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An Investigation on Quality Parameters of the Silages Made by Corn and Soybean Grown in Different Seeding Rates

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Abstract: The purpose of this study is to determine, the best seeding rates for corn and soybean for the highest quality of silage. To do this, the field experiments were carried out in randomized block design with 3 replications using corn variety P.32K61 and soybean variety OAC Salem in 2001 and 2002 as materials. They were seeded as monocropping and intercropping in alternated rows with the seeding rates of 100% corn + 0% soybean (SR1), 100% corn + 50% soybean (SR2), 100% corn + 100% soybean (SR3), 50% corn + 50% soybean (SR4), 50% corn + 100% soybean (SR5) and 0% corn + 100% soybean (SR6). The nutriments components, namely, Dry Matter (DM), Crude Ash (CA), Crude Protein (CP), Crude Fat (CF), Crude Cellulose (CC) and cell wall components, namely Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) were analyzed Before Ensiling (BE) and After Ensiling (AE) in both years. Hemicelluloses, cellulose and lignin were derived from the cell wall components. To determine the silage quality value, the Flieg points were calculated. The silages made using corn grown intercropped with soybean were good or very good quality in terms of physical characteristics. The soybean grown as mono-crop did not achieve high quality silages. The results substantiated that the mono-cropped corn and corn grown together with soybean at the different seeding rates gave rise to high quality silages. The digestibility of the silages mode from corn and soybean after ensiling was higher than that observed before ensiling.

Key words: Corn, soybean, quality parameters of silage, cell wall components, seeding rates

INTRODUCTION

Silo crops have not been effectively produced so far in Turkey even though it is a vital source of forage. Silage production has been becoming an indispensable solution to resolve the shortage of feed recently. Moreover, an increasing consumption of animal production brought about an increment in silage production. The amount of corn, being used in silage making, produced in an area of 27.500 ha reached 533.000 tons (Anonymous, 1999), a great deal of which is grown in Ege and Marmara regions (Tumer, 1996; Acikgoz, 2001). Ecological conditions of Turkey are suitable for growing many kinds of silage crops. Even though many crops are used in preparation of silage, sorghum and corn is used at most in the silage all over the world. This is because sorghum species and corn provide the greatest amount of green parts per unit area; they are the most suitable for silage production and their nutritional value is quite high (Acikgoz, 2001; Kilic, 1986; Baytekin *et al*., 1991). In general, it is possible to obtain high quality silage from these plants without any supplementation. Soybean (*Glycine max* (L.) Merr.) is generally grown for grain but its green parts and grains are also an important source of forage (Munoz *et al*., 1983).

To increase the quality of silage, it is not common to grow corn and soybean together at different seeding rate.

This study was undertaken to determine the best seeding rates for corn and soybean for the highest quality of silage depending upon the quality of silage, composition of nutriments and cell wall component.

MATERIALS AND METHODS

The field experiments were carried out in randomized block design with 3 replications at the Field Crops Department field during the growing seasons 2001-2002

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and 2002-2003. Corn variety P.32K61 and soybean variety OAC Salem in 2001 and 2002 were used as materials in the field experiments. They were seeded as monocropping and intercropping in alternated rows with the seeding rates of 100% corn + 0% soybean (SR1), 100% corn + 50% soybean (SR2), 100% corn + 100% soybean (SR3), 50% corn + 50% soybean (SR4), 50% corn + 100% soybean (SR5) and 0% corn + 100% Soybean (SR6).

The corn grains from the area of 4 m^2 located in the middle of each plot were harvested at the milk dough stage and chopped by using the garden shredder. After that, 2-l glass jars were filled with the chopped material and 2% of salt was added to the jars. The jars were left for fermentation for a 2 months period. In this way, the high quality silages was made from the green materials of corn and soybean grown on monocropped and intercropped corn with soybean.

The nutriments components, namely, Dry Matter (DM), Crude Ash (CA), Crude Protein (CP), Crude Fat (CF), Crude Cellulose (CC) (Akyildiz, 1984) and cell wall components, namely Neutral Detergent Fiber (NDF) (Goering and Van Soest, 1970), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) (Van Soest, 1963) were analyzed BE and AE in both years. Hemicelluloses, cellulose and lignin were derived from the cell wall components.

To determine the silage quality value, the Flieg points were calculated by means of the pH values and DM of the silages measured at the end of fermentation period by using the Eq. 1 (Akyildiz, 1984; Kilic, 1986):

$$\text{Flieg point} = 220 + (2\times \%\text{DM} - 15) - 40\times \text{pH}$$

The data was analyzed as the repeated randomized block experiments in years BE and AE separately by using ANOVA.

According to the ANOVA results, if necessary, Duncan multiple comparison method was used to investigate which seeding ratios was significantly different from each other (Winer *et al*., 1991). MSTAT and MINITAB 15.0 statistical packages were used in statistical analyses.

RESULTS AND DISCUSSION

The some physical characteristics and quality assessment of the silages produced the corn and soybean harvested in 2001-2002 and 2002-2003 at the seeding rates are presented in Table 1.

As shown in Table 1, the silages made using corn grown intercropped with soybean were good or very good quality in terms of physical characteristics namely, smell, colour and structure. The soybean grown as mono-crop did not achieve high quality silages. In other words, the silages produced from the mono-crop soybean were either medium quality or bad quality in both years. This result obtained in this study is in consistent with the result reported by Martin *et al*. (1998). They also stated that the use of soybean together with corn brought about high quality silages.

The DM (%) and pH values were obtained from the silages produced from the corn and soybean grown in different seeding rates. The results of variance analysis applied to them indicated that there was a statistically significant difference in DM between at least two seeding rates ($p<0.05$) although there was a statistically significant interaction between years and seeding rates with respect to pH values ($p<0.01$). To investigate, which seeding rates significantly differed from each other in terms of DM, Duncan multiple comparison test was applied. The results of this analysis are given in Table 2.

As shown in Table 2, the results verified that there was a statistically significant difference in DM between SR1 and SR6. However, it was shown that there was no significant discrepancy in DM between SR1, SR6 and SR3.

Table 1: The some physical characteristics and quality assessment of the silages produced the corn and soybean harvested at the seeding rates

Growing season	Seeding rates	N	Smell	Structure	Color	Total	Quality class
2001-2002	SR1	3	12.0	4.0	2.0	18.0	Very good
	SR2	3	10.0	4.0	1.3	15.3	Good
	SR3	3	8.6	4.0	1.6	14.2	Good
	SR4	3	12.0	4.0	1.6	17.6	Very good
	SR5	3	8.6	3.3	1.0	12.9	Good
	SR6	3	1.3	1.0	0.6	3.0	Useless
2002-2003	SR1	3	10.0	4.0	2.0	16.0	Very good
	SR2	3	12.0	4.0	1.7	17.7	Very good
	SR3	3	8.0	4.0	1.7	13.7	Good
	SR4	3	12.0	4.0	1.7	17.7	Very good
	SR5	3	10.0	4.0	1.7	15.7	Very good
	SR6	3	2.7	4.0	1.0	7.7	Medium

Table 2: Some chemical characteristics and quality classes of the silages produced from the corn and soybean grown in different seeding rates

Growing seasons	Seeding rates	pH	Flieg points	Quality class	Seeding rates	DM (%)
2001-2002	SR1	3.77^{c}	100	Very good		
	SR2	4.80^{b}	83	Very good		
	SR3	3.87^{c}	100	Very good		
	SR4	4.10^{c}	100	Very good	SR1	29.17^{b}
	SR5	4.03^{c}	100	Very good	SR2	31.67^{b}
	SR6	6.83^{a}	26	Medium	SR3	34.17^{ab}
2002-2003	SR1	3.83	100	Very good	SR4	31.17^{b}
	SR2	3.87	100	Very good	SR5	34.17^{b}
	SR3	3.90	100	Very good	SR6	41.33^{a}
	SR4	3.97	100	Very good		
	SR5	4.10	100	Very good		
	SR6	4.83	85	Very good		

The difference between the seeding rates having different letters is statistically significant ($p<0.01$)

Regarding pH values, the results emphasized that the effect of seeding rates changed from one year to another due to the significant interaction. Even though, there was no statistically significant difference among seeding rates in the 2nd year, the statistically significant difference was observed between SR1 and SR6 in the 1st year ($p<0.01$).

In this literature, the importance of water soluble carbohydrates in production of high quality silage is reported. Therefore, the feed plant should be rich in terms of water soluble carbohydrates (Altinok, 2002). The corn plant that does not necessitate a supplementation in silage making achieved high quality silages, when it is grown not only together with soybean but also mono-cropped, which was proved by low pH values presented in Table 2.

DM (%), CA (%), CP (%), CF (%) and CC (%) were measured from the dried samples BE and AE.

The results obtained for the dried samples taken BE pointed out that there was an evidence of statistically significant interaction between years and seeding rates regarding DM, CA and CP ($p<0.01$ for DM; $p<0.05$ for CA and CP). The seeding rates did, however, significantly vary from each other concerning CF ($p<0.01$) (Table 3). Moreover, the seeding rates did not vary significantly from each other with respect to CC ($p>0.05$) (Table 3). The results of Duncan test performed for DM, CA, CP and CF are presented in Table 3.

Although, there was no statistically significant difference among seeding rates as to DM, CA and CP in the 1st year, the results of the multiple comparison tests confirmed that the most significant differences in DM, CA and CP was observed between SR1 and SR6 in the second year. While the highest mean of DM was achieved for the mono-cropped corn, the mono-cropped soybean resulted in the highest mean of CA and CP (Table 3). The findings of this study agreed with the results stated by Lempp *et al.* (2000).

The results of analysis of variance performed for DM, CA, CP, CF and CC measured AE exhibited that there was an evident of statistically significant interaction between years and seeding rates ($p<0.05$). At least two seeding rates significantly differed from each other regarding CF and CP ($p<0.01$). By contrast, any significant divergence and interaction between years and seeding rates was detected with respect to CC and CA ($p>0.05$). Their mean for years and seeding rates and the results of Duncan test applied to DM, CF and CP are given in Table 4.

The results of Duncan test applied for the DM observed from dried samples taken AE showed that the biggest discrepancy was obtained between SR1 and SR5 in the 1st year. At the 2nd year the SR1, however, significantly diverged from all the other seeding rates (Table 4). Furthermore, the highest means of CF and CP were acquired from SR6, being significantly different from other seeding rates (Table 4).

Table 3: The results of Duncan's test for DM, CA, CP, CF and CC measured from the dried samples taken BE

Growing seasons	Seeding rates	DM (%)	CA (%)	CP (%)	Seeding rates	CF (%)	CC (%)
2001-2002	SR1	93.05	8.25	10.10			
	SR2	93.16	8.21	10.07			
	SR3	93.05	8.06	9.53			
	SR4	93.09	8.22	9.60	SR1	2.16^{b}	26.05
	SR5	92.94	8.03	9.47	SR2	2.44^{b}	27.16
	SR6	93.51	8.97	9.98	SR3	2.41^{b}	28.08
2002-2003	SR1	93.76^{a}	8.14^{bc}	8.77^{c}	SR4	2.82^{b}	26.24
	SR2	93.80^{a}	7.42^{c}	9.43^{bc}	SR5	3.02^{b}	26.29
	SR3	93.47^{a}	8.39^{bc}	10.13^{bc}	SR6	4.56^{b}	28.95
	SR4	93.59^{a}	7.64^{c}	9.90^{bc}			
	SR5	93.51^{a}	9.38^{ab}	10.60^{ab}			
	SR6	92.86^{b}	10.49^{a}	12.00^{a}			

Table 4: The results of Duncan test for DM, CF, CP, CC and CA measured from the dried samples taken AE

Growing seasons	Seeding rates	DM (%)	Seeding rates	CF (%)	CP (%)	CC (%)	CA (%)
2001-2002	SR1	96.66^{ab}					
	SR2	93.97^{a}					
	SR3	92.98^{b}					
	SR4	93.67^{ab}	SR1	2.28^{c}	8.43^{c}	25.75	9.66
	SR5	93.04^{b}	SR2	2.80^{bc}	9.60^{bc}	24.46	10.34
	SR6	94.18^{a}	SR3	3.20^{bc}	11.35^{ab}	28.07	9.41
2002-2003	SR1	93.10^{b}	SR4	3.19^{bc}	10.38^{bc}	26.26	9.76
	SR2	93.99^{a}	SR5	3.76^{b}	9.15^{c}	26.27	9.92
	SR3	94.05^{a}	SR6	5.94^{a}	13.07^{a}	27.81	11.69
	SR4	93.83^{a}					
	SR5	93.92^{a}					
	SR6	94.19^{a}					

The difference between the seeding rates having different letters is statistically significant ($p<0.01$)

The cell wall components, namely NDF, ADF, ADL, hemicelluloses, cellulose and lignin were also analyzed in the dried samples taken BE and AE. The results of analysis of variance highlighted that seeding rates significantly differed from each other as to NDF and hemicelluloses ($p<0.01$). The results of Duncan test performed for NDF and hemicelluloses were displayed in Table 5.

The fact that there was an increment in mean of CP for the silages made from intercropped corn verified that an addition of soybean resulted in an increment in the silage quality. The similar findings were also reported by Putnam *et al.* (1985) and Toniolo *et al.* (1987).

As shown in Table 5, the SR6 caused lower means of NDF and hemicelluloses than those observed from the other seeding rates, which was significantly different from the other seeding rates (Table 5).

Table 5: The results of analyses applied to the cell wall components observed AE and BE

Seeding rates	NDF (%)		ADF (%)		ADL (%)		Hemicelluloses (%)		Cellulose (%)		Lignin (%)	
	BE	AE	BE	AE	BE	AE	BE	AE	BE	AE	BE	AE
SR1	60.32[a]	57.96[a]	37.46	35.04	29.51	27.77	22.86[a]	22.92[a]	7.95	7.27	26.69	25.44
SR2	60.40[a]	57.61[a]	39.47	35.35	29.29	28.05	20.93[a]	22.25[a]	10.18	7.30	24.77	25.35
SR3	59.12[a]	58.38[a]	38.47	33.09	29.62	26.65	20.66[a]	25.29[a]	8.85	6.14	26.34	22.92
SR4	57.19[a]	56.17[a]	36.90	34.79	28.46	27.88	20.96[a]	21.38[a]	8.44	6.91	25.57	25.15
SR5	57.13[a]	56.03[a]	36.60	32.66	27.84	26.43	20.53[a]	23.37[a]	8.77	6.24	24.85	23.16
SR6	45.24[b]	47.84[b]	34.84	36.06	28.18	28.59	8.90[b]	11.62[b]	8.17	7.46	26.46	25.39

The difference between the seeding rates having different letters is statistically significant ($p<0.01$)

CONCLUSION

The following conclusions can be drawn based on the findings of this study:

- Mono-cropped soybean provided high amount of nutrient components, except for CC
- The lowest amount of NDF and hemicelluloses was attained by the mono-cropped soybean. By contrast, the remainder of cell wall components were not significantly influenced by the different seeding rates
- NDF, ADF, ADL, cellulose and lignin reduced in the dried samples taken after ensiling relatively before ensiling, except for the silages made from mono-cropped soybean. However, there was an increase in hemicelluloses after ensiling

Consequently, the findings of this study substantiated that the mono-cropped corn and corn grown together with soybean at the different seeding rates gave rise to high quality silages. The digestibility of the silages made from corn and soybean after ensiling was higher than that observed before ensiling.

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