Turk J Agric For
29 (2005) 69-74

An Investigation on the Establishment of Artificial Pasture under Ankara's Ecological Conditions*

Sebahattin ALBAYRAK
Black Sea Agricultural Research Institute, Samsun - TURKEY
Hayrettin EKİZ
Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara - TURKEY

Received: 13.10.2003

Abstract: This study was conducted to determine suitable perennial forage species and their mixtures for the establishment of short-term artificial pastures under dry conditions in Ankara between 2000 and 2002. Alfalfa (*Medicago sativa* L.), sainfoin (*Onobrychis sativa* Lam.), smooth brome (*Bromus inermis* Leys.), crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) and their binary and complex mixtures were used. The research was carried out in a randomized block design with 4 replicates. The results showed significant differences among the botanical composition ratio in mixtures. The highest green, hay and dry matter yield were obtained from alfalfa + smooth brome mixtures (16.05 t ha^{-1}, 5.04 t ha^{-1} and 4.71 t ha^{-1}, respectively) and the highest protein yield was obtained from alfalfa (0.859 t ha^{-1}). The highest mixture efficiency was found in the case of the alfalfa + smooth brome mixture (1.53). The results showed that mixtures of alfalfa and smooth brome may be used to establish artificial pastures in Ankara's climatic conditions, and that sainfoin might be a very suitable plant in the mixture including crested wheatgrass if some resistant varieties against root insects are improved.

Key Words: alfalfa, sainfoin, smooth brome, crested wheatgrass, mixed pasture

Ankara Ekolojik Koşullarında Yapay Mera Kurulması Üzerine Bir Araştırma

Özet: Bu araştırma Ankara koşullarında kısa süreli yapay meraların kurulmasında kullanılabilecek çokyıllık yem bitkisi tür ve karışımlarının belirlenmesi amacıyla 2000-2002 yılları arasında kuru koşullarda yürütülmüştür. Araştırmada baklagil yem bitkilerinden yonca (*Medicago sativa* L.) ve korunga (*Onobrychis sativa* Lam.), buğdaygil yem bitkilerinden ise kılçıksız brom (*Bromus inermis* Leys.) ve otlak ayrığı (*Agropyron cristatum* (L.) Gaertn.) türleri saf, ikili ve dörtlü karışımlar şeklinde denenmiştir. Araştırma tesadüf blokları deneme desenine göre dört tekrarlamalı olarak kurulmuştur. Araştırma sonuçlarına göre, karışımlardaki botanik kompozisyon oranları istatistiki olarak önemli bulunmuştur. En yüksek yeşil ot, kuru ot ve kuru madde verimleri yonca+kılçıksız brom karışımından (sırasıyla 16,05 t ha^{-1}, 5,04 t ha^{-1}, 4,71 t ha^{-1}) ve en yüksek ham protein verimi yoncadan (0,859 t ha^{-1}) elde edilmiştir. En yüksek karışım etkinliği, yonca+kılçıksız brom (1,53) karışımından elde edilmiştir. Bu araştımanın sonucunda Ankara ekolojik koşullarında yonca ve kılçıksız bromun yapay mera kurulmasında kullanılabilecek karışımlar olduğu belirlenmiştir. Bununla birlikte kök böceği zararına dayanıklı çeşitlerin geliştirilmesiyle korunganın otlak ayrığı ile uyumlu karışımlar oluşturacağı da söylenebilir.

Anahtar Sözcükler: yonca, korunga, kılçıksız brom, otlak ayrığı, karışım mera

Introduction

Grass-legume mixtures are preferred over pure grass forage stands throughout the world since they often increase total herbage and protein yields with a balanced nutrition (Bittman et al., 1991). Legumes are very valuable in pasture mixtures because they yield well, fix atmospheric nitrogen, have high nutritive value for ruminants, and are adapted to different climates and soils (Bozzo et al., 1996). Alfalfa is one of the most commonly used legumes for both hay and pasture in Turkey. It is mainly grown with a mixture of grasses, usually smooth brome (Altın, 1982). Sainfoin is a non-bloat forage legume. It provides a harmonious mixture with crested wheatgrass that has resistance to cold and dry conditions (Karnezos et al., 1994). On the other hand, grasses are

* A part of a PhD thesis from Ankara Univ.

** Correspondence to: sebo_albayrak@yahoo.com

grown with alfalfa to reduce invasion of weeds, to reduce the danger of bloat, and to provide insurance against yield reductions due to winterkill or alfalfa disease. Although grass-legume mixtures tend to provide a better nutrient balance and produce higher forage yields, it is more difficult to manage grass-legume mixtures compared to monoculture pastures because of light, water, and nutrients competition (Charles and Lehmann, 1989; Serin et al., 1998; Berdahl et al., 2001).

The objective of this study was to determine the best legume-grass composition using alfalfa (*Medicago sativa* L.), sainfoin (*Onobrychis sativa* Lam.), smooth brome (*Bromus inermis* Leys.), and crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) and to compare their performance in an artificial pasture establishment under Ankara's climatic conditions.

Materials and Methods

This study was carried out in the experiment field of the Field Crops Department, at the Agricultural Faculty of Ankara University from 2000 to 2002. Organic matter and $CaCO_3$ levels were approximately 1% and 5%, respectively. The total precipitation was higher in both 2001 (437.4 mm) and 2002 (420.1 mm) than the long-term precipitation mean (383.1 mm) of the region. The total precipitation was lower in 2000 (346.6 mm). The means of the temperature and relative humidity were close to the long-term mean during the study.

Alfalfa (*Medicago sativa* L.), sainfoin (*Onobrychis sativa* Lam.), smooth brome (*Bromus inermis* Leys.), and crested wheatgrass (*Agropyron cristatum* (L.) (Gaertn.) were used as experimental material. The experiment was conducted in a randomized complete block design with 4 replications. Each plot consisted of 10 rows each 4 m in length. Between-row spacing was 35 cm. The seed rates were 100 kg ha^{-1} for sainfoin and 20 kg ha^{-1} for the other species. Seed mixtures consisted of 1/3 legume and 2/3 grasses. The seeds of legume and grass species were sown in the same rows. Herbage was not harvested during the growing season of 2000. In 2001 and 2002, after all plots had been harvested only once every year, all samples were hand-separated, dried at 70°C for 48 h and weighed. Botanical compositions were determined from 2 randomly selected 1 m^2 quadrats in each plot. Dry matter content was determined from ground samples dried at 105 °C for 3 h. Crude protein content was calculated by multiplying the Kjeldahl nitrogen concentration by 6.25 (Nelson and Sommers, 1973). Crude protein yield was calculated by multiplying hay yield by crude protein content.

The land equivalent ratio (LER) was defined as the relative area of a monocrop plant required for the same yield obtained from its mixture. The LER was calculated using the formula given below (Ta and Faris, 1987):

$$LER = \frac{\text{yield of legume in mixture}}{\text{yield of legume alone}} + \frac{\text{yield of grass in mixture}}{\text{yield of grass alone}}$$

Data were analyzed by analysis of variance (SAS, 1998) at the $P \leq 0.05$ and 0.01 levels of significance, and means were compared using the least significant difference test at $P \leq 0.05$.

Results and Discussion

Botanical Composition

In 2001, the alfalfa rate was 63.86% and smooth brome rate 36.14% in alfalfa + smooth brome binary mixture, and the sainfoin rate was 50.85% and wheatgrass rate 49.15% in the sainfoin + wheatgrass binary mixture. In contrast, in 2002, the alfalfa rate was 86.28% and smooth brome rate 13.72% in the alfalfa + smooth brome binary mixture, and the sainfoin rate was 23.19% and wheatgrass rate 76.82% in the sainfoin + wheatgrass binary mixture (Table 1). In 2002, while the alfalfa rate increased the sainfoin rate decreased in legumes.

Complex mixtures, consisting of alfalfa + sainfoin + smooth brome + wheatgrass, were dominated by sainfoin (48.25%) in 2001. However, the rates of the species found in the mixture changed in 2002. The complex mixture was dominated by alfalfa in 2002 (58.74%). Since sainfoin does not cause bloating in livestock, is comparatively drought resistant, and is not attacked by the same insects, it is an important alternative perennial forage legume to alfalfa in arid conditions. In the longterm, the survival of sainfoin fields is reduced by root pathogens that invade through scars caused by root-feeding insects. Weevils feed in sainfoin foliage and their larvae attack the roots (Büyükburç et al., 1991; Morrill et al., 1998). Our research also encountered insect damage in sainfoin in 2002. Due to insect damage, the sainfoin

Table 1. Botanical composition in pure sown and mixture plots.

	Botanical composition (%)		
	2001	2002	mean
Botanical composition in alfalfa mixtures			
Alfalfa	100.00 a	100.00 a	100.00 a
Alfalfa + smooth brome	63.86 b	86.28 b	75.07 b
Alfalfa + sainfoin + s. brome + w. grass	16.97 c	58.74 c	37.85 c
LSD	14.31	8.02	5.49
Botanical composition in smooth brome mixtures			
Smooth brome	100.00 a	100.00 a	100.00 a
Smooth brome + alfalfa	36.14 b	13.72 b	24.93 b
S.brome + alfalfa + sainfoin + w.grass	2.44 c	3.95 c	3.19 c
LSD	4.58	2.26	1.68
Botanical composition in sainfoin mixtures			
Sainfoin	100.00 a	100.00 a	100.00 a
Sainfoin + wheatgrass	50.85 b	23.19 b	37.02 b
Sainfoin + alfalfa + s. brome + w. grass	48.25 b	9.36 c	28.80 b
LSD	33.61	5.18	10.16
Botanical composition in wheatgrass mixtures			
Wheatgrass	100.00 a	100.00 a	100.00 a
Wheatgrass + sainfoin	49.15 b	76.82 b	62.99 b
W. grass + alfalfa + sainfoin + s. brome	32.34 b	27.95 c	30.15 c
LSD	37.29	9.26	11.65

Means followed by the same column(s) are not significantly different at P = 0.05 level

rate decreased in the botanical composition. Furthermore, botanical composition rates of the species in the mixtures might vary because of light, water and nutrient competition (Charles and Lehmann, 1989; Serin et al., 1998; Berdahl et al., 2001).

Green and Hay Yield

The green yield obtained from the plots was different for each year. The pure sown sainfoin and smooth brome gave the highest (14.44 t ha^{-1}) and the lowest (6.16 t ha^{-1}) green yield in 2001, respectively. On the other hand, the highest and the lowest green yield were obtained from the alfalfa + smooth brome binary mixture (24.55 t ha^{-1}) and pure smooth brome (3.95 t ha^{-1}) in 2002, respectively (Table 2). Many studies have confirmed that alfalfa gave high average green yields in mixtures (Krzywecki et al., 1984; Gadziev and Svetlova 1985; Altın and Gökkuş 1988; Lazar et al., 1990).

The hay yields of the pure sown plots and mixtures were significantly different ($P \leq 0.05$) in both years (Table 2). The sainfoin + wheatgrass binary mixture was the highest yield (3.94 t ha^{-1}) while pure smooth brome gave the lowest (1.61 t ha^{-1}) in 2001. In 2002, the highest hay yield (7.53 t ha^{-1}) was obtained from the alfalfa + smooth brome mixture while the lowest hay yield (1.13 t ha^{-1}) was obtained from the pure smooth brome. Sainfoin root insects (*Dipsosphecia scopigera* and *Sphenoptera carceli)* damaged and lowered hay yield in 2002.

Based on the average of the 2 years, the lowest and highest hay yields were 1.38 t ha^{-1} with pure smooth brome and 5.04 t ha^{-1} with the alfalfa + smooth brome binary mixture, respectively. It was previously reported that grass + legume mixtures gave higher hay yield than pure grass (Akdeniz, 1998). In addition, Syglov (1991) pointed out that hay yield was higher in mixtures than in

Table 2. Green and hay yield in pure sown and mixture plots.

	Green yield (t ha^{-1})			Hay yield (t ha^{-1})		
	2001	2002	mean	2001	2002	mean
Alfalfa	7.18 c	22.67 a	14.93ab	2.19 cd	7.43 a	4.81 ac
Sainfoin	14.44 a	5.45 d	9.94 d	3.81 a	1.54 d	2.68 d
Smooth brome	6.16 c	3.95 d	5.06 e	1.61 d	1.13 d	1.38 e
Wheatgrass	7.82 c	16.97 c	12.40 c	2.84 bc	6.10 b	4.47 bc
Alfalfa + smooth brome	7.54 c	24.55 a	16.05 a	2.55 c	7.53 a	5.04 a
Sainfoin + wheatgrass	12.32 ab	14.72 c	13.52bc	3.94 a	4.77 c	4.36 c
Alfalfa + sainfoin + s.brome + w. grass	10.74 b	20.12 b	15.43ab	3.54 ab	6.45 b	4.95 ab
LSD	2.63	2.39	1.71	0.68	0.80	0.51

Means followed by the same column(s) are not significantly different at P = 0.05 level

pure sown species. Sleugh et al. (2000) stated that alfalfa and alfalfa + smooth brome mixtures produced greater yields because the deep root system of alfalfa plants was able to tap deeper soil water. Similarly, other investigators also found that the highest green and hay yields were produced by alfalfa and smooth brome mixtures (Bitmann et al., 1991; Bozzo et al., 1996; Berdahl et al., 2001). Therefore, the results of this study generally agree with previous reports.

Dry Matter Rate and Yield

Crested wheatgrass gave the highest dry matter rate compared to legumes, which were the lowest in both years. The dry matter rate increased in all species in 2002 (Table 3). Our results confirmed previous results reported by Ünal (2000), although there was no agreement with those of Manga (1978). These differences might be explained by the ecological conditions such as the precipitation and temperature recorded during the vegetative growth cycle, and the cultivars used in each experiment.

In 2001, the highest dry matter yield was obtained from the sainfoin + crested wheatgrass binary mixture (3.69 t ha^{-1}). On the other hand, in 2002, unlike the previous year, alfalfa + smooth brome produced the highest dry matter (7.06 t ha^{-1}) (Table 3). Grass + legume mixtures must be preferred for the feeding balance of livestock (Albayrak and Ekiz, 2000). Grigg and Matches (1991) reported that the forage production of mixtures usually did not exceed that of pure grasses, but utilization was 13-29% higher in mixtures than in pure grasses. Karnezos et al. (1994) found also that alfalfa or sainfoin offer more opportunities for spring lamb production than wheatgrass pastures.

Crude Protein Content and Yield

The crude protein content in both years showed that grasses had the lowest (8.62-10.30%) while mixtures had an intermediate (13.06-15.24%) and legumes had the highest (16.07-18.13%) crude protein contents (Table 4). The crude protein contents of all species decreased in 2002. Manga (1978) and Schmidt (1993) reported that the quality of forages could be altered due to differences in temperature and precipitation.

Previous studies have shown that alfalfa contains significantly more crude protein than grasses and that grass + legume mixtures contain more crude protein than the pure sowing grasses do (Altın, 1982; Barnett and Posler 1983; Höflich et al. 1990; Spandl and Hesterman 1997; Avcı, 2000).

In this study, the highest crude protein yield was obtained from pure sainfoin (0.628 t ha^{-1}) while pure smooth brome gave the lowest (0.176 t ha^{-1}) in 2001. On the other hand, the highest crude protein yield was obtained from pure alfalfa (1.322 t ha^{-1}) in 2002. In both 2001 and 2002, crude protein yields of mixtures were higher than those of pure grasses. These results were in agreement with those reported by Ta and Faris (1987), Casler (1988), Serin et al. (1997), Chakrov (1998), Serin et al. (1998), and Sleugh et al. (2000).

Table 3. Dry matter content and yield in pure sown and mixture plots.

	Dry matter content (%)			Dry matter yield (t ha^{-1})		
	2001	2002	mean	2001	2002	mean
Alfalfa	91.83 d	92.96 c	92.39 d	2.01 de	6.89 a	4.45 ab
Sainfoin	92.79 c	93.46bc	93.12 cd	3.54 a	1.44 d	2.49 c
Smooth brome	93.77 b	94.58ab	94.18 b	1.51 e	1.06 d	1.29 d
Wheatgrass	95.06 a	95.85a	95.45 a	2.70 bc	5.85 b	4.27 ab
Alfalfa + smooth brome	92.71cd	93.76 bc	93.23 cd	2.36 cd	7.06 a	4.71 a
Sainfoin + wheatgrass	93.84 b	94.74 ab	94.29 b	3.69 a	4.52 c	4.11 b
Alfalfa+sainfoin+s.brome+w.grass	92.86 c	94.31 bc	93.58 bc	3.20 ab	6.08 b	4.64 a
LSD	0.90	1.54	0.86	0.63	0.72	0.46

Means followed by the same column(s) are not significantly different at P = 0.05 level

Table 4. Crude protein percentage and yield in pure sown and mixture plots.

	Crude protein content (%)			Crude protein yield (t ha^{-1})		
	2001	2002	mean	2001	2002	mean
Alfalfa	18.32 a	17.94 a	18.13 a	0.396 c	1.322 a	0.859 a
Sainfoin	16.37ab	15.77 b	16.07 b	0.628 a	0.241 e	0.435 d
Smooth brome	10.97 e	9.64 d	10.30 d	0.176 d	0.108 f	0.142 e
Wheatgrass	9.04 e	8.20 d	8.62 e	0.257 d	0.501 d	0.379 d
Alfalfa + smooth brome	15.81bc	14.67bc	15.24 b	0.404bc	1.106 b	0.755 b
Sainfoin + wheatgrass	13.69cd	12.78 c	13.24 c	0.533ab	0.600 d	0.567 c
Alfalfa+sainfoin+s.brome+w.grass	13.36 d	12.77 c	13.06 c	0.458bc	0.824 c	0.641 c
LSD	2.35	2.09	1.53	0.129	0.115	0.084

Means followed by the same column(s) are not significantly different at P = 0.05 level

Land equivalent ratio (LER)

As mentioned above, LER was defined as "the relative area of a monocrop plant that is required to produce the same yield obtained from its mixture". The highest LER was obtained from alfalfa + smooth brome in both 2001 and 2002 (1.31 and 1.75, respectively) (Table 5). Serin et al. (1998) found that the LER of alfalfa + grass was 1.66, which is similar to our result.

Table 5. Land equivalent ratios in mixtures.

	Land equivalent ratio (LER)		
	2001	2002	mean
Alfalfa + smooth brome	1.31	1.75	1.53
Sainfoin + wheatgrass	1.20	1.32	1.26
Alfalfa + sainfoin + s.brome + w.grass	1.15	1.43	1.29
mean	1.22	1.50	1.36

Conclusions

The results of this study showed that mixtures of alfalfa and smooth brome may be used to establish artificial pastures under Ankara's climatic conditions. Alfalfa and alfalfa + smooth brome mixtures produced greater yields because the deep root system of alfalfa plants was able to tap deeper soil water. However considering the fact that alfalfa dominates smooth brome at the end of the third year the smooth brome rate should be higher than the alfalfa rate in the foundation year. The results also indicated that sainfoin might be a very suitable plant in the mixture including crested wheatgrass if some resistant varieties against root insect are improved.

References

Akdeniz, H. 1998. Korunga ile karışıma giren kılçıksız brom ve mavi ayrığın değişik ekim şekillerindeki kuru ot ve ham protein verimleri, ham protein oranları ve karışımların botanik kompozisyonları. Doktora Tezi. Yüzüncü Yıl Üniversitesi Fen Bil. Enst, p.102.

Albayrak, S. and H, Ekiz. 2000. Yapay meraların kurulması ve önemi. Türk-Koop. Ekin Dergisi. 4 (13): 95-99.

Altın, M. and A. Gökkuş. 1988. Erzurum sulu koşullarında bazı yem bitkileri ile bunların karışımlarının değişik ekim şekillerindeki kuru ot verimleri üzerinde bir araştırma. DOĞA TU Tar. ve Or. D. 12: 24-36.

Altın, M. 1982. Bazı yem bitkileri ile bunların karışımlarının değişik ekim şekillerindeki kuru ot ve ham protein verimleri, türlerin ham protein oranları ve karışımların botanik kompozisyonları. II. Ham protein oranları ve karışımların botanik kompozisyonları. Doğa Bilim Derneği Veteriner Hayvancılık ve Tarım ve Orman Dergisi. 6: 109-126.

Avcı, M. 2000. Çukurova'da geçici yapay mera kurma amacıyla yetiştirilebilecek kışlık çokyıllık buğdaygil+baklagil yem bitkileri karışımlarının saptanması. Doktora Tezi. Çukurova Üniversitesi. Fen Bilimleri Enstitüsü.

Barnett, F. and G.L. Posler. 1983. Performance of cool-season perennial grasses in pure stands and in mixtures with legumes. Agronomy Journal. 75: 4, 582-586.

Berdahl, J.D., J.F. Karn and J.R. Hendrickson. 2001. Dry matter yields of cool-season grass monocultures and grass-alfalfa binary mixtures. Agronomy Journal 93: 463-467.

Bittman, S., J. Waddington and D.H. McCartney.1991. Performance of alfalfa strains grown in mixtures with smooth bromegrass affected by management. Canadian Journal of Plant Science 71: 1029-1037.

Bozzo, F., F. Magro and P. Dossi. 1996. Advantages of mixtures of grasses and lucerne. Informatore Agrario. 52 (2): 53-57.

Büyükburç, U., E. Açıkgöz, H. Ekiz and N. Karagüllü. 1991. Değişik kökenli kültür ve yabani korunga türlerinin tarımsal özellikleri üzerinde araştırmalar. Doğa- Tr. J. of Agriculture and Forestry. 15: 35-45.

Casler, M.D. 1988. Performance of orchardgrass, smooth bromegrass, and ryegrass in binary mixtures with alfalfa. Agronomy Journal. 80: 509-514.

Chakrov, R. 1998. Nutrient content and productivity of grasses in pure stands and in mixtures with legumes. Rasteniev"dni-Nauki. 35: 723-725.

Charles, J.P. and J. Lehmann. 1989. The importance of grass/legume mixtures in forage production in Switzerland. Fourrages. 119: 311-320.

Gadzhiev, V. and A. Svetlova. 1985. Sown pastures of Azerbaijan. Kormoproizvodstvo. No.3, 31-32. Bakü.

Gökkuş, A., A. Koç, Y. Serin, B. Çomaklı, M. Tan and F. Kantar. 1999. Hay yield and nitrogen harvest in smooth bromegrass mixtures with alfalfa and red clover in relation to nitrogen application. European Journal of Agronomy, 10: 145-151.

Griggs, T.C. and A. Matches. 1991. Productivity and consumption of wheatgrasses and wheatgrass- sainfoin mixtures. Crop Science. 31: 1267-1273.

Höflich, G., G. Kühn, C. Meinsen, R. Schuppenies, E. Schafer and K. Stitz. 1990. Approaches to a greater use of biological nitrogen fixation in legume-grass mixtures. Archiv für Acker-und Pflanzenbau und Bodenkunde. 34: 701-707.

Karnezos, T.P., A.G. Matches and C.P. Brown. 1994. Spring lamb production on alfalfa, sainfoin, and wheatgrass pastures. Agronomy Journal. 86: 497-502.

Krzywiecki, S., A. Kroliczek, J. Orda and A. Szyszkowska. 1984. Yield and feeding value of grasses and their mixtures with legumes. 1. Yield and chemical composition. Zeszyty Naukowe Akademii Rolniczej we Wroclawiu. 150: 131-142.

Lazar, L., G. Kovacs, M. Szatmari and J. Adam. 1990. Rotation of alternating pasture and cereal crops on saline soil. Internationale Agrarindusrie Zeitshrift. 1: 24-27.

Manga, İ. 1978. Yonca ve korungada değişik olgunluk devrelerinde yapılan biçmelerin ot verimine otun kalitesine ve yedek besin maddelerine etkileri üzerinde araştırmalar. Atatürk Üniversitesi Yayınları: 482. Ziraat Fakültesi Yayınları No:228. Araştırma Serisi No:147.

Morrill, L.M., L.R. Ditterline and S.D. Cash. 1998. Insect pests and associated root pathogens of sainfoin in western USA. Field Crops Research, 59: 129-134.

Nelson, D.W and L.E. Sommers. 1973. Determination of total nitrogen in plant material. Agronomy Journal 65: 109-112.

SAS, SAS/STAT 1998. User's Guide. Version 7.0. SAS Institute, Inc. Cary. NC.

Schmidt, L. 1993. Use of plant height for determining the nutritive value, yield and the optimal use span of lucerne. Proceedings of the XVII International Grassland Congress, New Zealand, 869-870.

Schultz, R.D and J. Stubbendieck 1983. Herbage quality of fertilized cool-season grass-legume mixtures in Western Nebraska. Journal of Range Management. 36: 571-575.

Serin, Y., A. Gökkuş, M. Tan, B. Çomaklı and A. Koç. 1998. Sun'i çayır tesisinde kullanılabilecek uygun yem bitkileri ve karışımlarının belirlenmesi. Tr. J. of Agriculture and Forestry. 22: 13-20.

Serin, Y., A. Gökkuş, M. Tan, B. Çomaklı and A. Koç. 1997. Otlakiye amacıyla kullanılabilecek baklagil ve buğdaygil yem bitkileri ile bunların karışımlarının belirlenmesi. Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi 6: 15-26.

Sleugh, B., K.J. Moore, L.R. George and C.E. Brummer. 2000. Binary legume–grass mixtures improve forage yield, quality, and seasonal distribution. Agronomy Journal 92: 24-29.

Spandl, E. and O.B. Hersterman. 1997. Forage quality and alfalfa characteristics in binary mixtures of alfalfa and bromegrass or timothy. Crop Science 37: 1581-1585.

Syaglov, V.A. 1991. Legume/grass mixtures on solonetz soils of western Siberia. Zemledelie. 11: 62-63.

Ta, T.C. and M.A. Faris. 1987. Effects of alfalfa proportions and clipping frequencies on timothy-alfalfa mixtures. I. Competition and yield advantages. Agronomy Journal 79: 817-820.

Ünal, S. 2000. Nohut geveni - ayrık ekimi karışım oranlarının yem verimi ve botanik kompozisyona etkileri üzerinde araştırmalar. Doktora Tezi. Ankara Üniversitesi Fen Bilimleri Enstitüsü.