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THE EFFECT OF CONVENTIONAL AND REDUCED TILLAGE SYSTEMS ON GRAIN YIELD AND WEED SPECIES DENSITY IN COMMON VETCH (*VICIA SATIVA* L.) PRODUCTION

SUMMARY

The presence of weed species and their densities in agricultural fields are influenced significantly by tillage and planting methods. This study determined the effects of tillage systems on grain yield and weed species density in common vetch production following the harvest of a prior crop of wheat (*Triticum aestivum* L.). We compared conventional [moldboard plough + cultivator (two times) + drill] and reduced [cultivator (two times) + drill] tillage treatments using a random block design with four replications. We identified 23 and 24 different weed species belonging to 11 and 10 different weed families in the reduced tillage and conventional tillage plots, respectively. The weed density ranged from 1 to 56 plants m^{-2}. The weed species that was present at the highest density was *Sinapis arvensis*. The effects of the tillage treatments on weed density differed among the weed species. *Sorghum halepense* had the highest density under the reduced tillage method, while the *S. arvensis* density increased under the conventional tillage treatment. The seed yield of common vetch was not affected significantly by the tillage methods.

Key words: Tillage systems, weed, common vetch

INTRODUCTION

Conservation and reduced tillage (RT) systems have gained widespread acceptance in many countries over the past 25 years due to savings in time and economic input and reductions in environmental pollution and soil degradation. Many studies have evaluated the applicability of conservation tillage technologies extensively (e.g., Gürsoy et al., 2014). Changes in tillage practices can affect weed population dynamics, including factors such as weed seed distribution and abundance in the soil seedbank (Mulugeta and Stoltenberg, 1997). Hatfield et al. (1998) reported that changing the tillage system alters the distribution and density of weed seeds in agricultural soils. Gürsoy and Özaslan (2014) reviewed research on conservation tillage and changes in weed communities and concluded that successful weed control in conservation tillage systems requires accurate weed identification. Conservation tillage systems

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caused shifts in weed populations from annual to perennial species; however, reports of shifts in weed species have been inconsistent. The weed density in both conservation and conventional tillage (CT) systems depends on the production system, soil, and climatic conditions. Conservation tillage systems influence weed populations in a different manner than CT systems. Gürsoy et al. (2014) compared three tillage treatments (moldboard plough + cultivator + drill as CT, cultivator + drill as RT, and no-till planting) and two planting times for lentil cultivation and found that the effect of the treatments on weed density differed among weed species. The highest total dry weight of weed biomass was produced using the no-till planting treatment, while the lowest was obtained under the RT treatment. The tillage system and planting time had significant effects on the lentil seed yield and increases in the weed biomass dry weight and volunteer wheat density resulted in decreased lentil yield. Thompson and Grime (1983) and Locke et al. (2002) reported that the effects of the tillage method and surface residue on weed dynamics appear to be complex and are controlled by interacting factors, including soil type, climate, weed species, quality and type of residue, allelopathy, and environmental conditions. Tuesca et al. (2001) reported that knowledge of the long-term effects of tillage on weed species will provide useful information to improve weed management in agro-ecosystems.

Therefore, this study determined the weed species density and seed yield of common vetch cultivated under conventional [moldboard plough + cultivator (two times) + drill] and reduced [cultivator (two times) + drill] tillage methods after harvest of a prior wheat crop in the South Eastern Anatolia region of Turkey.

MATERIAL AND METHODS

The experiment was carried out during the 2013–2014 growing season at the Research and Application Land, Faculty of Agriculture, University of Dicle, Diyarbakır, Turkey. The experimental station was located at 37º55'36"N 40º13'49"E, at 670 m above sea level. The climate of the region is characterized by a semi-arid climate (humid winters and dry summers) and the rainfall distribution is variable within and among years. The mean annual precipitation, based on the long-term average, is 491 mm, approximately 80% of which occurs from November to May. Monthly rainfall and temperature records during the study years and the long-term averages (15 years) are summarized in Figures 1 and 2, respectively (Diyarbakır Meteorological Station Records, 2013–2014).

The rainfall during the growing season was highest in February and was slightly below the long-term average in November, higher than the long-term average in May and June, and lower than long-term average in the remaining months. The average temperature was near or higher than the long-term average during the growing season, except in December.

The soil was classified as silty-clay and was covered with the residue of a previous wheat (*Triticum aestivum* L.) crop. The pre-crop wheat was harvested at a cutting height of 5–10 cm using a combine equipped with a chopper and the straw was transferred to a trailer during the harvest

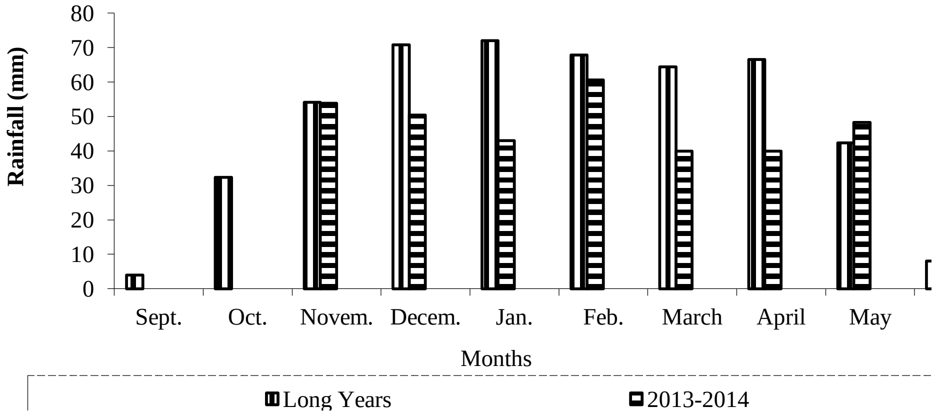

Figure 1. Long-term average monthly rainfall and monthly rainfall during the 2013–2014 growing season at Diyarbakir, Turkey.

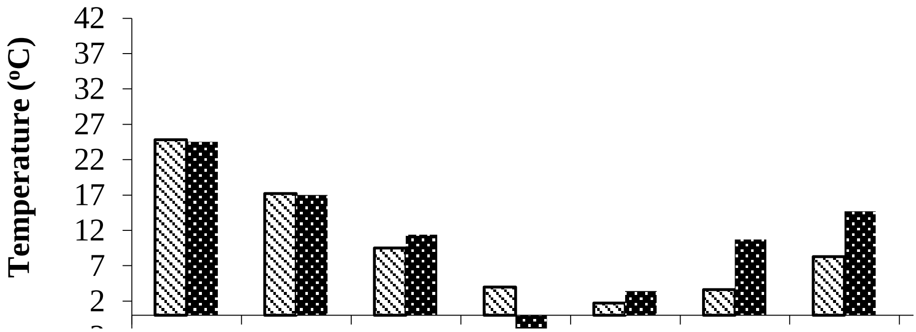

Figure 2. Long-term average monthly temperature and average monthly temperature during the 2013–2014 growing season at Diyarbakir, Turkey.

The field experiment was conducted after the wheat harvest. The experiment used a random block design with six replications to compare two tillage methods: moldboard plough + cultivator + drill representing a conventional tillage (CT) treatment and cultivator + drill serving representing a reduced tillage (RT) treatment. For the CT treatment, the plough was set at a depth of 15–20 cm and the field was ploughed 40 days after the wheat harvest, while for both the conventional and reduced tillage treatments, tillage with the cultivator was done at a depth of 8–10 cm 1 week before planting common vetch (*Vicia sativa* L.). The plot size was 100 m^2 (20 × 5 m). Seeds were planted using a universal seed drill at a density of 150 seeds m^{-2} in rows spaced 12 cm apart.

Planting was conducted on November 14, 2013. No fertilizer or herbicide compounds were applied to the experimental plots.

Weed densities by species were determined by counting weed species in a 1-m^2 sample area within each plot. Grain yield was measured by harvesting a 1-m^2 area from each plot and threshing by hand.

RESULTS AND DISCUSSION

The weed species identified in the experimental field are presented in Table 1.

Table 1. Weed species identified in the experimental field

Reduced Tillage Plots	**Conventional Tillage Plots**
Fam: APIACEAE (Umbelliferae)	**Fam: APIACEAE (Umbelliferae)**
Daucus carota L.	*Daucus carota* L.
Fam: ASTERACEAE (Compositae)	**Fam: ASTERACEAE (Compositae)**
Anthemis sp.	*Anthemis* sp.
Centaurea balsamita Lam.	*Centaurea balsamita* Lam.
Centaurea iberica Trevir ex Sprengel.	*Centaurea iberica* Trevir ex Sprengel.
Crepis alpina L.	*Cichorium intybus* L.
Crepis foetida L.	*Crepis alpina* L.
Lactuca saligna L.	*Crepis foetida* L.
Lactuca serriole L.	*Echinops orientalis* Trautv.
Notabasis syriaca (L.) Cass	*Lactuca serriole* L.
Sonchus asper (L.) Hill	*Notabasis syriaca* (L.) Cass
Tragopogon sp.	*Picnomon acarna* (L.) Cass.
Xanthium strumarium L.	*Sonchus asper* (L.) Hill
Fam:BRASSICACEAE (Cruciferae)	*Xanthium strumarium* L.
Sinapis arvensis L.	**Fam: BORAGINACEAE**
Fam: CONVOLVULACEAE	*Echiumitalicum* L.
Convolvulus arvensis L.	**Fam:BRASSICACEAE (Cruciferae)**
Fam: CUSCUTACEAE	*Sinapis arvensis* L.
Cuscuta sp.	**Fam: CONVOLVULACEAE**
Fam: EUPHORBIACEAE	*Convolvulus arvensis* L.
Euphorbia aleppica L.	*Convolvulus betonicifolius* Mill.
Fam: LAMIACEAE	**Fam: DIPSACACEAE**
Lallemantia iberica (Bieb.) Fisch. & Mey.	*Cephalaria syriaca* (L.) Schrad.
Fam: LEGUMINOSAE	**Fam: EUPHORBIACEAE**
Trifolium repens L.	*Euphorbia aleppica* L.
Fam: PAPAVERACEAE	**Fam: LAMIACEAE**
Fumaria asepale Boiss.	*Molucella laevis* L.
Fam: POACEAE	**Fam: POACEAE**
Avena sterilis L.	*Avena sterilis* L.
Sorghum halepense (L.) Pers.	*Cynodon dactylon* (L.) Pers.
Triticum sp.	*Triticum* sp.
Fam: RUBIACEAE	**Fam: POLYGONACEAE**
Galium tricornutum Dandy.	*Polygonum aviculare* L.

Statistical analysis for all variables was done by analysis of variance (ANOVA) and mean comparisons were made using Fisher's unprotected LSD at $P \leq 0.05$ (SAS software, 2002). Twenty-four weed species were identified in the experimental field, but the statistical analysis was performed only for the dominant weed species present in the experimental field. Before statistical analysis of the weed species density was performed, Bartlett's test was used to determine the homogeneity of variances. A square root (x + 0.5) transformation was deemed appropriate for the data with values less than 10 and with zeros present (Snedecor and Cochran, 1983).

The density of weed species ranged from 1 to 56 plants m^{-2}. The weed species present at the highest density in the experimental field was *Sinapis arvensis*. The effects of the RT and CT systems on the densities of the dominant weed species are shown in Table 2.

Table 2. The effects of reduced and conventional tillage methods on the densities of the dominant weed species in the experimental field.

Weed Species	**Weed density** (number m^{-2})			**F Ratio**
	Reduced tillage method	**Conventional tillage method**	**Mean**	
Sorghum halepense (L.) Pers.	13.05 a	0.00 b	6.53	8.936*
Centaurea balsamita Lam.	0.39	0.00	0.19	1.000^{ns}
Xanthium strumarium L.	0.66	0.39	0.52	0.077^{ns}
Crepis sp.	0.39	0.00	0.19	1.000^{ns}
Sinapis arvensis L.	2.52 b	29.76 a	16.14	16.589**
Lactuca serriola L.	0.39	0.00	0.19	1.000^{ns}
Euphorbia aleppica L.	3.00	1.50	2.25	0.330^{ns}
Trifolium repens L.	0.39	0.00	0.19	1.000^{ns}
Triticum sp.	0.00	1.89	0.95	2.444^{ns}
Convolvulus arvensis L.	0.00	1.76	0.88	0.248^{ns}
Anthemis sp.	0.00	0.39	0.19	1.000^{ns}
Cynodon dactylon (L.) Pers.	0.00	0.66	0.33	1.000^{ns}
Polygonum aviculare L.	0.00	0.39	0.19	1.000^{ns}
Total	245.07	302.36	273.72	2.145^{ns}

Weed density is expressed as square root (x + 0.5) transformed data. Values followed by the same or no letter(s) are not significantly different at the 5% level of the LSD test within a row for the tillage means. *, **, and ns indicate the statistical significance of the treatment effects using ANOVA at $P \leq 0.05$, $P \leq 0.01$, and not significant, respectively.

Based on analysis of variance (ANOVA), the effects of the tillage systems on *Sorghum halepense* (L.) Pers. and *Sinapis arvensis* L. density were significant, while no significant effect was observed on the densities of other weed species, including *Centaurea balsamita* Lam., *Xanthium strumarium* L., *Crepis* sp., *Sinapis arvensis* L., *Lactuca serriola* L., *Euphorbia aleppica* L., *Trifolium repens* L., *Triticum* sp., *Convolvulus arvensis* L., *Anthemis* sp., *Cynodon dactylon* (L.) Pers., and *Polygonum aviculare* L. While the *S. halepense* (L.) Pers. density was higher under the RT treatment than the CT treatment, the *S. arvensis L.* density was lower under the RT than the CT treatment. The effects of tillage system on weed population dynamics depend on species, location, and environment. The behavior of weeds and their interactions with crops grown under conservation tillage systems tends to be complex and not fully understood. Certain types of weed are more common under no-till conditions and may require special consideration. The extent and direction of shifts in weed species presence and density that result from conservation tillage practices depend on factors such as climate, crop species, and soil type (Thomas and Frick, 1993; Buhler, 1995; Gürsoy and Özaslan, 2014).

Gürsoy and Özaslan (2014) reported that conservation tillage systems caused shifts in weed populations from annual to perennial species; however, reports of weed species shifts have been inconsistent. Simple perennial species, such as dandelion and bromegrass, which reproduce only by seed, are usually killed by tillage and are therefore not a problem in CT systems. Other perennial species that reproduce vegetatively from buds on underground roots or rhizomes can survive tillage operations and are problems for conventional, reduced, and no-till systems. Gill and Arshad (1995) reported that RT systems often favor annual grasses and discourage annual dicotyledonous species. Gruber *et al.* (2012) found that perennial weeds, which often are typical species in RT systems, were present at lower density in non-inversion tillage systems than in inversion tillage systems.

Based on ANOVA, the seed yield of common vetch was not affected significantly by the tillage system used; however, RT resulted in higher seed yield (4278.53 kg ha^{-1}) than CT (3621.47 kg ha^{-1}). Sandoval-Avila *et al.* (1994), Pala *et al.* (2000), and Gürsoy *et al.* (2014) showed that legume yields did not differ significantly between CT and RT, while Camara *et al.* (2003) found that yield was significantly greater if a moldboard plow was used rather than a subsurface sweep and offset disk.

Table 3. The effect of reduced and conventional tillage methods on the seed yield of common vetch

Tillage method	Yield (kg ha^{-1})
Reduced tillage	4278.53 a
Conventional tillage	3621.47 a
F Ratio	4.0097^{ns}
C.V.	14.38

Values within a column for the tillage means followed by the same or no letter(s) are not significantly different at the 5% level of the LSD test; ns, no significant treatment effect with ANOVA; C.V., coefficient of variation.

CONCLUSION

Our results show that the effects of RT and CT methods on weed density varied with species. The RT treatment caused higher *S. halepense* (L.) Pers. density than the CT treatment, while the *S. arvensis* L. density was lower under RT than under CT. Although the seed yield of common vetch was not affected significantly by the RT or CT systems, RT resulted in higher seed yield (4278.53 kg ha^{-1}) than CT (3621.47 kg ha^{-1}). In conclusion, our findings suggest that the RT method (ducks-foot cultivator) can be used for legumes in the South-East Anatolia region of Turkey.

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