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# The Yield Potential of Sainfoin and Alfalfa Mixtures under Dry Land Conditions

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**Abstract:** The yield potential of sainfoin (*Onobrychis sativa*) and alfalfa (*Medicago sativa L.*) mixtures was estimated with tall wheat grass (*Agropyron elongatum*), creasted wheat grass (*Agropyron cristaturn*), and smoot bromegrass (*Bromus inermis*) under dry land conditions. The mixtures sown as cross like, legumes species were seeded one direction and grasses the other. Seeding rate were 8.0 kg sainfoin, 4.0 kg alfalfa, and 3.0 kg grasses per decar (1/10 $ha^{-1}$). Mixtures used 50% of legumes and grasses. 5.0 kg $P_2O_5$ in autumn, and 5.0 kg N were applied in spring for one of each subplots. The contribution of the mixtures of alfalfa and sainfoin with grasses to the hay yield ranged with years. The rate of alfalfa and sainfoin in mixtures decreased with years. The use of fertilizer increased rate of grasses in mixtures with eventually dominated the mixtures. Under dry land conditions, mixture of grasses with legumes appear to be well suited for the establishment of dry land pastures and hay crops, either use one grasses or legumes, or one legumes two grasses mixture. Those would greatly increased the yield of hay and crude protein content over the now prevailing unimproved pastures made up of poor yielding grasses with little or no legumes present.

**Key words:** Alfalfa, onobrchis, grasses, mixtures, hay yield, crude protein content

## Introduction

In forage-animal production systems, grass-legume mixtures are preferred, owing to their several advantages over mono cultures (Haynes, 1980). Yields are generally higher in the mixtures because of more efficient light utilization (Brougham, 1958), allopathic effects (Pudnam and Duke, 1978) and transfer of symbiotically fixed nitrogen to grasses (Ledgard, 1991). Furthermore, dry matter production is more balanced, grasses being more productive in spring and legume in summer (Mooso and Wedin, 1990). More erect leaves of grasses vs. more horizontal leaves of legumes also minimize any inter-specific plant competition (Mooso and Wedin, 1990). The production of high-protein and more nutritious hay (Jung *et al.*, 1991) and reduced nitrogen inputs (Whitehead, 1995) thanks to symbiotically fixed nitrogen (hence less environmental pollution) make mixtures even more attractive. The beneficial effects of mixtures may vary with sowing methods and mixture combinations (Altin and Gökkuþ, 1988). This work was undertaken to investigate the hay yield, N harvest, and crude protein content rate of grasses and legumes mixtures (alfalfa and onobrichis). The objectives of the experiment were to determine high yielding grass-legume combinations, to investigate the possibility of achieving high hay yields and greater protein content, and to determine how fertilizer effect on grass-legume components.

## Material and Methods

The experiment was conducted in the experimental fields of Agricultural Research institute field in Ilica, Erzurum valley Turkey, for 3 years between the 1987 and 1989 to determine the effect of sainfoin (*Onobrychis sativa*) and alfalfa (*Medicago sativa*) upon three associated forage grasses with tall wheat grass (*Agropyron elongatum*), creasted wheat grass (*Agropyron cristaturn*), and smoot bromegrass (*Bromus inermis*) under dry land conditions.

The experimental area (39° 55'N and 41°61'E) has an altitude of 1600m, with a total annual precipitation of 446 mm on average and an annual overall temperature of 6°C. The precipitation was 509.7, 373.7, 398.6, and 592.9mm, respectively, in four experimental years, with the temperatures being similar to the long-term average apart from a slightly higher temperature in 1989. The loamy experimental soil was poor in organic matter (1.92%) and phosphorous (14.3-36.9 kg $ha^{-1}$) but rich in potassium content (1457-2340 kg $ha^{-1}$) with a pH of 7.85.

The five species were grown alone and in combination as fallows: 1. *Medicago sativa* (M), 2. *Onobrychis sativa* (O), 3. *Bromus inermis* (B), 4. *A. cristatum* (C), 5. *A. elongatum* (E), 6. M+B, 7. M+C, 8. M+E, 9. O+B, 10. O+C, 11. O+E, 12. B+M+E, 13. B+M+C, 14. E+M+C, 15. B+O+E, 16. B+O+C, 17. E+O+C.

The experiment set up a randomized block design with four replications of 17 plots 7.60 X 3.60 $m^2$. Rows were spaced 40 cm apart and seeded with a hand drill. The mixtures sown cross like, in which legumes species were seeded in one direction and grasses on other. Seeding rate were 8.0 kg sainfoin, 4.0 kg alfalfa, and 3.0 kg grasses per decar (1/10 ha). Mixtures used 50% legumes and grasses. Each plot of replicant were divided by two subplot, and 5.0 kg $P_2O_5$ at autumn, and 5.0 kg N were applied in spring for one of each subplots.

Growth was measured in one cut taken in each of the three harvest years in stubble of 7 cm height (Soto and Lopez, 1986) 1987-89. The fresh sward was weighed and sub samples for drawn for dry matter and nitrogen determinations was upon drying at 78°C for 24 h (Jones, 1981). Further sub samples were drown to measure legumes contribution in the frash state. The dry matter and crude protein contents of the separated legumes varieties were determined from bulked samples. In the mixtures, the seeding rate was calculated by considering the area occupied by respective components in the mixtures (Altin and Gokku°, 1988). The data obtained from the experiment were subjected to analysis of variance, and means were separated using Duncan's multiple range test.

## Results and Discussion

Dry matter production varied significantly, depending on the treatments and years ($P<0.01$). On average of three years of the amount of dry matter produced of single crops *agropyron elongatum* was high both of fertilizer (5.01 t $ha^{-1}$) and unfertilized (4.19 t $ha^{-1}$). Alfalfa had lower production 2.46 t $ha^{-1}$, 1.67 t$ha^{-1}$ respectively. Comparing of alfalfa and onobrichis with grasses showed that both fertilized and unfertilized O + grasses 5.46 t $ha^{-1}$, 4.81 t $ha^{-1}$ was hay yielding than that of M+ grasses mixtures (5.06 t $ha^{-1}$, 4.02 t $ha^{-1}$) respectively (Table 1).

Table 1: A dry matter yield for three years (t $ha^{-1}$) Fertilized (F), Unfertilized (UnF)

| Combination | 1987 | | 1988 | | 1989 | | Average | | |
|---|---|---|---|---|---|---|---|---|---|
| | F. | UnF | F | UnF | F | UnF | F | UnF | Mean |
| M | 1.71g | 1.55e | 3.58d | 2.14e | 2.08d | 1.31 d | 2.46 | 1.67 | 2.06 g |
| O | 4.78ab | 4.39abc | 6.91ab | 5.91cd | 3.11cd | 2.63 c | 4.93 | 4.31 | 4.62c-f |
| B | 5.10a | 4.99a | 5.84bc | 5.53cd | 5.03c | 3.03 c | 5.32 | 4.52 | 4.16a-f |
| C | 3.77b-f | 3.52a-d | 6.23abc | 4.79 d | 4.46b | 2.21 c | 4.82 | 3.51 | 4.16 f |
| E | 4.62ab | 3.62a-d | 6.69abc | 6.03cd | 3.71c | 2.94 c | 5.01 | 4.19 | 4.60def |
| Average | 4.00 | 3.60 | 5.85 | 4.88 | 3.68 | 2.42 | 4.51 | 3.64 | 4.03 |
| M+B | 3.01ef | 3.16bcd | 5.90bc | 5.49cd | 6.43a | 3.15 b | 5.11 | 4.03 | 4.58def |
| M+C | 3.93b-f | 3.73a-d | 7.09abc | 5.63cd | 5.49a | 3.30 b | 5.90. | 4.22 | 4.86a-.f |
| M+E | 3.35c-f | 2.73a-d | 5.81bc | 5.49cd | 4.51c | 3.14bc | 4.56 | 3.77 | 4.17ef |
| Average | 3.43 | 3.20 | 6.27 | 5.53 | 5.48 | 3.20 | 5.06 | 4.02 | 4.54 |
| O+B | 4.34a-d | 4.94a | 7.14abc | 5.66cd | 6.09b | 3.40 b | 5.86 | 4.67 | 5.26a-d |
| O+C | 4.35abc | 4.19a-d | 7.29abc | 6.93acd | 5.78a | 4.00 a | 5.81 | 5.04 | 5.42abc |
| O+E | 4.61ab | 4.51ab | 5.88bc | 6.25bcd | 3.67a | 3.45 b | 4.72 | 4.72 | 4.72 f |
| Average | 4.43 | 4.55 | 6.77 | 6.28 | 5.18 | 3.61 | 5.46 | 4.81 | 5.14 |
| B+M+E | 3.30c-f | 2.74de | 5.69 c | 5.63cd | 4.84b | 3.41b | 4.61 | 3.84 | 4.22 f |
| B+M+C | 3.18e-f | 3.30bcd | 6.66abc | 5.90cd | 5.81a | 3.53 b | 5.21 | 4.24 | 4.73a-.f |
| E+M+C | 2.92f | 2.87cde | 7.16abc | 7.58ab | 5.72a | 3.47 b | 5.27 | 4.64 | 4.95a-.f |
| Average | 3.13 | 2.97 | 6.50 | 6.37 | 5.46 | 3.45 | 5.03 | 4.24 | 4.64 |
| B+O+E | 4.15a-e | 4.17a-d | 7.69a | 6.91abc | 3.93bc | 3.96ab | 5.25 | 5.01 | 5.13 e |
| B+O+C | 3.99a-f | 4.18a-d | 7.18abc | 7.92a | 5.51a | 4.42a | 5.56 | 5.50 | 5.53ab |
| E+O+C | 3.97f | 4.44ab | 7.43ab | 7.91a | 5.51a | 4.62 a | 5.63 | 5.66 | 5.64 a |
| Mean | 4.03 | 4.26 | 7.43 | 7.58 | 4.98 | 4.33 | 5.48 | 5.39 | 5.44 |
| Mix.mean | 3.26 | 3.75 | 6.74 | 6.46 | 5.27 | 3.65 | 5.26 | 4.62 | 4.94 |
| Over all mean | 3.80 | 3.72 | 6.56 | 6.14 | 4.95 | 3.40 | 5.11 | 4.42 | 4.76 |

Table 2: The effect of companion grasses on the percentage crude protein yield ( kg $ha^{-1}$)

| Combination | Fertilizer | Unfertilizer | Average |
|---|---|---|---|
| M | 4.392 | 2.659 | 3.526 |
| O | 6.200 | 5.737 | 6.268 |
| B | 5.109 | 3.475 | 4.292 |
| C | 3.561 | 2.374 | 2.967 |
| E | 4.925 | 4.599 | 4.762 |
| Average | 4.957 | 3.769 | 4.363 |
| M+B | 5.800 | 4.122 | 4.577 |
| M+C | 5.898 | 3.352 | 4.625 |
| M+E | 4.667 | 3.621 | 4.144 |
| Average | 5.455 | 3.669 | 4.577 |
| O+B | 6.793 | 5.143 | 5.968 |
| O+C | 7.040 | 5.542 | 6.294 |
| O+E | 5.067 | 5.989 | 5.528 |
| Average | 6.300 | 5.560 | 5.930 |
| B+M+E | 4.816 | 3.640 | 4.218 |
| B+M+C | 5.790 | 6.038 | 5.914 |
| E+M+C | 5.807 | 4.014 | 4.911 |
| Average | 5.471 | 4.557 | 5.014 |
| B+O+E | 6.390 | 5.785 | 6.087 |
| B+O+C | 6.819 | 5.964 | 6.391 |
| E+O+C | 7.306 | 6.629 | 6.968 |
| Average | 6.836 | 5.785 | 6.087 |
| Mix. mean | 6.016 | 4.986 | 5.501 |
| Overall mean | 5.804 | 4.742 | 5.293 |

Comparing with the mixtures, onobrychis + grasses mixture either single or two grasses was higher 5.46 t $ha^{-1}$, 5.63 t $ha^{-1}$ under fertilizer conditions. However unfertilized plots were lover than fertilized plots. The mixtures were superior to pure grass or legume stands. Utilization of symbiotically fixed nitrogen (Whitehead, 1995), more enhanced interception of light (Hay and Walker, 1989) and allelopathic (Pudnam and Duke, 1978) and some other effects in the mixtures created a micro-environment for higher yields as compare to sole legume or grass stands. Hence, substantial yields with minimal or no use of fertilizer inputs may be sustained in grass-legume mixtures, otherwise only achievable by a heavy application of N to pure grass stands, which may have far reaching effects for nitrogen leaching and subsequent pollution of water resources. Pure legume stands may still be behind the mixtures since both their yields were lower, and hay production in the mixtures was more evenly distributed during the season, with grass being more productive early in spring and legumes late in the season (Mooso and Wedin, 1990). The grass component may well benefit from the fixed N by legumes during the season and over the years, which was enhanced after the second year (Altýn, 1982; Heichel and Henjum, 1991).

The highest dry matter yields (grass + legume) were obtained in the second year (Table 1), most of which was from the combinations of the onobrychis in both fertilized and unfertilized plots. The use of fertilizer was affected and increased dry matter yield in all plots and it was approximately 75 to 80% in all single and mixtures.

The crude protein content was also higher in the mixtures (Table 2). Hay from E+O+C mixtures had the highest protein content (7.31 kg $ha^{-1}$) with fertilizer plots, whereas pure *Agropyron cristatum* plots had the lowest protein content (2.37 kg $ha^{-1}$) under no fertilizer used plots. On the average pure onobrychis (6.27 kg $ha^{-1}$) and its mixtures had more crude protein content than of the alfalfa and its mixtures. On the other hand mixtures of gave higher protein content than grasses alone. Those are showed that legumes provided nitrogen in the soil, and grasses associated with legumes profited from the nitrogen. Consequently use of fertilizer was increased percentage of protein content (Table 2).

The higher protein concentration and greater N harvest in the second and third years may substantiate that N uptake was somehow enhanced (Table 2). The protein content was higher

Table 3: Percentage of combination with fertilizer and unfertilizer condition on average of three year (%)

| Combination | Fertilizer | Unfertilizer | Mean |
|---|---|---|---|
| *Medicago sativa* | 21.53 | 16.97 | 19.25 |
| *Bromus inermis* | 78.47 | 83.03 | 80.75 |
| | | | |
| *Medicago sativa* | 13.23 | 12.80 | 13.02 |
| *Agropyron cristatum* | 86.75 | 87.20 | 86.98 |
| | | | |
| *Medicago sativa* | 20.23 | 23.23 | 21.73 |
| *Agropyron elangatum* | 79.77 | 76.77 | 78.27 |
| | | | |
| *Onobrychy's sativa* | 58.13 | 66.87 | 62.50 |
| *Bromus inermis* | 41.87 | 33.13 | 37.50 |
| | | | |
| *Onobrychy's sativa* | 47.30 | 46.86 | 47.08 |
| *Agropyron cristatum* | 52.70 | 53.13 | 52.92 |
| | | | |
| *Onobrychy's sativa* | 80.93 | 79.83 | 80.38 |
| *Agropyron elangatum* | 19.07 | 20.17 | 19.62 |
| | | | |
| *Bromus inermis* | 53.10 | 61.00 | 57.05 |
| *Medicago sativa* | 22.20 | 17.90 | 20.05 |
| *Agropyron elangatum* | 24.70 | 21.10 | 22.90 |
| | | | |
| *Bromus inermis* | 33.40 | 35.16 | 34.28 |
| *Onobrychy's sativa* | 58.00 | 57.26 | 57.63 |
| *Agropyron elangatum* | 8.60 | 7.56 | 8.08 |
| | | | |
| *Agropyron elangatum* | 19.70 | 25.10 | 22.40 |
| *Medicago sativa* | 19.08 | 18.43 | 18.73 |
| *Agropyron cristatum* | 61.30 | 56.47 | 58.87 |
| | | | |
| *Agropyron elangatum* | 4.93 | 3.43 | 4.18 |
| *Onobrychy's sativa* | 65.20 | 66.96 | 66.08 |
| *Agropyron cristatum* | 29.87 | 29.60 | 29.73 |
| | | | |
| *Bromus inermis* | 28.66 | 27.60 | 28.13 |
| *Medicago sativa* | 21.00 | 23.80 | 22.40 |
| *Agropyron cristatum* | 50.33 | 48.60 | 49.47 |
| | | | |
| *Bromus inermis* | 18.00 | 16.50 | 17.25 |
| *Onobrychy's sativa* | 53.63 | 53.33 | 53.48 |
| *Agropyron cristatum* | 28.37 | 30.16 | 29.27 |

a in the second years during the season because of a lower fraction of grass components at the pre-stem elongation stage and legume components having a higher leaf/stem ratio. This may be partly due to cumulative effects of enhanced N fixation over the season and years. N application may be eliminated with only yearly inclusion of phosphorus input into the system, although an improvement of symbolically fixed nitrogen in the mixtures may warrant further work( Gökku⁰ *et al.*, 1999)

The contribution of the mixtures of alfalfa and sainfoin with grasses to the hay yield ranged with years. The rate of alfalfa and sainfoin in mixtures decreased with years. The use of fertilizer increased rate of grasses in mixtures with eventually dominated the mixtures.

It is concluded that use of leguminous crops, fixed the atmospheric nitrogen in soil through bacteria located in root nodules. Consequently the grasses grown with legumes can use this nitrogen.

Under dry land condition, mixture of grasses with legumes appear to be well suited for the establishment of dry land pastures and hay crops, either use one grasses or legumes, or one legumes two grasses mixture. Those would greatly increased the yield of hay and crude protein content over the now prevailing unimproved pastures made up of poor yielding grasses with little or no legumes present.1999. Hay yield and nitrogen harvest in smooth bromegrass

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