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Effects of Different Sowing Design on Forage Yield and Yield Component of Sorgum and Soybeen Mixtures

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ABSTRACT: This research was conducted to determine the effects of different mixed cropping patterns sorghum with soybean on agronomic characters and forage yield in Bilecik, Turkey, 2015 growing season. Three mixed cropping patterns in alternate rows and pure stands for individual crops were designed field trials were arranged in complete randomized blocks with three replications. As a result of the study, sorghum was clearly determined as dominant crop for producing high yield. Therefore decreasing sorghum plant density in mixture reduced the total yield. But, soybean presence in forage improved the protein content of forage. Moreover, 33% soybean rate in mixed crop produced high total CP yield as much as sole sorghum promising an expectation in enhancing animal performance due to slight decreases in NDF and ADF contents compared to pure sorghum.

Keywords: Quality, mixed cropping, sorghum, soybean, yield

Farklı Sıralara Ekilen Sorgum ve Soya Bitkisinde Ekim Oranlarının Bazı Bitkisel Özelliklere Yem Verime ve Kalitesine Etkileri

ÖZET: Bu araştırma, Bilecik'te 2015 yetiştirme mevsiminde, sorgumun soya fasulyesi ile birlikte ekim sisteminde tarımsal özellikleri, yeşil ot verimi ve kalite üzerine etkilerini belirlemek amacıyla yürütülmüştür. Araştırmalar, alternatif sıralar halinde üç farklı birlikte ekim sistemi ve saf ekimler şeklinde üç tekerrürlü olarak planlandı. Araştırma sonucunda, sorgum, yüksek verim üretmek için açıkça baskın olarak belirlendi. Bu sebeple arazideki sorgum bitki tohumlama oranının düşürülmesi toplam verimde azalmaya neden olmuştur. Ancak, yemlerde bulunan soya fasulyesinin varlığı yemlerin protein içeriklerinde belirgin bir artışa neden olmuştur. Buna ilaveten ara ürünlerdeki % 33 soya oranı, saf sorgum ile karşılaştırıldığında NDF ve ADF içeriğindeki hafif azalmalara bağlı olarak hayvansal performansı arttırma konusunda bir umut vaad eden bir ekim sistemi olmuştur.

Anahtar Kelimeler: Birlikte ekim, kalite, sorgum, soya, verim

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INTRODUCTION

The main problem in livestock industry in Turkey is lack of quality forage production in agricultural systems due to rapidly increasing feed demand. Cereal forage crops such as corn, oat, triticale and sorghum are high yielded crops, and rich in carbohydrate and palatable for livestock while legume plants such as cowpea, bean and soybean are relatively low yielded ones but rich in protein content Because *Rhisobial* bacteria fixes atmospheric nitrogen and also improves soil fertility Ibrahim et al. (2014); Kavut et al. (2014). Most legume plants meet their own N requirements and eventually help in meeting N needs of cereals partially under mixed cropping designs Ibrar et al. (2002). Sorghum is an important silage crop and has an increasing popularity because of requiring relatively less water than corn for per unit dry matter production Bean et al. (2013). Additionally, dairy or beef cattle fed with sorghum silage showed equal performance with those fed with corn silage (Aydın et al., 1999; Oliver et al., 2004). Soybean is a legume plant and creating some difficulties in silage making through its high protein and fat content. But, it is relatively high yielded crop, compared to other warm season legumes.

Mixed cropping cereals with legumes, which is one of the most common practices in the tropics, leads to decrease in nitrogen requirement, limits insect and pest attack, improves soil fertility and enhances forage quality. Mixed cropping practices have been important part of sustainable agricultural systems and good agricultural practices thanks to its characteristics mentioned above. This cropping method also improves resource utilization and environmental factors Telleng et al. (2016) as well as land use efficiency. Moradi et al. (2014) emphasized that the main aim of mixed cropping is to produce higher forage yield per unit land area by optimizing environmental resources much more efficient than growing individual plants in monocrop systems. This study aimed to reports the sowing design effects of sorghum and soybean mixtures as forage on vegetative plant characteristics yield and feed quality as well as the land use efficiency.

MATERIAL AND METHODS

This research was carried out at experimental station of faculty of Agriculture and Natural Sciences, Bilecik Şeyh Edebali University during 2015 growing season. The monthly average temperature values of the region were 17.4, 23.2, 24.3 and 22.4 °C for June, July, August and September, respectively, which are slightly higher than that of long term values. The total rainfall in growing period was measured as 106.1 mm that is higher than that of total 63.3 mm for long term average. The experimental soil is sandy, slightly alkaline and medium in salt and lime, poor in organic matter, phosphorus and potassium content.

Sorghum cultivar "Teide" and soybean cultivar "Yesilsoy" as plant material were sown in pure stands for individual plants and in three different sowing density (67%, 50% and 33% plant density of pure sorghum or soybean) patterns in alternate rows. Experimental treatments for pure stands and mixed cropping patterns were arranged as i-Pure Sorghum (PSR), ii- Pure Soybean (PSB), iii- 67% Sorghum +33% Soybean (2SR+1SB; 2 rows sorghum and 1 row soybean), iv- 50% Sorghum +50% Soybean (1SR+1SB; 1 row sorghum and 1 row soybean) and v-33% Sorghum +67% Soybean (1SR+2SB; 1 row sorghum and 2 rows soybean). Sowing densities were 45x15 cm for sorghum and 45x4 cm for soybean as pure stands. The plot size was 2.7x5 m contained 6 rows. Diammonium phosphate was applied at the rate of 50 kg ha^{-1} to all plots at planting and no additional fertilizer was applied till the harvest. Plants were irrigated 5 times and other crop maintenance practices during the growing season were applied when needed. At the harvest time, 3 rows of sorghum or soybean in total were separately harvested as truly representing the cropping pattern. Vegetative plant parts rate were calculated the weight of plant parts to whole plant weight of 5 randomly sample plants. Dry matter (DM) rate were determined by weighting the samples dries in forced oven at 78^0C for 48 hours. Neutral detergent fiber (NDF) and Acid detergent fiber (ADF) were determined by fiber analysis device (ANKOM Technology Corp., Fairport, NY, USA) Anonymous (2005) while crude protein (CP) content determined by Kjeldahl method AOAC (1990). The land equivalent ratio (LER), explained as the relative land area required for sole crop to obtain the

same yield achieved in intercropping Mead and Willey (1980) was calculated by using both DM and CP yield data. The experiment was arranged as a randomized block design with three replicates. Data were subjected to variance analysis using MSTAT statistical software (MSTAT Office, Michigan State Univ., MI) and significant differences were indicated by using Least Significant Differences (LSD) values when p 0.05%.

RESULT AND DISCUSSION

Plant height of sorghum was significantly decreased in mixed cropping systems compared to its pure crop, contrary to higher plant height of soybean in 1SR+1SB and 1SR+2SB mixed cropping patterns, which are higher soybean density compared to 2SR+1SB systems (Table 1). When sorghum data were considered, it can be concluded that the intra-species competition was occurred when high sorghum plant was grown in regular plant density contrary to intra-species competition besides inter-species competition of soybean in mixture (Kızılşimşek and Erol 2000). Akhtar et al. (2013) indicated that the maximum plant height of sorghum was achieved in sole crop compared to mixture with cluster bean or cowpea. Ahmad et al. (2007) also emphasized significant differences in plant height of sorghum in sole crop than that of mixed cropping systems. Hence, soybean plant height in 2SR+1SB application in which soybean sowing rate was the lowest one, soybean plant height was decreased significantly compared to other sowing design (Table 1) due to superior competition ability of sorghum crop. Leaf ratio of both component crops in mixture was increased causing in increases in especially sorghum CP content.

Table1. Plant height and plant parts rate of sorghum and soybean in mixed cropping systems.

Cropping Patterns	Sorghum			Soybean			
	Plant Height (cm)	Leaf Rate (%)	Stem Rate (%)	Plant Height (cm)	Leaf Rate (%)	Stem Rate (%)	Pod Rate (%)
PSR	206 a	20.9 b	79.1 a				
2SR+1SB	173.2 bc	24.4 a	75.6 b	103.9 c	25.4 a	47.5 a	27.1 c
1SR+1SB	192.3 ab	23.7 ab	76.3 ab	125.4 a	24.9 a	44.3 ab	30.7 bc
1SR+2SB	166.8 c	24.7 a	75.3 b	124.1 a	23.3 b	43.7 bc	33.0 ab
PSB				112.1 b	24.8 ab	40.9 c	34.2 a
Means	184.6	23.4	76.6	116.4	24.6	44.1	31.3
LSD	66.154*	4.231*	4.195*	29.761	3.592	5.230	5.452
C.V. (%)	17.94	9.04	2.74	12.80	7.30	5.93	8.73

*:P≤0.05 **: P≤0.01

The fresh forage yields of both component crops were significantly decreased under mixed growing condition depending on their plant density and cropping design. This reduction in yield performance was more dramatic for soybean than that of sorghum because of its weaker competitive ability compared to sorghum. Accordingly, the DM yields of both mixture plants were also significantly decreased when mixture as it was expected. Sorghum is known as dominant component of mixture with respect to yield. Sole sorghum produced significantly higher DM yield than sorghum grown in mixture (Table 2) in which its density is decreased at sowing. It is inevitable that a yield decrease could occur when the plant density is decreased as mentioned by many authors Ahmad et al. (2007); Prasad and Brook (2005); Khot et al. (1992); Tansı (1987). The mixed cropping system in which sorghum plant density was the lowest (1SR+2SB) yielded less of 56.2% of sole

sorghum while soybean in mixed cropping system in which soybean plant density was the lowest yielded less of 69.4% of sole soybean. Explained was clear that sorghum in mixed cropping system is the dominant crop in yielded more and soybean was negatively affected by mixed cropping systems much more than that of sorghum.

Table 2. Fresh forage yield and DM yield of individual crops in sorghum and soybean mixed cropping systems

Cropping Patterns	Sorghum		Soybean	
	Forage Yield (kg da^{-1})	DM Yield (kg da^{-1})	Herbage Yield (kg da^{-1})	DM Yield (kg da^{-1})
PSR	10560 a	3936.0 a		
2SR+1SB	7604.0 b	2912.0 b	637.8 b	221.2 b
1SR+1SB	5753.0 c	2079.0 c	895.5 b	305.1 b
1SR+2SB	4360.0 c	1706.0 d	585.1 b	203.5 b
PSB	----------	---------	2153.0 a	644.9 a
Means	7069.3	2658.1	1067..95	343.7
LSD	1398.0**	258.1**	468.5 **	196.1**
C.V. (%)	6.53	7.79	14.49	18.85

*:P≤0.05 **: P≤0.01

Forage quality characters were significantly affected by mixed cropping patterns. NDF and ADF contents of sorghum grown in mixture were significantly decreased while CP content was significantly increased resulting in enhancement in forage quality. The CP yield of pure sorghum plant was higher than that of sorghum grown in mixture dependently the DM yields of sorghum in planting patterns. However ADF content of soybean in mixed crop systems was generally decreased significantly compared to sole soybean crop. When CP content of soybean taken into consider, the values were decreased parallel to decreasing plant density of soybean in mixture. When considering total DM yield of sole or mixed cropping systems, the highest DM yield was obtained from sole crop sorghum and total DM yield decreased by decreasing plant density of sorghum in mixed cropping systems. Sole soybean patterns gave the lowest DM yield.

Table 3. Forage quality components of sorghum and soybean in mixed cropping systems.

Cropping Patterns	Sorghum				Soybean			
	ADF (%)	NDF (%)	CP (%)	CP Yield (kg da^{-1})	ADF (%)	NDF (%)	CP (%)	CP Yield (kg da^{-1})
PSR	34.2 a	55.9 a	10.90 b	429.14 a				
2SR+1SB	33.3 ab	54.6 ab	12.17 a	354.42 b	29.8 a	47.4 a	31.13 c	68.84 b
1SR+1SB	31.7 bc	52.8 bc	11.20 b	232.64 c	29.6 a	46.3 ab	31.83 bc	97.13 b
1SR+2SB	31.5 c	51.6 c	12.77 a	217.43 c	29.1 ab	45.5 b	33.17 a	67.51 b
PSB	------	-------	-------	--------	28.8 b	45.9 ab	32.80 ab	211.21 a
Means	32.7	53.8	11.76	308.41	29.3	46.3	32.23	111.17
LSD	1.641*	1.648**	0.635**	72.67**	1.412*	1.435*	1.081*	57.35**
C.V. (%)	2.41	1.53	1.79	7.78	2.51	1.55	1.68	17.04

*:P≤0.05 **: P≤0.01

The differences of crop productivity between individual crops used in this experiment was so huge that sole sorghum produced 6.1 times much more DM than sole soybean (Table 4). As a result of that situation, sorghum plant density is so important than that of soybean in order to produce satisfactory DM production. Decreasing plant density of any individual crops in mixtures of small seed cereals such as wheat, barley and oat with some legumes such as vetch, whose DM yield is near to each other, had not significant effects on DM yield many times due to increasing plant density of the other component crop. However, if one of the crops in mixture was a dominant species, like sorghum in this experiment, in determining the yield, extreme reduction in plant density of dominant crop was not recommended due to DM yield loss. Even though DM yield is decreased dramatically in all mixed cropping systems, CP yield in 2SR+1SB, in which 67% of sorghum plant density compared to sole sorghum was used, was not decreased significantly (Table 4).

Table 4. Total DM and CP yield and LER values calculated by DM and CP base in sole or mixed crop of sorghum with soybean

Cropping Patterns	Total DM Yield (kg da^{-1})	LER DM Base	Total CP Yield (kg/da)	LER CP Base
PSR	3936.0 a	1.00 a	429.1 a	1.00 b
2SR+1SB	3133.0 b	1.09 a	423.3 a	1.16 a
1SR+1SB	2384.0 c	1.01 a	329.8 b	1.01 ab
1SR+2SB	1909.0 c	0.75 b	284.9 b	0.83 c
PSB	644.9 d	1.00 a	211.2 c	1.00 b
Means	2401.38	0.97	335.66	0.99
LSD	511.7**	0.150**	72.40**	0.150**
C.V. (%)	7.78	6.05	7.87	5.81

*:P≤0.05 **: P≤0.01 w

This data showed us that a far amount of soybean could be grown with sorghum as mixed crop by making a small reduction in sorghum plant density. The LER values calculated by both DM and CP base showed that the land used 9% and 16%, respectively, much more efficient in 2SR+1SB intercropping system than sole crop growing system.

CONCLUSION

Mixed cropping sorghum and soybean has some advantages in terms of feed quality and especially LER in many cases. Sole sorghum crops DM production capacity is so much higher than that of sole soybean. Therefore, it is recommended that at least 67% of sorghum plant density of sole sorghum should be kept in mixed cropping systems in order to obtain a satisfactory DM and CP yield as well as enhancing feed quality. However, further researches are needed with respect investigate year effects and the other cultural practices.

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