that the competition of red rice (*Oryza sativa* L.), a well known weed in cultivated rice, resulted in reduction of the number of rice tillers per plant, and the reduction generally increased with higher red rice population densities.

A comparison of wheat and wild barley tiller production showed that wild barley produced more tillers than wheat at all N treatments indicating its high capacity to occupy more space than wheat (Fig. 2). High tillering capacity has been recognized as a key to the competitive advantage for grassy weeds (10, 16 and 36).

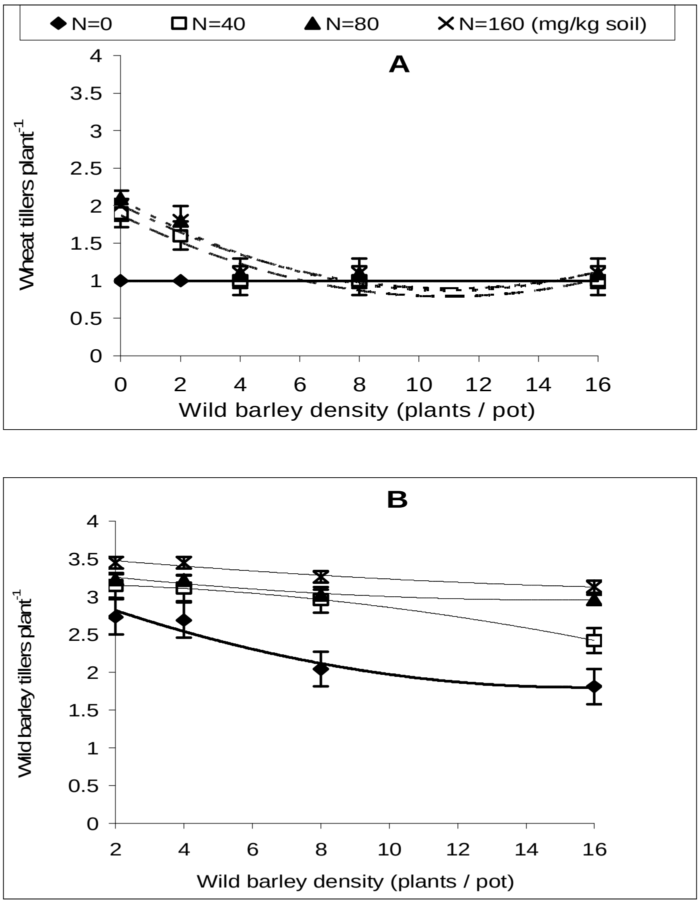

Fig. 2. Effects of wild barley densities on wheat (A) and wild barley (B) tillers per plant at various nitrogen application rates

Leaf area (LA)

The additive series showed a decrease in wheat LA with increasing wild barley density and a corresponding increase in wild barley LA (Fig. 3). The highest LA was observed at 80 mg N per kg soil for either wheat or wild barley in monocultures, however, wild barley had a higher LA than wheat at equivalent density, i e., 10 plants per pot (Fig. 4C). Since leaf area is an important measure of photosynthetic area potential and thus growth capability (30), it can be concluded that at equal density, wild barley can more effectively develop its canopy for light interception compared to wheat.

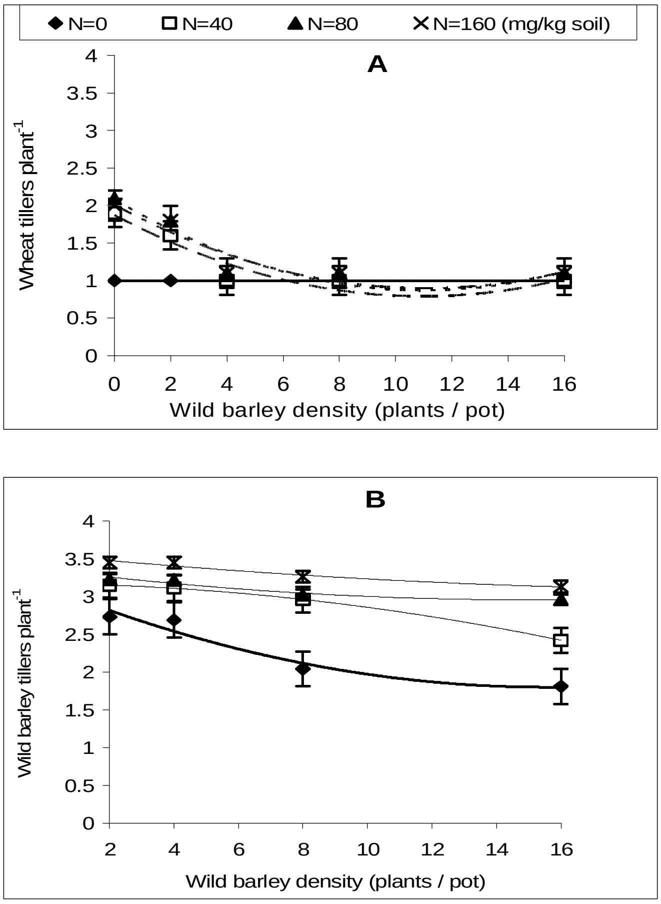

Fig. 3. Effects of wild barley densities on wheat (A) and wild barley (B) leaf area per pot at various nitrogen application rates

Shoot dry weight

Wheat and wild barley shoot dry weight increased with increasing N application rates compared to the unfertilized control (Figures 5A and 5B). In monocultures of both plants, i.e., at equal density (10 plants per pot), the highest value for wheat and wild barley shoot dry weight were found with 80 and 160 mg N per kg soil, respectively (Fig. 4A). This finding indicated that wild barley was more responsible to added nitrogen that wheat. Wheat shoot dry weight losses were greater at 80 mg N per kg soil when 16 wild barley plants per pot were allowed to interfere (Fig. 5A). This occurrence may be due to either the competitive ability of wild barley (34) or its increased allelopathic activity under nutrient stress of excessive N rates (17). Wheat shoot dry weight was different among all levels of the N application rates and all wild barley densities (Fig. 5A). In the presence of wild barley, wheat dry weight was greater on fertilized as compared to unfertilized pots. The application of nitrogen resulted in a greater accumulation of wild barley biomass relative to wheat biomass (Figures 5A and 5B). Such a result would help to explain why the effect of wild barley on wheat dry weight increased at higher nitrogen application rates.

Weed-free wheat dry weight was greater with all N application rates compared to the unfertilized control. This was expected because wheat is known to respond positively to higher soil N levels (32). There were significant differences among wheat dry weight values in all wild barley densities at all N application rates and this trend was true for wild barley biomass (Fig. 5). At each level of N application rate, the wild barley shoot dry weight per plant decreased with an increase in density, indicating intra- in addition to inter-specific competitions. Wild barley biomass increased as nitrogen increased from 40 to 160 mg per kg soil (Fig. 5B).

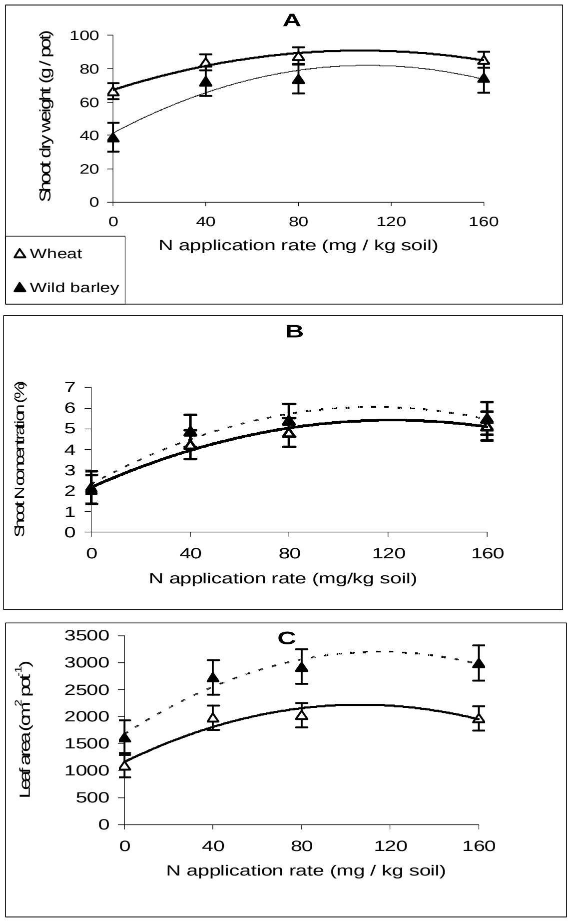

Fig. 4. Shoot dry weight (A), Shoot N concentration (B), and leaf area (C) calculated from monocultures of wheat and wild barley, plotted against N application rates. Open and shaded triangles represent wheat and wild barley, respectively

Shoot N concentration

When two plant species were grown in isolation, shoot N concentration increased with increasing N rates. Shoot N concentration of wild barley was often greater than that of wheat, indicating that wild barley is a higher competitor for soil N (Fig. 6). Wild barley competition always reduced shoot N concentration of wheat and this increased with increasing wild barley density (Fig. 6A). The results showed that in addition to wild barley density and leaf area, another factor causing wheat dry weight reduction was wild barley N concentration (Fig. 4B). This probably means that high N concentration in wild barley resulted in the loss of N available for wheat (21).

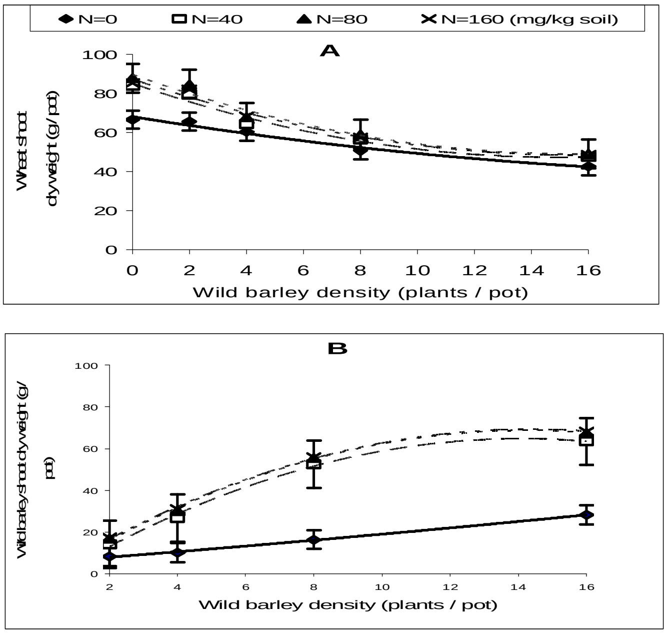

Fig. 5. Effects of wild barley densities on wheat (A) and wild barley (B) shoot dry weights at various nitrogen application rates

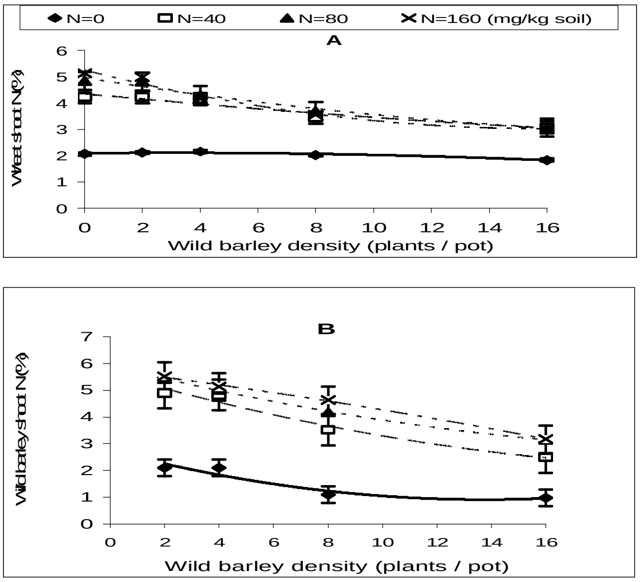

Fig. 6. Effects of wild barley densities on wheat (A) and wild barley (B) shoot N concentration// (%) at various nitrogen application rates

The results of the present study support previous findings indicating that many agricultural weed species are as responsive as or more responsive than crops to soil N levels (4, 20 and 27). Thus, indiscriminate N fertilizer use has the potential to benefit weeds at the expense of crops. However, the highly responsive nature of some weed species to higher N levels may be a weakness to be exploited. Shipley and Keddy (35) found that species with the highest relative growth rate under optimal nutrient conditions suffered the largest declines in growth rate under deficient nutrient conditions. In this study, wheat and wild barley responded positively to N fertilizer, but N application rates had a greater effect on the growth and competitive ability of wild barley as compared to those of wheat. This may be due to inherent differences among the species in their responsiveness to N (3) or in part due to their differing root structures (4). The information obtained from this study could be used to develop more integrated programs for wild barley control in winter wheat fields of Iran, although more information is needed about N application timing and/or methods. In addition, the application of higher rates of nitrogen fertilizers in wheat fields when wild barley is a dominant weed in the field should be avoided.

REFERENCES

1. Altieri, M. A. and M. Liebman. 1988. Weed management in agroecosystems: Ecological Approaches. Boca Raton, FL, Press. 354 p.

2. Blackshaw, R. E. 2005. Nitrogen fertilizer, manure, and compost effects on weed growth and competition with spring wheat. Agron. J. 97: 1612-1621.

3. Blackshaw, R. E., R. N. Brandt, H. H. Janzen, T. Entz, C. A. Grant, and D. A. Derksen 2003. Differential response of weed species to added nitrogen. Weed Sci. 51: 532-539.

4. Blackshaw, R. E., L. J. Molnar, and H. H. Janzen. 2004. Nitrogen fertilizer timing and application method affect weed growth and competition with spring wheat. Weed Sci. 52: 614-622.

5. Carlson, H. L. and J. E. Hill. 1985. Wild oat (*Avena fatua*) competition with spring wheat: effects of nitrogen fertilization. Weed Sci. 34: 29-33.

6. Chisaka, H. 1977. Weed damage to crop: yield loss due to weed competition. ***In*:** J. D. Fryer and S. Matsunaka (***eds***.), Integrated Control of Weeds. Tokyo, University of Tokyo Press. pp. 1-16.

7. Daugovish, O., D. J. Lyon, and D. D. Baltensperger. 1999. Cropping system to control winter annual grasses in winter wheat. Weed Technol. 13: 120-126.

8. Di Tomaso, J. M. 1995. Approaches for improving crop competitiveness through the manipulation of fertilization strategies. Weed Sci. 43: 491-497.

9. Estorninos, Jr, L. E. and D. R. Gealy. 2002. Growth response of rice (*Oryza sativa*) and red rice (*O. sativa*) in a replacement series study. Weed Technol. 16: 401-406.

10. Estorninos, Jr, L. E., D. R. Gealy, E. E. Gbur, R. E. Talbert, and M. R. Mc Clleland. 2005. Rice and red rice interference. II. Rice response to population densities of three red rice (*Oryza sativa*) ecotypes. Weed Sci. 53: 683-689.

11. Everaarts, A. P. 1992. Response of weeds to method of fertilizer application on low-fertility acid soils in Suriname. Weed Res. 32: 391-397.

12. Forcella, F. 1984. Wheat and ryegrass competition for pulses of mineral nitrogen. Aust. J. Exp. Agric. Anim. Husb. 24: 421-425.

13. Freckleton, R. P. and A. R. Watkinson. 2000. Design for greenhouse studies of interactions between plants: an analytical perspective. J. Ecol. 88: 386-391.

14. Hari, O. M., S. D. Dhiman, K. Hemant, and K. Sajjan. 2003. Biology and

management of *Phalaris minor* in wheat under a rice/wheat system. Weed Res. 43: 59-67.

15. Harlan, J. R. and D. Zohary. 1966. Distribution of wild wheats and barley. Science 153: 1074-1080.

16. Henson, J. F. and L. S. Jordan. 1982. Wild oats (*Avena fatua*) competition with wheat (*Triticum aestivum* and *T. turgidum durum*) for nitrate. Weed Sci. 30: 297-300.

17. Horowitz, M. and T. Friedman. 1971. Biological activity of subterranean residues of *Cynodon dactylon* L., *Sorghum halepense* L., and *Cyperus rotundus* L. Weed Res. 11: 88-93.

18. Jamali, M. and F. Termeh. 1998. Identification of Gramineae weeds in fields, gardens and pastures of Fars province. Proceeding of the 13th Iranian Plant Protection Congress. Vol. II. Plant Diseases and Weeds. 23-27 August 1998, Karaj, Iran, 327 p.

19. Jornsgard, B., K. Rasmussen, J. Hill, and J. L. Christiansen. 1996. Influence of nitrogen on competition between cereals and their natural weed population. Weed Res. 36: 461-470.

20. Liebman, M. and R. H. Robichaux. 1990. Competition by barley and pea against mustard: effect on resource acquisition, photosynthesis and yield. Agric. Ecos. Environ. 31: 155-172.

21. Mamolos, A. P. and K. L. Kalburtji. 2001. Competition between Canada thistle and winter wheat. Weed Sci. 49: 755-759.

22. Melander, B., A. Cirujeda, and M. H. Jorgensen. 2003. Effects of inter-row hoeing and fertilizer placement on weed growth and yield of winter wheat. Weed Res. 43: 428-438.

23. Moh`d, K., J. El-Shatnawi, and H. Z. Ghosheh. 2003. Interference of wild oat and wall barley on growth of dual-purpose barley under semi-arid Mediterranean climate. Crop Res. 25: 12-20.

24. Morals-Payan, J. P., B. M. Santes, W. M. Stall, and T. A. Bewick. 1998. Interference of purple nutsedge (*Cyperus rotundus*) population densities on bell pepper (*Capsicum annuum*) yield as influenced by nitrogen. Weed Technol. 12: 230-234.

25. Nelson, D. W. and L. E. Sommer. 1972. Determination of total nitrogen in plant materials. Agron. J. 65: 109-112.

26. Nevo, E., D. Kaplan, N. Storch, and D. Zohary. 1986. Genetic diversity and environmental associations of wild barley, *Hordeum spontaneum,* (Poaceae), in Iran. Plant Syst. Evol. 153: 141-164.

27. Paolini, R., M. Principi, R. J. Froud-Williams, S. Del Puglia, and E. Biancardi. 1999. Competition between sugar beet and *Sinapis arvensis* and *Chenopodium album*, as affected by timing of nitrogen fertilization. Weed Res. 39: 425-440.

28. Park, S. E., L. R. Benjamin, and A. R. Watkinson. 2003. The theory and application of plant competition models: an agronomic perspective. Ann. Bot. 92: 741-748.

29. Peterson, J. 2003. Weed: spring barley competition for applied nitrogen in pig slurry. Weed Res. 43: 33-39.

30. Potter, J. R. and J. W. Jones. 1977. Leaf partitioning as an important factor in growth. Plant Physiol. 59: 10-14.

31. Radosevich, S. R. 1988. Methods to study crop and weed interactions. ***In*:** M. A. Altieri and M. Liebman (***eds***.). Weed Management in Agroecosystems: Ecological Approaches. Boka Raton, Fl, CRC Press. pp. 121-143.

32. Raun, W. R. and G. V. Johnson. 1999. Improving nitrogen use efficiency for cereal production. Agron. J. 91: 357-363.

33. Robinson, R. A. and W. J. Sutherland. 2002. Post-war changes in arable farming and biodiversity in Great Britain. J. Appl. Ecol. 39: 157-176.

34. Scurson, J. A. and E. H. Sattore. 2005. Barley (*Hordeum vulgare*) and wild oat (*Avena fatua*) competition is affected by crop and weed density. Weed Technol. 19: 790-795.

35. Sipley, B. and P. A. Keddy. 1988. The relationship between relative growth rate and sensitivity to nutrient stress in twenty eight species of emergent macrophytes. J. Ecol. 76: 1101-1110.

36. Storninos, Jr, L. E., D. R. Gealy, E. E. Gbur, R. E. Talbar, and M. R. Mc Clelland. 2005. Rice and red rice interference. II. Rice response to population densities of three red rice (*Oryza sativa*) ecotypes. Weed Sci. 53: 683-689.

37. Teyker, R. H., H. D. Hoelzer, and R. A. Liebl. 1991. Maize and pigweed response to N supply and form. Plant and Soil 135: 287-292.

38. Valenti, S. A. and G. A. Wicks. 1992. Influence of nitrogen rate and wheat (*Triticum aestivum*) cultivars on weed control. Weed Sci. 40: 115-121.

39. Walker, R. H. and G. A. Buchanan. 1982. Crop manipulation in integrated weed management systems. Weed Sci. 30: 17-24.

40. Wicks, G. A., P. T. Nordquist, P. S. Baenziger, R. N. Klein, R. H. Hammons, and J. E. Watkins. 2004. Winter wheat cultivar characteristics affect annual weed suppression. Weed Technol. 18: 988-998.

41. Zhang, W. E. I., E. P. Webster, D. Y. Lanclos, and, J. P. Geaghan. 2003. Effect of weed interference duration and weed-free period on glyphosinate-resistant rice. Weed Technol. 17: 876-880.

42. Zohary, D. 1969. The progenitors of wheat and barley in relation to domestication and agricultural dispersal in the Old World. pp. 47- 66, ***In*:** P.J. Ucko and G. W. Dimbleby (***eds.***). The Domestication and Exploitation of Plants and Animals. Duckworth, London. 581 p.

واکنش رشد گندم زمستانه و جو وحشی به نیتروژن

رضا حمیدی[1**]، داریوش مظاهری[2*] و حمید رحیمیان[2*]

[1] بخش زراعت و اصلاح نباتات دانشکده کشاورزی دانشگاه شیراز، شیراز، جمهوری اسلامی ایران
[2] گروه زراعت و اصلاح نباتات دانشکده کشاورزی کرج، کرج، جمهوری اسلامی ایران

چکیده - در یک پژوهش گلخانه ای، اثر نیتروژن برتوانایی رقابتی یک رقم گندم زمستانه (رقم پیشتاز) با جو وحشی با استفاده از روش افزایشی مورد بررسی قرار گرفت. در تمام کرت های دارای نیتروژن، تعداد دو بوته‌ی جو وحشی در گلدان، بلندی گندم را تحت تأثیر قرار نداد در حالی که تراکم ۱۶ بوته ی جو وحشی در گلدان، بلندی گندم را به میزان ۳۰، ۱۰و۱۰ درصد به ترتیب در تیمارهای۴۰ ، ۸۰ و160 میلی گرم نیتروژن در کیلوگرم خاک کاهش داد .در تمام تیمارهای دارای نیتروژن، پنجه های گندم با رقابت ٤، ۸ و۶۰ بوته جو وحشی در گلدان کاهش معنی داری یافت .در کشت خالص هر دو گیاه، بیشترین مقدار سطح برگ در مقدار ۸۰ میلی گرم نیتروژن در کیلوگرم خاک به دست آمده هم چنین در کشت خالص، بیشترین وزن خشک اندام های رویشی هوایی برای گندم در ۸۰ و برای جو وحشی در ۱۶۰ میلی گرم نیتروژن در کیلوگرم خاک تولید شد .درصد نیتروژن اندام های هوایی جو وحشی در تمام تیمارهای دارای نیتروژن بیشتر از گندم بود. نتایج این پژوهش نشان داد که جو وحشی برای به دست آوردن نیتروژن خاک رقابت زیادی با گندم داشته و از این راه می تواند عملکرد این گیاه زراعی را کاهش دهد.

واژه های کلیدی: توانایی رقابتی، جو وحشی، روش افزایشی ، گندم، نیتروژن

---

[*] به ترتیب استادیار, استاد و استاد
[**] مکاتبه کننده