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## Performance of Grass-Legume Mixtures under Irrigation in the Southeastern Anatolia Region of Turkey

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**Abstract:** This research was conducted in the 2000 and 2002 growing season in the Southeastern Anatolia Region of Turkey. In the research, alfalfa (*Medicago sativa* L.) (P.5929), crested wheatgrass (*Agropyron cristatum* (L.) Gaertner) (Fairway), orchardgrass (*Dactylis glomerata* L.) (Amba), timothy (*Phleum pratense* L.) (Bilbo), smooth brome (*Bromus inermis* Leyss.) (Leif), meadow-fescue (*Festuca pratensis* Huds.) (Laura) and their binary mixtures were used. The research was carried out in a randomized block design with 4 replicates. In all the observed characters, statistically significant differences were determined in 2001, 2002 and two year's average. According to two years averages; the highest green and dry herbage yields were obtained from alfalfa+timothy, alfalfa+smooth brome, alfalfa+meadow-fescue mixtures. The average values of mixtures for two years green herbage yield ranged from 99.027-116.727 kg ha<sup>-1</sup>, dry herbage yield from 32.130-37.140 kg ha<sup>-1</sup>, protein yield from 4.971-6.107 kg ha<sup>-1</sup>.

**Key words:** Alfalfa, crested wheatgrass, orchardgrass, timothy, smooth brome, meadow-fescue, mixtures

### INTRODUCTION

It's difficult to increase agricultural area for plant production in the world. In addition to this, world population getting increasing. So, there is a danger of hunger for some part of world population. For solution to this problem, crop production must increase.

Alfalfa is the most important legume forage crop among all legume crops. Alfalfa is planted on 14.8 million ha in the world, while average world forage yield is 306,685 kg ha<sup>-1</sup> and production is 455 million tonnes (Anonymous, 2004). In general, alfalfa was sown as pure, at the same time it can be sown as mixture with perennial grasses in artificial pasture and field areas. Alfalfa is very valuable in pasture mixtures because their herbage yield is very well, fix atmospheric nitrogen, have high nutritive value for ruminants. The amounts of N fixed from atmospheric N<sub>2</sub> in legume/grass pastures throughout the world is summarized and range from 13 to 682 kg N ha<sup>-1</sup> year<sup>-1</sup> (Ledgard and Steele, 1992). At the same time, grass-legumes tend to provide a better nutrient balance and higher forage yields in artificial pasture areas (Ladge *et al.*, 1972; Lawrence and Heinrichs, 1977; Charles and Lehman, 1989; Sheaffer *et al.*, 1990; Rotar and Şuteu, 1994; Serin *et al.*, 1998; Berdahl *et al.*, 2001; Albayrak and Ekiz, 2003).

The objective of this investigation was to determine the best legume+grass composition using alfalfa

(*Medicago sativa* L.), crested wheatgrass (*Agropyron cristatum* (L.) Gaertner), orchardgrass (*Dactylis glomerata* L.), timothy (*Phleum pratense* L.), smooth brome (*Bromus inermis* Leyss.), meadow-fescue (*Festuca pratensis* Huds.) and to compare their performance under irrigation in the Southeastern Anatolia Region of Turkey.

### MATERIALS AND METHODS

This research was carried out at Dicle University in Diyarbakir (37°54' N, 40°14' E altitude 660 m).

Generally, Mediterranean and East Anatolian continental climates are dominant in this region. The average annual temperature is 15.8°C, rainfall is 481.6 mm and the average relative humidity is about 53.8%. The average temperature can reach 30°C in July and August. The lowest average temperature can be 7°C in December and January. The earliest frost in the region is usually at the end of October and the last frost around end of April.

Most rain falls in winter and there is almost no rainfall from July to September. The highest humidity (70%) occurs in winter, lowest (27%) in summer.

Weather conditions during the years when the research was carried out, are given in Fig. 1 (Anonymous, 2002).

The total rainfall in 2000 (382.8 mm) was similar to the long term average value, but the total rainfall for 2001 (605.2 mm) was higher than normal (Fig. 1). There was no

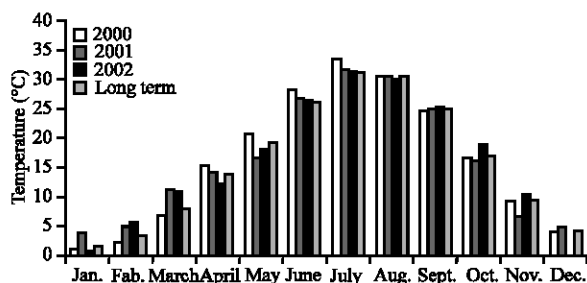


Fig. 1: Average air temperatures (°C) of the research area

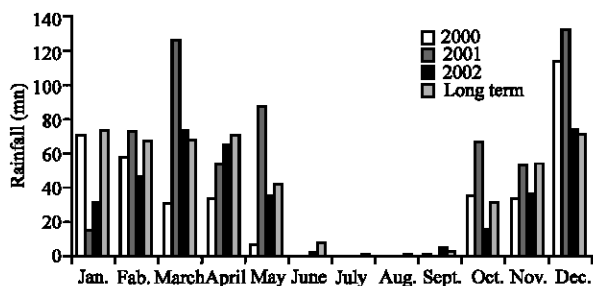


Fig. 2: Average the amount of rainfall (mm) of the research area

important difference in average temperature between the years of the experiments and the long-term average (Fig. 2).

The soils of the experimental area were thinly structured alluvial material or limestone. The soil is low in organic material and phosphorus, has adequate calcium and high clay content (49-67%) in the 0-150 cm profile. Water permeability of the soil is good and salt levels are suitable for alfalfa production (Anonymous, 1997).

Alfalfa (*Medicago sativa* L.) (P 5929), crested wheatgrass (*Agropyron cristatum* (L.) Gaertner) (Fairway), orchardgrass (*Dactylis glomerata* L.) (Amba), timothy (*Phleum pratense* L.) (Bilbo), smooth brome (*Bromus inermis* Leyss.) (Leif), meadow-fescue (*Festuca pratensis* Huds.) (Laura) were used as experimental material.

The experimental design was a completely randomised block with four replications. Planting was performed in 6 rows on 4.2 m long plots. Between row spacing was 30 cm. The seed rates were 20 kg ha<sup>-1</sup> for all species. Seed mixtures consisted of 1/3 alfalfa and 2/3 grasses. Sowing was performed by hand into 1-2 cm depths on the 20th of April in 2000. The experimental area was fertilized with 4 kg nitrogen (N) and 10.2 kg P<sub>2</sub>O<sub>5</sub> before planting. The trial was irrigated by sprinkler after planting. Other irrigations were furrow irrigation. The irrigation intervals were between 7-12 days

Alfalfa was harvested 3 times during the growing season of 2000. But, pure grasses and grasses in mixtures

were not harvested. In 2001 and 2002, all plots were harvested four times each year.

The cuts were made when 10-30% flowering of alfalfa and the yield (kg ha<sup>-1</sup>) of the green herbage of different cultivars were determined.

The dry herbage percentage was determined by randomly taking 0.5 kg green herbage from each plot and drying it in the greenhouse. The percentage obtained was multiplied by the green herbage yield to determine the dry herbage yield.

For protein analysis, the herbage samples (alfalfa and grasses) which were taken from each plot through the year were ground at the end of the season and mixed equally and a sample taken from this mixture was used for protein analysis. The crude protein percentage was determined with Leco FP-528 protein analyser.

Analysis of variance was done by using a MSTAT-C statistic programme and differences were compared by LSD tests.

## RESULTS AND DISCUSSION

**Green herbage yield:** There were significant differences among treatments in total green herbage yield for each year and the average of the two years (Table 1).

The green herbage yields were obtained between 29.285-113.077 kg ha<sup>-1</sup> in 2001, 32.532-122.172 kg ha<sup>-1</sup> in 2002, 30.990-116.727 kg ha<sup>-1</sup> in two years average. The highest green herbage yields were obtained from alfalfa + grasses mixtures (except alfalfa + meadow fescue) in 2001, 2002 and two years average.

According to the average values of the two years, alfalfa + timothy, alfalfa + smooth brome, alfalfa + orchardgrass and alfalfa + meadow fescue gave the highest green herbage yield (116.727, 115.097, 114.240 and 110.746, respectively). The lowest green herbage yields were obtained from the pure smooth brome and other grasses. It was reported that legume+grasses mixtures

Table 1: The average green herbage yields (kg ha<sup>-1</sup>) in pure sown and mixtures and statistical groups\*

| Treatments                                 | 2001     | 2002      | Average  |
|--|----------|-----------|----------|
| Alfalfa ( <i>M. sativa</i> L.)             | 73.075b  | 69.055d   | 71.065c  |
| Crested wheatgrass ( <i>A. cristatum</i> ) | 39.712cd | 32.532e   | 36.122de |
| Orchardgrass ( <i>D. glomerata</i> )       | 44.492cd | 41.547e   | 43.020d  |
| Timothy ( <i>P. pratense</i> )             | 48.640c  | 44.530e   | 46.585d  |
| Smooth brome ( <i>B. inermis</i> )         | 29.285d  | 32.695e   | 30.990e  |
| Meadow-fescue ( <i>F. pratensis</i> )      | 42.980cd | 43.385e   | 43.182d  |
| Alfalfa+Crested wheatgrass                 | 104.517a | 93.537c   | 99.027b  |
| Alfalfa+Orchardgrass                       | 106.307a | 122.172a  | 114.240a |
| Alfalfa+Timothy                            | 112.772a | 120.682ab | 116.727a |
| Alfalfa+Smooth brome                       | 111.212a | 118.982ab | 115.097a |
| Alfalfa+Meadow-fescue                      | 113.077a | 108.415b  | 110.746a |
| LSD (0.005)                                | 15.710   | 12.610    | 10.490   |
| CV (%)                                     | 14.480   | 11.600    | 13.840   |

\*Means shown with the same letter in the same column are not significantly different at 0.05 probability level

Table 2: The average dry herbage yields (kg ha<sup>-1</sup>) in pure sown and mixtures and statistical groups\*

| Treatments                                 | 2001     | 2002     | Average  |
|--|----------|----------|----------|
| Alfalfa ( <i>M. sativa</i> L.)             | 24.890b  | 20.937d  | 22.914c  |
| Crested wheatgrass ( <i>A. cristatum</i> ) | 12.932cd | 10.157e  | 11.545ef |
| Orchardgrass ( <i>D. glomerata</i> )       | 16.110c  | 13.487e  | 14.799de |
| Timothy ( <i>P. pratense</i> )             | 16.627c  | 13.640e  | 15.134d  |
| Smooth brome ( <i>B. inermis</i> )         | 10.422d  | 9.980e   | 10.201f  |
| Meadow-fescue ( <i>F. pratensis</i> )      | 14.857cd | 13.825e  | 14.341de |
| Alfalfa+Crested wheatgrass                 | 35.760a  | 28.500c  | 32.130b  |
| Alfalfa+Orchardgrass                       | 35.082a  | 37.857a  | 36.470a  |
| Alfalfa+Timothy                            | 37.232a  | 36.737ab | 36.985a  |
| Alfalfa+Smooth brome                       | 38.125a  | 36.155ab | 37.140a  |
| Alfalfa+Meadow-fescue                      | 39.825a  | 33.457b  | 36.641a  |
| LSD (0.005)                                | 5.546    | 3.892    | 3.442    |
| CV (%)                                     | 14.990   | 11.640   | 14.00    |

\*Means shown with the same letter in the same column are not significantly different at 0.05 probability level

gave higher herbage yield than pure grass (Albayrak and Ekiz, 2005; Serin *et al.*, 1998; Berdahl *et al.*, 2001; Rotar and Suteu, 1994).

**Dry herbage yield:** There were significant differences among treatments in total dry herbage yield for each year and the average of the two years (Table 2).

The average dry herbage yields were obtained between 10.422-39.825 kg ha<sup>-1</sup> in 2001, 9.980-37.857 kg ha<sup>-1</sup> in 2002, 10.201-37.140 kg ha<sup>-1</sup> in two years average. The highest green herbage yields were obtained from alfalfa+grasses mixtures (except alfalfa + meadow fescue) in 2001, 2002 and two years average. According to the average values of the two years, alfalfa + smooth brome, alfalfa + timothy, alfalfa + meadow fescue and alfalfa + orchardgrass were gave the highest dry herbage yield (37.140, 36.985, 36.641 and 36.470, respectively). The lowest dry herbage yields were obtained from the pure smooth brome and other grasses. It was reported that legume+grasses mixtures gave higher dry herbage yield than pure grass (Albayrak and Ekiz, 2005; Serin *et al.*, 1998; Berdahl *et al.*, 2001; Rotar and Suteu, 1994).

**Plant height:** There were significant differences among treatments in plant height for each year and the average of the two years (Table 3).

The plant heights were obtained between 18.15-67.02 cm in 2001, 26.35-73.97 cm in 2002, 22.25-70.50 cm in two years average. According to the average values of the two years, the highest plant height was obtained from only pure alfalfa. The lowest plant heights were obtained from pure smooth brome and other pure grasses.

**Protein yields:** There were significant differences among treatments in total protein yield for each year and the average of the two years (Table 4).

Table 3: The average plant height (cm) in pure sown and mixtures and statistical groups\*

| Treatments                                 | 2001    | 2002    | Average |
|--|---------|---------|---------|
| Alfalfa ( <i>M. sativa</i> L.)             | 67.02a  | 73.97a  | 70.50a  |
| Crested wheatgrass ( <i>A. cristatum</i> ) | 25.77ef | 29.77ef | 27.77e  |
| Orchardgrass ( <i>D. glomerata</i> )       | 26.90e  | 43.17d  | 35.04d  |
| Timothy ( <i>P. pratense</i> )             | 25.27ef | 43.17d  | 34.22d  |
| Smooth brome ( <i>B. inermis</i> )         | 18.15g  | 26.35f  | 22.25f  |
| Meadow-fescue ( <i>F. pratensis</i> )      | 21.87fg | 38.90de | 30.39de |
| Alfalfa+Crested wheatgrass                 | 45.60d  | 53.97c  | 49.79c  |
| Alfalfa+Orchardgrass                       | 53.85b  | 64.52ab | 59.19b  |
| Alfalfa+Timothy                            | 51.57bc | 65.42ab | 58.50b  |
| Alfalfa+Smooth brome                       | 49.70c  | 63.87b  | 56.79b  |
| Alfalfa+Meadow-fescue                      | 44.90d  | 63.77b  | 54.34bc |
| LSD (0.005)                                | 4.020   | 9.562   | 5.352   |
| CV (%)                                     | 17.380  | 11.690  |         |

\*Means shown with the same letter in the same column are not significantly different at 0.05 probability level

Table 4: The average protein yields (kg ha<sup>-1</sup>) in pure sown and mixtures and statistical groups\*

| Treatments                                 | 2001    | 2002   | Average |
|--|---------|--------|---------|
| Alfalfa ( <i>M. sativa</i> L.)             | 4881c   | 3880b  | 4380d   |
| Crested wheatgrass ( <i>A. cristatum</i> ) | 1133d   | 789c   | 961e    |
| Orchardgrass ( <i>D. glomerata</i> )       | 1248d   | 738c   | 993e    |
| Timothy ( <i>P. pratense</i> )             | 1382d   | 966c   | 1174e   |
| Smooth brome ( <i>B. inermis</i> )         | 1043d   | 950c   | 997e    |
| Meadow-fescue ( <i>F. pratensis</i> )      | 1178d   | 865c   | 1022e   |
| Alfalfa+Crested wheatgrass                 | 5582abc | 4360ab | 4971c   |
| Alfalfa+Orchardgrass                       | 5313bc  | 5419ab | 5366bc  |
| Alfalfa+Timothy                            | 5903ab  | 5342ab | 5623ab  |
| Alfalfa+Smooth brome                       | 6267a   | 5946a  | 6107a   |
| Alfalfa+Meadow-fescue                      | 5910ab  | 4532ab | 5221bc  |
| LSD (0.005)                                | 909.3   | 1639   | 523.1   |
| CV (%)                                     | 17.38   | 11.69  |         |

\*Means shown with the same letter in the same column are not significantly different at 0.05 probability level

The average protein yields were between 1043-6267 kg ha<sup>-1</sup> in 2001, 865-5946 kg ha<sup>-1</sup> in 2002, 961-6107 kg ha<sup>-1</sup> in two years average.

The highest protein yields were obtained from alfalfa+smooth brome in 2001, 2002 and the average of the two years (6267.05946 and 6107 kg ha<sup>-1</sup>, respectively). The lowest protein yields were obtained from pure grasses. These findings are in agreement with Serin (1988) and Albayrak and Ekiz (2005).

**Botanical composition:** There were significant differences among treatments in plant height for each year and the average of the two years (Table 5).

The botanical composition was changed between 70.12-100% in 2001, 60.65-100% in 2002, 67.44-100% in two years average.

The highest botanical composition values in the mixtures were from alfalfa+crested wheatgrass in 2001, 2002 and two years average.

This situation shows that competition ability of crested wheatgrass was lower than alfalfa. In respect of botanical composition, green and dry herbage yields the other mixtures were similar and better values than alfalfa+crested wheatgrass.

Table 5: The botanical composition (%) in alfalfa and mixtures and statistical groups\*

| Treatments                     | 2001    | 2002    | Average |
|--------------------------------|---------|---------|---------|
| Alfalfa ( <i>M. sativa</i> L.) | 100.00a | 100.00a | 100.00a |
| Alfalfa+Crested wheatgrass     | 81.23b  | 83.07b  | 82.15b  |
| Alfalfa+Orchardgrass           | 70.12d  | 68.85cd | 69.48c  |
| Alfalfa+Timothy                | 74.23c  | 60.65e  | 67.44c  |
| Alfalfa+Smooth brome           | 72.24cd | 69.61c  | 70.93c  |
| Alfalfa+Meadow-fescue          | 71.55cd | 65.13d  | 68.34c  |
| LSD (0.005)                    | 3.532   | 3.748   | 3.689   |
| CV (%)                         | 8.780   |         |         |

\*Means shown with the same letter in the same column are not significantly different at 0.05 probability level

**CONCLUSIONS**

The results of this study showed that mixtures of alfalfa + Smooth brome, alfalfa + timothy, alfalfa + orchardgrass and alfalfa + meadow fescue may be used to establish artificial pastures and as forage crops in the field areas in South-eastern Anatolia under irrigation conditions.

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