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THE EFFECTS OF SOWING DESIGNS ON FORAGE YIELD AND QUALITY OF SWEET SORGHUM AND MUNG BEAN MIXTURES UNDER MEDITERRANEAN CONDITIONS

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ABSTRACT

This study was conducted to determine the effects of sowing designs on forage yield and quality in sweet sorghum and mung bean grown as binary mixture with different cultivation systems in Mediterranean conditions under second crop season during 2019-2020. As sowing design, twin-row (20×55 cm row spacing), narrow-row (55 cm row spacing) and conventional-row (75 cm row spacing) were used. The mixtures were formed based on the plant density and alternative row numbers of sweet sorghum and mung bean. Sowing was done on alternating rows of 1 row of sweet sorghum and 1 row of mung bean and 2 rows of sweet sorghum and 1 row of mung bean. The plant density of sweet sorghum was 14 plants m^{-2} and plant densities of mung bean were 14 plants m^{-2}, 21 plants m^{-2} and 28 plants m^{-2}. This experiment was planned as two-factor (sowing designs and mixtures) and conducted in randomized complete block design arranged in split plot with 3 replications. To evaluate the forage yield and quality, fresh forage yield, dry matter yield, NDF, ADF, ADL, crude ash crude protein and ether extract characteristics were examined. In addition, the intercropping potential of mung bean and sweet sorghum mixtures was evaluated by the land equivalent ratio. As a result of the present study, mixed cultivation of 14 plants m^{-2} with one row of sweet sorghum and 14 plants m^{-2} with one row of mung bean gave the best results in narrow row sowing design. It was concluded that an efficient and high quality intercropping system can be realized in the second crop conditions in regions where Mediterranean climatic conditions prevail, especially for mung beans and sweet sorghum.

Keywords: Intercropping, forage quality, forage yield, mung bean, sweet sorghum

INTRODUCTION

Sweet sorghum (*Sorghum bicolor* (L.) Moench *saccharatum*) is an annual forage plant from the Poaceae family. This plant, which is a C4 crop, has high photosynthetic efficiency (Acaroglu, 2013). Compared to other C4 crops, it is seen that sorghum does not need much irrigation and has a very good drought resistance (Propheter et al., 2010; Atis et al., 2012). Sweet sorghum is widely used in ruminant feeding around the world (Bennett, 1990). This crop adapts much better to various adverse environmental conditions compared to other plants, while it needs less nitrogen for high yields (Geng et al., 1989).

Mung bean (*Vigna radiata* (L.) Wilczek) is a member of the Fabaceae family and is a species that is cultivated for human nutrition in the main sense. This plant has been widely cultivated in India since ancient times. In Turkey, it is grown in certain regions, yet its cultivation is not included in the statistics. No mung bean variety is registered in the national variety list of Turkey, and genotypes brought from Pakistan and India are grown as introduction material in Turkey. Today, the plant is widely cultivated in Southeast Asia, Africa, South America and Australia (Anonymous, 2020). Although generally grown as human food, mung bean can also be used for animal feeding in arid and semi-arid areas (Oplinger et al., 1990).

Modern agricultural practices that emerged with the green revolution in agriculture have had negative effects on biodiversity within the ecosystem service, as well as leading to economic and environmental problems. In this respect, low input, energy efficient and self-sufficient agricultural systems have been on the agenda of many farmers, researchers and politicians around the world in the context of the sustainable agriculture model (Altieri, 1999). One of these systems is intercropping. Intercropping is expressed as the cultivation of two or more plant species in the same area. With this planting method, demands can be met by using the existing resources and labor more efficiently (Tolera, 2003). The most common advantage of intercropping is the fact that the species used as a mixture give higher yield and quality products by supporting each other due to their different rooting ability, canopy structure, height and nutrient requirements and by using per unit area grown more effectively. Intercropping has several advantages over mono-cropping systems (Lithourgidis et al., 2011). In intercropping systems, growing alternate rows and different row spacing is a popular practice especially in warm season crops (Yilmaz et al., 2008; Lithourgidis et al., 2011). Sowing the plants in the mixture in different row numbers is one of the most researched subjects (Ram and Meena, 2014). In addition, the density of the plants used in the mixture is one of the most important factors affecting their competition with each other (Maitra et al., 2019). Intercropping systems, which are based on the densities and row numbers of the plant species in mixture, have been the subject of many scientific studies in recent years (Ram and Meena, 2014; Salama et al., 2022).

Sowing designs significantly affect growth, yield and quality of forage crops (Yilmaz et al., 2008). Some investigators reported that yield and quality of forage crops vary according to different sowing designs (Maqsood et al., 2003; Yilmaz et al., 2008; Kizil-Aydemir and Kizilsimsek, 2019). Therefore, sowing designs are a significant issue to be investigated in intercropping systems.

Lack of information in forage crops cultivation and quality roughage production lead to the emergence of many problems in terms of animal nutrition and therefore animal product. The cultivation of different types of forage crops and their culture with different strategies can ensure the production of high quality roughage. In this study, the effects of sowing designs on forage yield and quality in mixture of sweet sorghum and mung bean grown mixed with different cultivation systems were investigated in Mediterranean conditions.

MATERIALS AND METHODS

Material

In this study, the Erdurmus sweet sorghum cultivar obtained from the Western Mediterranean Agricultural Research Institute and the mung bean population obtained from Uzbekistan were used as plant materials. The mung bean crop used in the study is a semi-erect plant with a light green color.

Experimental Field, Soil and Climate Characteristics

The present study was conducted at Hatay Mustafa Kemal University, Faculty of Agriculture, Field Crops Department, Telgalis Research and Application Area (36°15'13.56"N 36°30'7.96"E, altitude 96 m) for two years in 2019 and 2020 under second crop conditions. The soil of the research field had a clay-loam structure and the total salt content was quite low and slightly alkaline. Lime and phosphorus content was moderate and organic matter content was low.

Climatic data of experimental area for experimental period and long term average are given in figure 1. The long-term averages of precipitation data in the 4-month period covering the experimental periods seem to be considerably higher than that of 2019 and 2020. It was determined that the temperature data in 2019 and 2020 were higher than long term average.

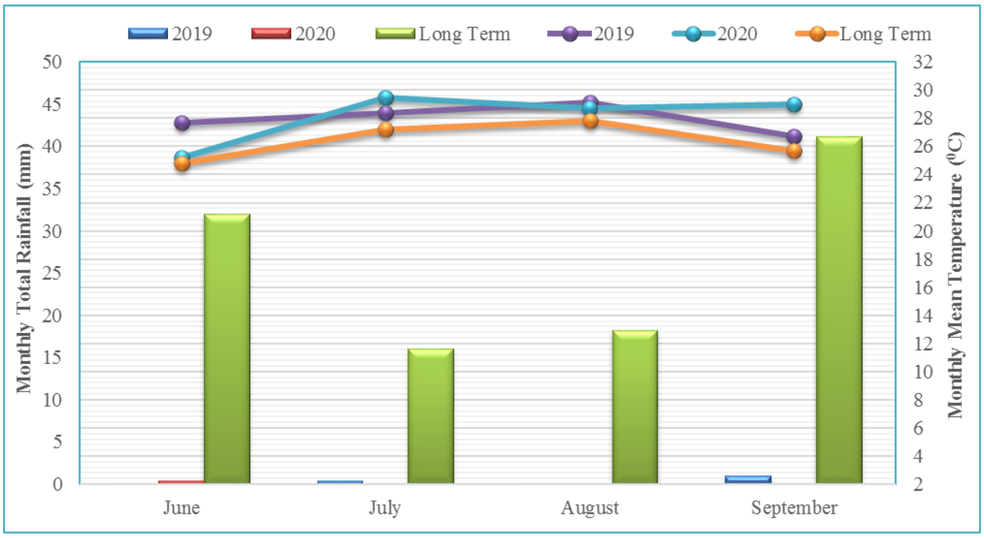

Figure 1. Monthly total rainfall and mean temperature of 2019 and 2020 growing seasons and long term averages (1940-2019) for research area

Experimental factors and cultivation

This research was carried out with two-factor (sowing designs (SD) and mixtures (M)) in randomized complete block design arranged in split plot with 3 replications. In the experimental design, the main plots were sowing designs and the sub-plots were mixtures. As sowing design, twin row (20×55 cm row spacing), narrow row (55 cm row spacing) and conventional row (75 cm row spacing) were used. The mixtures were formed based on the plant density and alternative row numbers of sweet sorghum and mung bean. Sowing was done on alternating rows of 1 row of sweet sorghum plus 1 row of mung bean (R1:1) and 2 rows of sweet sorghum plus 1 row of mung bean (R1:2). The plant density of sweet sorghum was 14 plants m^{-2} (SS14) and plant densities of mung bean were 14 plants m^{-2} (MB14), 21 plants m^{-2} (MB21) and 28 plants m^{-2} (MB28). In-row distances according to plant density are given in

Table 1. Seed sowing was done in rows with a length of 5 m. The seeds were sown on June 20, 2019 and on June 23, 2020. Before sowing, the rows were opened with a marker in accordance with the sowing methods. Sowing was carried out with rulers in accordance with the in-row distances (Table 1) calculated according to the plant density and 2-3 seeds were left in each seedbed. During the period when the plants formed their first true leaves, plant thinning was made in the entire experimental area and only one plant was left in each seedbed. Weeds in the whole trial area were removed by hand during the plant thinning.

Table 1. Distances in row according to the sowing designs and plant density used in present study

Plant species and planting density	Distance (cm) in row for twin row	Distance (cm) in row for narrow row	Distance (cm) in row for conventional row
MB-14	≈ 18.9	≈ 12.8	≈ 9.4
MB-21	≈ 12.7	≈ 8.6	≈ 6.3
MB-28	≈ 9.5	≈ 6.5	≈ 4.8
SS-14	≈ 18.9	≈ 12.8	≈ 9.4

The fertilizer (15-15-15) was applied with sowing as 5 kg da^{-1} NPK. When the plants reached 40-50 cm height (approximately 30 days after emergence), a deep hoeing was made by hand for weed control and soil aeration in the entire experimental area. In both years, 2 days after hoeing, 5 kg da^{-1} N as urea was applied and irrigation was done at field capacity. Harvesting of the plants was done on September 20, 2019 and on September 23, 2020. After removing the side effects, the crops were harvested manually. Sweet sorghum and mung bean crop species in the parcels with intercropping systems were harvested separately. Weighing of the obtained forages for fresh forage yield (FFY) was made with a hand scale (± 0.01 g). The samples taken from the weighted forages were dried in a drying-oven for dry matter yield (DMY) and various chemical analyses till the samples have a constant weight. The dried samples were theoretically ground in a 1 mm diameter mill for chemical analysis.

The land equivalent ratio (LER) values of the forages obtained from intercropping were calculated according to the formula below, based on the fresh grass yields (Yilmaz et al., 2008).

$$\mathbf{LER}=\left[\frac{\text{SSY-I}}{\text{SSY-M}}\right]+\left[\frac{\text{MBY-I}}{\text{MBY-M}}\right] \qquad (1)$$

Where; SSY-I: Sweet sorghum yield in intercropping, SSY-M: Sweet sorghum yield in mono-cropping, MBY-I: Mung bean yield in intercropping, MBY-M: Mung bean yield in mono-cropping

NDF, ADF and ADL analyzes in the obtained forages were perform according to Van Soest et al. (1991) and crude protein (CP), ether extract (EE) and crude ash (CA) contents of forages were determined according to AOAC (1990). Crude protein yield (CPY) was calculated using dry matter yield and crude protein ratio.

All the data obtained from the current study were subjected to variance analysis in the JMP statistical package program according to split plot arrangement in randomized complete block design based on the experimental factors with the effect of the year. Treatment mean differences were separated and tested by Tukey's pairwise test considering significance level.

RESULTS AND DISCUSSIONS

According to the results of the Anova test (Table 2), there were significant effects of year (P<0.05), sowing designs (P<0.05), mixtures (P<0.01) and all interactions (P<0.01) on land equivalent ratio. While the land equivalent ratio was 1.23 in 2019, it was 1.03 in 2020 (Table 3). Land equivalent ratios in sowing methods were determined between 1.04 and 1.20 (Table 3). The highest land equivalent ratio was determined in narrow row treatment whereas the lowest was recorded in twin row treatment. The land equivalent ratio values of mixture treatments varied between 1.04 and 1.23 (Table 3). The highest land equivalent ratio was determined in the (R1:2) SS14+MB28, while the lowest was determined in the (R1:1) SS14+MB28. In the three-way interactions, the highest land equivalent ratio was determined in (R1:2) SS14+MB28 intercropping of conventional row in 2019, while the lowest was obtained from (R1:2) SS14+MB14 intercropping of twin row in 2019 (Figure 2.a). Sarlak et al. (2008) determined that the land equivalent ratios were between 0.79 and 1.09 in sweet corn and mung bean at different plant densities and mixing ratios. They reported that the highest land equivalent ratio was at low plant density and 75:25 mung bean+sweet corn mixing ratio.

While the effect of year and SD×M interactions on fresh forage yield (FFY) was not significant, the effects of sowing design (P<0.01), mixtures (P<0.01), Y×SD interaction (P <0.01) and Y×M interaction (P <0.01) were significant (Table 2). Among the sowing methods, the fresh forage yields varied between 52.25 t ha^{-1} and 59.62 t ha^{-1} (Table 3). The highest fresh forage yield was obtained from narrow row treatment. The lowest fresh forage yield was determined in twin row treatment. In addition, twin and conventional row gave statistically similar results. Fresh forage yields among the mixtures varied between 36.17 t ha^{-1} and 66.42 t ha^{-1}. While the highest fresh forage yield was reached with SS14 pure sowing, the lowest was determined in MB14 pure sowing. In Y×SD interaction, only narrow row in 2019 and all sowing designs in 2020 gave the similar results (Figure 3.a). The lowest fresh forage yield was obtained from twin row in 2019. In Y×M interaction, the highest fresh forage yield was recorded in SS-14 in 2020, while the lowest value was in MB-14 in 2019 (Figure 3.b). Similarly, Kizil-Aydemir and Kizilsimsek (2019) reported that the highest forage yield was in pure sorghum and the lowest was in pure soybean. The fresh forage yield values determined for the sweet sorghum were within the values determined in previous studies (Ahmad et al.,2007; Kizil-Aydemir and Kizilsimsek, 2019).

Table 2. Anova test results of investigated characteristics in the present study

Source of Variance	LER	FFY	DMY	NDF	ADF	ADL	CA	CP	EE	CPY
Year (Y)	*	ns	ns	ns	ns	ns	*	**	*	ns
Sowing design (SD)	*	**	**	*	**	**	ns	**	**	**
Y×SD	**	**	*	ns	ns	ns	ns	ns	ns	*
Mixtures (M)	**	**	**	**	**	**	**	**	**	**
Y×M	**	**	**	ns	ns	ns	ns	*	ns	**
SD×M	**	ns	**	**	**	**	**	**	**	**
Y×SD×M	**	ns	*	ns	ns	ns	ns	ns	ns	ns
CV	10.92	11.62	11.65	3.54	3.93	11.79	2.68	3.05	5.00	19.14
SEM	0.07	3.69	1.01	1.00	0.66	0.27	0.12	0.15	0.05	0.09

LER: Land equivalent ratio, FFY: Fresh forage yield, DMY: Dry matter yield, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin, CA: Crude ash, CP: Crude protein, EE: Ether extract, CPY: Crude protein yield, *: $P<0.05$, **: $P<0.01$, ns: not statistically significant, CV: Coefficient of variation, SEM: Standard error mean

While the effect of year on dry matter yield (DMY) was insignificant, the effects of sowing design ($P<0.01$), mixtures ($P<0.01$), SD×M interactions ($P<0.01$) and Y×SD×M interaction ($P<0.05$) were significant (Table 2). The highest dry matter yield was obtained from narrow row treatment with 16.33 t ha^{-1}, while the lowest was found in twin row treatment with 13.62 t ha^{-1} (Table 3). Among the mixtures, the highest dry matter yield (19.03 t ha^{-1}) was obtained from SS14 pure sowing, and the lowest from MB14 (8.10 t ha^{-1}) pure sowing (Table 3). In triple interactions, the highest dry matter yield was obtained from (R1:1) SS14+MB21 intercropping of narrow row treatment in 2020, while the lowest value was determined in MB14 pure sowing of conventional row treatment in 2019 (Figure 2.b). Data obtained from the present study were similar to the findings of Zhang et al. (2015).

Table 3. Land equivalent ratio, fresh forage yield, dry matter yield, neutral detergent fiber (NDF), acid detergent fiber (ADF) contents of years, sowing designs and mixtures

Years	Land equivalent ratio	Fresh forage yield (t ha^{-1})	Dry matter yield (t ha^{-1})	Neutral detergent fiber (%)	Acid detergent fiber (%)
2019	1.23 a	51.50	14.24	48.97	29.35
2020	1.03 b	58.92	15.66	49.04	29.38
Sowing designs					
Conventional-row	1.14 ab	53.76 b	14.89 b	49.57 a	29.50 a
Narrow-row	1.20 a	59.62 a	16.33 a	49.72 a	30.33 a
Twin-row	1.04 b	52.25 b	13.62 b	47.73 b	28.26 b
Mixtures					
MB-14	-	36.17 b	8.10 c	44.64 c	31.61 a
MB-21	-	40.38 b	9.44 c	41.30 d	29.02 bc
MB-28	-	43.75 b	10.11 c	43.67 c	30.36 ab
SS-14	-	66.42 a	19.03 a	52.17 a	28.27 c
(R1:1)SS14+MB14	1.16 ab	63.83 a	17.96 ab	52.39 a	29.03 bc
(R1:1)SS14+MB21	1.12 ab	64.08 a	17.98 ab	52.40 a	29.12 bc
(R1:1)SS14+MB28	1.04 b	59.82 a	17.20 ab	52.21 a	29.55 bc
(R1:2)SS14+MB14	1.11 ab	59.25 a	16.90 ab	49.93 b	28.54 c
(R1:2)SS14+MB21	1.10 ab	58.85 a	16.48 b	50.58 ab	29.03 bc
(R1:2)SS14+MB28	1.23 a	59.55 a	16.28 b	50.74 ab	29.12 bc

Data shown with different letters in the same column are statistically different from each other.

While the effect of year on NDF was not significant, the effects of sowing design ($P<0.05$), mixtures ($P<0.01$) and SD×M interactions ($P<0.01$) were significant (Table 2). The NDF contents of the forages varied between 47.73% and 49.72% according to sowing designs (Table 3). The highest NDF was determined in the narrow row treatment and the lowest in the twin row treatment. The NDF contents in the mixtures varied between 41.30% and 52.40% (Table

3). The lowest NDF content was determined in MB21 pure sowing and the highest in (R1:1) SS14+MB21 intercropping. The lowest NDF was observed in the MB21 system in double-row cultivation and the highest in (R1:1) SS14+MB28 intercropping system of conventional row among all SD×M interaction combinations (Figure 4.a). Lower NDF content was detected in pure MB systems compared to pure SS and intercropping systems. Kizilsimsek et al. (2017) reported that the NDF ratio increased with the addition of corn plant to soybean plant similar to our results.

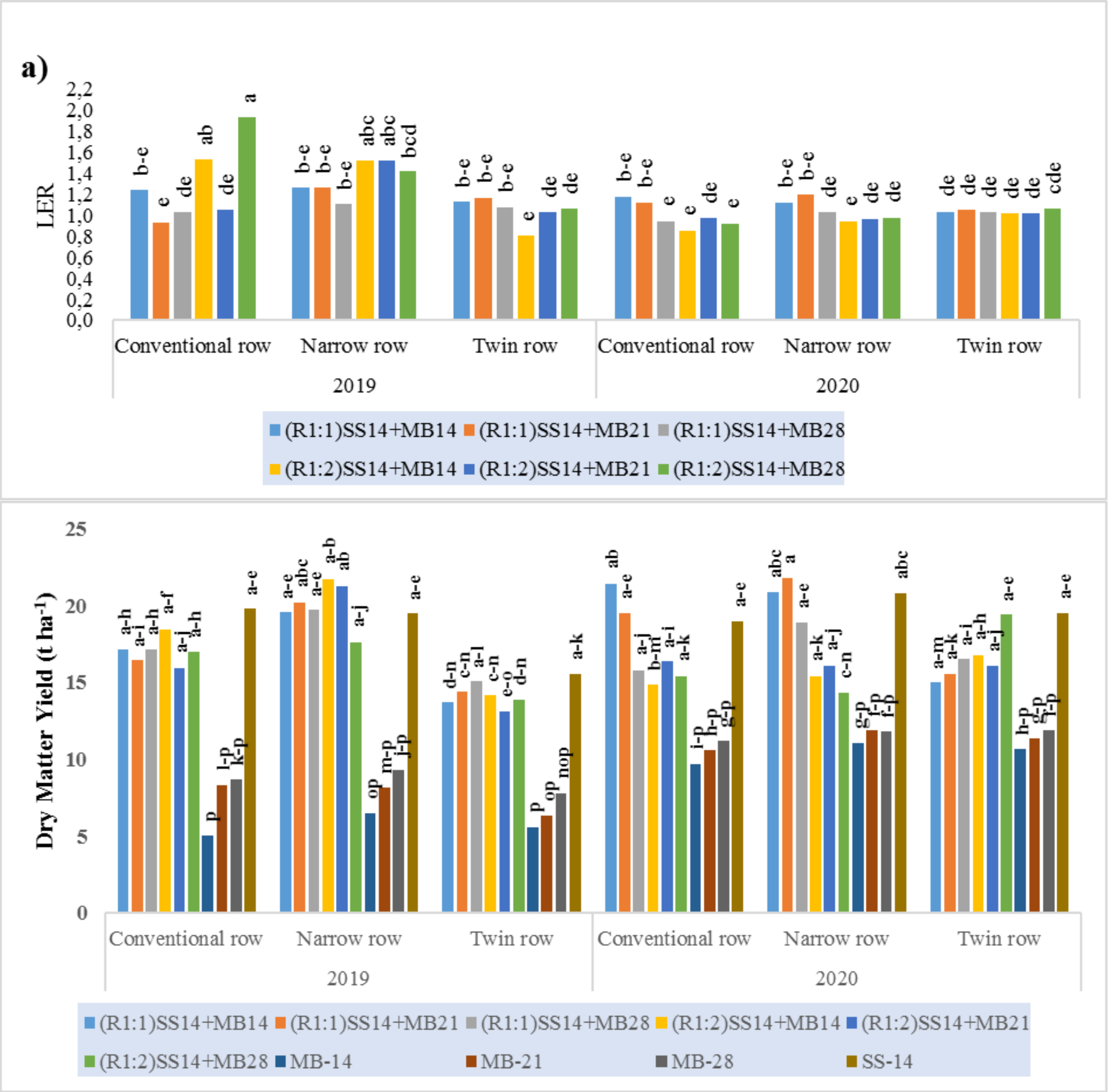

Figure 2. Land equivalent ratio (a) and dry forage yield (b) changes of years, sowing designs and mixtures (Y×SD×M) interactions

While the effect of year on ADF contents was not significant, the effects of sowing design (P<0.01), mixtures (P<0.01) and SD×M interactions (P<0.01) were significant (Table 2). The ADF contents gave results parallel to NDF contents in term of sowing designs (Table 3). The ADF contents of the mixtures varied between 28.27% and 31.61% (Table 3). The highest ADF content was determined in pure MB14 cultivation and the lowest in pure SS14 cultivation. When we examined the interactions (Figure 4.b), the lowest ADF content was determined in pure sweet sorghum cultivation in all three cultivation methods. Baghdadi et al. (2016) reported that ADF of pure cowpea was higher than pure maize.

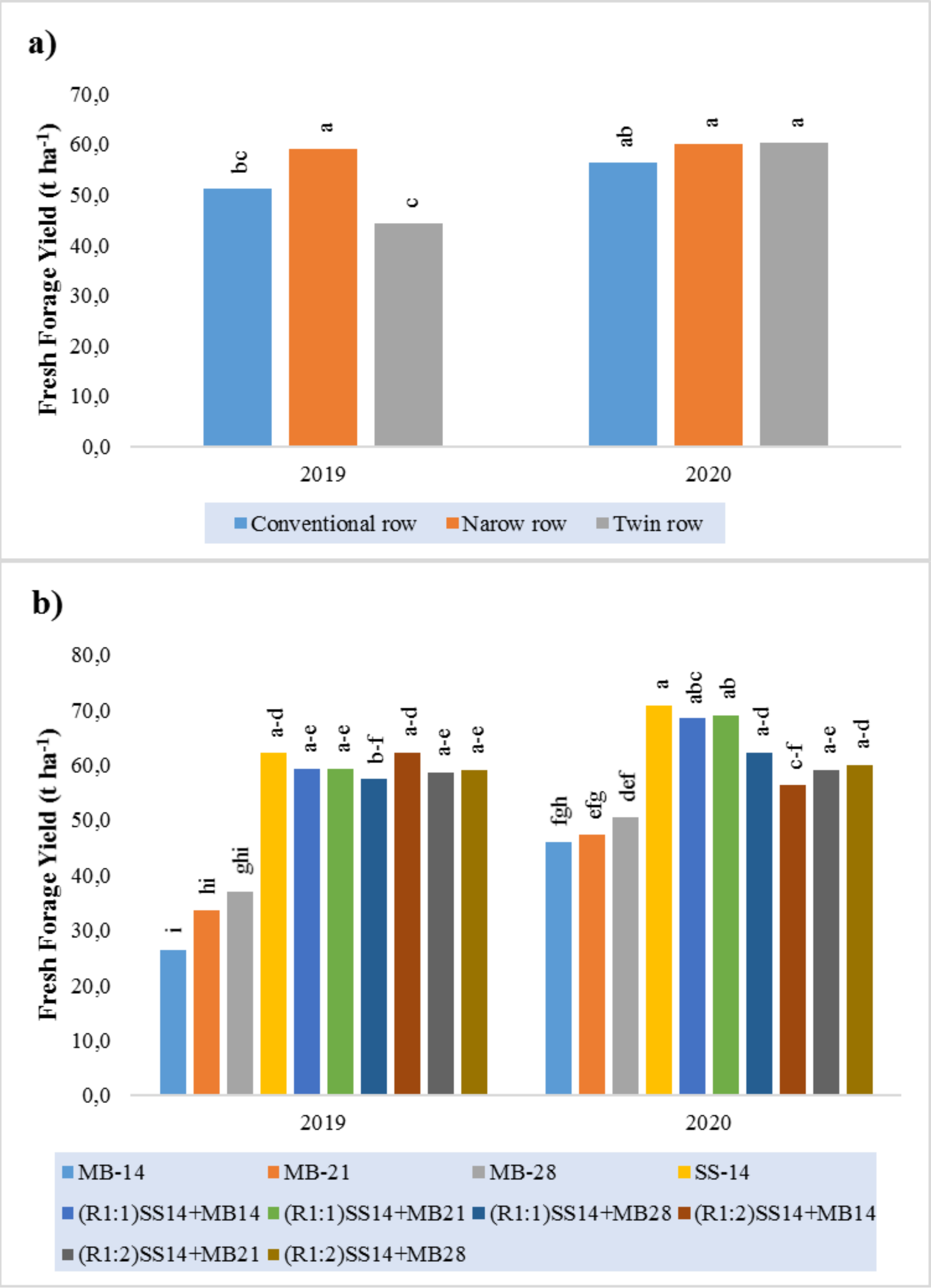

Figure 3. Fresh forage yield of years and sowing designs (a) Y×SD) and years and mixtures (b) Y×M) interactions

While the effect of year on ADL contents was not significant, the effects of sowing design ($P<0.01$), mixtures ($P<0.01$) and SD×M interactions ($P<0.01$) were significant (Table 2). The ADL contents determined in narrow row and conventional row treatments were found to be higher compared to twin row treatment (Table 4). The ADL contents of the mixtures ranged from 2.76% to 6.77%, and higher ADL content was detected in pure MB systems compared to pure SS14 and intercropping systems. Among the interactions, the highest ADL was determined in the pure MB14 system of conventional row treatment and the lowest in the pure SS14 system in the same sowing design (Figure 5.a). Karaman et al. (2020) reported that the ADL contents of two mung bean genotypes varied between 4.39-7.00% according to different harvesting times. In addition, Erdal et al. (2016) found that the highest ADL content was from pure soybean cultivation in their intercropping system (corn with soybean), similar to the results obtained from our study.

While the effect of sowing design on crude ash (CA) was not significant, the effects of year ($P<0.05$), mixtures ($P<0.01$) and SD×M interactions ($P<0.01$) were significant (Table 2). Crude ash was determined as 8.37% in 2019 and 8.43% in 2020 (Table 4). The crude ash contents of the mixtures varied between 5.41% and 13.36%. Pure MB cultivation gave higher crude ash content compared to pure SS14 and intercropping systems. When examining the interactions (Figure 5.b), the highest crude ash was detected in the pure MB14 system of conventional row and the lowest in pure SS14 system of the same sowing design. Ibrahim et al. (2012) found that the higher total ash content than pure maize was in pure cowpea cultivation and intercropping systems, similar to the results obtained from this study.

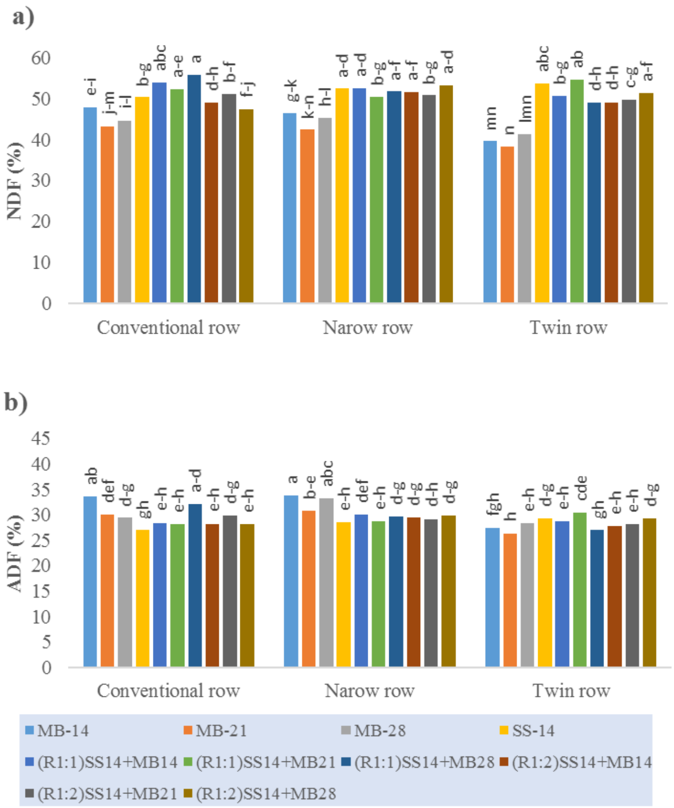

Figure 4. NDF (a) and ADF (b) changes of sowing designs and mixtures interactions

Table 4. Acid detergent lignin (ADL), crude ash, crude protein and ether extract contents of years, sowing designs and mixtures

Years	**Acid detergent lignin (%)**	**Crude ash (%)**	**Crude protein (%)**	**Ether extract (%)**	**Crude protein yield (t ha^{-1})**
2019	4.37	8.37 b	8.79 b	1.61 b	1.11
2020	4.39	8.43 a	9.06 a	1.62 a	1.33
Sowing designs					
Conventional row	4.66 a	8.40	9.02 a	1.57 c	1.23 ab
Narrow row	4.56 a	8.39	8.77 b	1.66 a	1.30 a
Twin row	3.93 b	8.41	8.99 a	1.61 b	1.14 b
Mixtures					
MB-14	6.77 a	13.36 a	13.98 a	2.01 a	1.14 ab
MB-21	6.21 a	12.85 b	12.91 b	1.86 b	1.22 ab
MB-28	6.60 a	12.93 b	12.95 b	1.77 b	1.31 a
SS-14	2.76 c	5.41 f	5.90 f	1.31 d	1.12 b
(R1:1)SS14+MB14	3.57 b	6.62 cd	7.29 cde	1.51 c	1.31 a
(R1:1)SS14+MB21	3.54 b	6.41 de	7.14 de	1.55 c	1.28 ab
(R1:1)SS14+MB28	3.68 b	6.30 e	7.47 c	1.53 c	1.29 ab
(R1:2)SS14+MB14	3.58 b	6.67 c	7.25 cde	1.58 c	1.22 ab
(R1:2)SS14+MB21	3.39 bc	6.70 c	7.38 cd	1.53 c	1.21 ab
(R1:2)SS14+MB28	3.74 b	6.75 c	6.99 e	1.51 c	1.14 ab

Data shown with different letters in the same column are statistically different from each other.

The effects of year, sowing design, mixtures and SD×M interactions on crude protein (CP) (P<0.01) content were found to be significant (Table 2). While crude protein was 8.79% in 2019, it was 9.06% in 2020 (Table 4). Crude protein content was higher in conventional row and twin row than that narrow row. Crude protein contents of the mixtures varied between 5.90% and 13.98%. Compared to pure SS14 and intercropping systems, pure MB cultivations yielded higher crude protein content. As the plant density increased in pure MB cultivation, there was a slight decrease in the crude protein content of the forages. In intercropping systems, the crude protein content increased compared to pure sweet sorghum cultivation. Among the interactions, the highest crude protein content was detected in pure MB14 cultivation of conventional row, and the lowest was in pure SS14 cultivation of the same sowing design (Figure 6.a). Along with the intercropping of corn and soybean, the highest crude protein content was determined in soybean, a legume species, and the lowest was in corn, a cereal species. In addition, it was reported that the crude protein ratio increased as legume crop ratio in the mixture increased (Baghdadi et al., 2016; Atis and Acikalin, 2020). Basaran et al. (2017) determined that crude protein content of roughage obtained from intercropping of sorghum-sudan grass and some legumes improved.

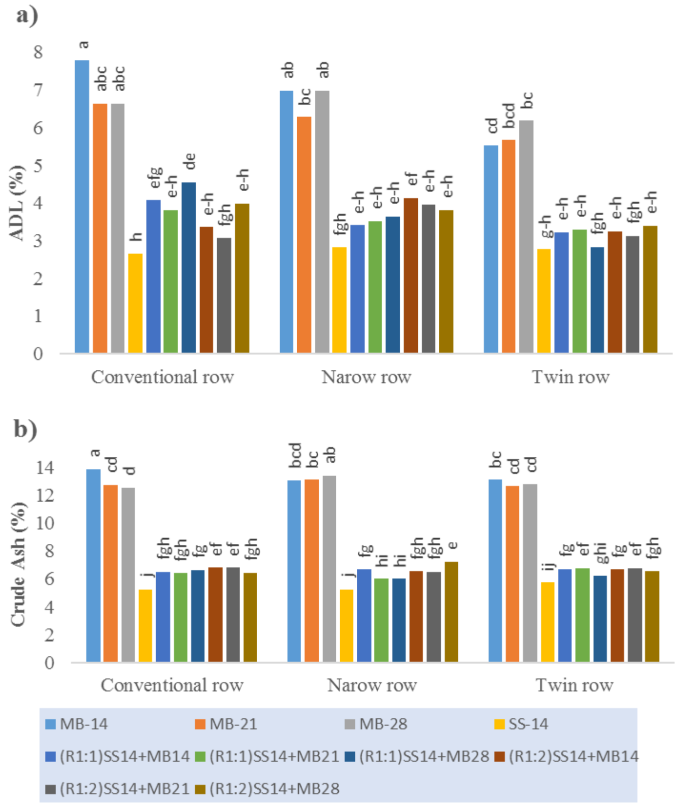

Figure 5. ADL (a) and crude ash (b) changes of sowing designs and mixtures interactions

The effects of year (P<0.05), sowing design (P<0.01), mixtures (P<0.01) and SD×M interactions (P<0.01) on ether extract (EE) were found as significant (Table 2). While ether extract was 1.61% in 2019, it was 1.62% in 2020 (Table 4). Ether extract contents depending on sowing designs varied between 1.57% and 1.66%, and the highest ether extract was determined in narrow row treatments. The ether extract content of the intercrops was lower than pure MB cultivations and slightly higher than pure SS cultivations. The highest ether extract was determined in pure MB14 cultivation of conventional row and the lowest was in pure SS14 cultivation of twin row treatment among all SD×M interaction combinations (Figure 6.b). Serbester et al. (2015) reported that the ether extract contents varied between 1.0-2.5% in an intercropping study conducted on corn and soybean and the ether extract contents increased according to the increase in the ratio of legumes in the mixture.

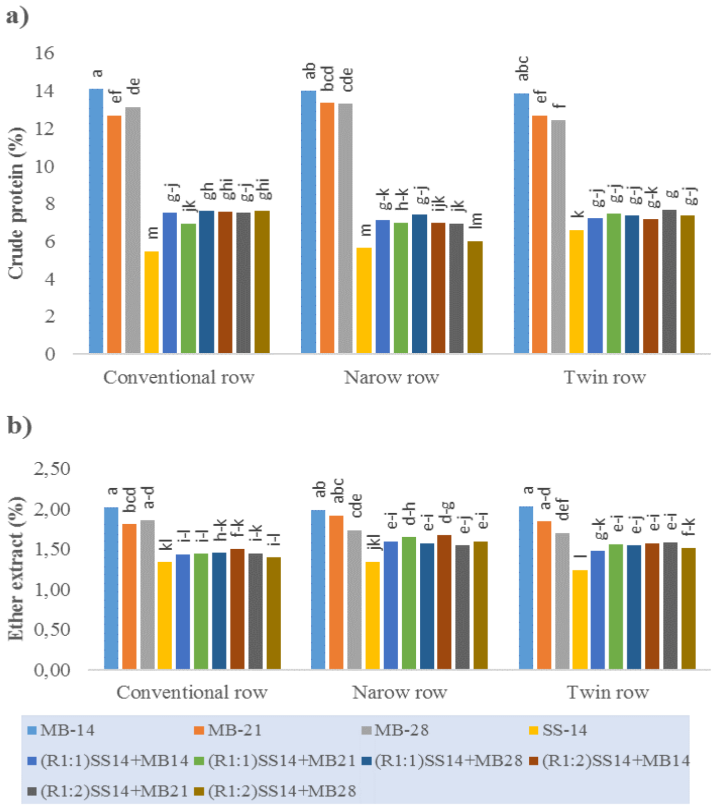

Figure 6. Crude protein (a) and ether extract (b) changes of sowing designs and mixtures interactions

The effects of years (Y) on crude protein yield (CPY) were not significant, whereas the effects of sowing designs (SD), mixtures (M) and double interactions (Y×SD, Y×M and SD×M) were significant (Table 2). In sowing designs, while the highest crude protein yield (1.30 t ha^{-1}) was obtained from narrow row, conventional row and narrow row gave statistically similar results (Table 4). In mixtures, crude protein yield improved with the intercropping systems and the lowest value (1.12 t ha^{-1}) was determined in SS-14. In Y×SD interactions, the highest crude protein yield was recorded in narrow row of 2020, however all sowing designs in 2020 and narrow row in 2020 gave statistically similar results (Figure 7.a). On the other hand, the lowest crude protein yield was obtained from twin row in 2019. In Y×M interactions, the highest crude protein yield was detected in MB-28 in 2020 while the lowest value was determined in MB-14 in 2019 (Figure 7.b). In SD×M interactions, the highest crude protein yield was obtained from (R1:1) SS14+MB21 of narrow row while the lowest value was determined in (R1:2) SS14+MB28 of narrow row (Figure 7.c). Yilmaz et al. (2008) reported that there were changes in crude protein yield from year to year in forage maize grown in different sowing designs. Indeed, the crude protein results from the current study were similar to their results. In addition, in Figure 1, it is observed that there is a difference in rainfall and temperature data 2019 and 2020. Therefore, it can be thought that there were year differences in crude protein yield.

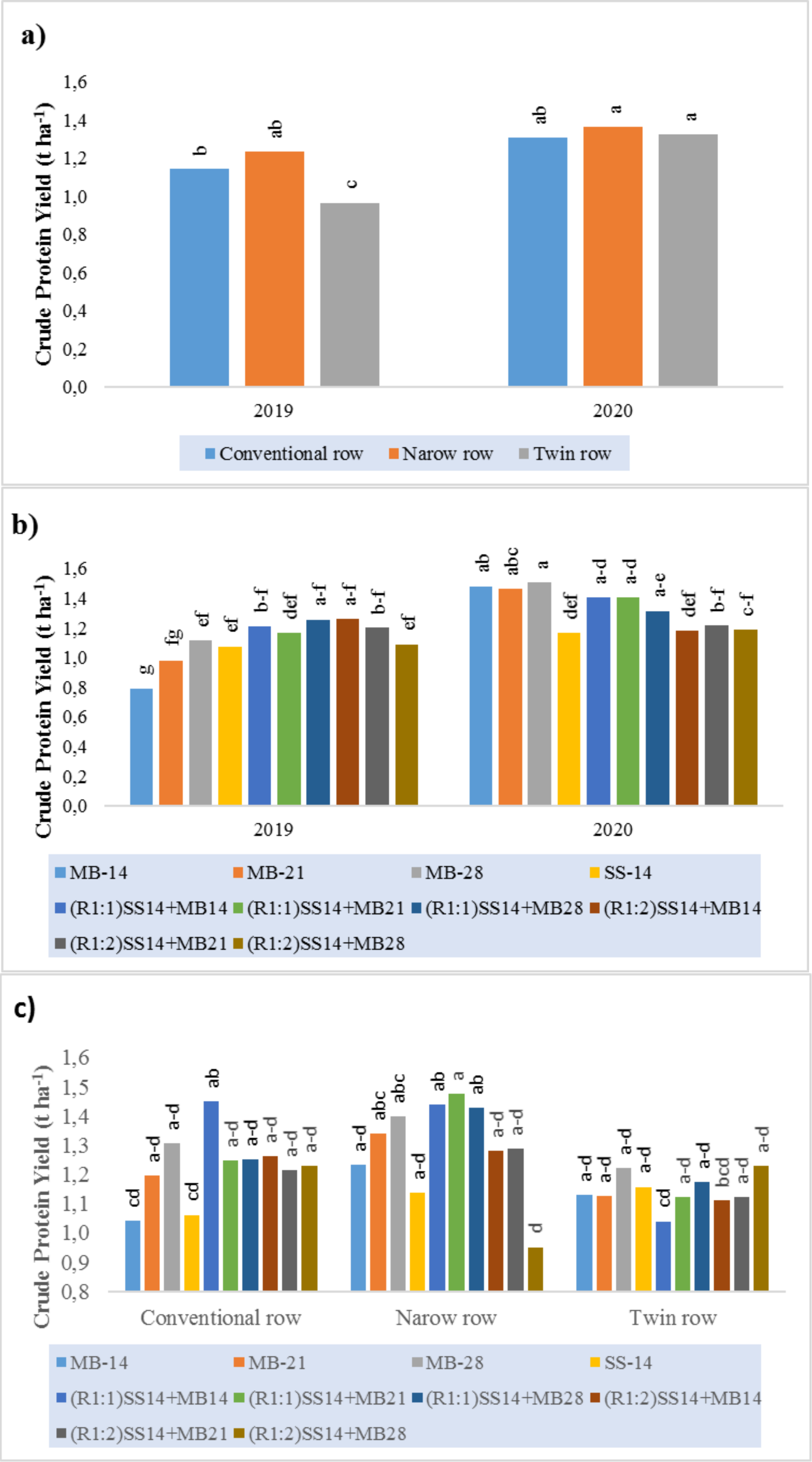

Figure 7. Crude protein yield of years and sowing designs (a) Y×SD), years and mixtures (b) Y×M) and sowing designs and mixtures (c) SD×M) interactions

CONCLUSION

According to the results of this study, narrow row treatment and twin row treatment came to the fore in terms of land equivalent ratio, forage yield and quality. Although the highest dry matter yield was obtained from pure sweet sorghum (SS14), considering the crude protein yield 14 plant m^{-2} density of 1 rows of sweet sorghum + 14 plants m^{-2} density of 1 row of mung bean ((R1:1) SS14+MB14) mixture can be recommended. According to the interaction results, intercropping of 14 plants m^{-2} density with 1 rows of sweet sorghum + 21 plants m^{-2} density with 1 row of mung bean ((R1:1) SS14+MB21) in a narrow row gave the best results. However, intercropping of 14 plants m^{-2} density with 1 rows of sweet sorghum + 14 plants m^{-2} density with 1 row of mung bean ((R1:1) SS14+MB14) system, which is in the same group statistically, is recommended in terms of seed saving. As a result of this study, it has been concluded that an efficient and high quality intercropping system can be realized in Mediterranean climate conditions, especially for mung bean and sweet sorghum.

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