

Araştırma Makalesi/Research Article (Original Paper)

Performance of Alfalfa under Different Intercropping Treatments

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Abstract: This study was aimed to determinate the yield and quality pattern of alfalfa stand under different intercropping treatments. Alfalfa was intercropped with sorghum-sudangrass hybrid, soybean, cowpea, and buckwheat at seed ratio of 100%:100%, 100%:80% or 100%:60%, and 100% alfalfa was used as control. The experiment was arranged in randomized block design with three replications and conducted at the research field of Yozgat Bozok University located in inner Anatolia, Yozgat-Turkey. Alfalfa and companion crops were sown as binary mixtures with 60 cm row distance in the spring of 2015. All the data was collected in the establishment year and the first production year (2016). Hay yield, protein yield, ADF (Acid detergent fiber), NDF (neutral detergent fiber), Ca, Mg, P and K content were investigated in all the treatments. Alfalfa intercropped sorghum-sudangrass hybrid at 100%:60% seed ratio produced the highest hay yield both in the establishment year (18.25 t ha⁻¹) and the first production year (17.91 t ha⁻¹). This study showed that intercropping increased hay and protein yield of alfalfa stand compare to sole alfalfa with the significant effect of companion crop and seed ratio.

Keywords: Alfalfa, Buckwheat, Hay yield, Intercropping, Sorghum

Yoncanın Farklı Karışık Ekim Uygulamaları Altındaki Performansı

Öz: Bu çalışmada farklı bitkiler ile karışık ekilen yoncanın verim ve kalite özelliklerinin belirlenmesi amaçlanmıştır. Yonca ile birlikte karışık olarak; sorgumxsudanotu melezi, soya, börülce ve karabuğday kullanılmıştır. Karışımlar % 100:100, % 100:80 veya % 100:60 tohum oranlarıyla ekilmiş, kontrol olarak ise yalın yonca kullanılmıştır. Çalışma Tesadüf Blokları Deneme Desenine göre 3 tekrarlamalı olarak kurulmuş olup, Yozgat Bozok Üniversitesi Uygulama ve Araştırma arazisinde yürütülmüştür. Yonca ile arkadaş bitkilerin ekimi sıra arası 60 cm olacak şekilde ve 2015 ilkbahar döneminde yapılmıştır. Çalışmada tüm gözlemler hem denemenin kurulduğu yılda hem de ikinci yılda alınmıştır. Araştırmada tüm işlemlerde kuru ot verimi, protein verimi ile ADF, NDF, Ca, Mg, P ve K içerikleri incelenmiştir. En yüksek kuru ot verimi hem denemenin kurulduğu ilk yıl (18.25 t/ha) hem de ikinci yılda (17.91 t/ha) yonca + sorgumxsudanotu melezinin % 100:60 karışımından elde edilmiştir. Bu çalışmada karışık ekimin yalın yonca ekimine oranla ot ve protein verimini yükselttiği ve yoncanın arkadaş bitkiden ve karışım oranlarından etkilendiği belirlenmiştir.

Anahtar kelimeler: Yonca, Karabuğday, Kuru ot verimi, Karışık ekim, Sorgum

Introduction

Alfalfa is generally considered as one of the best forage crops for feeding ruminant animals because of its high nutritional value. Alfalfa leaves are rich in protein and vitamin and low in cell wall concentration. In contrast to leaves, stems exhibit low digestibility as a result of high concentrations of cell wall polysaccharides and lignin (Schnurra et al. 2007). However, weak growth and weed infestation are important problems of alfalfa in the establishment year, which can be largely solved with the intercropping (Coruh and Tan 2008). Intercropping is cultivation of two or more crops simultaneously in same field has been widely applied due to its economic, ecological and environmental benefits (Whitmore and Schröder 2007) compared to sole cropping. In addition, intercropping increases yield and controls pests and diseases (Fenández-Aparicio et al. 2007; Ren et al. 2008). However, companion crops generally act like weeds by competing young seedling for water, minerals and light. Companion crop selection, seed ratio arrangement (Lanini et al. 1991) and harvest time (Miller and Stritzke 1995) are extremely important to reduce competition between plants in the intercropping systems. Therefore removing time of companion crop is very important and should be decided based on alfalfa stage. The legume/grass intercropping system is common systems for small-scale farmers.

Alfalfa is intercropped with many annual crop such as wheat, oat, barley, buckwheat, field pea, forage turnip etc., (Tan and Serin 2004; Basaran et al. 2014; Sheaffer et al. 2014) depending on ecological condition and season. Alfalfa can be sown in spring, summer and early autumn when the temperature is consistently adequate (>3 °C) for germination. Alfalfa seeded in spring, when summer annual weeds and grasses grow more rapidly, weed control can be more difficult in alfalfa stand (Coruh and Tan 2008).

In the present study, alfalfa was seeded with four annual crops (sorghum-sudangrass hybrid, soybean, cowpea and buckwheat) with three seed ratio in the spring season and, yield and quality of stand were monitored both in the establishment and first production year.

Material and Methods

The study was carried out during 2015 and 2016 growing seasons in Yerkey/Yozgat. Soil analysis and climatic conditions of experiment field during the growing season are shown in Table 1 and 2 of respectively.

Table 1. Physical and Chemical Properties of Soil in Research Area*

Properties	2015	2016
Structure	Clay-loam	Clay-loam
CaCO ₃ (%)	7.93	7.90
Total salt (%)	0.018	0.020
P ₂ O ₅ (kg ha ⁻¹)	85.2	85.8
K ₂ O (kg ha ⁻¹)	501.2	510.2
pH	8.15	8.12
Organic matter (%)	1.91	1.98

*Turkish chamber of agriculture cooperation.

Table 2. Climatic Conditions Long-term and Growing Season in Research Area*

Months	Long-term			2014-2015			2015-2016		
	Temp. (°C)	Moist. (%)	Precipt. (mm)	Temp. (°C)	Moist. (%)	Precipt. (mm)	Temp. (°C)	Moist. (%)	Precipt. (mm)
October	10.3	65.9	36.5	10.8	69.3	72.6	11	58.3	7.3
November	4.6	72.5	56.2	4.2	70.2	61.3	5.2	68.2	63.3
December	0.5	77.3	76.3	4.1	77.9	53.3	4.6	73.6	51.5
January	- 1.9	77.5	67.9	-1.0	76.7	54.5	-2.3	80.4	139.9
February	- 1.0	75.8	62.3	0.8	73.3	68.0	4.6	73.1	63.4
March	2.9	71.0	65.2	4.4	69.5	115.3	5.4	63.1	62.2
April	8.3	66.6	62.3	6.1	61.9	28.0	12	49.8	24.6
May	13.0	64.2	65.0	14.1	59.9	131.6	12.6	67.5	101.5
June	16.8	60.5	43.5	16.0	71.5	95.3	18.4	58.9	31.1
July	19.7	56.8	12.3	19.8	54.7	7.1	20.4	53	0.8
August	19.6	55.7	8.90	21.3	56.7	5.4	21.8	55.8	3.2
September	15.5	58.1	18.0	20.1	49.4	24.7	15.4	56.6	15
Average	9.0	66.82		10.05	65.91		10.76	63.19	
Total			574.4			717.1			563.8

Alfalfa was intercropped with four companion crops at the spring season of 2015 under irrigated field. All the companion crops removed from the field end of the establishment year and, only alfalfa left on the field in the second year. And data was collected both in the establishment and first production year. The establishment year (in 2015), firstly alfalfa “Victoria” was broadcasted to finely prepared soil by hand with 30 kg ha⁻¹ seed rate, than companion crops (buckwheat ‘Güneş’, sorghum-sudangrass hybrid ‘Sugar Graze II’, soybean ‘Yesilsoy’ and cowpea ‘Ülkem’) were sown in binary rows with three seed rates (100:100; 100:80; 100:60). Row distance was maintained at 30 cm for alfalfa x buckwheat mixtures and at 60 cm for others. Sole seed rates of companion crops were as fallows; soybean, cowpea (12 seed m⁻²), sorghum (30 kg ha⁻¹) and buckwheat (40 kg ha⁻¹). Experiment was planned in a randomized complete block design with three replications and a plot area of 12 m². After the sowing, 200 kg ha⁻¹ DAP (18% N:46% P₂O₅) was applied. Irrigation was performed when needed during the both year.

In the establishment year (2015), companion crops were harvested as forage at different stages based on their and alfalfa growth. Buckwheat was cut at the full flowering stage. Cowpea and soybean were cut when they

reach 50 and 55 cm respectively. Sorghum was harvested three times due to regrowth ability when it reaches 120-190 cm depending on harvest time. Alfalfa was cut tree times (3 July, 11 August, 27 September) in the establishment year and five times (19 May, 16 June, 18 July, 24 August, 29 September) in the first production year. Alfalfa and companion crops were harvested together at the each harvest and, total forage yield and mean quality of the cropping treatments were determined as follows;

$$\text{Forage Quality}_{(\text{mean})} = \frac{(Y_{C1} * X_{C1\%}) + (Y_{A1} * X_{A1\%}) + \dots + (Y_{An} * X_{An\%}) + (Y_{Cn} * X_{Cn\%})}{Y_{\text{Total}}}$$

$$\text{Yield}_{(\text{total})} = (Y_{C1} + Y_{A1}) + \dots + (Y_{Cn} + Y_{An})$$

**Quality traits: CP (Crude protein), ADF (Acid Detergent Fiber), NDF (Neutral Detergent Fiber) and mineral matters, Y: yield, A: alfalfa, C: companion crop, X: content of quality traits in forage. 1,2,..,n: cutting number.

In both years, tree samples were taken from each treatment. To determine dry matter yield, samples were dried at 65 °C until the constant weight. Dry samples were ground (<1 mm) and subjected to quality analyses regarding Crude protein (CP), Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF), Ca, P, Mg and P by using Near Reflectance Spectroscopy (NIRS, 'Foss XDS') with software package program 'IC-0904FE'.

Results and Discussion

The effect of the intercropping on the hay yield, protein yield, ADF and NDF content was significant ($p < 0.01$) in the alfalfa stand both establishment (2015) and first production year (2016) (Table 3). Total hay yield of alfalfa intercropped different crops in the establishment year was given in Figure 1. Total hay yield of the alfalfa at the establishment year increased when it seeded with sorghum-sudangrass hybrid (SR), soybean (SY) and buckwheat (B) but decreased with cowpea (C) compared to sole alfalfa (A). At the establishment year, the highest hay yield was obtained from the treatments of 100A:60SR (18.25 t ha⁻¹). SR was cut three times during to establishment year like alfalfa while other companion crops were fully removed at the first cutting. Therefore the higher yield in AxSR mixtures was due to the multi-cutting characteristics of the SR, which can be clearly seen with the ratio of SR in total yield (Figure 1). In addition hay yield of the AxSR mixtures increased with the decreasing seed ratio of the SR, indicating that the seed ratio in the mixtures is as importance as crop selection. The portion of the alfalfa in total yield was also lower in AxSR mixtures.

Table 3. Hay yield, protein yield, average ADF and NDF contents of alfalfa under intercropping with different crops in the establishment year (in 2015) and in the first production year (in 2016)

Intercropping*	Hay Yield (t ha ⁻¹)		Protein Yield (t ha ⁻¹)	ADF (%)		NDF (%)	
	2015	Total**	Total**	2015	2016	2015	2016
100A:100SR	9.83 h	24.94 f	5.83 e	26.75 e	26.49 f	42.37 c	39.67 h
100A:80SR	16.90 b	33.25 b	7.66 b	31.27 b	23.58 j	33.81 h	36.68 l
100A:60SR	18.25 a	36.17 a	7.98 a	32.28 a	25.04 h	34.34 g	38.29 i
100A:100C	7.72 k	21.96 j	5.18 g	25.55 f	27.59 c	34.97 f	39.78 f
100A:80C	7.59 k	22.18 i	5.21 g	27.20 de	26.84 e	39.69 d	39.72 g
100A:60C	9.42 i	24.40 g	5.88 e	27.50 d	26.75 ef	39.49 d	39.68 h
100A:100SY	12.07 e	28.31 d	6.32 c	27.28 de	30.42 a	38.70 e	44.33 a
100A:80SY	10.46 f	25.09 f	5.52 f	32.27 a	28.97 b	45.85 a	42.04 c
100A:60SY	9.80 h	24.94 f	5.92 de	31.45 b	25.38 g	45.03 b	38.12 j
100A:100B	10.39 g	23.36 h	5.06 g	18.32 h	27.24 d	26.70 j	40.13 d
100A:80B	13.10 d	27.24 e	5.83 e	20.04 g	27.57 c	29.79 i	39.91 e
100A:60B	15.99 c	31.32 c	6.14 cd	17.88 h	28.94 b	25.91 k	42.40 b
100A	8.13 j	21.18 k	5.19 g	29.23 c	24.26 i	42.17 c	37.84 k

*: $p < 0.01$, There is no differences same letters in same column. A: alfalfa, SR: sorghum-sudangrass hybrid, SY: soybean, C: cowpea and B: buckwheat.

** : The sum of 2016 and 2015

Buckwheat is a low forage yielding crop compared to SR, it is fast-growing crop that provides weed control in the alfalfa field. Intercropping alfalfa with cowpea and soybean produced lower hay yield almost all the seeding rates than other mixtures, moreover, lower than sole alfalfa particularly in AxC mixtures with the 100:100 and 100:80 seeding rate in the establishment year (Figure 1). Soybean and cowpea almost disappeared

from the mixture when alfalfa reached at the flowering stage. Therefore, their contribution to yield was eliminated.

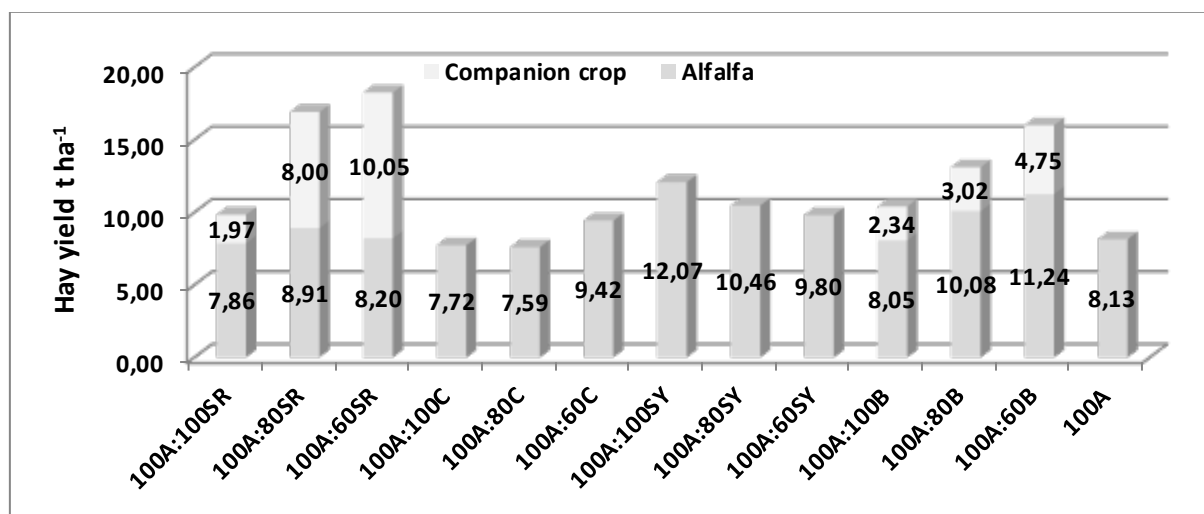


Figure 1. Hay yield of the intercropping alfalfa in the establishment year and, the contribution of the companion crops to yield.

A: alfalfa, SR: sorghum-sudangrass hybrid, SY: soybean, C: cowpea and B: buckwheat.

Hay yield in the establishment year and protein yield in the first production year of intercropping treatments were given in Figure 2 and Figure 3 of respectively. Total hay yield highly increased in compared with pure alfalfa (A), when alfalfa intercropped all companion crops. But, the highest it was A x SR intercropped with the seeding rate of 100:60 (36.16 t ha⁻¹), 100:80 (33.25 t ha⁻¹). Similarly, total protein yields were the highest in same treatments (100A:60SR and 100A:80SR) with 7.98 t ha⁻¹ and 7.65 t ha⁻¹, respectively. According to combined data, also A x B intercropping produced good results with 31.32 t ha⁻¹ and 6.15 t ha⁻¹ protein yield at 100:60 seed rate, This situations showed that SR and B can be a good company crop for alfalfa.

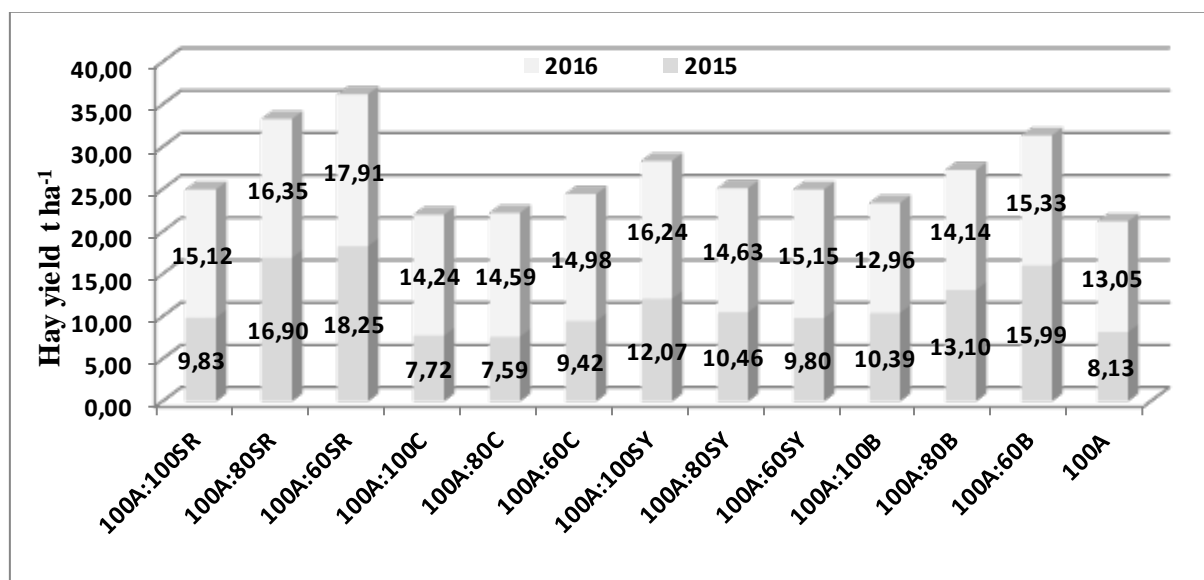


Figure 2. Total hay yield of alfalfa under intercropping with different crops in the establishment year (in 2015) and sole alfalfa in the first production year (in 2016).

A: alfalfa, SR: sorghum-sudangrass hybrid, SY: soybean, C: cowpea and B: buckwheat.

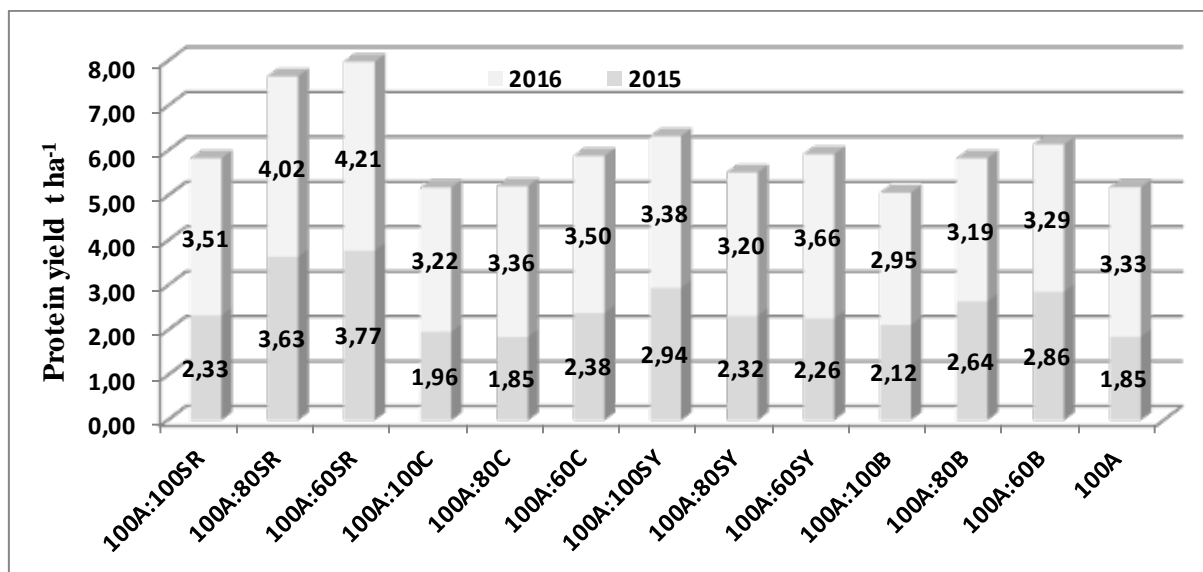


Figure 3. Total protein yield of alfalfa under intercropping with different crops in the establishment year (in 2015) and sole alfalfa in the first production year (in 2016).

A: alfalfa, SR: sorghum-sudangrass hybrid, SY: soybean, C: cowpea and B: buckwheat.

ADF (%) and NDF (%) of alfalfa stand in the establishment and the first production year were also affected by companion crops and its seed rates (Figure 4). As expected, ADF and NDF content of the hay showed differences among treatments and seed rates due to companion crop effect in the establishment year while more stable in the first production year. In the establishment year, ADF and NDF content of AxB mixtures exhibited more differences and lower values compare to other treatments. It can be attributed lower fiber content of the buckwheat. Engin and Mut (2017) reported that ADF and NDF contents in alfalfa varied from 28.8 to 30.6% and 41.9 to 45.8% in establishment year and 27.5 to 29.7% and 40.0 to 42.9% in first production year, respectively.

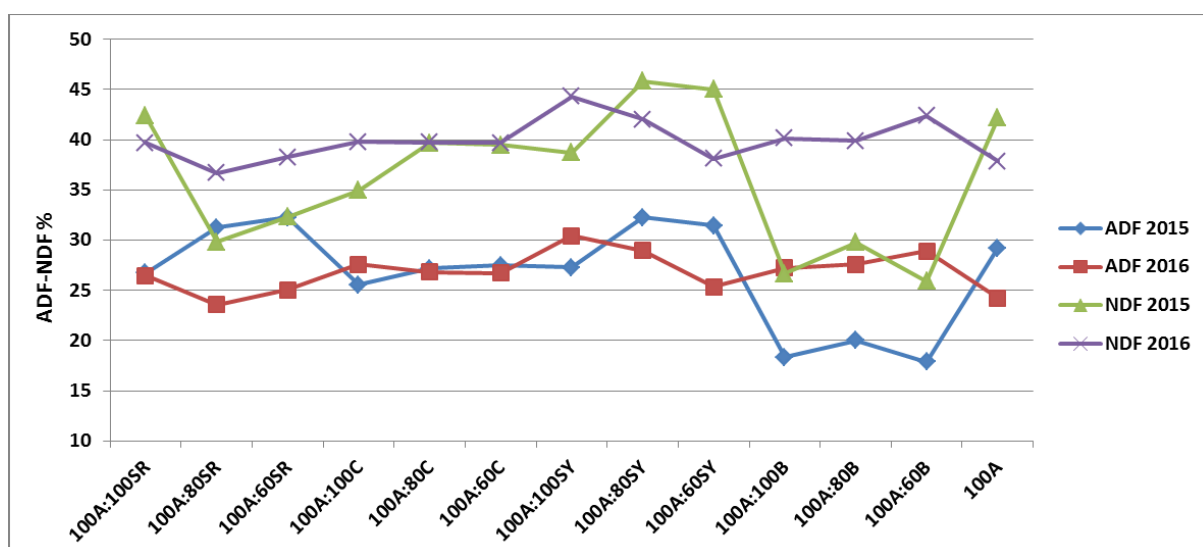


Figure 4. ADF and NDF (%) content of the alfalfa intercropping with different crops in the establishment year (in 2015) and sole alfalfa in the first production year (in 2016).

A: alfalfa, SR: sorghum-sudangrass hybrid, SY: soybean, C: cowpea, B: buckwheat.

Mineral matter content was investigated only establishment year and, significant ($p < 0.01$) differences were observed among intercropping treatments in terms of mineral matter content (Ca, Mg, K and P) (Table 4).

The highest mineral contents were determined in sole alfalfa and it followed by AxSY and AxC mixtures (Figure 5). AxSR and especially AxB mixtures had lower mineral content decreasing with the increasing seed

rate of companion crop. The lowest of mineral matter content was recorded in AxB intercropping at the seed rate of 100:60 (Ca: 0.97, K: 2.27, Mg: 0.22 and P: 0.30%). The previous studies suggested that mineral content for gestating or lactating beef should be in range of 0.18-0.44% for Ca, 0.04-0.1% for Mg, 0.6-0.8% for K and 0.18-0.39% for P (NRC 1996). Therefore mineral matter content of all the treatments were higher or in the limits for animal feeding.

Table 4. Average mineral matter (Ca, K, Mg and P) contents of alfalfa stand under intercropping with different crops in the establishment year (in 2015)

Intercropping*	Ca(%)	K(%)	Mg(%)	P(%)
100A:100SR	1.28 d	3.33 cd	0.28 bcd	0.41 a
100A:80SR	0.89 h	3.27 e	0.25 cde	0.43 a
100A:60SR	0.77 i	3.20 f	0.24 de	0.44 a
100A:100C	1.42 a	3.34 c	0.32 a	0.42 a
100A:80C	1.37 bc	3.45 b	0.33 a	0.42 a
100A:60C	1.34 c	3.45 b	0.29 abc	0.43 a
100A:100SY	1.36 bc	3.29 de	0.29 abc	0.41 a
100A:80SY	1.33 c	3.00 h	0.27 bcd	0.4 a
100A:60SY	1.39 ab	3.12 g	0.30 ab	0.40 a
100A:100B	1.14 e	2.52 j	0.26 b-e	0.33 bc
100A:80B	1.08 f	2.57 i	0.25 cde	0.35 b
100A:60B	0.97 g	2.27 k	0.22 e	0.30 c
100A	1.34 c	3.51 a	0.27 bcd	0.40 a

*:p<0.01, There is no differences same letters in same clone.

A: alfalfa, SR: sorghum-sudangrass hybrid, SY: soybean, C: cowpea and B:buckwheat.

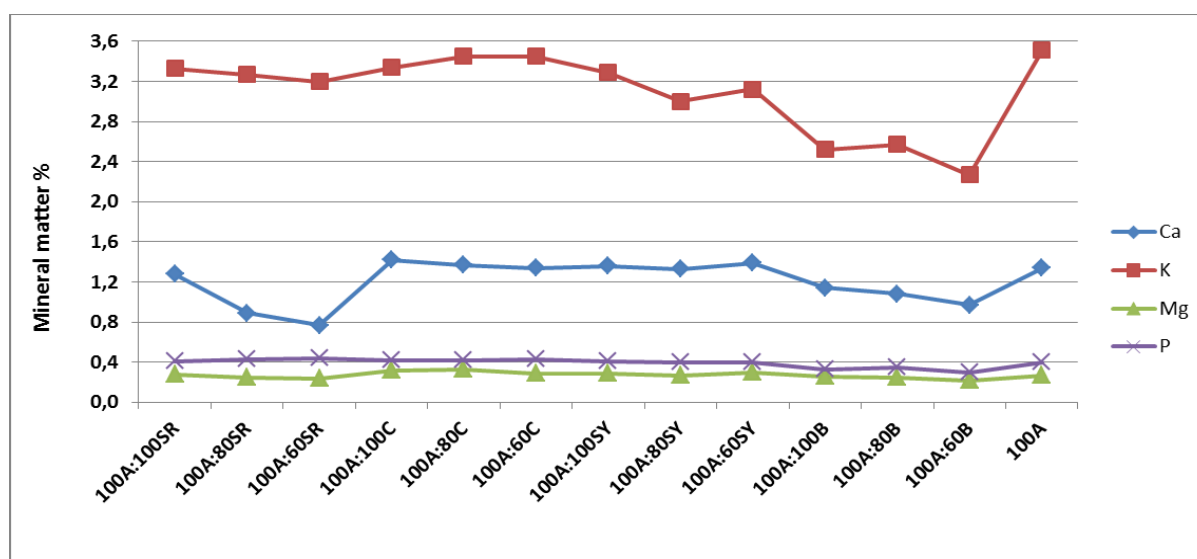


Figure 5. Mineral matter (Ca, Mg, K and P) (%) content of intercropping with different crops in the establishment year (in 2015).

A: alfalfa, SR: sorghum-sudangrass hybrid, SY: soybean, C: cowpea and B:buckwheat.

Sheaffer et al. (2014) reported that the effect of the spring-seeded companion crops on alfalfa forage yield was depended on companion crop and environment, and authors also stated that small grain companion crops (wheat, barley and oat) provided high and consistent net returns without adversely affecting alfalfa yields. Also barley as companion crop significantly increased yield of alfalfa stand at the establishment year with a low adverse effect on alfalfa density in the establishment and following year (Tan and Serin 2004). Liu et al. (2006) notified that alfalfa yield increased intercropping with maize with no significant effect in the following year.

The current study revealed the advantages of intercropping in alfalfa under spring-sowing conductions. Intercropped alfalfa produced higher hay and protein yield in establishment year compare to sole sowing.

Moreover, intercropping did not negatively affected alfalfa yield in following year. Alfalfa seeded with sorghum-sudangrass hybrid exhibited the best results both in the establishment and the first production year except lower mineral matter content. Therefore, sorghum-sudangrass hybrid (SR) can be suitable companion crop for alfalfa especially with 100:80 and 100:60 seeding rate for higher forage and protein yield. Buckwheat showed lower performance compare to sorghum-sudangrass hybrid as companion crop for alfalfa. However, the earliest companion crop was buckwheat. So it can be a good company crop for alfalfa if weeds are serious problem.

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