Research Article

Turk J Agric For
35 (2011) 235-245
© TÜBİTAK
doi:10.3906/tar-0908-363

Can triticale be used as a companion crop with red clover?

Zeki ACAR[1,*], Özlem ÖNAL AŞCI[2], Uğur BAŞARAN[3], İlknur AYAN[1], Hanife MUT[3]

[1]Ondokuz Mayıs University, Agriculture Faculty, Department of Agronomy, 55139 Kurupelit, Samsun - TURKEY

[2]Ordu University, Agriculture Faculty, Department of Agronomy, 52200 Ordu - TURKEY

[3]Bozok University, Agriculture Faculty, Department of Agronomy, Yozgat - TURKEY

Received: 28.08.2009

Abstract: The purpose of this research, carried out under irrigated conditions, was to determine the effects of sowing rate and harvest stage of triticale, used here as a companion plant, on hay yield of red clover and weed densities. The field studies, which were conducted as 2 separate experiments, continued over the 2004-2008 period. Each experiment continued for 3 years (Experiment I was carried out between 2004 and 2007, and Experiment II was carried out between 2005 and 2008). Red clover and triticale were sown together. Triticale was seeded at 200, 300, 500, and 650 seed m^{-2}. Plots were harvested when either a flag leaf appeared on the plant or the triticale reached the milk dough stage. In addition, pure red clover was sown as control plots and harvested at the 50% flowering stage. In both experiments, triticale increased hay yield in the establishment year. The degree of influence of triticale on weed species as a companion plant varied depending on weed density and species. *Matricaria* sp., *Sinapsis arvensis* L., and *Veronica* sp. were strongly influenced by the companion crop, and an apparent decrease was not noticed in the number of red clover seedlings. In cases where *Alopecurus myosuroides* Huds. and *Vicia* sp. densely existed, triticale was not very effective and correspondingly a greater decrease was observed in the number of red clover seedlings. The assessment of total yield obtained at the end of the experiment showed that the highest hay yield was realized at the milk dough stage with 500 or 650 seed m^{-2} of triticale.

Key words: Companion crop, red clover, triticale

Tritikale çayır üçgülü ile arkadaş bitki olarak kullanılabilir mi?

Özet: Bu araştırma; sulanan koşullarda, arkadaş bitki olarak kullanılan tritikalenin ekim oranı ve biçim zamanlarının çayır üçgülünün kuru ot verimi ile yabancı ot yoğunluğuna etkisini belirlemek amacıyla yürütülmüştür. Tarla çalışmaları iki ayrı deneme olarak 2004 - 2008 yılları arasında yürütülmüştür. Her deneme 3 yıl devam etmiştir (Deneme I, 2004-2007; Deneme II, 2005-2008 yılları arasında devam etmiştir). Çayır üçgülü, tritikale ile birlikte ekilmiştir. Tritikale 200, 350, 500 ve 650 tohum m^{-2} olacak şekilde ekilmiştir. Parseller tritikalede bayrak yaprağı görüldüğünde ve tritikale süt olum döneminde iken ot için hasat edilmiştir. Ayrıca kontrol amacıyla çayır üçgülü saf olarak ekilmiş ve %50 çiçeklenme döneminde hasat edilmiştir. Tesis yılında her iki denemede de tritikale elde edilen verimi artırmıştır. Tritikalenin yabancı otlara olan etkisi, yabancı ot türüne ve sayısına bağlı olarak değişmiştir. *Matricaria* sp., *Sinapis arvensis* L. ve *Veronica* sp., tritikale tarafından etkili bir şekilde baskılanmış ve çayır üçgülünde çok fazla seyrelme meydana gelmemiştir. Yabancı ot olarak *Alopecurus myosuroides* Huds. ve *Vicia* sp.'nin yoğun olarak bulunduğu yerlerde ise, tritikale yabancı otları yeterince baskılayamamış ve çayır üçgülünde daha fazla seyrelme olmuştur. Denemenin sonunda elde edilen toplam ot verimi değerlendirildiğinde, en yüksek kuru ot verimi, m^2'de 500 veya 650 adet tritikale tohumu olacak şekilde karışık ekilen ve tritikale süt olum döneminde iken hasat edilen parsellerden elde edilmiştir.

Anahtar sözcükler: Arkadaş bitki, çayır üçgülü, tritikale

* E-mail: zekiacar@omu.edu.tr

Introduction

Under optimum moisture conditions, a perennial legume forage crop generally produces 50%-60% of a normal yield during the seeding year (Miller 1984). Additionally, weeds and erosion are problems in the newly sown forage crops (Tan et al. 2004). During the initial growth of the forage in the sowing year, weed content and density may be reduced by the presence of a companion crop (Lanini et al. 1991; Simmons et al. 1995; Spandl et al. 1999). However, companion crops can also compete with young forage seedlings for nutrients, light and moisture, and may reduce the yield and persistence of perennial forages. Dense or lodged companion crops can interfere with forage plants, resulting in sparse stands (Tan et al. 2004).

Several strategies have been implemented to minimize competition by cereal companion crops, including the manipulation of row spacing, row orientation, sowing rate and selecting species that are not strong competitors (Chastain and Grabe 1988). Triticale plants have lower tiller when compared with barley (Taşyürek et al. 1999) and triticale plants are taller than barley (Mut et al. 2004). Comparative trials involving various cultivars have shown that the biomass yield potential of triticale is similar to, or greater than, other cereals. Triticale produces at least 20% more forage than wheat, and is higher in forage quality than rye or wheat (Koch and Paisley 2004). Triticale can be sown as a companion crop due to the above-mentioned characteristics. Currently, there are no sowing rate guidelines for triticale as a companion crop with red clover in Turkey.

The purposes of this study were to suppress weeds and increase hay yield without resorting to herbicides in red clover. Therefore, our objective was to determine the influence of the sowing rate and harvest stage of triticale as a companion crop on red clover yield, weed growth, and red clover and weed density.

Materials and methods

The study was conducted in 2 separate experiments between 2004 and 2008. Each experiment was conducted for 3 years. The first experiment (Experiment I) was established in November 2004 and continued until 2007. Another experiment (Experiment II) was established in November 2005 and continued until 2008. They were conducted at the Ondokuz Mayıs University Agronomy Experiment Farm in Samsun (41°21′N, 36°15′E, 195 m), Turkey.

Veronica sp., *Sinapis arvensis* L., and *Matricaria* sp. existed dominantly in the establishment year of Experiment I, while *Vicia* sp. and *Alopecurus myosuroides* Huds. were the dominant species during the study in Experiment II.

Mean monthly temperature and total precipitation are shown in Figures 1 and 2, respectively.

The experiments were conducted in a clay soil with a pH of 6.9 and 7.4, available P_2O_5 contents were 131 kg P_2O_5 ha^{-1} and 213 kg P_2O_5 ha^{-1}, K_2O was 300 and 319 kg ha^{-1} and organic matter content were 2.9% and 3.2% in Experiments I and II, respectively.

When available water in the soil decreased to 50% of the field capacity, plots were irrigated up to field capacity (Comaklı 1991). Then about 500 t ha^{-1} of water was given per irrigation.

Red clover (*Trifolium pratense* L.) cv. Start was sown at 25 kg ha^{-1} with a 35 cm row space. Red clover was sown alone as a control and harvested at the 50% flowering stage. Also, red clover was sown with triticale (*Triticosecale Wittmack)* cv. Tatlıcak - 97. Triticale, used here as a companion crop, was sown between the red clover rows, at 4 sowing rates (200, 350, 500, and 650 pure lived seed m^{-2}) (Mut et al. 2004; Mut et al. 2005) and harvested at 2 different growth stages (flag-leaf appearance [FL] and milk-dough [MD] stage) (Brink and Marten 1986; Sulc et al. 1993; Tan and Serin 2004). Each experiment was arranged as randomized complete plots with 3 replicates. In total, there were 27 plots in each experiment. Individual plots were $2.1 \times 4 = 8.4$ m^2 in size.

Fertilizers were only applied in the establishment year of each experiment. Phosphorus was incorporated into the seedbed before planting for each experiment at 50 and 20 kg P_2O_5 ha^{-1} in the autumn. N and K were broadcast in the early spring of the establishment year of each experiment; 150 and 100 kg K_2O ha^{-1} was applied in Experiments I and II, respectively, and 25 and 20 kg N ha^{-1} for each experiment was broadcast in the pure sown red clover plot. In the red clover + companion crop plots, 40 and 30 kg N ha^{-1} was applied.

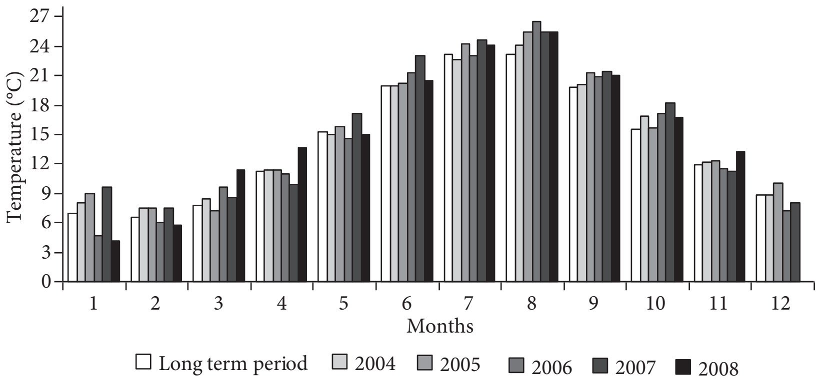

Figure 1. Temperature values for individual experimental years and over the long term.

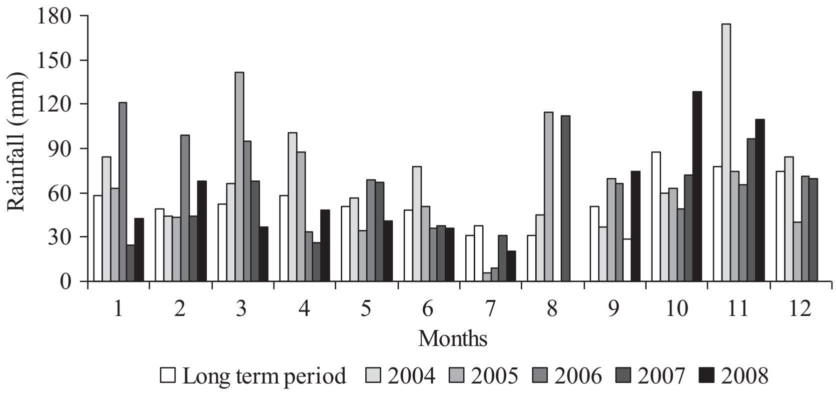

Figure 2. Rainfall values for individual experimental years and over the long term.

In the establishment year of each experiment, harvesting was performed at different dates depending on the developmental stage of the companion crop (triticale) and red clover. When red clover was sown with triticale, the plots were harvested at 2 different growth stages of triticale (FL and MD). The plots, which had previously been harvested at FL, were cut 3 times. However, plots that had previously been harvested at the MD stage were cut twice. Pure sown plots (used here as controls) were cut 3 times as well.

In the second year of Experiment I, the red clover was harvested 4 times. The first harvest was done earlier when the red clover reached the 10% flowering stage because of rust disease (*Uromyces trifolii-repentis*) and powdery mildew (*Erysiphe polygoni*). The second and third harvests were done at the 50% flowering stage. The last harvest was performed at the end of fall to avoid winter damage. In the second year of Experiment II, the red clover was harvested twice when it reached the 50% flowering stage.

In the third year of each experiment, the red clover was harvested 2 times when the red clover reached the 50% flowering stage. After the second harvest in 2007 (the second year of Experiment II and the third year of Experiment I) and 2008 (the third year of Experiment II), the red clover (C_3 plant) failed to show regrowth at harvest maturity due to excessive hot weather, though C_4 weeds flourished such as *Echinocloa crus-galli* (L.) P. Beauv., *Setaria* sp., *Amaranthus* sp., and *Chenepodium* sp. (Hakansson 2003), as they inhabit hot, dry environments and have very high water-use efficiency so that there can be up to twice as much photosynthesis per gram of water than for C_3 plants. In order to prevent weed-seed spreading, the plots were cut above 10 cm without determining yield.

Forage yields were obtained from an area of 4.2 m^2 (1.4 × 3 m). A 500 g hay subsample was taken from each harvested plot and dried at 70 °C for 48 h in an oven. Fresh and dry weights were used to calculate yields. The biomass of triticale, weeds and red clover in the total herbage material were determined after sorting the samples, and then drying and weighing them.

Red clover and weed densities were determined from randomly selected 1 m^2 quadrats in each plot at the harvest time for triticale in the establishment year and in the early spring of the second and third year of each experiment. Weed density was divided by broadleaf and grass weeds by type, and the floristic composition of the weeds was determined as described by Lanini et al. (1991).

Statistical analysis

The harvest time for the companion crop was evaluated separately. Data were analyzed using one-way ANOVA in a completely randomized design: $\hat{Y}_{ij} = \mu + a_i + e_{ij}$, where $\hat{Y}_{ij}$ is observation values (hay yield, weed density), μ is the overall mean, α_i is the effect of the ith treatment (sowing rates), and e_{ij} = residual error. The means were ranked according to Duncan's multiple range test. Results from the sowing rate of companion crop treatments 1 through 5 were analyzed as an orthogonal polynomial. Linear, quadratic and cubic effects were determined by orthogonal polynomial contrasts (Cankaya and Kayaalp 2003). All the computational work was performed by means of SPSS 10.0 V (SPSS 10.0 V. 1999).

Results

Establishment year

The first harvest yields in the establishment year of each experiment increased with the addition of the triticale, used as a companion crop, to red clover. A large increase in yield was observed at the higher triticale seeding rate (650 seed m^{-2}) compared to the plots without triticale (approximately 4 t ha^{-1}). Hay yield increased as the sowing rate of triticale increased as well, but this increase was not the same for each sowing rate of triticale (Figure 3). Therefore, in both experiments, the linear ($P \leq 0.01$) and quadratic ($P \leq 0.05$) effects of the sowing rate of the companion crop (except when harvested at the MD stage in Experiment I) were significant. Higher herbage yields were obtained from the triticale harvested at the MD stage in both experiments.

In Experiment I, the highest tiller number was recorded in plots with 500 seed m^{-2} and harvested at the FL stages, thus the lowest weed density and biomass occurred in these plots. The tiller number of triticale increased, depending on decreasing the sowing rate in mixture plots harvested at the MD stage (Figure 4). *Vicia* sp. densities, having a higher biomass, remained when the sowing rate of triticale increased from 500 to 650 seed m^{-2}. In Experiment II, the number of broadleaf weeds generally declined by increasing the companion crop density in both

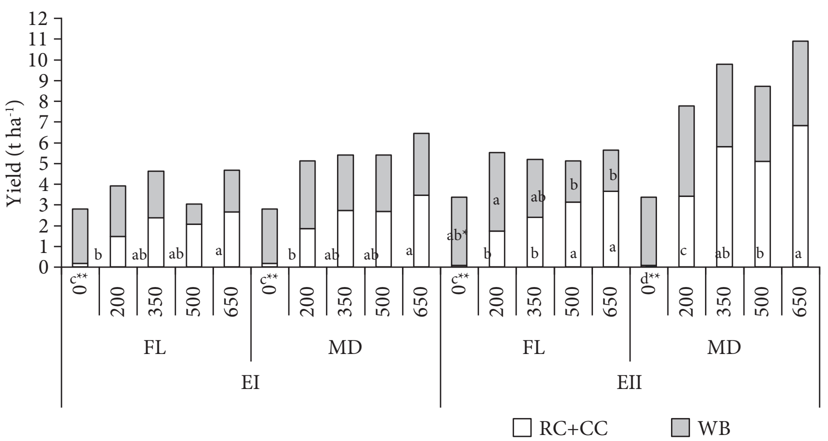

Figure 3. Hay yields (RC+CC) and weed biomass (WB) with regard to triticale seeding rate and harvesting stage (FL/MD) in the establishment year (First harvest). RC: Red clover, CC: Companion crop, WB: Weed biomass, FL: Flag leaf, MD: Milk dough, EI: Experiment I, EII: Experiment II. *,**: Significant $P \leq 0.05$ and $P \leq 0.01$, respectively.

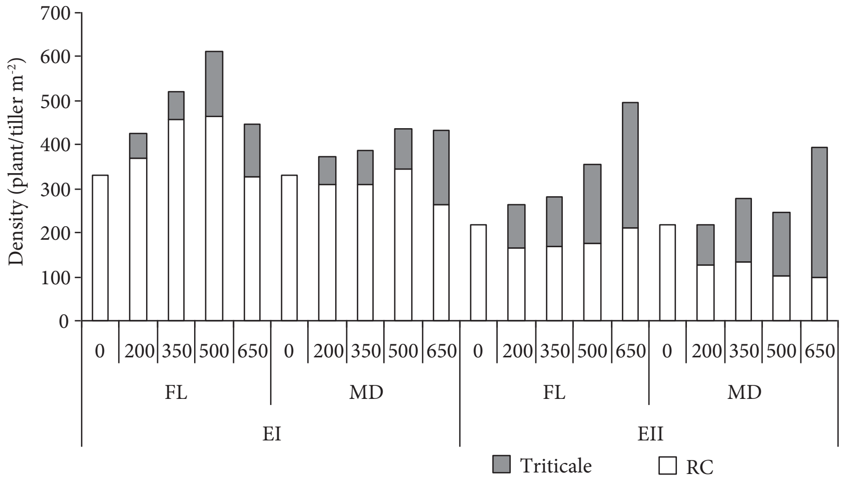

Figure 4. RC and CC densities with regard to triticale seeding rate and harvesting stage (FL/MD) in the establishment year (first harvest). RC: Red clover, CC: Companion crop, FL: Flag leaf, MD: Milk dough, EI: Experiment I, EII: Experiment II.

harvest stages, and thus weed biomass decreased as well (Figures 3 and 5). In contrast, *Rumex* sp., which existed in the only plots where red clover was sown with triticale at a rate of 650 seed m^{-2}, caused an increase in weed biomass. However, weed biomass in the control plots decreased overall (Figure 3).

The maximum dry matter yield of red clover in the establishment year was obtained from the plots sown with triticale (at a sowing rate of 650 seed m^{-2}) harvested at the MD stage in Experiment I. Likewise, the highest dry matter yield of red clover was noted in the same plots, but harvested at the FL stage in Experiment II (Figure 6).

It was determined that broadleaf weed density was the lowest in the control plot in Experiment I. However, in Experiment II, the highest number of broadleaf weeds was recorded in the control plots. It was also determined that broadleaf weed density generally declined as the sowing rate increased (Figure 5). Triticale inhibited some weeds such as *Sinapis arvensis* L., *Matricaria* sp., *Echinocloa crus-galli* (L.) P. Beauv., and *Setaria* sp. Moreover, in both experiments, the number of red clover plants greatly decreased in the harvests performed at the MD stage.

Second year

The hay yields of red clover at the both harvest stage of the companion crop in the first harvest of Experiment II were not affected by the sowing rate of the companion crop, but hay yields were statistically influenced ($P \leq 0.05$) when the companion crop was harvested at the MD stage in Experiment I. The highest hay yield was obtained from plots sown with triticale (650 seed m^{-2}) at the MD stage in Experiment I. Pure sown red clover plots gave the maximum hay yields in Experiment II (Figure 7).

Weed density significantly decreased in the second year of Experiment I (Figure 8). It was noticed at both harvest times that triticale decreased the intensive weed composition for weeds such as *Sinapis arvensis* L. and *Matricaria* sp.

In Experiment I, the red clover hay yield for the second harvest of the second year was not affected by the companion crop (Figure 7).

In Experiment I, the highest hay yield was obtained from plots sown with triticale (650 seed m^{-2}). However in Experiment II, the highest hay yield was obtained from pure-sown red clover plots (Figure 7).

Third year

It was determined that the sowing rate of the companion crop had no statistical effect on most of the measured characteristics in Experiment II. However, the hay yield for red clover was influenced by the sowing rate of triticale at the FL

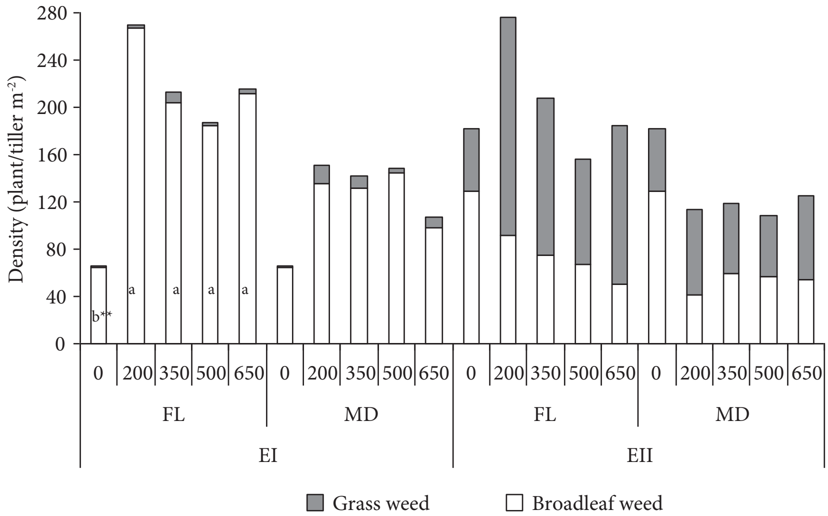

Figure 5. Broadleaf and grass weed densities with regard to triticale seeding rate and harvest stage (FL/MD) in the establishment year (first harvest). FL: Flag leaf, MD: Milk dough, EI: Experiment I, EII: Experiment II. **: Significant P ≤ 0.01.

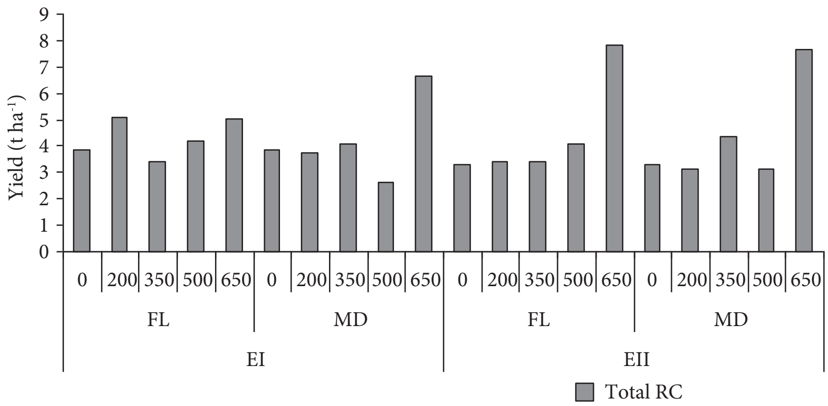

Figure 6. Total hay yield of RC with regard to triticale seeding rate and harvest stage (FL/MD) in the establishment year. RC: Red clover, FL: Flag leaf, MD: Milk dough, EI: Experiment I, EII: Experiment II.

stage of the first harvest. In addition, grass weeds were negatively affected as well. In Experiment I, the highest hay yield of red clover was obtained from plots sown with triticale (200 seed m^{-2}) and harvested at the FL stage. At the same time, in the first harvest, weed density was also very low (Figure 9). In Experiment II, the weed population decreased in the plots with triticale compared to those plots pure sown with red clover (Figure 10), though the weed composition varied. This change caused higher weed biomass. In conclusion, in Experiment II, the highest hay yield for red clover was obtained from the pure red clover stands in the third year as well (Figure 10).

Regarding total hay yield at the end of the 3-year study, a yield increase (about 10.00 t ha^{-1}) was recorded when compared to pure sown plots where triticale was sown (650 seed m^{-2}) and harvested at the MD stage in both experiments (Figure 11).

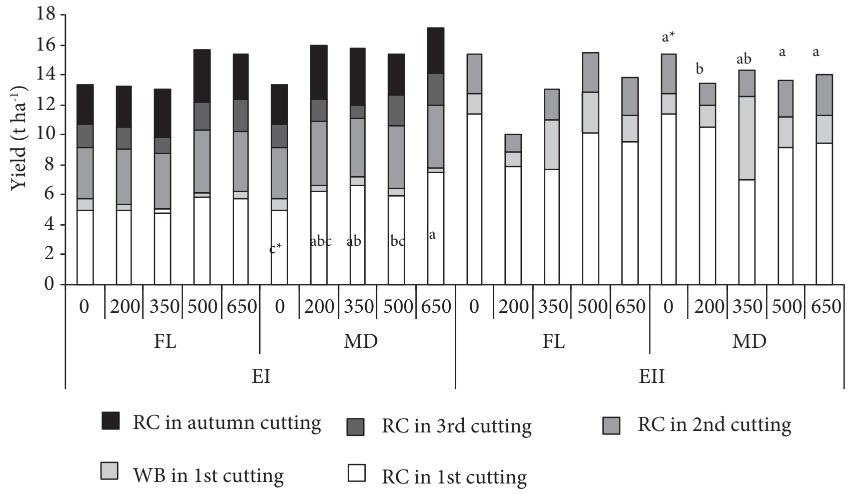

Figure 7. Hay yield of RC and weed biomass with regard to triticale seeding rate and harvest stage (FL/MD) in the subsequent year. RC: Red clover, WB: Weed biomass, FL: Flag leaf, MD: Milk dough, EI: Experiment I, EII: Experiment II. *: Significant $P \leq 0.05$.

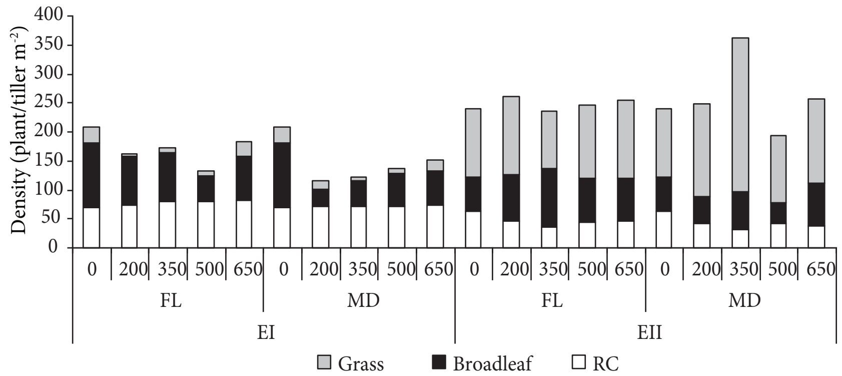

Figure 8. RC, broadleaf and grass weed densities with regard to triticale seeding rate and harvest stage (FL/MD) in the spring of the subsequent year. RC: Red clover, FL: Flag leaf, MD: Milk dough, EI: Experiment I, EII: Experiment II.

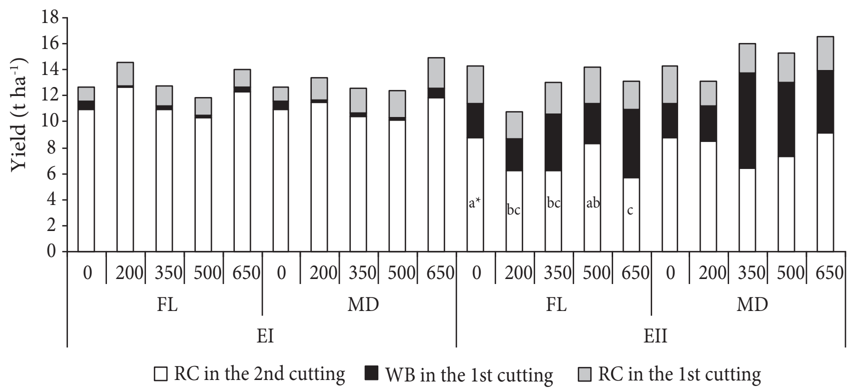

Figure 9. Hay yield of RC and weed biomass with regard to triticale sowing rate and harvest stage (FL/MD) in the third year. RC: Red clover, WB: Weed biomass, FL: Flag leaf, MD: Milk dough, EI: Experiment I, EII: Experiment II. *: Significant $P \leq 0.05$.

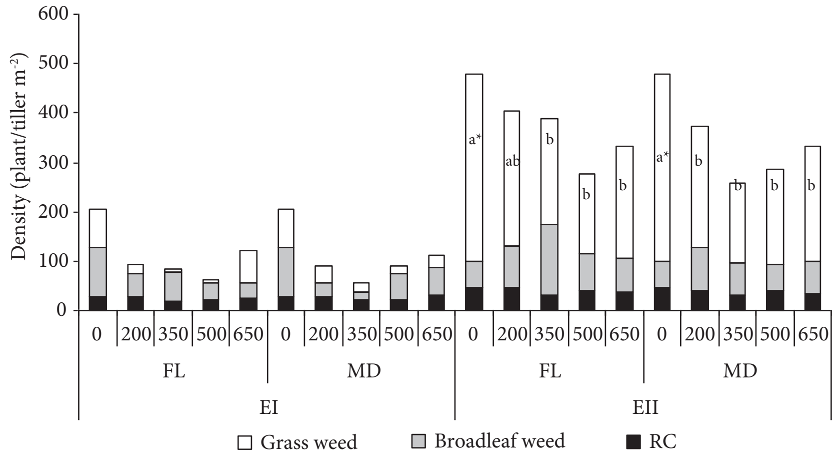

Figure 10. RC, broadleaf and grass weed densities with regard to triticale seeding rate and harvest stage (FL/MD) in the spring of the third year. RC: Red clover, FL: Flag leaf, MD: Milk dough, EI: Experiment I, EII: Experiment II. *,**: Significant P ≤ 0.05 and P ≤ 0.01, respectively.

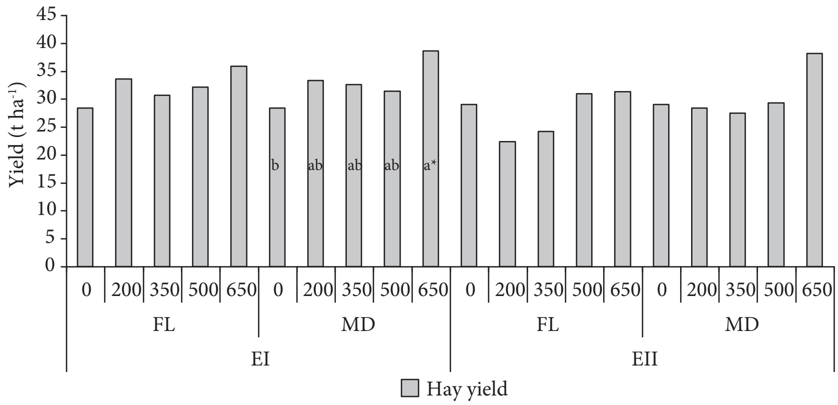

Figure 11. Total hay yield (RC+CC) obtained during the study with regard to triticale seeding rate and harvest stage (FL/MD). RC: Red clover, CC: Companion crop, FL: Flag leaf, MD: Milk dough, EI: Experiment I, EII: Experiment II. *: Significant P ≤ 0.05.

Discussion

Establishment year

The first harvest yields in the establishment year increased with the addition of triticale to red clover similar to those reported by Simmons et al. (1995). A significant increase in hay yield was observed at the higher triticale seeding rate (650 seed m^{-2}) compared to the plots established without triticale. These results are supported by Latta and Blacklow (2001), Tan and Serin (2004), Tan et al. (2004), and Tan and Erkovan (2004). Higher herbage yields were obtained from the triticale harvested at the MD stage in both experiments. The dry matter yield of small grain crops increases with maturation through the dough stage of maturity (Cherney and Marten 1982). As an annual plant, triticale grows rapidly and it produces more biomass. Unlike annual plants, red clover is a perennial plant, and thus it grows very slow during the establishment year (Tan and Serin 2004; Tan et al. 2004; Tan and Erkovan 2004).

Both yield and weed biomass were higher in Experiment II than in Experiment I. It was rainy and cooler in the vegetation period of 2005-2006 (especially in March and April) compared to the vegetation period of 2004-2005 (Figures 1 and 2). These conditions were more convenient for growing both triticale and weeds, which naturally caused biomass increases in Experiment II.

When weeds were at higher densities, the hay yield for red clover in the second harvest was lower in the plots harvested at the MD stage of triticale. At this stage, both the triticale and the weeds remained for a longer time in the plots. Therefore, the red clover was exposed for a longer time to competitive resistance from the weeds and triticale. Other studies have revealed that companion crops can also compete with forage seedlings for light, moisture and nutrients (Brede and Brede 1988; Chastain and Grabe 1988; Tan and Serin 2004). To reduce competition, early harvesting may be recommended (Miller and Stritzke 1995). The hay yield of red clover in the establishment year of each experiment at both harvest stages was not affected by the sowing rate of triticale. This finding is supported by Gibson et al. (2008).

Because of the later harvests, some weeds spread their seeds, and so the weed biomass declined in the control plants at the MD stage. *Veronica* sp., one of the dominant weeds, had already disappeared as it completed its life cycle by the time the control plots were harvested. Thus, the control plots had the lowest weed density in Experiment I.

In Experiment II, the number of red clover decreased when red clover was sown with triticale; however, this decrease was not significant. Blaser et al. (2006) reported a similar decrease in their research.

In both experiments, the amount of red clover greatly decreased in harvests performed at the MD stage. It is possible that late harvesting influenced the amount of red clover since harvesting at the MD stage were done 35 days later than harvests done at the FL stage. During this time, the red clover seedlings were strongly affected by the fast growing triticale and weeds.

Second year

In Experiment II, as the sowing rate of triticale increased, red clover density decreased, and hence the hay yield was lower in the plots sown with triticale than in the control plots. Weed biomass was not affected by the sowing rate of triticale. In Experiment I, triticale was effective against weeds and it relatively inhibited weed growth in the establishment year. Also, the suppression effect of triticale lasted into the second year, though this was dependent on different sowing rates and harvest stages. Similar results were not observed in Experiment II because weed species and density in Experiment II were different from Experiment I. The reduction in weed density and growth during establishment probably reduced weed seed production and in turn the weed population in the second year (Lanini et al. 1991).

In Experiment II *Vicia* sp. and *Alopecurus myosuroides* Huds. were intensively present in the first year. Triticale was not effective at suppressing both species, and this caused an increase in weed buried seed reserves in the area of Experiment II. In the same way, it has been noted that a weed's buried seed reserve could affect weed density (Moonen and Barberi 2004). In the intensive weed areas, even triticale became competitive with red clover (Sheaffer et al. 1988; Lanini et al. 1991).

In the second year of Experiment I, the first harvest was done earlier when the red clover reached the 10% flowering stage because of rust disease (*Uromyces trifolii-repentis*) and powdery mildew (*Erysiphe polygoni*). Thus, the first harvest yield in the second year was higher in Experiment II than in Experiment I.

As a result of red clover and triticale competition in the dense plots, the number of red clover decreased, and in consequence the inadequate number of red clover plants could not suppress the weeds in the second year. Ultimately, the weeds had a better chance of growing. In contrast, in the second harvest of the second year, no strong effect from triticale was recorded on the hay yield of red clover. As the red clover seedlings grew strongly, the weeds were unable to find a chance to spread.

Considering the second year, it has been mentioned in numerous studies that forage yields are not affected by companion crops when red clover is sown with barley (Tan and Serin 1998; Chastain and Grabe 1988; Jefferson et al. 2000). Furthermore, triticale can inhibit weed growth owing to its allelopathic effect. Dhima et al. (2006) reported that triticale decreased *Echinochloa crus-galli* (L.) P. Beauv. and *Setaria verticillata* (L.) P. Beauv. growth.

Average hay yields in Experiment II were lower than in Experiment I. This was probably caused by weak red clover seedlings in the establishment year, resulting in sparse stands and a lower harvest.

Third year

In Experiment II the number of weeds decreased in the plots sown with triticale compared to the pure-sown red clover plots. Surprisingly, weed composition changed. For example, *Sonchus* arvensis L. and *Rumex crispus*, perennial plants with rhizomes that can rapidly colonize by vegetative reproduction and high mass, showed an increase in the third year. This resulted in a higher weed proportion for the total hay yield (Figure 9). Spandl et al. (1999) reported that establishing forage mixtures with an oat companion greatly reduced weed content in the sowing year, but resulted in greater dandelion density in the third year of the stand.

Conclusion

The results of this study indicate that triticale increased the total hay yield in the establishment year and inhibited weeds. The competitiveness of triticale, as a companion crop, varied depending on weed species and densities. Triticale competed effectively against *Matricaria* sp., *Sinapis arvensis* L., and *Veronica* sp. Thus, triticale could be recommended at the sowing rate of 500 or 650 seed m^{-2} and harvested at the MD stage as a companion crop to decrease weeds and, correspondingly, increase hay yields.

Acknowledgement

This study was supported by the OMU Scientific Committee.

References

Blaser BC, Gibson LR, Singer JW, Jannink J-L (2006) Optimizing seeding rates for winter cereal grains and frost-seeded red clover intercrops. Agron J 98: 1041-1049.

Brede AD, Brede JL (1988) Establishment clipping of tall fescue and companion annual ryegrass. Agron J 80: 27-30.

Brink GE, Marten GC (1986) Barley vs. oat companion crop. II. Influence on alfalfa persistence and yield. Crop Sci 26: 1060-1067.

Cankaya S, Kayaalp GT (2003) Orthogonal decomposition and an application. Journal Agriculture Faculty of Çukurova University 18: 93-100. (In Turkish with English abstract).

Chastain TG, Grabe DF (1988) Establishment of red fescue seed crops with cereal companion crops. I. Morphological responses. Crop Sci 28: 308-312.

Cherney JH, Marten GC (1982) Small grain crop forage potential: II. interrelationships among biological, chemical, morphological and anatomical determinants of quality. Crop Sci 22: 240-245.

Comaklı B (1991) A study on the effects of different row spacings, irrigation levels and phosphorus doses on the hay and crude protein yield and crude protein rate of the hay of red clover (*Trifolium pratense* L.). In: The Second Forage Congress, (Ed. Avcıoğlu R) 28-31 May 1991, İzmir, Ege University Press. Pp. 449–460. (In Turkish with English abstract)

Dhima KV, Vasilakoglou IB, Eleftherohorinos IG, Lithourgidis AS (2006) Allelopathic potential of winter cereals and their cover crop mulch effect on grass weed suppression and corn development. Crop Sci 46: 345-352.

Gibson LR, Singer JW, Vos RJ, Blaser BC (2008) Optimum stand density of spring triticale for grain yield and alfalfa establishment. Agron J 100: 911-916.

Hakansson, S (2003) Weeds and Weed Management on Arable Land. An Ecological Approach. CABI Publishing, Oxon, UK.

Jefferson PG, Coulman BE, Kielly GA (2000) Establishment of irrigated timothy for forage production in Saskatchewan. Agron J 92: 1291-1293.

Koch DW, Paisley S (2004) Cereal crops - management for supplemental and emergency forage. http://www.uwyo.edu/ces/PUBS/B-1122.4.htm. (12.10.2004)

Lanini WT, Orloff SB, Vargas N, Orr JP, Marble VL, Grattan SR (1991) Oat companion crop seeding rate effect on alfalfa establishment, yield, and weed control. Agron J 83: 330-333.

Latta RA, Blacklow LJ (2001) Reducing the cost of lucerne establishment in Western Australia. In: Proceedings of the 10th Australian Agronomy Conference, (Ed. B Rowe) Hobart, 2001. Australia.

Miller DA (1984) Forage Crops. McGraw-Hill Book Company, USA.

Miller DA, Stritzke JF (1995) Forage establishment and weed management. (Eds. RF Barnes, DA Miller, CJ Nelson) Forages Vol. I: An introduction to grassland agriculture. Ames, Iowa, USA, Iowa State University Press. pp. 89-104.

Moonen AC, Barberi P (2004) Size and composition of the weed seedbank after 7 years of different cover crop- maize management systems. Weed Res 44: 163-177.

Mut Z, Sezer I, Gulumser A (2004) A research on yield, yield components and some quality characteristics of triticale, wheat, barley and rye. Journal of the Faculty of Agriculture Ondokuz Mayıs University 19: 1-8. (In Turkish with English abstract).

Mut Z, Sezer I, Gulumser A (2005) Effect of different sowing rates and nitrogen levels on grain yield, yield components and some quality traits of triticale. Asian J Plant Sci 4: 533-539.

Sheaffer CC, Barnes DK, Marten GC (1988) Companion crop vs. solo seeding: Effect on alfalfa seeding year forage and N needs. J Prod Agric 1: 270-274.

Simmons SR, Sheaffer CC, Rasmusson DC, Stuthman DD, Nickel SE (1995) Alfalfa establishment with barley and oat companion crops differing in stature. Agron J 87: 268-272.

Spandl E, Kells JJ, Hestarman OB (1999) Weed invasion in new stand of alfalfa seeded with perennial forage grasses and an oat companion crop. Crop Sci 39: 1120-1124.

SPSS Inc (1999) SPSS for Windows. Release 10.0 Copyright SPSS Inc., Chicago, USA.

Sulc RM, Albrecht KA, Casler MD (1993) Ryegrass companion crop for alfalfa establishment: I. Forage yield and alfalfa suppression. Agron J 85: 67-74.

Tan M, Erkovan HI (2004) Using a companion crop of barley to improve white clover production in the highlands of Turkey. New Zealand J Agricultural Research 47: 219-224.

Tan M, Serin Y (1998) Determination of suitable companion crop and its cutting stage for alfalfa. Journal of the Faculty of Agriculture of Atatürk University 29: 219-229. (In Turkish with English abstract).

Tan M, Serin Y (2004) Is the companion crop harmless to alfalfa establishment in the highlands of east Anatolia? J Agronomy and Crop Sci 190: 1-5.

Tan M, Serin Y, Erkovan HI (2004) Effects of barley as a companion crop on the hay yield and plant density of red clover and the botanical composition of hay. Turk J Agric For 28: 35-41.

Taşyürek T, Gökmen S, Temirkaynak V, Sakin MA (1999) A study on yield and yield components of wheat, barley and triticale in Sivas-Şarkışla ecological conditions. Cereal Symposium. pp: 616-620, Konya, Turkey. (In Turkish with English abstract).