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Forage yield and nutritive value of maize-legume mixtures

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Abstract

This study was aimed to investigate the effects of intercropping maize with legumes for improving forage yield and nutritive value in Yozgat conditions located in Inner Anatolia, Turkey in 2013 and 2014 growing season. Maize intercropped with three legumes; Yemsoy and Yesilsoy variety of soybean and Ulkem variety of Cowpea at three different seed rates. The percentage of maize and legumes in mixtures was 100:100, 100:50, and 50:100 respectively. Experiments were arranged in a randomized complete block design with three replicates. Mixture plots were harvested when maize was at dough stage, and alone legumes were at the end of seed filling. Intercropping treatments and seed rates significantly affected yield and nutritive value of forage and also morphological traits of crops. The lowest hay yield was determined in alone legumes in 2013, 2014 and combined year. Maize intercropping with Yemsoy at 50:100 seed rate produced the highest hay yield in separate and combined years (19.78, 21.54 and 20.66 t ha^{-1}, respectively). Alone cowpea had the highest protein content in 2013 (19.66%), 2014 (17.57%) and combined years (18.61%). Crude protein content in maize sown alone was minimum. However, it showed a superior protein yield compared to the pure legumes. The highest protein yield (2.33 t ha^{-1}) was observed in maize intercropped with Yemsoy at 50:100 seed rate. Present study indicated that intercropping maize with soybean at the seed rate of 50:100 was the most suitable choice with respect to hay and protein yields. However, it produced low mineral contents.

Keywords: Intercropping, Legume, Maize, Protein, Yield

Abbreviations: ADF: Acid detergent fiber; **C:** Cowpea; **Ca:** Calcium; **CP:** Crude Protein; **K:** Potassium; **M:** Maize; **Mg:** Magnesium, **NDF:** Neutral detergent fiber; **P:** Phosphorus; **S_{yem}:** Yemsoy variety of soybean; **S_{yes}:** Yesilsoy variety of soybean

Introduction

Forages are important part of ruminant animal's diet and play a key role in profitable milk production. Silage is high in energy and digestibility and it is easily adapted to mechanization during the whole process. Maize is very popular crop (Sah *et al.,* 2016) and also the most preferred crop for silage in Turkey (Turgut, 2002) as in the world. Maize provides a silage having higher dry matter yield, uniformity and efficient energy concentration (Allen *et al*., 2003). Maize silage is capable of satisfying the needs of animals for forage. Moreover, it can reduce the concentrate feed requirements up to 50% (Sade and Soylu, 2008).

A major weakness of maize silage is that it's lower protein content with compared legumes. Therefore, additional protein supplementation is required for milk production. So, intercropping maize and forage legumes can contribute to increase forage protein content, enhance the fermentation characteristics and thereby helps in improvement of nutritive value of silages (Heathcliffe and Kenneth, 2008; Qu *et al*., 2013). For this purposes, various forage legumes such as common bean, lablab (Heathcliffe and Kenneth. 2008), soybean (Martin *et al*., 1990) cowpea (Ibrahim *et al*., 2006), red clover and lupine (Carruthers *et al*., 2000) were successfully intercropped with maize. However, benefits in intercropping relates strongly with local conditions, crop management, planting pattern, cultivar selection and with competition between legume and main crop (Singh *et al*., 2008; Lawson *et al*., 2007). Each legume may not give the desired result in silage quality when combined with maize (Dawo *et al*., 2007). High growing potential of maize leads to shadow effect and forces legumes to compete for light. In this respect, it is quite important to determine the appropriate legumes and also it's seed ratio in mixture. Previously, many studies were performed to deduce light competition in maize-legume mixtures by arranging row distance and seed ratio (Zhang *et al*., 2015: Choudhary, 2014; Yilmaz *et al*., 2008). The objective of the study was to test legume (cowpea and soybean) – maize mixtures with different seed ratio for forage yield and nutritive value at the silage harvest stage under irrigated condition.

Materials and Methods

Experimental site and design: The study was conducted during summer season of 2013 (May 24) and 2014 (May 13) respectively at Research Field, Faculty of Agriculture, Bozok University located in Yerkoy-Yozgat. Soil of experimental area was clay-loam with low organic matter (1.91%) and high pH (8.20), and contained low phosphorus (8.62 kg/da) and potassium (48.47 kg/da). Long-term mean temperature and annual rainfall during vegetation period (May-August) were 17.67 ^{0}C and 131.4 mm, respectively. Average temperature and total rainfall in growing season of 2013 and 2014 were 18.07 ^{0}C, 61.3 mm and 18.45 ^{0}C, 231.9 mm respectively. Plant materials consisted of Arifiye variety of Maize (M), Yesilsoy (S_{yes}) and Yemsoy (S_{yem}) varieties of soybean and Ulkem variety of cowpea (C) and they were sown as binary mixtures with three seed rate (100:100, 100:50, 50:100) and as alone.

Seed rate of each plant was determined based on alone sowing rate (12 plant/m^2 for maize and 20 plant/m^2 for soybean and cowpea). Row distance was arranged in 70 cm in alone plots. In mixtures, plants were sown in alternate rows with 35 distances. Plot area was 16.8 m^2 (6 m long and 8 rows in mixtures; 6 m long and 4 rows in alone sowing). Experiments were arranged in a randomized complete block design with three replicates. As fertilizer; 3 kg/da N and 8 kg/da P_2O_5 were applied after planting. Additionally 3 kg/da N was applied when plants reach to 35 cm. During the vegetation period, all the plots were irrigated three times until reached field capacity.

Observations and methods of analysis: Mixture plots were harvested based on maize maturity (when it was at dough stage) while alone legumes were at the end of seed filling. Morphological observations (plant height, stem diameter and stem number) were performed just before the harvest. For hay yield plant samples were dried 65 ^{0}C until constant weight. Crude Protein (CP), Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF), Ca, K, Mg and P content of hay were determined by using Near Reflectance Spectroscopy (NIRS, 'Foss 6500') with software package program 'IC-0904FE'. The data was analyzed in sperate and combined years. ANOVA was performed by using SPSS 13.0 package program (SPSS, Chicago, IL, USA) and, mains were grouped with Duncan's multiple-range test.

Results and Discussion

Maize growth in mixtures**:** The variation in vegetative traits of maize among intercrop treatments and years were given in Table 1. Plant height and stem diameter of maize were significantly affected by years ($P<0.05$) and were higher in 2014 than 2013. This could be explained by higher total rainfall and mean temperature during the vegetation period in 2014. The effects of intercrop treatments was significant on maize plant height in both years ($P<0.05$) and, intercropping maize with legumes was observed to significantly increase plant height compared to sole cropping. In sperate and combined years, the highest plant height in maize was determined in maize-soybean mixtures, especially when maize intercropped with Yesilsoy variety (S_{yes}) with 100:100 seed ratio. The effect of legume intercrops on maize stem diameter was not significant. However, it was relatively high in maize-soybean mixture ($M:S_{yes}$) with the seed rate of 50:100 in 2013 (20.97 mm) and also high in maize-cowpea mixture at 100:50 seed ratio in 2014 and combined years as 31.04 mm and 25.16 mm, respectively.

Legume growth in mixtures**:** Plant height, main stem diameter and branches of legumes were given in Table 2. Vegetative traits of legumes were significantly affected by years ($P<0.05$) and were higher in 2014, which was possibly due to more suitable climatic condition in the same year. In addition, the effect of intercrop treatments on examined traits of legumes was significant in sperate and combined years. Under sole cropping, the highest plant height was observed in S_{yes} in 2013 (110.1 cm) and cowpea in 2014 (139.3 cm). Considering the intercropping treatments, S_{yes} exhibited the highest plant height in separate and combined years; 120.1 cm in 2013 with 100:100 seed rate, 163.6 cm in 2014 and 134.7 cm in combined years with 50:100 seed rate. Intercropping with maize promoted plant height of legumes. But this is not case for cowpea. Cowpea had shorter plant height in mixtures in both years compared to sole cropping. Plant height of soybean varieties generally increased with the decreasing seed rate of maize in mixture. On the other hand, stem diameter and branch number of legumes was negatively affected by intercropping and, the highest values for these traits were obtained from sole crop treatments in both years. Over the treatments and plants, S_{yes} had the highest stem diameter (8.50 mm, 12.23 mm, 10.37 mm) and branch number (14.03, 14.97, 14.50) in separate and combined years, respectively.

Intercropping significantly influenced and increased plant height of maize and soybean. It was probably due to

Table 1. Plant height and stem diameter of maize under intercropping with legumes

Treatment	Maize plant height (cm)			Maize stem diameter (mm)		
	2013**	2014**	Mean**	2013	2014	Mean
Maize (M)	150.3 ^{d}	289.3 ^{b}	219.8 ^{d}	20.76	27.26	24.01
Yemsoy (S_{yem})	-	-	-	-	-	-
Yesilsoy (S_{yes})	-	-	-	-	-	-
Ulkem (C)	-	-	-	-	-	-
100M:100S_{yem}	239.4 ^{abc}	279.3 ^{b}	259.4 ^{c}	20.14	22.48	21.31
100M:50S_{yem}	220.8 ^{c}	328.0 ^{a}	274.4 ^{bc}	18.92	27.84	23.38
50M:100S_{yem}	227.8 ^{c}	344.3 ^{a}	286.1 ^{ab}	18.84	28.83	23.84
100M:100 S_{yes}	276.8 ^{a}	330.6 ^{a}	303.7 ^{a}	19.29	25.98	22.64
100M:50S_{yes}	224.0 ^{c}	322.6 ^{a}	273.3 ^{bc}	19.61	27.26	23.43
50M:100S_{yes}	248.3 ^{abc}	296.6 ^{b}	272.5 ^{bc}	20.97	27.32	24.15
100M:100C	234.0 ^{bc}	293.0 ^{b}	263.5 ^{c}	19.13	26.25	22.69
100M:50C	266.8 ^{ab}	290.0 ^{b}	278.4 ^{bc}	18.72	24.84	21.78
50M:100C	243.7 ^{abc}	279.0 ^{b}	261.3 ^{c}	19.27	31.04	25.16
*Mean***	*233.19* ^{B}	*305.3* ^{A}		*19.57 B*	*26.91 A*	

*S: Soybean, C: Cowpea; Means followed by the same letter in same column did not significantly differ ** P<0.01*

Table 2. Plant height, stem diameter and branch number of legumes under intercropping with maize

Treatment	Legume plant height (cm)			Legume stem diameter (mm)			Legume number of branches		
	2013**	2014**	Mean**	2013**	2014**	Mean**	2013**	2014**	Mean**
Maize (M)	-	-	-	-	-	-	-	-	-
Yemsoy (S_{yem})	91.3 ^{cde}	115.0 ^{cd}	103.1 ^{c}	6.56 ^{ab}	10.43 ^{b}	8.49 ^{b}	13.20 ^{ab}	13.10 ^{ab}	13.15 ^{ab}
Yesilsoy (S_{yes})	110.1 ^{ab}	129.3 ^{bcd}	119.7 ^{b}	8.50 ^{a}	12.23 ^{a}	10.37 ^{a}	14.03 ^{a}	14.97 ^{a}	14.50 ^{a}
Ulkem (C)	51.7 ^{f}	139.3 ^{b}	95.5 ^{cd}	5.76 ^{bc}	12.80 ^{a}	9.28 ^{ab}	11.00 ^{bc}	11.97 ^{bc}	11.48 ^{bc}
100M:100S_{yem}	74.9 ^{e}	110.0 ^{d}	92.5 ^{cde}	3.87 ^{c}	6.66 ^{cd}	5.26 ^{c}	7.93 ^{d}	11.43 ^{bcd}	9.68 $^{c-e}$
100M:50S_{yem}	84.1 ^{de}	114.0 ^{cd}	99.0 ^{cd}	4.28 ^{bc}	7.12 ^{c}	5.70 ^{c}	7.40 ^{d}	12.83 ^{ab}	10.12 ^{cde}
50M:100S_{yem}	109.0 ^{ab}	125.0 ^{bcd}	117.0 ^{b}	3.72 ^{c}	7.02 ^{c}	5.37 ^{c}	8.53 ^{cd}	12.87 ^{ab}	10.70 ^{cd}
100M:100 S_{yes}	120.1 ^{a}	128.3 ^{bcd}	124.2 ^{ab}	4.70 ^{bc}	6.44 ^{cd}	5.57 ^{c}	6.73 ^{d}	9.83 ^{cd}	8.28 ^{ef}
100M:50S_{yes}	93.9 ^{bcd}	138.0 ^{b}	115.9 ^{b}	3.91 ^{c}	6.24 ^{cd}	5.09 ^{c}	7.27 ^{d}	11.77 ^{bc}	9.52 ^{ef}
50M:100S_{yes}	105.7 ^{abc}	163.6 ^{a}	134.7 ^{a}	4.72 ^{bc}	6.02 ^{cd}	5.37 ^{c}	7.93 ^{d}	9.97 ^{cd}	8.95 ^{def}
100M:100C	50.5 ^{f}	114.6 ^{cd}	82.6 ^{e}	4.50 ^{bc}	5.70 ^{cd}	5.10 ^{c}	5.53 ^{d}	5.20 ^{e}	5.37 ^{g}
100M:50C	45.5 ^{f}	76.0 ^{e}	60.8 ^{f}	4.14 ^{c}	5.41 ^{cd}	4.77 ^{c}	6.53 ^{d}	9.40 ^{d}	7.97 ^{f}
50M:100C	42.8 ^{f}	131.3 ^{bc}	87.1 ^{de}	5.32 ^{bc}	5.01 ^{d}	5.17 ^{c}	6.40 ^{d}	9.80 ^{cd}	8.10 ^{f}
*Mean***	*81.6* ^{B}	*123.7* ^{A}		*4.99* ^{B}	*7.59* ^{A}		*8.54* ^{B}	*11.09* ^{A}	

*S: Soybean, C: Cowpea; Means followed by the same letter in same column did not significantly differ ** P<0.01*

competition for light. Adesoji *et al.* (2013) reported that higher growth of maize intercropped with legumes was due to nitrogen effects. However plant height of cowpea was similar between alone sowing and intercropping at all the seed rates. Contrary to our results plant height was decreased in cowpea (Ibrahim *et al.*, 2006) and soybean (Marchiol *et al.*, 1992) when intercropped with maize. Ibrahim *et al.* (2006) reported that plant height decreased in maize intercropped with cowpea and this was probably due to pressure caused by high plant density. Compare to sole cropping, stem diameter decreased in mixtures for both maize and legumes. This situation was due to lower plant density in pure sowing.

***Forage yield of the maize-legume mixtures*:** There were considerable variations in hay yield, protein ratio and protein yield among cropping treatments and years (Table 3). Over the treatments, mean hay yield and protein ratio were significantly affected by year ($P<0.05$) and higher in 2014, however, protein yield was approximately similar between the years. The effect of intercropping on hay yield was positive and significant ($P<0.05$). The lowest hay yield was recorded in sole cropping of legumes in 2013, 2014 and combined year. Maize intercropping with S_{yem} at 50:100 seed rate produced the highest hay yield in separate and combined years and the values were 19.78, 21.54 and 20.66 t ha^{-1}, respectively.

Table 3. Hay yield and crude protein content of maize-legume mixtures

Treatment	Hay yield (t ha^{-1})			Crude protein (%)			Crude protein yield (t ha^{-1})		
	2013**	2014**	Mean**	2013**	2014**	Mean**	2013**	2014**	Mean**
Maize (M)	18.3 ^{bc}	18.86 ^{cd}	18.58 ^{bc}	10.69 ^{d}	10.64 de	10.67 ^{e}	1.99 ^{bc}	2.00 ^{cd}	1.99 ^{cd}
Yemsoy (S_{yem})	2.49 ^{f}	2.20 ^{e}	2.34 ^{f}	15.30 ^{b}	12.61 c	13.96 ^{c}	0.38 ^{f}	0.27 ^{e}	0.32 ^{g}
Yesilsoy (S_{yes})	3.06 ^{f}	2.73 ^{e}	2.90 ^{f}	16.47 ^{b}	15.22 b	15.85 ^{b}	0.50 ^{ef}	0.41 ^{e}	0.46 ^{fg}
Ulkem (C)	3.70 ^{f}	1.63 ^{e}	2.66 ^{f}	19.66 ^{a}	17.57 a	18.61 ^{a}	0.72 ^{e}	0.28 ^{e}	0.50 ^{f}
100M:100S_{yem}	20.27 ^{a}	17.44 ^{d}	18.86 ^{b}	12.33 ^{c}	11.05 de	11.69 ^{d}	2.49 ^{a}	1.92 ^{d}	2.21 ^{ab}
100M:50S_{yem}	16.68 ^{cd}	19.53 ^{bc}	18.10^{bcd}	11.31 ^{cd}	10.83 de	11.07 ^{de}	1.88 ^{c}	2.11 ^{bc}	2.00 ^{cd}
50M:100S_{yem}	19.78 ^{ab}	21.54 ^{a}	20.66 ^{a}	11.37 ^{cd}	11.20 d	11.29 ^{de}	2.25 ^{ab}	2.41 ^{a}	2.33 ^{a}
100M:100 S_{yes}	14.12 ^{e}	18.54 ^{cd}	16.33 ^{e}	10.72 ^{d}	10.82 de	10.77 ^{e}	1.51 ^{d}	2.00 ^{cd}	1.75 ^{e}
100M:50S_{yes}	17.00 ^{cd}	19.71 ^{bc}	18.36 ^{bc}	11.35 ^{cd}	10.72 de	11.04 ^{de}	1.93 ^{c}	2.11 ^{bc}	2.02 ^{cd}
50M:100S_{yes}	15.66 ^{de}	18.47 ^{cd}	17.07 ^{de}	11.46 ^{cd}	10.42 e	10.94 ^{de}	1.79 ^{c}	1.92 ^{d}	1.85 ^{de}
100M:100C	17.48 ^{cd}	17.89 ^{d}	17.68 ^{cd}	11.87 ^{cd}	11.26 d	11.56 ^{d}	2.07 ^{bc}	2.01 ^{cd}	2.04 ^{c}
100M:50C	17.28 ^{cd}	20.43 ^{ab}	18.85 ^{b}	11.65 ^{cd}	10.72 de	11.18 ^{de}	2.01 ^{bc}	2.19 ^{b}	2.10 ^{bc}
50M:100C	16.42 ^{d}	18.86 ^{cd}	17.64 ^{cd}	12.00 ^{cd}	10.82 de	11.41 ^{de}	1.97 ^{bc}	2.03 ^{cd}	2.00 ^{cd}
*Mean***	*14.02 ^{B}*	*15.22 ^{A}*		*12.78 ^{A}*	*11.83 ^{B}*		*1.65*	*1.60*	

*S: Soybean, C: Cowpea; Means followed by the same letter in same column did not significantly differ ** P<0.01*

In terms of protein ratio, the variation among treatments and between years were also significant (P<0.05). Over the cropping treatments, mean crude protein content was significantly higher in 2014 (12.78%) than in 2013 (11.83%). Sole cowpea had the highest protein content in 2013 (19.66%), 2014 (17.57%) and combined years (18.61%). Crude protein yield was affected by cropping treatments (P<0.05). However, over the treatments, the effect of year was not significant on protein yield. Although with low protein content, sole maize showed a superior protein yield compared to the pure legumes, which was clearly due to the high hay yield of maize. In separate and combined years, the highest protein yield was observed in maize intercropped with S_{yem} at 50:100 seed rate as 2.25, 2.41, 2.33 t ha^{-1} respectively and except 2014, at 100:100 seed rate. These results showed that S_{yem} with high seed rate was more suitable crop for maize in mixed cropping system with respect to hay and protein yields.

Nutritive value of maize-legume mixtures: Average ADF, NDF and mineral contents were also affected significantly by maize-legume intercropping, seed combinations and years in different ratio (Table 4 and 5). Over the year and cropping treatments, the maize sown alone produced maximum ADF (36.39%) (Table 4). However, except 100M: 50S_{yem} treatment, other intercropping treatments were statistically similar to maize. The lowest ADF content (30.13%) was determined in sole S_{yes} fallowed by S_{yem} and cowpea. Similarly, mean NDF content was lowest in sole legumes over the treatments and years (Table 4). Sole maize and all the maize-legume mixtures produced statistically at par NDF content varied from 61.52% to 55.16%. Unlike other minerals, P content did not show much variability between years and treatments except in 2013 and it ranged from to 0.25% (sole cowpea) to 0.32 (100M: 100C) over the years and intercropping treatments. As given in Table 5, the effect of year was significant (P<0.05) on K, Ca and Mg contents; Ca and Mg contents were higher in 2013 but K content was higher in 2014. While the highest K content was recorded in 50M:100S_{yes} (3.14%), 100M:100S_{yem} (3.11). 100M:100 S_{yes} (3.06%) mixtures in 2013, it was also recorded in 50M:100C (3.69%) and 100M:100C (3.43%) mixtures in 2014. With respect to Ca and Mg contents, sole cowpea exhibited the highest values in both years and the values were 1.52% and 1.39% for Ca and 0.52% and 0.55% for Mg, respectively.

In comparison to sole sowing, maize-legume intercropping at certain seed rates led to positive results regarding hay and protein yield with the decisive effects of year. Similar results were reported earlier by Hong *et al.* (1987), Yilmaz *et al.* (2008), Geren *et al.* (2008), Ibrahim *et al.* (2012), Zhang *et al.* (2015), Sahoo *et al.* (2015) and Karforma *et al.* (2016). However Heathcliffe and Kenneth (2008) noted that the maize-legume mixtures had lower forage yield than pure maize. In the present study, maize-cowpea intercropping did not show good performance with any seed rate because of the low contribution of cowpea on yield. Besides maize-cowpea discordance, this result might be associated with high pH (8.2) in the experimental soil. Soil pH of 7.5 or higher negatively affected the cowpea growth and resulted yield reduction (Goenaga *et al.*, 2010). As expected, crude protein content was higher in pure legume plots especi-

Table 4. ADF, NDF and Phosphorus contents of maize-legume mixtures

Treatment	ADF (%)			NDF (%)			P (%)		
	2013**	2014**	Mean**	2013**	2014**	Mean**	2013**	2014	Mean
Maize (M)	35.36^{a}	37.41^{abc}	36.39^{a}	57.92^{b}	57.43^{abc}	57.68^{ab}	0.31^{abc}	0.29	0.30
Yemsoy (S_{yem})	31.11^{cd}	32.32^{de}	31.72^{cde}	41.57^{d}	45.39^{d}	43.48^{c}	0.28^{bc}	0.25	0.26
Yesilsoy (S_{yes})	30.04^{d}	30.22^{e}	30.13^{e}	45.41^{c}	50.19^{bcd}	47.79^{c}	0.25^{d}	0.25	0.25
Ulkem (C)	30.39^{d}	32.25^{de}	31.32^{de}	41.84^{d}	44.88^{d}	43.36^{c}	0.31^{ab}	0.31	0.31
100M:100S_{yem}	33.18^{abc}	35.60$^{a\text{-}d}$	34.39^{ab}	60.06^{ab}	54.70^{abc}	57.38^{ab}	0.32^{a}	0.30	0.31
100M:50S_{yem}	31.93^{bcd}	34.14$^{b\text{-}e}$	33.03^{bcd}	62.00^{a}	60.62^{a}	61.31^{a}	0.29^{abc}	0.26	0.29
50M:100S_{yem}	34.07^{ab}	33.71^{cde}	33.89^{abc}	61.07^{ab}	49.25^{cd}	55.16^{b}	0.30^{abc}	0.30	0.30
100M:100 S_{yes}	34.51^{ab}	34.97$^{a\text{-}d}$	34.74^{ab}	59.26^{ab}	57.65^{abc}	58.45^{ab}	0.29^{bc}	0.29	0.29
100M:50S_{yes}	33.98^{ab}	38.69^{a}	36.34^{a}	60.51^{ab}	58.55^{ab}	59.63^{ab}	0.28^{bcd}	0.28	0.29
50M:100S_{yes}	34.75^{a}	36.41$^{a\text{-}d}$	35.58^{a}	59.75^{ab}	58.93^{ab}	59.34^{ab}	0.28^{bcd}	0.28	0.28
100M:100C	34.49^{ab}	37.25^{abc}	35.87^{a}	61.01^{ab}	54.64^{abc}	57.83^{ab}	0.30^{abc}	0.33	0.32
100M:50C	33.52^{abc}	38.86^{a}	36.19^{a}	60.95^{ab}	62.09^{a}	61.52^{a}	0.28^{cd}	0.30	0.29
50M:100C	33.11^{abc}	38.23^{ab}	35.67^{a}	58.47^{ab}	59.08^{ab}	58.77^{ab}	0.29^{bc}	0.28	0.29
*Mean***	*33.11^{B}*	*35.39^{A}*		*56.14*	*54.88*		*0.29*	*0.29*	

*S: Soybean, C: Cowpea; Means followed by the same letter in same column did not significantly differ ** P<0.01*

Table 5. Potassium, calcium, and magnesium contents of maize-legume mixtures

Treatment	K (%)			Ca (%)			Mg (%)		
	2013*	2014*	Mean	2013**	2014**	Mean**	2013**	2014**	Mean**
Maize (M)	1.88$^{a\text{-}d}$	1.70^{c}	1.79	0.53^{cd}	0.22^{e}	0.38^{f}	0.26^{de}	0.24^{cde}	0.25^{cd}
Yemsoy (S_{yem})	1.74^{bcd}	2.18^{abc}	1.96	1.26^{b}	1.10^{b}	1.18^{c}	0.34^{bc}	0.28^{bc}	0.31^{b}
Yesilsoy (S_{yes})	1.57^{d}	2.29^{abc}	1.93	1.48^{a}	1.16^{b}	1.32^{b}	0.37^{b}	0.33^{b}	0.35^{b}
Ulkem (C)	1.72^{bcd}	2.25^{abc}	1.98	1.52^{a}	1.39^{a}	1.45^{a}	0.52^{a}	0.55^{a}	0.54^{a}
100M:100S_{yem}	2.11^{a}	1.71^{c}	1.91	0.52^{cd}	0.52^{c}	0.52^{d}	0.25^{de}	0.27^{bcd}	0.26^{c}
100M:50S_{yem}	1.72^{bcd}	1.96^{bc}	1.84	0.58^{cd}	0.23^{e}	0.40^{f}	0.24^{de}	0.16^{e}	0.20^{de}
50M:100S_{yem}	2.04^{abc}	2.05^{bc}	2.05	0.51^{cd}	0.31^{de}	0.41^{ef}	0.21^{e}	0.16^{e}	0.18^{e}
100M:100 S_{yes}	1.68^{cd}	1.91^{bc}	1.79	0.60^{c}	0.47^{cd}	0.54^{d}	0.29^{cd}	0.19^{de}	0.24^{cd}
100M:50S_{yes}	2.06^{ab}	2.06^{bc}	2.06	0.35^{e}	0.43^{cd}	0.39^{f}	0.25^{de}	0.20^{cde}	0.22^{cde}
50M:100S_{yes}	2.14^{a}	1.78^{c}	1.96	0.61^{c}	0.50^{c}	0.55^{d}	0.25^{de}	0.22^{cde}	0.23^{cde}
100M:100C	2.02^{abc}	2.43^{ab}	2.23	0.48^{d}	0.45^{cd}	0.46^{def}	0.24^{de}	0.21^{cde}	0.23^{cde}
100M:50C	1.83$^{a\text{-}d}$	2.00^{bc}	1.92	0.57^{cd}	0.45^{cd}	0.51^{de}	0.21^{e}	0.25^{cd}	0.23^{cde}
50M:100C	1.88$^{a\text{-}d}$	2.69^{a}	2.33	0.57^{cd}	0.44^{cd}	0.51^{de}	0.23^{de}	0.23^{cde}	0.23^{cde}
*Mean***	*1.88^{B}*	*2.08^{A}*		*0.74^{A}*	*0.59^{B}*		*0.28^{A}*	*0.25^{B}*	

*S: Soybean, C: Cowpea; Means followed by the same letter in same column did not differ significantly ** P<0.01 and * P<0.05*

-ally in cowpea. However, protein yield of pure legumes was very low and even lower than pure corn. Minimum ADF and NDF contents were also obtained from pure legumes. Crude protein content in pure maize was minimum and it was at par with maize - soybean (S_{yes}) intercropping at 100:100 seed rate over the years. These findings were supported by earlier studies of Khandaker (1994) and Ibrahim *et al.* (2006).

Conclusion

From the present study, it was concluded that the most suitable crop for intercropping with maize was soybean. Especially intercropping maize with Yemsoy cultivar of soybean (M:S_{yem}) at the seed rate of 50:100 was the most suitable choice with respect to hay and protein yields, however it had low mineral contents. In terms of mineral contents, M:S_{yem} intercrops with 100:100 seed rate was found as better treatment.

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