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Full Length Research Paper

An investigation of artificial pasture establishment under dryland conditions

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This study was conducted to determine the suitable mixtures of perennial forage species for the establishment of artificial pasture under dry conditions in Karapinar-Konya between 2004 and 2006. In this study, complex mixtures of crested wheatgrass (*Agropyron cristatum* (L.) Gaertner), tall wheatgrass (*Agropyron elongatum* (Host) Beauv.), intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.), smooth brome (*Bromus inermis* Layss), sheep fescue (*Festuca ovina* L.), tall oatgrass (*Arrhenatherum elatius* (L.) Presl.), alfalfa (*Medicago sativa* L.), sainfoin (*Onobrychis sativa* Lam.) and garden burnet (*Poterium sanguisorba* L.) were used. The experiment design was conducted in a randomized block design with three replications. The highest fresh forage yields were obtained from crested wheatgrass, garden burnet and alfalfa mixtures in 2005 and 2006 (1708.1 and 1763.6 kg ha^{-1}, respectively) and the highest dry matter yield was obtained in 2006 (933.9 kg ha^{-1}). The results showed that mixtures of crested wheatgrass, garden burnet and alfalfa may be used to establish artificial pasture under dryland conditions in similar ecology of Karapınar-Konya.

Key words: Artificial pasture, dryland conditions, crested wheatgrass, garden burnet, alfalfa.

INTRODUCTION

In most situations, dryland pastures best comprised a simple mixture containing two and three species having similar palatability, season of growth, grazing tolerance, drought tolerance and rare cases of regrowth (Holzworth et al., 2003). Alfalfa, sweet clover, or other legumes planted in mixtures with grasses, provide nitrogen to increase yield and nutritive values of the entire mixture. However, it is sometimes difficult to keep legumes in the mixture because of their high palatability (Holzworth and Weisher, 2010). Alfalfa, intermediate wheatgrass, crested wheatgrass and smooth brome cultivar would be suited for use in binary grass-alfalfa mixtures for dryland hay production in most sub-humid to semiarid portions of Northern Great Plains (Berdahl et al., 2001). Artificially, reseeded dryland pastures are costly since they are man-made, although like the native pasture, they are harvested by animals. Seeded pasture may, however, produce greater yields of high quality forage than native ranges since a lot of the undesirable species present on most sites are destroyed or materially reduced in the process of preparing the seedbed. Nonetheless, many of the short-comings of native ranges are likewise apparent in artificially re-seeded dryland pasture (Morrill, 1959).

Plant formations in different parts of the world are composed of many different species, yet the characteristics of the plants within a group or type are the same wherever they are found. As such, the regulation of plant communities according to rainfall climate is as follows: true desert: 0 to 125 mm rainfall, desert shrub: 125 to 250 mm, short-grass: 250 to 375 mm, mid-grass: 375 to 500 mm, etc. (Meimandi-Nejad et al., 1959). The choosing of species that are suitable and well grown in the areas where they are to be planted is of utmost importance. Some of the species which should be quite suitable under 'middle east' conditions would be crested wheatgrass, tall wheatgrass, tall oatgrass, orchardgrass, smooth bromegrass and several legumes as alfalfa and sweet clover. Mixtures of two or three adapted species with similar palatabilities and seasons of growth take better advantage of the site conditions and as such, will usually withstand extremities of weather, diseases and pests better than the pure-stand plantings. Also, mixtures generally

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Table 1. Some soil properties of the research area in Karapinar conditions*.

Depths (cm)	Sand (%)	Silt (%)	Clay (%)	Body	Farm cap (mm)	Volume weight (g/cm^3)	pH	EC (25°C)	Lime (%)	Organic matter (%)
0-15	68.1	15.1	16.6	SL	23.3	1.10	8.1	0.62	44.7	1.9
15-30	57.2	22.7	20.1	SC	32.9	1.09	8.1	0.45	48.6	1.6
30-60	31.0	28.0	43.0	C	79.6	1.01	8.2	0.45	53.5	1.5
60-90	16.0	24.4	59.6	C	88.6	1.06	8.3	0.85	54.6	1.3
90-120	12.5	42.3	45.2	SL	85.7	1.18	8.0	1.10	53.3	1.2

* Konya Research Institute, Directorate of Rural Services.
EC, Electrical conductivity at 25°C.

result in a better cover and provide a greater variety of forage (Nixon et al., 1959). Agronomic improvements of arid rangelands such as reseeding, offer a series of risk that must be considered seriously because of the high expenses involved in this practice. Nevertheless, encouraging results have been obtained in different locations, where reseeding was combined with water conservation practices. Common objectives and goals have been, among others, to eliminate or reduce the competition of noxious plants and substitute them by desirable species, reduce runoff and improve infiltration and implement the adequate management plan after improvement actions (Gonzalez, 1990). The research was established for a suitable artificial pasture in dry conditions of Central Anatolia by using intermediate wheatgrass, smooth brome and alfalfa mixture in 1971 and 1974. In this research, the total dry matter yield was 23.63 kg ha^{-1} in the first year, but it decreased to 16.59 kg ha^{-1} with the general mean being 20.61 kg ha^{-1}. However, the second year yields were lower than the first year yields in this research. From the stand point of weight to botanical composition in mixtures, general mean contributions were 53, 31 and 16% in alfalfa, intermediate wheatgrass and smooth brome, respectively (Özer, 1984). 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.

Nonetheless, for the fact that alfalfa dominates smooth brome at the end of the third year, means that the smooth brome rate should be higher than the alfalfa rate in the foundation year (Albayrak and Ekiz, 2005). Selecting appropriate plant species is one of the most important and fundamental steps in establishing dryland pasture. Wheatgrasses tolerate grazing well and are adapted to many soil types. Thus, they have good seedling vigor. Crested wheatgrass is the best choice for the dry side with sandy or shallow soil. As such, most wheatgrasses species can be mixed with drought tolerant forbs and shrubs (Lile et al., 2006).

MATERIALS AND METHODS

This research was carried out at the Karapinar Wind Erosion Area within the Konya Research Institute, Directorate of Rural services during 2004, 2005 and 2006. Climate and soil characteristics of Karapinar and its surroundings are as follows. The area consists of alluvial, colluvial, sieorezem and regosol soils which have a texture of light sandy loam on upper layers and heavy clay on lower layers (Table 1). They are rich in lime and potash and poor in organic material and phosphorous (Demiryürek, 2000). Climate of the region can be defined as semi-arid and continental. The summers are dry and have warm day-temperatures, followed by cold nights. The winters are usually cold with a verge of twenty days a year in which the soils are covered with snow. As such, the greatest amount of snow falls in January and February. The average annual precipitation in the area is about 270 to 280 mm, which approximates to about 40% falls in winter. During the growing season, rainfall normally amounts to only 90 to 120 mm and is not enough for many crops, because the average temperature is 11°C. The nights are cold in winter in a time when the temperature falls below -20°C or lower. In summer, the temperature is often between 30 and 35°C and is occasionally above 35°C. However, the average relative humidity is between 40% in summer and 80% in winter (Tables 2 and 3) (Acar and Dursun, 2010).

Crested wheatgrass, tall wheatgrass, intermediate wheatgrass, smooth brome, sheep fescue, tall oatgrass, alfalfa, sainfoin and garden burnet were used as the experimental materials. The experiment was conducted in a randomized complete block design with 3 replications and each plot area is 36 m^2 (6 m x 6 m). The amount of species seed for pure seeding were 30 kg ha^{-1} crested wheatgrass, 30 kg ha^{-1} tall wheatgrass, 30 kg ha^{-1} intermediate wheatgrass, 40 kg ha^{-1} smooth brome , 30 kg ha^{-1} sheep fescue , 50 kg ha^{-1} tall oatgrass , 30 kg ha^{-1} alfalfa , 180 kg ha^{-1} sainfoin and 50 kg ha^{-1} garden burnet. The 9 species were grown in combination as fallows: A [crested wheatgrass (30%) + sheep fescue (30%) + garden burnet (20%) + alfalfa (20%)], B [intermediate wheatgrass (40%) + smooth brome (30%) + alfalfa (30%)], C (smooth brome (30%) + crested wheatgrass (30%) + sainfoin (40%)] and D (tall wheatgrass (30%) + tall oatgrass (30%) + sainfoin (40%)]. The determinated weight of species' seed ratios in mixtures were calculated using the formulas given as follows (Avcioğlu, 1999):

Pure live seed percentage (PLS) = [(% Germination) x (% Purity)] / 100

Amount of seed that entered into the mixed combination (g) = [Amount of pure species' seed (10%) added to the combination (g) x participated ratio (%)] / PLS.

Table 2. The maximum (max.) and minimum (min.) temperatures (°C) in Karapinar conditions.

Years/temperatures		Months											
		1	2	3	4	5	6	7	8	9	10	11	12
2004	Max.	14.2	20.5	25.5	29.8	28.5	32.0	36.1	37.1	32.2	30.9	22.0	15.2
	Min.	-18.0	-14.8	-11.0	-8.0	2.6	6.3	8.0	9.7	0.0	-0.5	-15.0	-15.8
2005	Max.	17.2	17.0	23.0	28.6	35.0	33.2	38.5	37.0	30.2	26.4	24.1	21.4
	Min.	-9.5	-17.0	-9.5	-5.2	-2.1	5.6	11.2	10.0	2.5	-5.4	-8.7	-21.2
2006	Max.	12.5	18.2	25.1	25.5	34.1	36.5	33.8	39.8	31.6	28.8	17.0	13.5
	Min.	-24.6	-19.5	-6.8	-4.2	1.0	5.2	8.0	9.0	3.2	1.7	-9.1	-17.4
Long years*	Max.	19.6	20.5	25.5	31.4	36.0	36.8	41.2	38.4	36.2	33.2	25.3	18.4
	Min.	-21.6	-26.8	-22.8	-8.0	-2.3	3.1	5.0	4.5	-3.3	-6.5	-15.0	-21.2

*1983 – 2006.

Table 3. Rainfall (mm) in Karapinar conditions.

Years	Months												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
2004	20.1	14.4	4.6	59.1	12.1	5.4	7.2	-	-	0.2	38.2	10.3	171.6
2005	32.6	18.8	13.3	23.9	18.9	48.7	-	0.2	20.3	14.9	59.0	16.8	267.2
2006	33.7	21.7	22.7	31.6	13.7	1.0	-	0.1	35.7	48.6	21.8	0.1	230.7
Long years*	29.9	27.6	28.5	39.6	38.9	25.5	4.6	2.7	7.5	22.6	27.5	39.5	294.4

*1983 – 2006.

Sowing was performed by hand in 1 to 2 cm depths on the 15th of April, 2004, whereas herbage was not harvested during the growing season of 2004. In 2005 and 2006 growing seasons, all plots had been harvested only once every year and all samples were separated by hand, dried at 70°C for 48 h and weighed. Botanical compositions were determined from 2 random selected 1 m^2 quadrats in each plot (Gökkuş et al., 1995). Crude protein content was calculated by multiplying the Kjeldahl nitrogen concentration by 6.25 (Nelson and Sommers, 1973). The data were analyzed using MSTAT-C statistical package program and the differences were compared by the LSD tests. Although, it could not be measured in the first year of experiment, measurements were made just before harvest. However, the harvest dates were June 22, 2005 and June 20, 2006.

RESULTS AND DISCUSSION

The growth of species in the combination seemed low since the results of drastic soil conditions (Table 1) and weather condition for the first year (2004) of experiment caused drastic results in the research area (Tables 2 and 3). As a result of this situation, it could not be measured for the first year, in that *Festuca ovina* in the combination of A (*Agropyron cristatum + F. ovina+ Poterium sanguisorba + Medicago sativa*) and *A. elatius* in the combination of D (*A. elongatum+ A. elatius+ Onobrychis sativa*) died and they could not be observed in 2005. Despite their death, it is stated that both species were drought resistant (Serin and Tan, 2004) and did not take any place in the botanical composition of the A and D plots in 2005 and 2006. Both of them could not be resistant to drought since they could not grow root in the first year. While determining the botanical composition (according to the surface covering and weight) and the fresh forage yield for the years 2005 and 2006, the plant height, hay rate, hay yield, N ratio, ratio of protein and phosphorous were also determined in 2006 in addition to these. As such, the area in which the experiment was conducted was an area where wind erosion was prevented and soil conditions were degraded very much. Also, the area has the least precipitation in Turkey.

Botanical composition

In the surface covering, the maximum surface covering, according to the measurement, was determined as 74.0% in mixture C in 2005 and 76.6% in mixture A in 2006. Before the fertilization program, the percentage of the area, covered by plants, was 66.6% on an artificial pasture established by a mixture of different gramineous and leguminous forage crops at Animal Husbandry Research Institute of Konya in 1998 (Aksu et al., 2002). The covered area with plant, in 2006, increased in mixtures A and B as 6.6 and 11.7% and decreased in mixtures C and D as 2.4 and 6.6%, respectively. The ratio of leguminacea in the surface covering of mixtures B and D increased as 6.7 and 12.9% and decreased as 4.3 and 18.3% in mixture A and C, respectively in 2006 when

Table 4. Botanical composition according to the surface covering area and fresh forage weight.

Mixture	Botanical composition	2005 covering area (%)	2006 covering area (%)	2005 - 2006 variation	2005 fresh forage in weight (%)	2006 fresh forage in weight (%)	2005-2006 variation
A	Covered with plant	70.0	76.6	+ 6.6			
	Ba	10.0	5.7	- 4.3	11.23	7.48	- 3.75
	Bu	74.6	86.6	+ 12.0	62.41	78.53	+ 16.12
	Di	15.4	7.7	- 7.7	26.36	13.99	- 12.37
B	Covered with plant	63.3	75.0	+ 11.7			
	Ba	56.6	63.3	+ 6.7	54.98	58.16	+ 3.18
	Bu	43.4	36.7		45.02	41.84	
C	Covered with plant	74.0	71.6	- 2.4			
	Ba	23.6	4.7	- 18.9	27.99	11.19	- 16.80
	Bu	76.4	95.3		72.01	88.81	
D	Covered with plant	61.6	55.0	- 6.6			
	Ba	80.4	93.3	+ 12.9	80.52	83.55	+ 3.03
	Bu	19.6	6.7		19.48	16.45	

Ba: Leguminacea family; Bu: grasses (graminea family); Di: garden burnet (from other families).

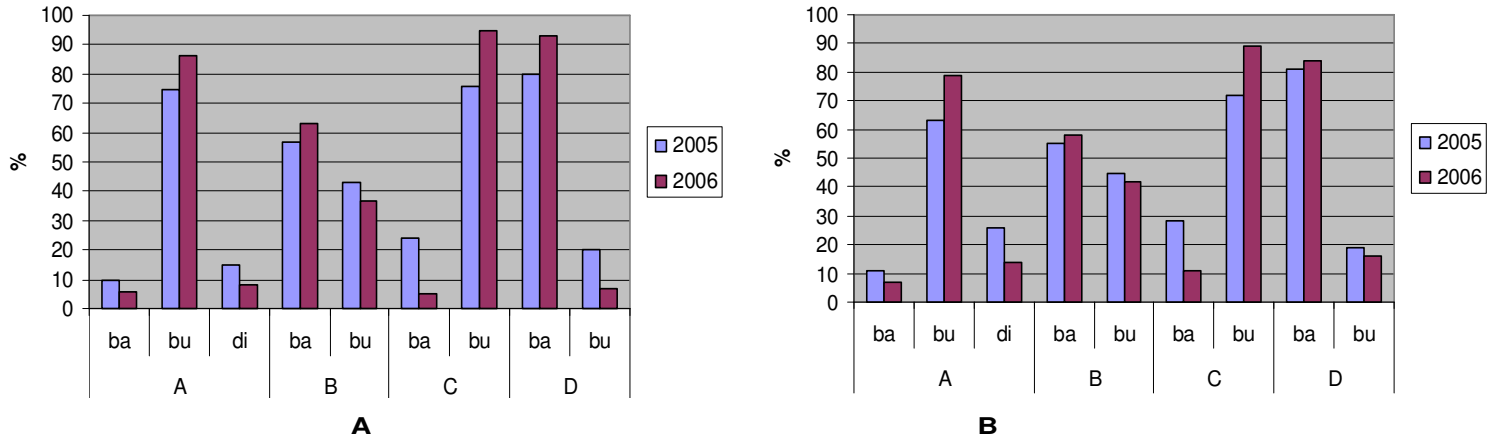

Figure 1. Botanical composition according to the surface covering area (A) and fresh forage yield (B).

compared to 2005. While garden burnet in mixture A was 15.4% of the entire covered surface area in 2005, this ration decreased to 7.7% in 2006. However, the ratio of grasses in the surface covering area for mixtures A and C increased in 2006 as 12.0 and 18.9%, respectively (Table 4 and Figure 1). Despite the ratio of plant groups in fresh forage provided according to the weights that showed parallelism with the surface covering area, differences were still observed in its ratios. The ratios of the botanical composition of grasses in respect to weight were 16.12% in mixture A and 16.80% in mixture C, which showed that an increase was determined in 2006 when compared to 2005. This situation in leguminacea showed that an increase was observed as 3.18% in mixture B and 3.03% in mixture D. The ratio of increase and decrease in weight in these plant groups showed parallelism with the ratio of increase and decrease in surface covering areas, but differs in terms of ratio (Table 4 and Figure 1). However, the difference of species in each mixture was the results of the reaction and competition to environmental conditions and to each other (Nixon et al., 1959; Gonzalez, 1990; Berdahl et al., 2001).

Fresh forage yield and other yield components

Fresh forage yield could not be obtained with respect to yield since harsh weather conditions resulted to drought condition in the first year of the experiment (Table 3). As such, important differences were obtained from the mixtures in respect to fresh forage yield in 2005 and 2006 (Table 5). While the maximum fresh forage yield in 2005

Table 5. Mean values, groups and variance analysis results.

Parameter	Mixtures				Average	LSD	KO	CV (%)
	A	B	C	D				
Area covered with plant (%) (2005)	70.00	63.33	74.00	61.66	67.25		99.639	17.01
Fresh forage yield (Kg ha^{-1}) (2005)	1708.1a	1451.3ab	988.7bc	863.1c	1252.8	46.34 **	4683.196**	12.22
Area covered with plant (%) (2006)	76.66a	75.00a	71.66a	55.00b	69.58	13.63 *	296.528*	9.80
Fresh forage yield (Kg ha^{-1}) (2006)	1763.6a	1019.0b	1088.5b	981.3b	1213.1	52.39 **	4099.318**	14.27
Plant height (cm) (2006)	50.33a	38.33bc	40.33b	30.00c	39.75	9.459 *	209.417*	11.91
Hay ratio (%) (2006)	52.89	44.34	53.69	48.98	49.97		55.047	8.19
Hay yield (Kg ha^{-1}) (2006)	933.9a	451.9b	581.2b	479.9b	611.7	26.85 **	1476.845**	14.50
N ratio (%) (2006)	0.25b	0.27b	0.26b	0.33a	0.28	0.03027**	0.004**	5.24
Protein ratio (%) (2006)	1.50b	1.67b	1.62b	2.09a	1.73	0.3027 **	0.191**	5.78
Phosphorous ratio (%) (2006)	0.56a	0.52ab	0.30c	0.45b	0.46	0.09573**	0.040**	5.02

*P < 0.05; **P < 0.01; KO: mean square; LSD, least significant difference; CV, coefficient of variance.

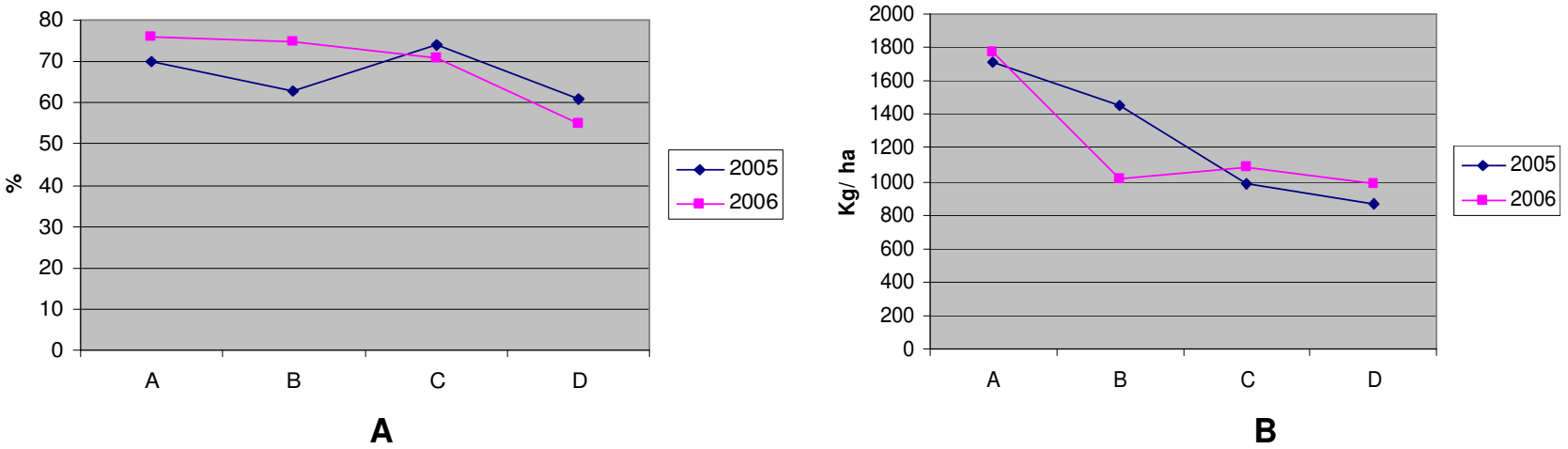

Figure 2. A, Surface covering area (%); B, green forage yield (kg ha^{-1}).

and 2006 was obtained from mixture A (1708.0 kg and 1763.6 kg ha^{-1}, respectively), mixtures B, C and D in 2005 and mixtures C, B and D in 2006 followed mixture A. When we compared the fresh forage yield in 2005 to that in 2006, it increased in mixtures A, C and D, but decreased in mixture B (*A. elongatum + A. elatius + O. sativa*). In the other measurements conducted in 2006, mixture A ranked first in hay yield and plant height, while mixture D ranked first in the ratio of nitrogen and protein (Table 5 and Figure 2). The most outstanding reason for this situation was the reason

of it having the maximum level (83.55%) in the weight of leguminacea's ratio (Table 4) (Holzworth and Weisher, 2010; Morrill, 1959; Özer, 1984).

Conclusion

It is difficult to establish an artificial pasture in an area that has improper soil and weather conditions like Karapinar sub-province in order to obtain sufficient fodder from herbage plants to feed a great number of animals. It should be aimed at the protection of these areas from erosion and applied grazing under control with less number of animals rather than establishing pasture. As such, it should give precedence to alternative methods and resistant-drought plant which is in form of shrubs. The weak seedlings such as *F. ovina* die since they can not reach the sufficient root length even if they are drought-resistant. Therefore, the probability for plants to live, which is formed by strong root and drought-resistance, is highly superior in establishing the pasture in the non-irrigated area such as Karapinar. In this research, mixture A (*A. cristatum+ P. sanguisorba+ M. sativa*) takes the lead with the highest fresh forage.

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