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PEA COMPANION CROP FOR RED CLOVER ESTABLISHMENT

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ABSTRACT

This study was conducted under irrigated conditions to determine the effects of seeding rate and harvest stage of pea (*Pisum sativum ssp. arvense* L. Poir), which was used here as a companion crop, on the hay yield, red clover (*Trifolium pratense* L.) densities and weed densities. Field studies were conducted as two separate experiments between 2004-2008. Red clover was sown together with pea at the rate of 20, 40, 60 and 80 seed m^{-2}. Plots were cut either at the 50% flowering stage for pea or when 70% of pea pods reached at typical lenght. Also, red clover was sown alone as a control and harvested at 50 % flowering stage. In the establishment year, companion crop had increasing effect on hay yield. Regarding total yield at the end of the 3 years, it is suggested that red clover was able to sown with pea at the seeding rate of 40 or 60 seed m^{-2} and it was harvested at 70% of pea pods reached typical lenght.

Keywords: Competititon, companion crop, pea, red clover, hay yield, weed

INTRODUCTION

Ground water in the large part of Çarşamba and Bafra plains, which are the most important cultivated area in the North part of Turkey, rises up from September to March. Red clover (*Trifolium pratense* L.) is less affected by ground water compared to alfalfa, hence, it is one of the most essential forage in these areas. In as much as sowing area of tobacco (*Nicotiana tabacum* L.) in the region has alleviated gradually as a result of its policy, red clover can grow easily at shallow and sloping field where tobacco was sown previously. Moreover, red clover has a light compensation point at 6 % of daylight (Taylor and Smith, 1995). This advantage makes red clover an excellent small seeded legume to Northern part of Turkey which has low light compensation and short daylight period.

An important objective in perennial forage production systems is the maintenance of high yield and productivity throughout several years. An appropriate plant population obtained with the inital planting is one of the most important steps for productivity (Tan *et al*., 2004). Even though a companion crop is an annual crop growing quickly enough to compete with weeds and providing a return in the establishment year (Tan and Serin, 2004), they compete with forage seedlings for light, water and nutrients as well (Brede and Brede, 1988; Chastain and Grabe, 1988; Tan and Serin, 2004). Some strategies such as seeding rate, harvest stage and using different species have been implemented to minimize competition by companion crop. Residues and extracts of pea plants suppressed the growth and population of several plant species (Schenk and Werner, 1991), indicating that pea may have chemicals involved in allelopathy.

This was the first study that red clover had been sown with pea as a companion crop in the North part of Turkey. Our objective was to determine the influence of pea sowing rate and harvest time on red clover yield and weed growth.

MATERIALS AND METHODS

The experimental area

Field experiments were conducted under irrigation conditions between 2004 and 2008. Sowings were repeated over 2 years in the fall of 2004 (Exp. I) and 2005 (Exp. II) at The University of Ondokuz Mayis Research Station, Samsun, located in the Black Sea coast of Turkey (41°21´ N 36°15´ E, 195 m). Exp. I was conducted in 2004-2007, Exp. II was conducted between 2005-2008. According to State Meteorology Department, long-term period (1974-2007) total annual precipitation was 670.2 mm per year, annual mean temperature was 14.2 °C. The distribution of precipitation was uneven, with more than 75 % of annual rainfall occurring from September to April (Figure 1).

Soil characteristics of the experiment areas were determined by the Rowell (1996) method. Soil pH values in saturation extracts were 6.86 in Experiment I and 7.35 in Experiment II, and EC values were 0.468 and 0.533 mmhos cm^{-1} (low) in the same saturation extracts. Soil textures were clay, organic matter was medium (2.93% and 3.23%), extractable P by 0.5N $NaHCO_3$ extraction was 22.8 and 37.2 mg kg^{-1} (high), respectively and exchangeable K by 1N ammoniumacetate extraction was between 100 and 132.6 mg kg^{-1} (low).

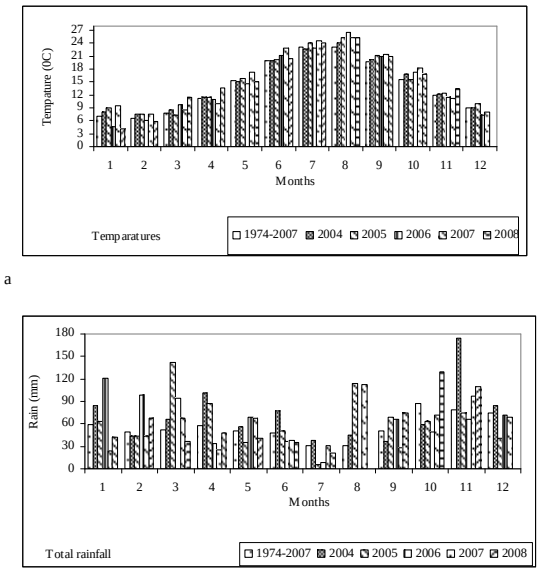

Figure 1. Climatic diagram of Samsun (a) monthly temperature, (b) monthly precipitation

Plots were irrigated when available water in the soil reached 50% (Comaklı, 1991) except in June and August in 2007 and 2008, because amount of water highly decreased in the long standing irrigation pond of the university campus in June and August in 2007 and 2008 due to severe drought (Figure 1). Although, it was recorded as 111.8 mm rainfall in August, 2008; 87.9 mm of the rainfall in this month occurred in 4 or 5 h.

Veronica sp., *Sinapis arvensis* L., and *Matricaria* sp. were dominant in the first year of Exp. I. There were *Vicia* sp. and *Alopecurus myosuroides* Huds. as dominant weeds during the establisment of Exp. II.

Experimental design and treatments

Red clover (*Trifolium pratense* L.) cv. Start was sown at 25 kg ha^{-1} with 35 cm row spacing either alone or in binary mixtures with pea (*Pisum sativum ssp. arvense* L. Poir) cv. Kirazlı (semi-leafless).

Pea as a companion crop was sown between the red clover rows, at 4 sowing rates (20, 40, 60 and 80 pure lived seed m^{-2}) (Carr *et al.*, 2004) and harvested at two growth stages [50 % flowering (F) or podding (P) (70% of pods have typical size) stages for hay] (Koivisto *et al.*, 2008) and also, red clover was sown alone as a control. Each study was arranged as a randomized complete plot design with three replicates. So there were 27 plots in each study.

Phosphorus fertilizer was applied in autumn of establishment year at 50 and 20 kg P_2O_5 ha^{-1} in Exp. I and Exp. II, respectively. N and K fertilizers in Exp. I and Exp. II were applied in early spring of establishment year at 25 and 20 kg N ha^{-1}, 150 and 100 kg K_2O ha^{-1}, respectively (Horuz 2004, 2005, personal commucination).

In the establishment year, binary mixtures were harvested when the companion crop had reached the 50% flowering (F) or podding (P) stages. Red clover seedlings were too young when pea plants were 50% flowering stage (at the begining of May), thus, the plots were harvested from top of red clover. They were cut three times after pea harvest. Both companion crop and red clover were harvested when pea was podding stage (at the beginning of June), this time red clover was vegetatif stage, the plots were cut twice after companion crop harvest. Pure sown plots (control) were cut three times (The first harvest was done at 65-70 % flowering stage, the others was done at 35-40 % flowering stage).

In the second year (in 2006 for Exp. I and in 2007 for Exp. II), plots were harvested four times for Exp. I and twice for Exp. II. In Exp. I, first cut was made when the red clover reached at 10% flowering stage because of rust disease (*Uromyces trifolii-repentis*) and powdery mildew (*Erysiphe polygoni*), second and third cuts were made at 50% flowering stage, and it was harvested at the end of fall (fourth cut). In Exp. II plots were harvested when the red clover reached at 50% flowering stage.

Both experiments were cut twice when red clover reached at 50% flowering stage in the third year (in 2007 for Exp. I and in 2008 for Exp. II). After second cut in 2007 for Exp. I and 2008 for Exp. II, red clover was not able to grow at harvest maturity due to excessive hot weather and severe drought, but C_4 weeds such as *Echinocloa crus-galli* (L.) P. Beauv, *Setaria* sp., *Amaranthus* sp., *Chenepodium* sp. (Hakansson, 2003), which inhabit hot, dry environments, have very high water-use efficiency, so that there can be up to twice as much photosynthesis per gram of water as in C_3 plants (Anon, 2010a), flourished. In order to prevent weed-seed spreading, cleaning cut was done above 10 cm without determining yield.

Forage yields were determined by cutting an area of 4.2 m^{-2} (1.4 by 3 m). A 500 g hay subsample was taken by hand from each plot and weighed fresh and after drying at 70 ^{o}C for 48 h. Fresh and dry weights were used to calculate yields on a dry matter basis. The mass of pea, weeds and red clover in the total herbage material were determined after sorting the samples, drying and weighing.

Red clover and weed densities were determined from randomly selected 1 m^2 quadrats in each plot at the harvest time of pea in the establishment year and at the early spring of the subsequent years. Weed contents were calculated as the broadleaves, grasses and noted species (Lanini *et al.*, 1991). Red clover and broadleaved weeds were counted as plant in square meter, grass weeds were counted as tiller in square meter, too (Hoy *et al.*, 2002).

Statistical analysis

Harvest time of companion crop was evaluated separately. Data except number of pea plants in per m^2 were analyzed using One-way ANOVA in a completely randomized design. DUNCAN Multiple Range Test was then utilized to separate the differences. Results from sowing rate treatments 1 through 5 were analyzed as 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

First harvest yields in the establishment year increased with the addition of the pea companion crop to red clover ($p \leq 0.01$). The linear effect of the sowing rate of companion crop in Exp. I was significant ($p \leq 0.01$) and the linear and quadratic effects of the sowing rate of companion crop in Exp. II were also significant ($p \leq 0.01$, $p \leq 0.05$ respectively). A large increase in forage yield was observed at higher pea seeding rates (60 and 80 seed m^{-2}) compared with the plots without pea (Table 1). Maximum hay yield (6.6 t ha^{-1}) was obtained in the plot where red clover was sown with 80 seed pea m^{-2} and harvested at podding stage of pea (Table 1).

Weed mass was less in the plots harvested at 50% flowering stage of companion crop thanks to early harvested plots (at the begining of May) (Table 1). It was observed that *Veronica* sp. and *Sinapis arvensis* L. were at full flowering, *Vicia* species were at the bud stage when pea was at 50% flowering stage. Because the other weeds were the same height as red clover, either they were not cut or a few parts of them were removed. A great amount of weed mass in this time was formed *Sinapis arvensis* L. in Exp. I and *Vicia* sp. in Exp. II.

Although companion crop seeding rate did not affect total hay yield of red clover in the first year, hay yield of red clover increased (approximately 1.5 t ha^{-1}) when pea used (data not shown).

When pea sowing rate increased, pea density increased, but, number of plant in m^2 was approximately half of number of sown seed. Companion crop density affected red clover density significantly ($P \leq 0.05$ and $P \leq 0.01$) in Exp. II owing to great many of weeds. Number of red clover decreased in plots harvested at podding stage than flowering stage. In Exp. II, red clover plants became less frequent in plots (Figure 2).

It was determined that weed density generally reduce increasing with companion crop seeding rate (Figure 3). In both experiments, broadleaves weeds minimized at the highest companion crop density. *Matricaria* sp., *Vicia* sp. and *Legousia* sp. decreased with increased seeding rate of pea.

Table 1. Hay yields (RC+CC) and weed mass with regard to companion crop seeding rates and cutting stages (F/P) in the establishment year (First cutting)

Properties	Exp.	Companion crop					
		Cutting Stage	Sowing rate (seed m^{-2})				
			0	20	40	60	80
Hay yields (t ha^{-1})	E1	F**	0. 16d	0.81c	1.12bc	1.26ab	1.58a
		P**	0. 16c	0.77c	2.63b	4.58a	4.55a
	E2	F**	0.07d	1.21c	3.07b	2.97b	4.04a
		P**	0.07d	3.67c	4.85bc	6.3ab	6.62a
Weed mass (t ha^{-1})	E1	F**	2.65a	0.16b	0.27b	0.07b	0.49b
		P	2.65	2.73	2.46	2.22	3.55
	E2	F	3.3	2.97	2.13	3.41	1.33
		P*	3.3c	8.12a	6.78ab	5.41bc	6.51ab

F: Flowering, P: Podding, E1: Experiment 1, E2: Experiment 2.
*,** There are no differences among the seeding rates shown the same letter in the same experiment and same stage $p \leq 0.05$ and $p \leq 0.01$; respectively.

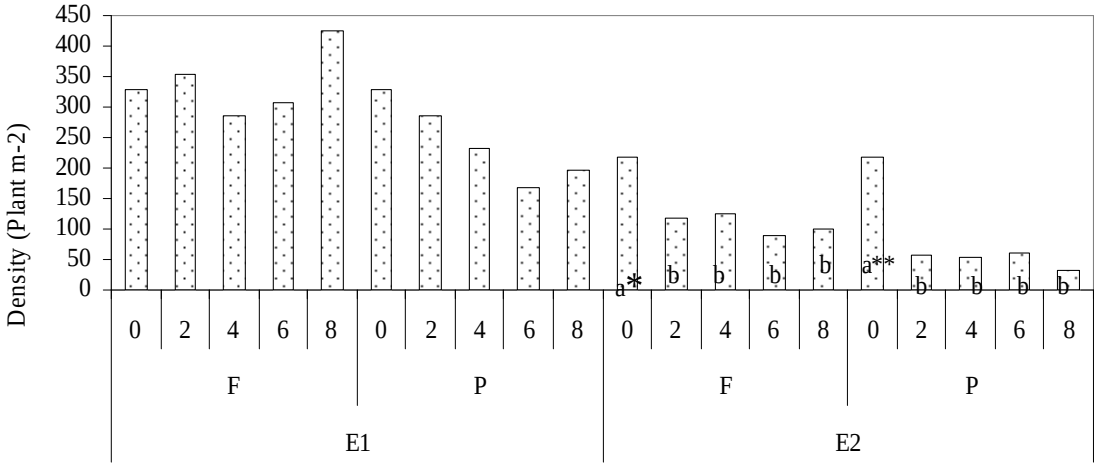

Figure 2. Red clover densities with regard to companion crop seeding rates and cutting stages in the establishment year (First cutting)
*,** There are no differences among the seeding rates shown the same letter in the same experiment and same stage $p \leq 0.05$ and $p \leq 0.01$; respectively.

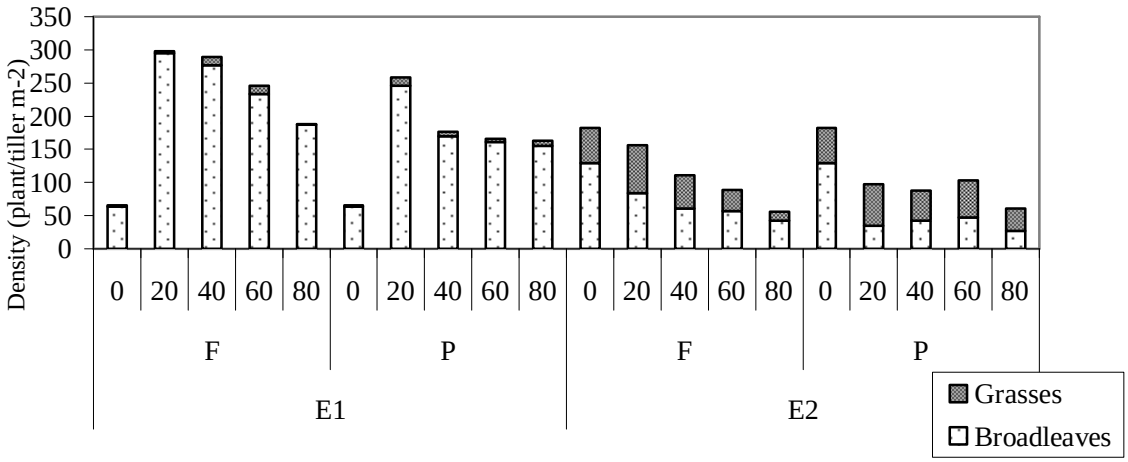

Figure 3. Broadleaves and grasses weed densities with regard to companion crop seeding rates and cutting stages in the establishment year (First cutting)

Second year

While the highest total hay yield of red clover in the second year was obtained the plot in which red clover had been sown with 20 pea seed m^{-2} and harvested at podding stage of pea in Exp. I (in 2006), it was obtained from control plot in Exp. II (in 2007) (Figure 4).

As weed species and density were different in the experiment fields, the effects of the pea on the hay yield and weeds were different. Though pea competed against *Sinapis arvensis* L., *Matricaria* sp. and *Alopecurus myosuroides* Huds., it did not suppress *Vicia* sp. in the establishment year. If weed presents intensively, companion crop affect adversely forage growth. Red clover density significantly decreased both establishment year and second year of Exp. II (Table 2), *Vicia* sp., and *Alopecurus myosuroides* Huds. were the dominant weed species present after seeding, when pea sowing rate increased. Therefore, both grasses and broadleaves weeds density, and weed mass generally increased, and red clover yield decreased in pea used plots compared to control plot in the second year of Exp. II (Figure 2 and 5).

Third year

Unlike Exp. I (in 2007), when red clover was sown with pea as a companion crop, hay yield was generally lower and weed mass was higher compared with the control plot in Exp. II (in 2008) (Figure 6). Grass weeds decreased, still, broadleaves increased when companion crop used in Exp. II. Number of red clover decreased increasing with pea seeding rate (Figure 7).

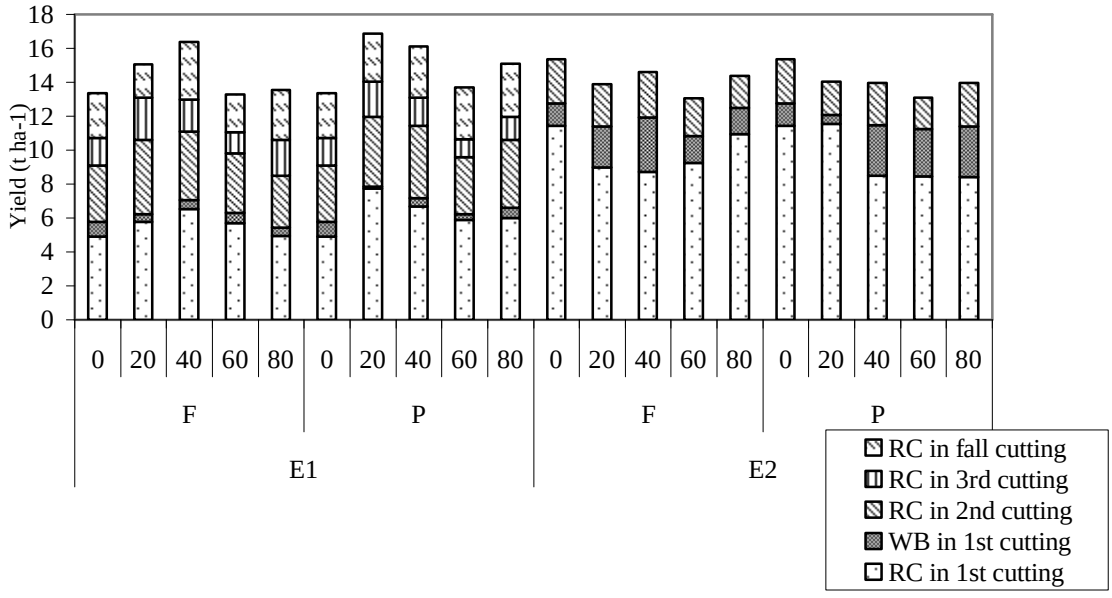

Figure 4. Hay yield of red clover and weed mass with regard to companion crop seeding rate and cutting stage (F/P) in the subsequent year

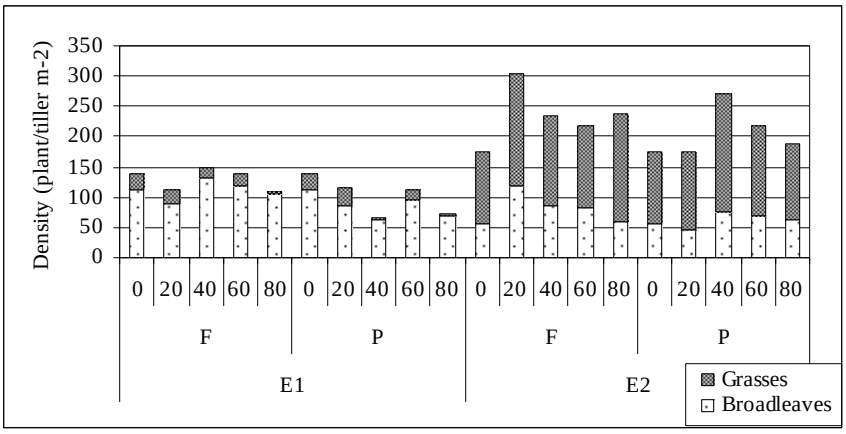

Figure 5. Broadleaves and grasses weed densities with regard to companion crop seeding rates and cutting stages in the spring of subsequent year

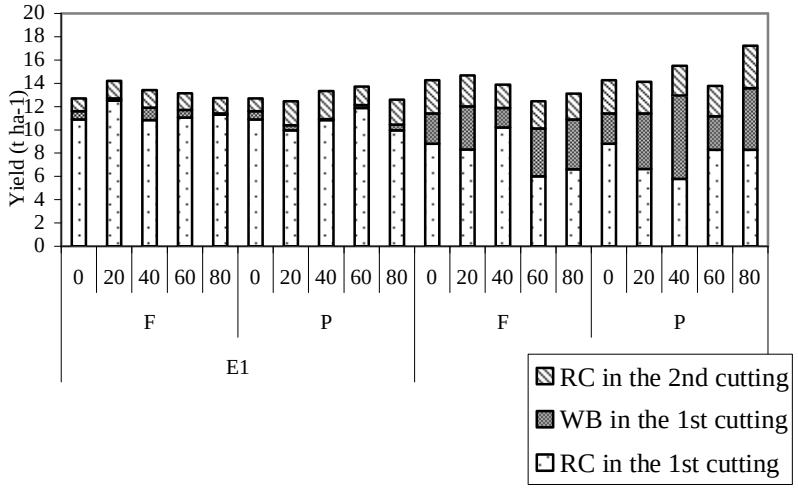

Figure 6. Hay yield of red clover and weed mass with regard to companion crop seeding rates and cutting stages in the third year

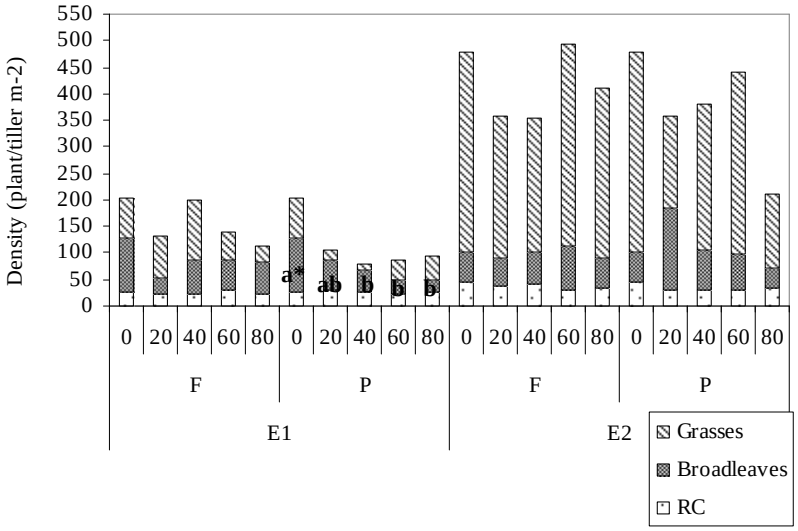

Figure 7. Red clover, broadleaves and grasses weed densities with regard to companion seeding rates and cutting stages in the spring of the third year. * There are no differences among the seeding rates shown the same letter $p \leq 0.05$.

In both experiments, total hay yield as a sum of three years was increased when red clover was sown with pea compared to control plot (Table 3).

Table 3. Total hay yield (RC+CC) obtained during the study with regard to companion crop seeding rates and cutting stages (t ha^{-1})

Exp.	Companion crop					
	Cutting Stage	Sowing rate (seed m^{-2})				
		0	20	40	60	80
E1	F	28.37	33.39	34.78	30.27	32.82
	P**	28.37b	32.42ab	37.00a	36.16a	36.68a
E2	F	28.99	27.09	31.79	26.52	30.06
	P	28.99	30.95	29.21	30.09	33.97

** There are no differences among the seeding rates shown the same letter $p \leq 0.01$.

DISCUSSION

Establishment year

First harvest yields in the establishment year were increased with the addition of the pea companion crop to red clover (Table 1). Some researchers found that total yield was highest from sowing red clover into the wheat + peas (Vrzal *et al*., 2001) or the oat + peas (Wiersma *et al*., 1999) companion crop. In close agreement with previous studies (Åmand and Graham 1987; Mustafa and Seguin 2004; Borreani *et al*., 2007), higher herbage yields were obtained from the pea harvested at the podding stage in both experiments. In this study, a large increase in forage yield was observed at the higher pea seeding rates (60 and 80 seed m^{-2}) compared with the control plots as reported by Koivisto *et al.* (2008).

Weed mass in the first harvest reduced as the planting density of pea was increased in both experiments, but, this reduction was not linearly (Table 1). It was similar to Lanini *et al.* (1991)'s results.

In the Exp. I, the lowest weed mass was obtained the plot which red clover was sown with pea at seeding rate of 60 seed m^{-2} in both harvest stage of companion crop, but, weed mass increased from 60 to 80 seed m^{-2} (Table 1). Much as number of broadleaves weeds diminished (Figure 3), *Vicia* sp. and *Sinapis arvensis* L. densities increased when pea seeding rate was increased from 60 to 80 seed m^{-2} (data not shown). The number of tillers per pea plant usually declined with increasing seeding rate (Uzun and Acikgoz 1998). This reduction might adversely affect the weed competition.

In Exp. II, while the lowest weed mass was obtained from the plots sown with pea (80 seed m^{-2}) at harvest F, it was obtained from the plots sown with pea (60 seed m^{-2}) at harvest P (Table 1). Severity of lodging occurring pea increased with increasing seeding rate of pea when plot was harvested at podding stage of companion crop. It was similar to Uzun *et al*. (2005) found that semi-leafless pea line had significantly better standing ability until full flowering but the superiority of semi-leafless genotypes in lodging disappeared at full podding. Much light reached to weeds located at the roots of pea plants than the others when pea lodged, thus, they had much mass. For this reason, though number of weed was lower in seeding rate of 80 seed m^{-2} than 60 seed m^{-2} harvested at P (Figure 3), weed mass was higher in seeding rate of 80 seed m^{-2} than 60 seed m^{-2}. Moreover, weed mass might increase with Nitrogen fixation, likewise Corre-Hellou and Crozat (2005) found that an increase in weed infestation was associated with an increase in the proportion of pea N derived from nitrogen fixation. Thus pea appeared to be less competitive for soil N than weeds.

Because of the latest harvested plot, weed mass reduced in the control plot. Some weeds lossed weight to spread seed when the pure sown plot was harvested.

It was rainy and cooler in the vegetation period of 2005-2006 (especially in March and April) compared to vegetation period of 2004-2005 (Figure 1). These conditions were more convenient for both pea and weed growing and increased the masses in Exp. II.

The highest dry matter yield of red clover in establishment year was obtained from the plot sown with pea (in the sowing rate of 80 seed m^{-2}) harvested at the F (5.6 t ha^{-1}) in Exp. I and it was obtained from the plot which sown with pea in the rate of 40 seed m^{-2} and harvested at the P (5.4 t ha^{-1}) in Exp. II (data not shown). When 35.3 and 25.4 pea plant m^{-2} were in the above-mentioned plots respectively (data not shown), our finding is similar to Sheaffer *et al*. (2007) results, who indicated that when sowing rate of pea increased from 38 to 76 seed m^{-2} sown with alfalfa, hay yield of alfalfa decreased in the establishment year. In opposition to Kandel and Porter (2005), a mixture of 2/3 field pea and 1/3 oat can be seeded with alfalfa or clover as a companion crop and harvest is recommended when field pea is in full bloom and oat is in the late boot stage. Hay yield was generally higher when harvest was done at podding stage of companion crop rather than at the flowering stage. Some weeds such as *Matricaria* sp. which were too young when pea plants were at 50 % flowering stage, so they could not be removed the plots which the first harvest in the establishment year was done at the 50 % flowering stage of companion crop. As these weeds growing rapidly after first cutting suppressed red clover plant, hay yield reduced in the second harvest and total hay yield reduced in the establishment year (data not shown).

Number of red clover plants was the lowest in the plot where red clover was sown with pea at the seeding rate of 80 seed m^{-2} and harvested at podding stage of pea in Exp. II owing to lodging of pea (Figure 2). This result is consistent with Jefferson *et al*. (2000) findings who reported that forage plant density decreased when pea density as a companion crop increased. Especially, if number of weeds such as *Vicia* sp. and *Lathyrus* sp. having semierect growth habit increase, lodging increases. Additionally, it was reported that 2% of full sunlight reached the *Poa pratensis* L. seedlings where pea was sown on 40 cm row spacing as a companion crop (Anonymous, 2008).

Number of weeds generally declined depending on companion crop seeding rate in both harvest stage of pea. *Veronica* sp., dominantly presenting in Exp. I, disappeared as it completed its life cycle until control plot harvest, thus, weed density was the lowest in the control plot. Since *Vicia* sp. and *Alopecurus myosuroides* Huds. located by a majority in Exp. II do not complete its life cycle before companion crop harvests, the effect of pea on the weeds determined easily. Roots of pea seedlings produce the nonprotein amino acid β-alanine, which reduced growth of seedlings of various grasses, and has been proposed as an allelochemical (Schenk and Werner, 1991). Grass weeds decreased due to the allelochemical in Exp. II. The lowest broadleaves weed presented the plot which red clover was sown with pea at seeding rate of 80 seed m^{-2} in both experiments (Figure 3). It was determined that *Matricaria* sp., *Vicia* sp. and *Legousia* sp. densities decrease depending on pea sowing rate (data not shown). Moreover, in both experiments, number of red clover highly decreased at the harvests which were done at podding stages. Possibly, late harvests influenced number of red clover plants since harvests of podding stages were done one month later than the harvests done at 50 % flowering stages. During that time, red clover seedlings were strongly affected by fast growing pea and weeds.

Second year

In contrast to Exp. II, red clover yield in the first cutting of the second year was higher when pea used in the first year than control plot in Exp. I. Number of red clover declined with increasing seeding rate of pea in the establishment year of Exp. II (Figure 2). Therefore, hay yield decreased in mixture plots in the second year. Koivisto *et al.* (2008), reported that higher sowing density of peas reduced the yield of undersown forage.

Weed mass was less in the plot with pea than without pea in Exp. I. Spandl *et al*. (1999), similarly reported that weed yields were reduced from 80 kg ha^{-1} in seedings without a companion crop to 50 kg ha^{-1} in companion crop at the first harvest in the second year after seeding. Unlike Exp. I, weed mass was less in the control plot than in the pea used plots in Exp. II (Figure 4). It is similar that weed content was greater in established stands of alfalfa-bromegrass (Moyer *et al*., 1995) and timothy (Lemieux *et al*., 1987) when seeded with a companion crop than without a companion crop.

In the Exp. I, companion crop did not affect the red clover yield at the second harvest of the second year because warm season weed seedlings were not able to compete against fast growing red clovers. Yet, in Exp. II, red clover yield obtained from the second cut decreased depending on the increasing sowing rate of pea. Weak red clover seedlings in establishment year, and hotter and drier conditions in vegetation period of 2007, the second year of Exp. II could cause of this decrease.

Weed density significantly decreased in the second year of Exp. I when red clover was sown with pea compare to weed density of establishment year (Figure 2 and 5). 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). Furthermore in the Exp. I, as weeds, *Sinapis arvensis* L. and *Matricaria* sp. dominantly existed in the first year. It was noticed that pea decreased this weeds. In the Exp. II, *Vicia* sp. and *Alopecurus myosuroides* Huds. were intensively located in the first and second year. Although pea generally suppressed weed in the establishment year (Figure 3), this weeds increased in the second year (Figure 5). It might be caused by high weed seed reserves in the area of Exp. II. It was revealed that seed reserves affect weed density (Moonen and Barberi, 2004). Furthermore, as a result of both weed and pea dominations per square meter, number of red clover decreased (Figure 2) in the first year. The residual effect of pea was not able to suppress the weeds in the second year (Figure 5). In addition, number of red clover was lessen in the plots when companion crop used than control in the second year (Table 2). Ultimately, weeds found an opportunity more space to grow better.

Third year

In the Exp. I, the residual effects of seed rate of companion crop on weed suppression continued in the first harvest of the third year. As a result, weed mass and weed densities were lower in with pea than without pea (Figure 6 and 7).

Although grasses weed density decreased in the plots sown with pea, compared to pure sown plots (Figure 7), broadleaved weeds increased and also weed composition changed in the third year. Weeds such as *Sonchus arvensis* L. and *Rumex crispus* L., perennial plants with rhizomes (Anonymous, 2010b,c) can rapidly colonize by vegetative reproduction and high mass, showed an increase in the Exp. II. In conclusion, in the Exp. II, the highest total dry matter yield of red clover was obtained from the red clover plot sown with pea at 40 seed m^{-2} and harvested podding stage of pea stand in the first harvest of third year (Figure 6).

Total hay yield obtained during the experiments was generally increased when red clover was sown with pea compared to control plot. It ranged from 27.09 t ha-1 to 37.0 t ha-1 (Table 3). Because weeds presented intesively in the Exp. II, dry matter yield of red clover sown with companion crop was lower than pure sown red clover in the second year (Figure 5). As a result, this increase was lower in Exp. II.

CONCLUSIONS

1. The results of this study indicate that pea used as a companion crop increased total hay yield in the establishment year.

2. Hay yield was higher when the companion crop harvested when 70% of pea pods reached at normal size.

3. The suppression of pea as a companion crop varied depending on the weed species and densities. If weed density is low, pea plants compete effectively against *Matricaria* sp., *Sinapis arvensis* L., *Veronica* sp. and *Alopecurus myosuroides* Huds. and, red clover seedling losses were not great, in this way the effects of companion crop continued during the 3 years.

4. Providing *Alopecurus myosuroides* Huds. and *Vicia* sp. presented densely, though pea suppres grasses weed, pea is

not able to compete enough them; as a result, much patchier area occurred in red clover plots sown with pea.

5. It was suggested that the first harvest in the establishment year should be done to compete with *Matricaria* sp. when 70% of pea pods reached at normal size.

6. Especially, if number of weeds such as *Vicia* sp. and *Lathyrus* sp. having semierect growth habit increases, lodging increases, and also pea and the weeds begin to decay from soil surface, hence, mortality of red clover increase.

7. When companion crop is dense, the plants underneath are damaged either by competition and by lodging of pea, thus, pea can be sown at the rate of 40 or 60 seed m^{-2}.

8. It was determined that persistency of red clover continued during the three year in the experiments.

9. During the study, red clover plants were infected by rust and powdery mildew, therefore a red clover variety tolerating these diseases should be used in the region where climate is rainly and warm in spring.

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LITRATURE CITED

Åmand, P., H. Graham, 1987. Whole-crop peas. I. Changes in botanical and chemical composition and rumen in vitro degradability during maturation. Anim. Feed Sci. Tech. 17: 15-31.

Anonymous, 2008. Kentucky bluegrass establishment for seed production. Available at: http://www.agr.gc.ca/pfra/csidc/blgrass_e.htm (Accessed 2 May 2008).

Anonymous, 2010a. Livestock and Climate Change. Available at: http://www.ifad.int/lrkm/events/cops/papers/climate.pdf (Accessed 20 January 2010)

Anonymous, 2010b. Perennial Sowthistle (*Sonchus arvensis* L.). Available at: http://www.cdfa.ca.gov/phpps/ipc/weedinfo/sonchus-arvensis.htm (Accessed 13 January 2010).

Anonymous, 2010c. *Rumex crispus* L. (*Polygonaceae*). Available at: http://polj.ns.ac.yu/~korovi/engleski/rumex__crispus.html, (Accessed 13 January 2010).

Borreani G., P.G. Peiretti, E. Tabacco, 2007. Effect of harvest time on yield and pre-harvest quality of semi-leafless grain peas (*Pisum sativum* L.) as whole-crop forage. Field Crop Res. 100(1): 1-9.

Brede A.D., J.L. Brede, 1988. Establisment clipping of tall fescue and companion annual ryegrass. Agron. J. 80: 27-30.

Cankaya S., G.T. Kayaalp, 2003. Orthogonal decomposition and an application. J. Agric. Fac. C.U. 18(4): 93-100.

Carr P.M., R.D. Horsley, W.W. Poland, 2004. Barley, oat, and cereal-pea mixtures as dryland forages in the northern great plains. Agron. J. 96: 677-684.

Chastain T.G., D.F. Grabe, 1988. Establishment of red fescue seed crops with cereal companion crops. I. Morphological responses. Crop Sci. 28: 308-312.

Comaklı B., 1991. A study on the effects of different row spacing, irrigation levels and phosphorus doses on the hay of red clover (Trifolium pratense L.). In: Avcioglu, R. (ed.), Turkısh 2. Grasslands and Forage Crop Congress, 28-31 May 1991, Ege University Press, İzmir, pp.28-31.

Corre-Hellou G., Y. Crozat, 2005. N_2 fixation and N supply in organic pea (*Pisum sativum* L.) cropping systems as affected by weeds and peaweevil (*Sitona lineatus* L.). Eur. J. Agron. 22(4): 449-458.

Hakansson S., 2003. Weeds and weed management on arable land. An ecological approach. CABI Publishing, Oxon, UK.

Hoy M.D., K.J. Moore, J.R. George, E.C. Brummetr, 2002. Alfalfa yield and quality as influenced by establishment method. Argon. J. 94: 65-71.

Jefferson P.G., B.E. Coulman, G.A. Kielly, 2000. Establishment of irrigated timothy for forage production in Saskatchewan. Agron. J. 92: 1291-1293.

Kandel H., P. Porter, 2005. Field pea production in Minnesota. Available at: http://www.extension.umn.edu/cropEnews/2005/pdfs/05MNCN19.pdf (Accessed 3 March 2009).

Koivisto J.M., G.P.F. Lane, W.P. Davies, 2008. Red clover and alfalfa establishment under peas. Avaliable at: http://www.royagcol.ac.uk/flg/pdf/peas%20as%20a%20Compa-nion %20Crop%20for%20Red%20Clover;%20A%20Field%20Trials (Accessed 2 May 2008).

Lanini W.T., S.B. Orloff, N. Vargas, J.P. Orr, V.L. Marble, S.R. Grattan, 1991. Oat companion crop seeding rate effect on alfalfa establishment, yield, and weed control. Agron. J. 83: 330-333.

Lemieux C., A.K. Watson, J.M. Deschenes, 1987. Weed population dynamics in recently established timothy stands: Growth and physiognomy of the weed components. Can. J. Plant Sci. 67: 1035-1044.

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

Moyer J.R., D.E. Cole, D.C. Maurice, A.L. Darwent, 1995. Companion crop, herbicide and weed effects on establishment and yields of alfalfa-bromegrass mixtures. Can. J. Plant Sci. 75: 121-127.

Mustafa A.F., P. Seguin, 2004. Chemical composition and in vitro digestibilty of whole-crop pea and pea-cereal mixture silages grown in South-western Quebec. J. Agron. Crop. Sci. 190: 416-421.

Rowell D.R., 1996. Soil Science: Methods and Applications. Longman, Harlow.

Schenk S.U., D. Werner, 1991. β-(3-isoxazolin-5-on-2-yl)-alanine from Pisum: allelopathic properties and antimycotic bioassay. Phytochemistry 30:467-470.

Sheaffer C., D. Wyse, K. Moncada, 2007. Companion crops for organic alfalfa establishment. Available at: http://www.extension.umn.edu/forages/pdfs/2007_Companion_Organic_ Alfalfa.pdf (Accessed 3 March 2009).

Spandl E., J.J. Kells, O.B. Hestarman, 1999. Weed invasion in new stand of alfalfa seeded with perennial forage grasses and an oat companon crop. Crop Sci. 39: 1120-1124.

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

Tan M., Y. Serin, 2004. Is the companion crop harmless to alfalfa establishment in the highlands of East Anatolia. J. Agron. Crop Sci. 190: 1-5.

Tan M., Y. Serin, H.I. Erkovan, 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.

Taylor, N.L., R.R. Smith, 1995. Red clover. In: Barns, R.F., Miller, D.A., Nelson, C.J. (eds), An Introduction to Grassland Agriculture Forages. 5. ed, Iowa State Univ Press, Ames, pp 217–226.

Uzun A., E. Acikgoz, 1998. Effect of sowing season and seeding rate on the morphological traits and yields in pea cultivars of differing leaf types. J. Agron. Crop Sci. 181(4): 215-222.

Uzun A., U. Bilgili, M. Sincik, I. Filya, E. Acikgoz, 2005. Yield and quality of forage type pea lines of contrasting leaf types. Eur. J. Agron. 22(1): 85-94.

Vrzal J., J. Santrucek, M. Svobodova, J. Fogl, 2001. Inserting red clover stands into different cover crops. Grasslands and Forage Abst. 71(7): 326.

Wiersma D.W., P.C. Hoffman, M.J. Mlynarek, 1999. Companion crops for legume establishment: Forage yield, quality, and establishment success. Journal of Production Agric. 12 (1): 116-22.