Genetic improvements in yielding potential and inter and intra-specific competitive ability of Iranian winter wheat (*Triticum aestivum* L.) cultivars released during the past 50 years

E. Zand[1] and H. Rahimian Mashhadi[2]

[1] Weed Research Department, Plant Pest and Disease Research Institute, Tehran, Iran
[2] College of Agriculture, Tehran University, karaj, Iran, hrahimian@hotmail.com

Abstract

Genetic improvement of ecophysiological traits of Iranian winter wheat cultivars released during the last 50 years was studied during 1998 and 1999 growing seasons in Mashhad, NE of Iran. The results showed a significant yield difference among old and new cultivars. In both years a significant positive correlation was found between yield and harvest index (r = 0.65 and 0.93 for 1998 and 1999, respectively). New cultivars showed advantages over old cultivars for some yield components and growth indices (e.g., leaf area index and crop growth rate) and had higher resource capture ability by means of radiation and nitrogen use efficiency. Path analysis showed that about 89% of grain yield variation could be explained by harvest index, crop biomass, internode length, and number of fertile florets per spikelet. New wheat cultivars were better competitors with wild oats than old cultivars. An increasing trend in yielding ability of wheat cultivars was observed in the presence of wild oat with a higher competition index in new cultivars. It seems that competitive ability of wheat cultivars was mainly related to their leaf area index, height at which maximum leaf area occurred, and leaf area at the end of tillering. In all cultivars grain yield decreased with increasing sowing density above the optimal level but this was not significant. It was concluded that during the last 50 years Iranian wheat cultivars have been improved for higher grain yield and better inter-specific competitive ability. Intra-specific competition ability of cultivars, however, has not undergone significant change.

Key words

Wheat, wild oat, competitive ability and genetic improvement

Introduction

Improved crop tolerance to pests is an important component of sustainable crop production. Although insect and disease-tolerant cultivars have long been selected and used in crop production systems, research efforts have only recently focused on evaluating crop tolerance to weeds. If a crop cultivar can tolerate weeds, it may reduce the need for synthetic herbicide (Christensen, 1995), allow the use of less costly and more environmentally sound herbicides (Wicks *et al*. 1994), decrease the number of cultivations, or improve yield stability in weedy fields (Lindquist and Mortensen, 1998).

Planting a more competitive wheat cultivar has been suggested as a cultural practice to suppress weed growth. However, few studies have been conducted to determine the competitiveness of winter wheat cultivars or to identify wheat characteristics that are important in enhancing competitiveness. Before a more competitive winter wheat can be developed, plant breeders need to know what combination of plant characteristics will make a cultivar more competitive (Ogg and Seefeldt, 1999). Lemele *et al*. 2001 determined that competitive ability may be negatively associated with crop yield, particularly under a weed-free environment.

Hamblin (1975) hypothesized that a "competitive ideotype", which is taller than its neighbours, tillers more, and with an extensive leaf display, will yield well in a mixed community and poorly in monoculture. In contrast a weakly competitive" crop ideotype" (short, low tillering, erect leaf display and high harvest index) would optimise grain yield in monoculture.

Tollenaar *et al* (1997) reported inter-plant competition for incident photosynthetic photon flux density (PPFD), soil nutrients, and soil water is more severe at high than at low plant density. It can be postulated

that the increased high plant density tolerance of modern hybrids is a reflection of increased stress tolerance. They also imply that weed interference is a kind of stress and showed that the reduction in maize grain yield due to weed interference was 21% greater in old than new cultivars. Kawano *et al*. (1974) studied inter-specific competition and plant spacing response in rice and showed there was a positive relationship between inter and intra- specific competition. They believed the cultivars that can tolerant high densities are probably more competitive against weeds.

Materials and methods

Experiments were conducted during 1998 and 1999 at the research station of the College of Agriculture, Ferdowsi University of Mashhad. In 1998 yielding ability of 12 Iranian wheat cultivars released during the past 50 years were studied under the same sowing date, density and N fertilisation in a complete randomised block design with 4 replications. In the second year 6 wheat cultivars from the first trial were selected and sown with wild oat (*Avena fatua*) sown at 80 plants/m^2. The wheat was sown at three densities, their recommended density (Table 1); 133% recommended density; and 166% recommended density. For this trial sowing date, crop density and N fertilisation were different for each cultivar and set as recommended for maximum yield (Table 1). Other management practices were kept similar for all cultivars. Biomass and grain yield of wheat and their respective weed biomass were measured and competitive index (CI) was calculated on the basis of the following equation:

$$CI = (V_i / V_{mean}) / (W_i / W_{mean})$$

Where Vi is the yield of each weed-infested cultivar, V_{mean} the mean wheat yield in all weed-free plots, W_i the biomass of wild oat in each weed-infested plot and W_{mean} the mean biomass of wild oat in all weed-infested plots.

Table 1. Cultivars, year of release, and their corresponding optimum density and nitrogen requirement used during the 1999 experiment.

Cultivars	N fertiliser recommended (kg/ha Urea)	Optimum density (seeds/m2)	Year of release
mid	110	300	1956
Bezostaya	220	410	1969
Azadi	220	325	1989
Ghods	220	325	1989
Alamot	250	350	1995
Alvand	250	350	1995

Results and discussion

The yield potential has increased during the last 50 years (Figure 1). These results agree with many studies that have been conducted to assess genetic improvement of winter wheat cultivars in other countries (Cox *et al*., 1988; Slafer *et al*., 1990; Slafer *et al*., 1991, and Abbate *et al*., 1998).

Higher yields may be obtained by increasing biomass, harvest index, or both.. In our trials grain yields have been increased mainly due to increased harvest index. There was a significant positive correlation between grain yield and harvest index (Table 2). These results are similar to other studies (Slafer *et al*., 1990 and 1991).

Table 2. Correlation coefficient of wheat grain yield with harvest index and crop biomass in the

	Grain yield (1998)	Grain yield (1999)
Harvest index	0.65*	0.92**
Crop biomass	0.25	0.64

1998 and 1999 experiments.

*, ** Significant at the 0.05 and 0.01 probability levels, respectively

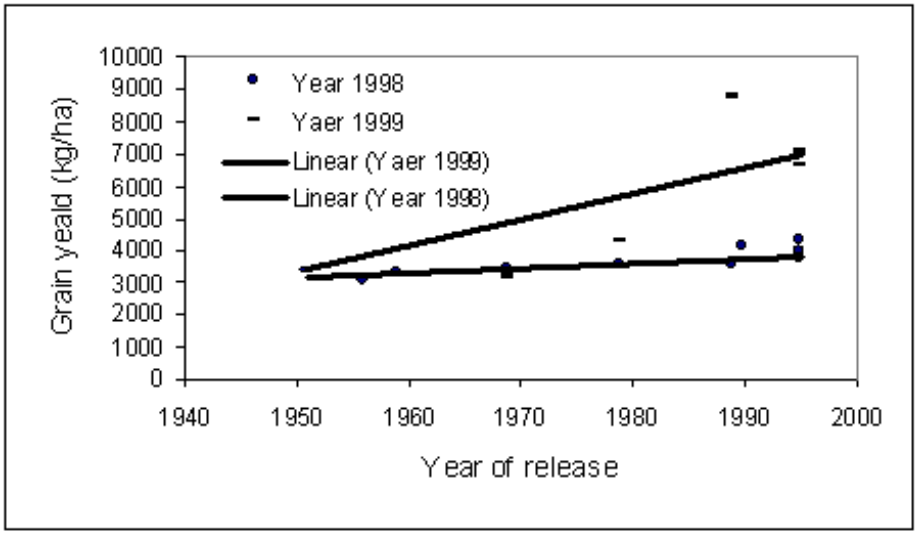

Figure 1. Grain yield of wheat cultivars released during the past 50 years

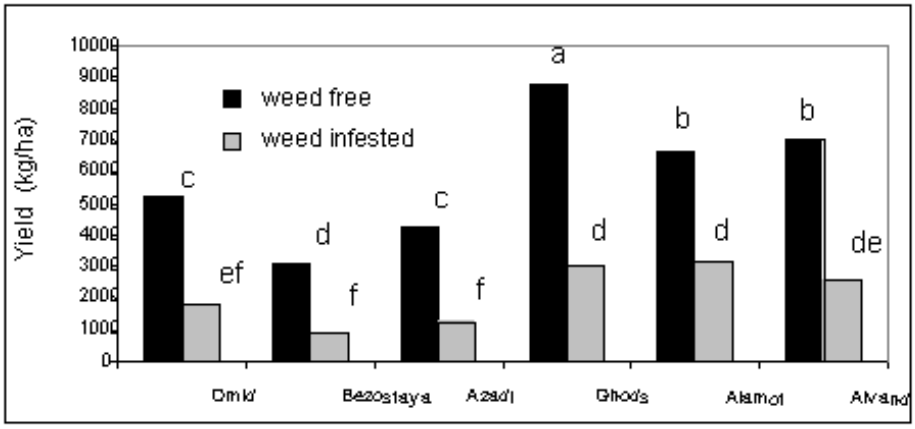

Figure 2. Grain yield of wheat cultivars with and without competition with wild oat.

New varieties yielded more than older varieties in 1999 but differences were negligible in 1998 (Figure 1).

In both weed-free and weed-infested conditions, new cultivars (Ghods, Alamot and Alvand) had greater grain yield compared to the older cultivars (Omid, Bezostaya and Azadi) (Figure 2). Tollenaar *et al*. (1997) reported the reduction in grain yield due to weed interference was 21% greater in new maize hybrids compared to older cultivars.

Grain yield of more recent cultivars was higher in weed-infested condition, while their corresponding weed dry matter was lower (Figure 3). New cultivars also had higher Competitive Index (Figure 4). Increase in the competitive index was mainly due to higher wheat grain yield and lower weed dry matter under weed-infested conditions.

In all cultivars grain yield decreased with increasing sowing density above the optimal level, but it was not statistically significant. It can be concluded that during the past 50 years Iranian wheat cultivars have been improved for higher grain yield and better inter-specific competition ability. Intra-specific competition ability of cultivars, however, has not undergone significant change.

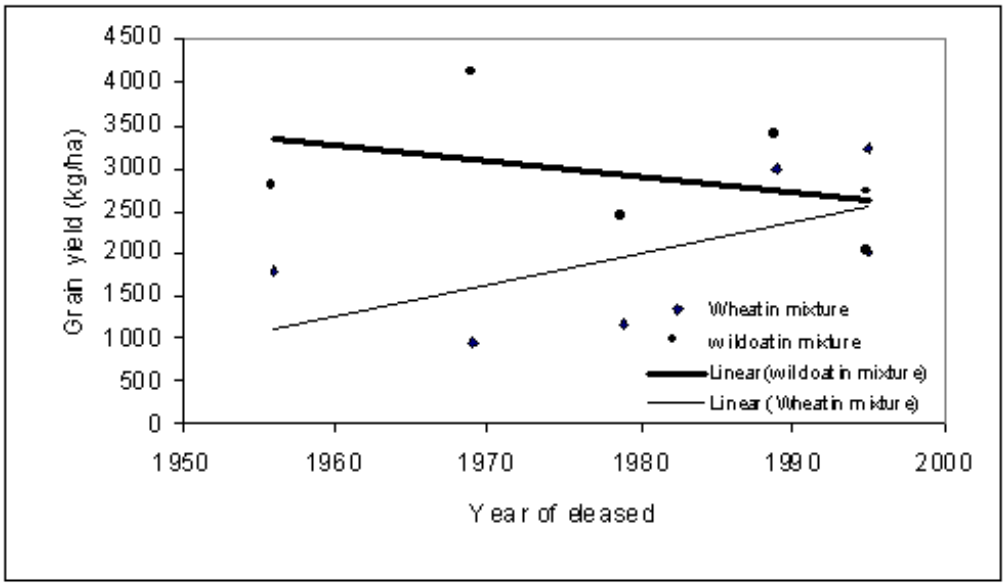

Figure 3. Grain yield of wheat cultivars released during the past 50 years and their respective wild oat biomass

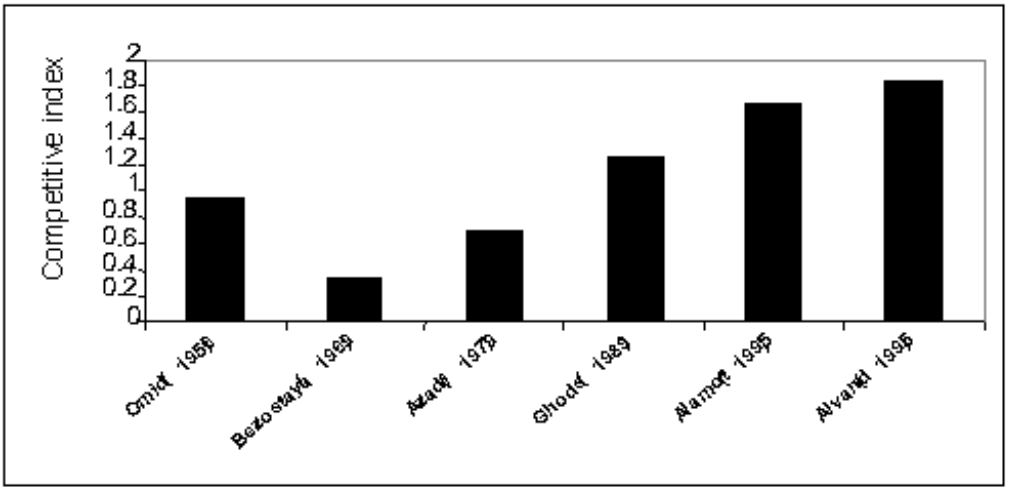

Figure 4. Competitive index of wheat cultivars released during the past 50 years.

References

Abbate, P. E., F. H. Andrade., L. Iazaro., Y. H. Bariffi., H. G. Beradocco., V. H. Inza, and F. Martura. 1998. Grain increase in recent Argentine wheat cultivars. Crop Sci. 38: 1203-1209.

Christensen, S. 1995. Weed suppressive ability of spring barley cultivars. Weed Res. 35: 241-247.

Cox, T. S., R. J. Shroyer., L. B. Hui., R. G. Sears, and T. J. Martin. 1988. Genetic improvement in agronomic traits of hard red winter wheat cultivars from 1919 to 1987. Crop Sci. 28: 756-760.

Hamblin, J., and J. G. Rowell. 1975. Breeding implications of the relationship between competitive ability and pure cultivars yield in self-pollinated grain crops. Euphytica 24: 221-228.

Kawano, k., H. Gonzalez, and M. Lucena. 1974. Intrasoecific competition with weeds, and spacing response in rice. Crop Sci. 14: 814-845.

Lemerle, D., G, S Gill., C. E. Murphy., S. R. Walker. R. D. Cousens. S. Mokhtari., S. J. Peltzer., R. Coleman and D. J. Luckett. 2001. Genetic improvement and agronomy for enhanced wheat competitiveness with weeds. Aust. J.Agric. Res. 2001. 52: 527-548.

Linquist, J. L., D. A. Mortensen, and B. E. Johnson. 1998. Mechanisms of corn tolerance and velvetleaf suppressive ability. Agron. J. 90: 787-79.

Ogg, A. G., S .S. Ssefeld. 1999. Characterizing traits that enhance the competitiveness of winter wheat (*Triticum aestivum*) against jointed goat grass (*Aegilops cylindrica*). Weed Science. 47: 74-80.

Slafer, G. A., F. H. Andrade, and S. E Fiengold. 1990. Genetic improvement of bread wheat (*Triticum aestivum*) in Argentina. Relationship between nitrogen and dry matter. Euphytica. 50: 63

Slafer, G. A., and F. M. Rade. 1991. Changes in physiological attributes of dry matter economy of bread wheat (*Triticum aestivum*) through genetic improvement of grain yield potential at different regions of the world. A review. Euphytica. 58: 37-49

Tollenaar. M., A. Aguilera, and S. P. Nissanka. 1997. Grain yield is reduced more by weed interference in an old than in a new maize hybrid. Agron . J. 89: 239-246

Wicks, G. A., P. T. Nordquist., G. E. Hanson, and J. W. Schmidt. 1994. Influence of winter wheat (*Triticum aestivum*) cultivars on weed control in sorghum (*Sorghum bicolor*). Weed Sci. 42: 27-34.