Asian Journal of Chemistry Vol. 20, No. 5 (2008), 4071-4076

Performance of White-Clover Grasses Mixtures: Part-I Dry Matter Production, Botanical Composition, Nitrogen Use Efficient, Nitrogen Rate and Yield

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In legume-grass mixtures, nitrogen relations are among the factors that affect the performance of the mixture. In this study, performance of the binary mixtures composed of white clover (*Trifolium repens* L.) with smooth bromegrass (*Bromus inermis* Leyss), orchardgrass (*Dactylis glomerata* L.) and red fescue (*Festuca rubra* L.), respectively was investigated in the establishment and following years. From a general point of view, mixtures were found to be more productive than white clover sown alone. In the establishment year, productivity of plants was reduced and the highest dry matter yield was obtained in the year following establishment. Higher yield in the following years was caused by increased grass species ratio in the mixture. Competitive strength of grass species was also found to be high in the following years. In the mixtures, where smooth bromegrass, grass species which has the highest competitive strength, takes place, legume ratio was found to be low and dry matter yield was high. The highest nitrogen content was determined to be in white clover sown alone while the highest nitrogen yield was observed in the mixture of white clover with smooth bromegrass.

Key Words: White clover-grasses mixtures, Yield, Nitrogen use efficient, N concentrations.

INTRODUCTION

Selection of compatible species in grass-legume mixtures is of great importance to take the advantages expected from a mixture. In order for the field constitution to have longevity and high yield, competition strength of the species in the mixtures should be close to each other and distribution of their roots and crowns should be different. Mixtures established with incompatible species have either lower crop yields or the constitution is disrupted in a short time[1].

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White clover is one of the legumes which are durable and frequently chosen for basal rangelands[2]. However, because of the risk of bloat, its sole use is not preferred. It is recommended that it be grown in a mixture with grass species, such as, smooth bromegrass, red fescue and meadow fescue on basal rangelands in Eastern Anatolia region[3]. In white clover symbiotic nitrogen fixation capacity is considerably high. Frame and Newbould[4] stated that white clover can provide grass species in mixtures with nitrogen between 150 and 280 kg ha^{-1}.

The most important indicator of a successful mixture (legume and grass) is high crop yield. In addition, longevity of the constitution, perpetuation of the botanical composition in the mixture and nutrient value of the crop are also among the features of successful mixtures. White clover is a legume species which has unique features. Because of its short length it is easily suppressed by tall grass. However, it is more competitive with its stolonous stem nature against weak developing grass species[5]. For these reasons, great care should be taken when selecting grass species for the mixtures where white clover is used. Grass species which has high yield contribution, good nutrient values and unchanging rates in botanical composition of mixtures are preferential. This study was designed to determine the performance of mixtures with recommended grass species and white clover. In the study, botanic composition of mixtures, nitrogen use efficiency, nitrogen rates and yields as well as dry matter yield were investigated.

EXPERIMENTAL

Study was carried out over three years (2002, 2003 and 2004) in experimental field of Atatürk University Agricultural Faculty under irrigable conditions. A randomized complete block design with four replications was used for the field experiments. In the spring of 2002, white clover (*Trifolium repens* L. var. Tohum Islah) was sown alone while smooth bromegrass (*Bromus inermis* Leyss. var. Tohum Islah) was with red fescue (*Festuca rubra* var. Nova Rubra and orchardgrass (*Dactylis glomerata* L. var. Tohum Islah) separately in binary mixtures. Seeds were sown in alternative lines with a 15 cm distance between and the ratio of 1:1 (legume: grass)[6]. During sowing process, amount of white clover and orchard-grass was 10 kg ha^{-1}, smooth bromegrass and red fescue was 15 kg ha^{-1}.

As nitrogenous fertilizer, labelled nitrogen adjusted to 50 kg ha^{-1} and 120 kg P_2O_5 ha^{-1} were delivered[7]. Phosphorous fertilizer was re-applied in autumn every year during the study period. So as to determine the nitrogen use efficiency, micro plots with the size of 0.6 m × 1.0 m in each plot were formed[8] and these micro plots received labelled ammonium sulphate [$(^{15}NH_4)_2SO_4$)] including 5 % atom excess (a.e.) at the beginning of spring every year. Legumes on the plots were harvested upon flowering. They

were harvested only once in 2002 (constitution year) and thrice in other years (2003 and 2004). Samples from micro plots were taken separately. Dry matter yield was obtained by a process in which the harvested wet samples were weighed. This amount (0.5 kg) was dried in the air first and then in the oven set at 78 ºC for 24 h. Dried legume and grass samples were rated to find the proportion of legumes in the mixture. By estimating the nitrogen rate in Kjeldahl method and calculating atom excess *via* emission spectrophotometer in percentage, nitrogen use efficiency and nitrogen yields were found[9]. In order to determine competitive strength of grass species, 10 plants from each plot were collected and dried, then their weight per plant was determined. Using these weight values, competitive strength of grass plants was determined by reported method[10].

In the first year of the study (2002), plants were harvested only once as it was the establishment year and yield was lower. Thus, although results from the first year were evaluated, they were not included in the statistical analysis. Statistical analysis was performed over the values obtained in 2003 and 2004. Analysis was carried out according to randomized complete block design and means found to be significant were compared in LSD test.

RESULTS AND DISCUSSION

In the first year of the study a dry-matter yield of 6421 kg ha^{-1} was obtained. In the second year plants showed their actual performances and the yield increased to a value of 15118 kg ha^{-1} while in the third year this value was determined to be 9952 kg ha^{-1} (Table-1). Crop yields of perennial forage plants are generally lower in the first years, however, they give the highest yield in the year following the constitution (first) year after they well settle in soil[11]. In the years following sowing year, yields of mixtures were found to be higher compared to that of white clover alone. Mixtures composed of compatible legumes and grass species are more productive than plants sown alone[12,13]. However, in the present study an inconvenient result to this condition was obtained and yields of the mixtures were found to be lower in the first year.

According to the means obtained over two years, the mixture composed of white clover and smooth bromegrass gave the highest yield and this mixture was followed by the white clover and orchardgrass and white clover and red fescue mixtures, respectively. Since smooth bromegrass is a tall plant whose biomass production is high. Serin *et al.*[3] also found the mixture of white clover and smooth brome to be more productive.

White clover can take root and establish in the field more quickly. For this, majority of the hay (90.4 %) obtained from mixtures in the sowing year was from legume (Table-1). Grass species show an increase in the

years following constitution year in botanical composition of the mixtures[14]. Hence, in the study, legume ratio reached up to 63.1 % in the second year and then decreased to 46.0 % in the third year. The highest legume ratio (64.4 %) was found to be in white clover and red fescue mixture while the lowest (48.5 %) was in white clover and smooth bromegrass mixture. Similar results were reported by Serin *et al.*[1,3]. Botanical composition of a mixture is shaped as a result of the competitive strength of plants in the mixture. Smooth brome was determined to have the highest competitive strength while red fescue had the lowest among the grass species in the study (Table-2). The fact that the grass species had a very low competitive strength in the first year may explain that grass plants grow more gradually and thus have lower dry matter yields[15].

TABLE-1
DRY MATTER YIELD AND LEGUME RATIO OF HAY IN WHITE CLOVER-GRASS MIXTURES

Mixture	Dry matter yield (kg ha^{-1})				Legume ratio of hay (%)			
	2002	2003	2004	Mean	2002	2003	2004	Mean
W clover (Wc)	8142	13462	7455	10459C	–	–	–	–
Wc-S. bromegrass	6139	16457	12912	14684A	88.6	55.2	41.8	48.5b
Wc-R. fescue	5071	14636	8058	11347B	94.8	79.5	49.3	64.4a
Wc-Orchardgrass	6334	15917	11383	13650A	87.7	54.6	46.8	50.7b
Mean	6421	15118A	9952B	12535	90.4	63.1	46.0	54.6
Year × mixture: ns				LSD year × mixture: 7.5				

Means with capital letters and small letters are not significantly different $p <$ 0.01 and 0.05, respectively.

TABLE-2
COMPETITION COEFFICIENT OF GRASSES AND NITROGEN USE EFFICIENCY IN WHITE CLOVER-GRASS MIXTURES

Mixture	Competition coefficient of grasses				Nitrogen use efficiency (%)			
	2002	2003	2004	Mean	2002	2003	2004	Mean
W clover (Wc)	–	–	–	–	78.75	32.51	12.95c	22.73
Wc-S. bromegrass	0.21	1.03	1.64A	1.34A	44.45	25.06	24.26a	24.66
Wc-R. fescue	0.05	0.40	0.79C	0.59B	43.58	27.07	15.30bc	21.18
Wc-Orchardgrass	0.04	0.89	1.12B	1.01A	61.90	27.51	21.80ab	24.66
Mean	0.10	0.78B	1.18A	0.73	57.17	28.04A	18.58B	23.31
Year × mixture: ns					Year × mixture: ns			

Means with capital letters and small letters are not significantly different $p <$ 0.01 and 0.05, respectively.

Among the mixtures in the study, the highest nitrogen use efficiency was observed in white clover-smooth bromegarss and white clover-orchardgrass mixtures (Table-2). A nitrogen use efficiency value of 22.73 % was found in white clover sown alone, which was lower than both mixtures. Since white clover is a legume species, it has lower reliance on nitrogen from fertilizers. Smooth bromegrass and orchardgrass are the most responsive species to fertilizer nitrogen among the grass plants[16]. Because the legume in the study could not perform symbiotic fixation completely in the first year, nitrogen use efficiency was found to be very high (78.75 %). In the last year, this rate reduced to 12.95 %. It is natural for the ecosystems where legumes take place that nitrogen use efficiency reduces over years. The reason for this is that while roots and nodules are dying, an increase in the decayed materials fallen from above ground parts of the plants to soil increases[17,18]. Thus, plants in the media can use this come out nitrogen more.

The highest nitrogen content was obtained in the hay from white clover sown alone (Table-3). In general, since legumes have more leaves, they also content more nitrogen[1]. The mixtures composed of white clover and smooth bromegrass and white clover and red fescue had more nitrogen than the mixture of white clover and orchardgrass. Nitrogen contents of hay obtained in the sowing year was the highest (3.34 %). This condition proceeded depending largely on the legume ratio in the mixture. Altin[19] also stated that as the grass rate in mixtures increased, nitrogen ratio decreased.

TABLE–3
NITROGEN CONCENTRATION AND NITROGEN YIELD OF HAY IN WHITE CLOVER-GRASS MIXTURES

Mixture	Nitrogen concentration (%)				Nitrogen yield (kg ha^{-1})			
	2002	2003	2004	Mean	2002	2003	2004	Mean
W clover (Wc)	3.14	2.96ab	2.92A	2.94A	257.8	381.7b	176.8D	279.3C
Wc-S. bromegrass	3.39	3.02a	2.41B	2.71B	199.8	486.9a	290.2A	388.5A
Wc-R. fescue	3.52	2.87ab	2.40C	2.64BC	171.7	407.8ab	192.2C	300.0BC
Wc-Orchardgrass	3.30	2.69b	2.24D	2.47C	201.0	415.2ab	229.8B	322.5B
Mean	3.34	2.89A	2.49B	2.69	207.6	422.9A	222.0B	322.6

LSD year × mixture: 0.25 Year × mixture: ns

Means with capital letters and small letters are not significantly different $p < 0.01$ and 0.05, respectively.

Nitrogen yield of the mixtures of white clover with smooth brome was found to be higher compared to others (Table-3). The results mentioned above were found since nitrogen yield results from biomass production and nitrogen content of plants. In 2003, when dry matter yield was the

highest, nitrogen yield was also higher with 422.9 kg ha^{-1} than that found in other years. However, nitrogen yield in the first year was determined to be 207.6 kg ha^{-1}. These results are in convenience with those found by study of Altin[20].

The results obtained in the present study shows that in white clover-grass mixtures, yield and chemical composition changes depending on the grass species taking place in the mixture. In the mixtures where smooth bromegrass took place more in the botanical composition, more yield was obtained. In this mixture, nitrogen use efficiency, competitive strength of grass species and nitrogen yield were also found to be higher.

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(*Received*: 30 November 2007; *Accepted*: 11 February 2008) AJC-6350