Tillage system and nitrogen affect weed populations in wheat (*Triticum aestivum*)

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Summary A field experiment was conducted to study changes in the populations of weeds in wheat (*Triticum aestivum* L.) crops under conservation (minimum tillage and no tillage) and conventional tillage systems, influenced by nitrogen rates. The evenness index, Shannon's H index, species richness, and weed biomass were all significantly (P <0.05) higher under the no tillage system than in the minimum and conventional tillage systems. With increasing nitrogen from 0 to 200 kg ha^{-1}, the evenness index, Shannon's H index, species richness and weed biomass decreased significantly (P <0.05). The application of nitrogen increased the competitive ability of wheat more than the associated weeds, particularly when the crop was grown under the no tillage system.

Keywords No tillage, minimum tillage, conventional tillage.

INTRODUCTION

Conservation tillage systems, as part of an ecological approach, have been developed in south of Iran in the last few years. These systems have often shown higher efficiency than conventional tillage in improving soil properties and crop yields. However, they often result in a change in weed species and populations, and consequently weed management practices. This is a major concern for farmers who prepare to adopt conservation tillage systems. A literature review on conservation tillage systems suggests that the vital factor in the success of conservation tillage approaches is weed control, which is highly depend on the application of herbicides, a practice that is not compatible with ecological weed management. Therefore, a proper understanding of weed population dynamics, under conventional and conservation tillage systems, is the first step towards the proper use of herbicides and in reducing the amount of herbicides applied so as to protect agroecosystems against chemical pollutants.

Any reduction in tillage intensity or frequency may pose serious concerns with regard to weed management practices. Weed species shifts (Buhler *et al*. 1994, Derksen *et al*. 1993) and loses in crop yields as a result of increased densities of weeds (Blackshaw *et al*. 2001) have been cited as major reasons why conservation tillage systems have not been widely adopted by growers.

Reports of weed species shifts, however, have been inconsistent. Cussans (1976), for example, reported an increase of some broad-leaved weeds accompanying increased levels of cultivation. In contrast, Wrucke and Arnold (1985) reported similar distribution patterns for broad-leaved weeds in both conservation and conventional tillage systems and Pollard *et al*. (1982) demonstrated that most weeds showed no consistent response to tillage systems. Swanton *et al*. (1999) found that tillage was an important factor influencing the composition of weeds population while Derksen *et al*. (1993) suggested that changes in weed communities were influenced more by environmental factors than by tillage systems. Finally, Childs *et al*. (2001) reported that tillage system do affect weeds species and in long-term, with small-seeded annual broadleaf weeds and perennial weeds becoming more dominant in no tillage fields.

Crop fertilisation, principally nitrogen, is another important crop production practice influencing weed communities in agroecosystems (DiTomaso 1995, Stevenson *et al*. 1997). There are numerous studies showing that weed emergence and growth in the field can be stimulated by nitrogen and the rate of application, e.g. see Blackshaw *et al*. (2004). It is likely that long term changes in the weed community in agroecosystems are influenced by many factors such as tillage practices, environmental factors, cultural practices and resources availability. There are no data on such weed community dynamics in conservation tillage systems in wheat cropping systems under different nitrogen rates in south of Iran. The aim of this study was to examine changes in weed populations under tillage systems as influenced by nitrogen rates.

MATERIALS AND METHODS

The experiment was carried out using a strip plot design with three replicates at Darab Faculty of Agriculture and Natural Resources, Shiraz University, Iran in the 2011–2012 growing season. The plot size was 6 m × 3 m. Treatments were a factorial combination of three tillage systems: conventional tillage (CT), minimum tillage (MT) and no tillage (NT) and five nitrogen levels: 0, 50, 100, 150 and 200 kg N ha^{-1} (as urea 46%). The nitrogen fertiliser was added to the experimental plots at three growing stages of the crop;

planting, stem elongation and ear emergence. Crop residues on the soil surface were 230 g m^{-2}. Winter wheat (*Triticum aestivum* L. cv. Chamran) was sown at 240 kg ha^{-1}.

Weed data were collected within five randomly selected 0.25 m^2 areas in each plot. The Simpson index (Simpson 1949), evenness index, Shannon's H index (Magurran 1988) and Species richness (Dorado and Lopez-Fando 2006) were determined by considering five quadrats per plot. To measure the biomass of weeds grown under tillage systems, shoots of weeds were collected from five locations in each plot using a 0.5 m × 0.5 m quadrat. The weed samples were then taken to the laboratory and oven dried at 70°C for 72 hours.

The effects of treatments, tillage system and nitrogen rate, on the variables were statistically analysed and tested by an analysis of variance (ANOVA). Comparisons among treatment means were made using the least significant difference (LSD) multiple range test calculated at $P < 0.05$. Statistical procedures were carried out with the software program SAS (1989).

RESULTS AND DISCUSSION

The results indicated significant differences in weed populations in both tillage systems and nitrogen rates.

The effect of tillage systems on weed population indices has been summarised in Table 1. Tillage systems affected the Simpson index significantly ($P < 0.05$). The highest Simpson index, across all nitrogen rates was found in the MT system whereas the lowest one was observed in the NT system. There was no significant difference between CT and MT systems for Simpson index. The evenness index was significantly ($P < 0.05$) higher in NT system than in other two tillage systems which were not significantly different (Table 1). The same results were found for the Shannon's H and Species richness indices. There was a tendency toward higher weed species diversity in no tillage system than conventional and minimum tillage systems. Our results are in agreement with other studies that reported greater weed diversity and density under NT than under CT systems, e.g. Blackshaw *et al*. (1994) and Bilalis *et al*. (2001).

The Simpson index increased significantly ($P < 0.05$) with increasing nitrogen from 0 to 200 kg ha^{-1} while the evenness index, Shannon's H index and Species richness decreased significantly ($P < 0.05$) (Table 2). Across all tillage systems, increasing nitrogen increased the growth and development of the crop more than weeds. Therefore, application of nitrogen fertiliser in conservation tillage systems may increase crop vigour thereby reducing weed density and competition.

Several studies have reported the positive influence of N fertiliser on weed species emergence and growth (Fawcett and Slife 1978, Peterson and Nalewaja 1992). However, Swanton *et al.* (1999) reported that in corn monoculture, nitrogen rates ranging from 0 to 200 kg N ha^{-1} had no effect on the weed density or species composition after 9 years of continual application.

Weed biomass in the NT system was significantly greater than other two tillage systems, and there was no significant differences between CT and MT systems (Figure 1). The ability of the crop for tillering and tillage practices could be the reason for lower weed density in CT and MT tillage systems. Our results showed the plants grown under CT and MT systems produced significantly more tillers than those plants grown under NT system (data not shown). Changes in the weed flora and weed density under minimum and no tillage systems have also been reported by other authors, e.g. Bilalis *et al*. 2001, Blackshaw *et al.* 1994, Anderson *et al*. 1998).

Table 1. Effects of tillage systems on weed population indices.

	Tillage systems		
Indices	CT	MT	NT
Simpson index	0.32a[A]	0.34a	0.16b
Evenness index	0.52b	0.51b	0.83a
Shannon's H index	1.01b	0.99b	1.56a
Species richness	3.24b	2.58c	7.7a

[A] Means in each row followed by the same letter are not different at $P < 0.05$.

Table 2. Effects of nitrogen on weed population indices.

	Nitrogen (kg ha^{-1})				
Indices	0	50	100	150	200
Simpson index	0.15e[A]	0.18d	0.21c	0.29b	0.52a
Evenness index	0.80a	0.74b	0.64c	0.50d	0.45e
Shannon's H index	1.51a	1.41b	1.22c	0.96d	0.83e
Species richness	7.50a	5.73b	4.27c	3.06d	2.06e

[A] Means in each row followed by the same letter are not different at $P < 0.05$.

Weed biomass significantly (P <0.05) decreased with increased nitrogen from 0 to 200 kg ha^{-1}, (Figure 2). It is postulated that under high rates of nitrogen, the crop was more competitive than the weeds. Having said this, it is well documented that the effects of nitrogen on weed competition can be affected by many factors such as time of application, placement of N fertiliser, and the rate of application, e.g. Blackshaw *et al*. (2004). Jornsgard *et al*. (1996), for instance, reported that weed biomass in barley and winter wheat could be increased, unchanged, or decreased with increased nitrogen application, depending on the weed and crop.

In conclusion, both tillage system and nitrogen rate affected on the weed population indices and weed biomass. The results showed greater weed species diversity in NT system compared to CT and MT systems. We also found that crops grown under the MT system with a high amount of nitrogen were able to suppress weeds more than those grown under CT and NT systems and that application of nitrogen fertiliser in all tillage systems reduced weed population and their biomass significantly (P <0.05) (data not shown).

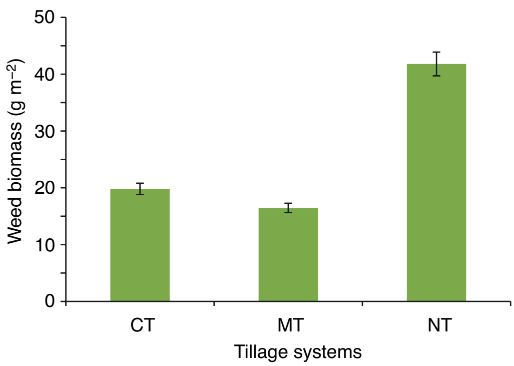

Figure 1. The effects of tillage systems on weed biomass across all nitrogen rates. Error bars show the standard error of the mean.

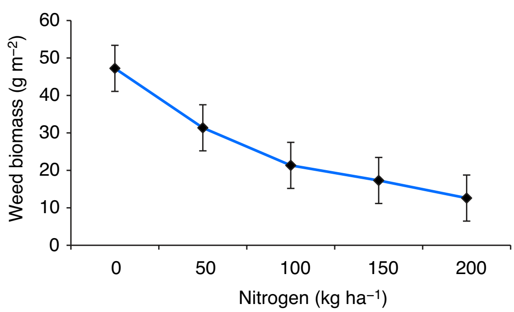

Figure 2. Effects of nitrogen on weeds biomass across all tillage systems. Error bars show the standard error of the mean.

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