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Crude Fiber, Ether Extract, and Some Mineral Contents of the Corn Silage Grown at Different Weed Densities

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A R T I C L E I N F O

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A B S T R A C T

Silage quality has great importance in animal feeding as much as yield. Quality characteristics are generally evaluated over crude protein and digestibility, but parameters related to mineral, total fiber, and sugar contents are also important indicators of silage quality and its nutritive value. Plant characteristics could affect these parameters, as silage material, and thereby, any environmental factors could affect these parameters indirectly. Weeds are one of the main environmental problems in silage corn production and in this study, the effect of weed density (0, 2, 4, 6, 8, 10, 12, 14 weeds plant m^{-2}) on ether extract, crude ash, crude fiber, starch, and mineral (Mg, Ca, P) contents of the silage was investigated in the years of 2019 and 2020. Inter-annual climatic variations had significant effects on ether extract, crude fiber, starch, Ca, and P contents of corn silage. The effect of weed densities was observed only on starch and Ca content. Increasing weed density decreased the Ca content but starch content showed an irregular variation. Weed density did not cause any significant variations in ether extract, crude ash, crude fiber, Mg, and P contents of the corn silage, but the total amount of the nutrition could be increased in silage by decreasing the competitive ability of the weeds at growth conditions of the silage corn.

1. Introduction

More than half of the livestock production costs consist of forage inputs. However, good quality forage is necessary for the proper nutrition of livestock because forage quality has a significant effect on animal performance (Kara et al., 2021). The quality of forage is determined by plant species, climate, soil fertility, and growth conditions. Besides, some manageable factors such as fertilization, irrigation, and weed struggle directly affect the quality (Lukangila, 2016).

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The quality degree could be related to the maturity level and/or the participation of some parts such as stem, leaf, and generative organs in the forage (Hassannejadd and Navid, 2013). Losses of plant tissues or organs could cause significant yield losses as well as quality. Therefore, management practices could be carried out properly to avoid low yield and lower quality than expected. For example, the yield of silage corn could be decreased by about 20-80 % depending on weed density in the stand (Shrestha et al., 2019) because weed competition causes yield losses by decreasing plant height, leaf area, and photosynthetic efficiency (Butts et al., 2017). Thereby, lignification decreased, while other quality parameters increased. This increment in quality is only ratio-based and decreased due to significant yield losses (Rajcan and Swanton, 2001). Indeed, the contribution of the plant part could also affect the silage quality significantly.

The photosynthetic efficiency of silage corn decreases due to competition with weeds for light, water, and nutrients, and consequently, the growth rate and dry matter ratio are decreased. Decreasing the dry matter ratio causes significant variations in CP, fiber, NDF, ADF, ether extract, starch, ash, mineral, amino acid contents, and digestibility of silage corn positively or negatively (Carvalho et al., 2006; Abdelqader et al., 2009; Azevedo et al., 2011; Heuze et al., 2017). Weed competition is for limited resources and negatively affects the seedling growth of silage corn. Production performance decreases and the contribution of leaf, cob, and stem change due to poor growth. In some cases, even cob could not be formed. The cob ratio is a significant parameter for quality and silage quality significantly decreases if cob did not exist (Kilic, 1986). The quality of silage prepared using the plants, which did not complete their potential growth, could be high, but despite the high quality, this type of production could not compensate for the needs due to low yield.

This study was planned to examine the silage quality of the corn (crude ash, ether extract, crude fiber, starch, Ca, Mg, and P) grown at different weed densities.

2. Materials and Methods

The research was carried out in the experimental station of Eskişehir Osmangazi University, Faculty of Agriculture during the main crop season of 2019 and 2020 years. The experiment was conducted due to a randomized complete blocks design with 6 replications. Simpatico was used as the corn cultivar and ensilaged after growing in different weed densities as 0, 2, 4, 6, 8, 10, 12, 14 weeds m^{-2}. Weed species were identified as *Chenopodium album, Amaranthus blitoides, Amaranthus hybridus, Solanum nigrum, and Xanthium strumarium* in the plots. In every plot, 70 kg ha^{-1} N and 180 kg ha^{-1} P_2O_5 were applied while sowing. Additional fertilization was carried out using 70 kg ha^{-1} N both during the V1-V5 and V6-V8 stages. Plants were irrigated once a week for 15 hours using drip irrigation that has a 1.9 l h^{-1} flow rate.

Harvest was carried out when corns reached to dough stage in weed-free plots for both years. Harvested plants were mechanically processed and ensilaged. All samples were subjected to the same mechanical process and any inoculant was not used. After filling, silage bags were vacuumed and strapped to avoid air intake of the bags.

Silage bags were opened and investigated after 8 weeks of the fermentation period. Samples from each bag were oven-dried at 70 ºC until reached constant weight. Dry samples were grounded to pass through a 2 mm sieve and ash, ether extract, crude fiber, starch, Ca, Mg, and P contents were determined using FT-NIR (Fourier Transform Near-Infrared, Bruker MPA) spectroscopy.

All data were subjected to analysis of variance using SAS statistical software (SAS Institute, 2011). Means were compared using Bonferroni/Dunn multiple comparison test.

3. Results and Discussion

Average crude ash was determined as 7.67%. Despite it varied between years and among the weed densities in the range of 7.07 – 8.54%, the variation between the years and among the weed densities was statistically non-significant. The interaction was also non-significant (Table 1).

Ether extract of the silage significantly varied between the years ($p<0.01$) but weed densities and interaction were statically non-significant. The ether extract was 1.85% in 2019 and increased to 2.27% in 2020 (Table 1). Ether extracts of the silages prepared from weed-free plots were numerically higher but this variation was statically non-significant (Table 1).

The variation of crude fiber content was statically significant between the years ($p<0.01$). It was 17.75% in 2019 and significantly increased to 22.30% in 2020 (Table 1). Weed densities did not have a significant effect on crude fiber content and the interaction was also non-significant. However, the crude fiber content of the silage was numerically the highest for the plants that were grown at the weed density of 14 weeds m2, which was 21.19% (Table 1).

Table 1. Means and ANOVA results of the examined characteristics

	Crude Ash (%)	Ether Extract (%)	Crude Fibre (%)	Starch (%)	Ca (%)	Mg (%)	P (%)
Year (Y)							
2019	7.86	1.85 B	17.75 B	26.13 B	0.38 A	0.14	0.16 B
2020	7.48	2.27 A	22.30 A	33.84 A	0.24 B	0.13	0.21 A
Weeds Density (WD)							
0	7.63	2.27	19.13	24.39 D	0.34 B	0.12	0.19
2	7.49	1.93	20.26	26.97 D	0.38 A	0.17	0.18
4	7.48	1.94	20.62	28.32 C	0.32 B	0.13	0.19
6	8.54	2.00	20.00	33.60 B	0.37 A	0.14	0.19
8	8.33	1.96	18.73	29.70 C	0.32 B	0.12	0.19
10	7.07	2.09	19.36	37.61 A	0.33 B	0.10	0.20
12	7.51	2.07	20.92	30.53 C	0.20 C	0.20	0.19
14	7.31	2.22	21.19	28.81 C	0.23 C	0.11	0.18
Average	**7.67**	**2.06**	**20.03**	**29.99**	**0.31**	**0.14**	**0.19**
Y	ns	**	**	**	**	ns	**
WD	ns	ns	ns	**	**	ns	ns
YxWD	ns	ns	ns	**	ns	ns	ns

ns: non significant, *: P≤0,05, **: P≤0,01

Starch content was 26.13% in 2019 but it was significantly higher in 2020 (33.84%) and this variation was significant at the level of 1% (Table 1). Weed densities significantly affected (p<0.01) the starch content of the silage and the highest starch content was determined from the plots that contain 10 weeds m^{-2} (37.61%), while it was the lowest (24.39%) for weed-free plots (Table 1). Weed-related variation of silage starch content was different in each year and therefore, a significant year × weed density interaction was determined.

Average Ca content was 0.31% and it was significantly higher (p<0.01) in 2019 than in 2020 (Table 1). Ca content significantly varied (p<0.01) among the weed densities in the range of 0.20-0.38%. Increasing weed density caused an irregular decrement in the Ca content of the silage. Year × weed density interaction was non-significant.

Silage Mg content did not vary significant between the years, among the weed densities, and year × weed density interaction was also non-significant. Average Mg content was recorded as 0.14% (Table 1).

P content of the silage was 0.16% in the first experimental year and increased to 0.21% in the second year. This variation was significant at the level of 1% (Table 1). Weed densities did not cause significantly changes in P content and year × weed density interaction was also non-significant (Table 1).

High-quality silage could be ensured by avoiding dry matter loss and by providing aerobic stability. Besides, sufficient nutrition content is preferred. The quality of silage could be determined through physical and chemical analyses. Plant characteristics are the most important factor in silage quality as long as the spoilage is prevented. In the study, the crude ash content of the silage, which was prepared using silage corn grown at different weed densities, did not change in different years and depending on weed densities. The crude ash content of silage could change between 4.9 – 9.8% (Azevedo et al., 2011; Heuze et al., 2017).

Silage ether extract and crude fiber contents are changed depending on dry matter and plant organs, which affect the dry matter content of the plant (Seydoşoğlu and Cengiz, 2020). Yearly variations of ether extract and crude fiber content of the silage are possibly related to differences in cob, stem, and leaf ratios between the experimental years. Because a low leaf and stem ratio with a high cob ratio was observed in the first year but contrarily, a low cob ratio was observed in the second experimental year (unpublished data). Consequently, ether extract and fiber content of the silage showed significant variations between the years.

Starch is the main product of photosynthesis and could be stored in plant organs. The starch stored in the leaves is hydrolyzed into sucrose at night but starch is stored longer in the storage organs of the plants and used for metabolic processes (Ölçer and Akın, 2008). For silage corn, most of the starch is stored in cob but if the plant could not develop cobs due to any reason, starch is stored in leaves and stem. Leaves, stems, and cobs of the silage corn contain starch at the harvest stage because it is green-chopped (Figure 1.). Different starch content among the weed densities might be related to differences in leaf, stem, and cob ratios of the silage corn that is grown at different weed densities. Some plant organs might not develop under intense weed density. In this study, weed density increased the leaf and stem ratio but decreased the cob ratio. Therefore, starch content significantly varied. In other words; leaf, stem, and cob ratios change as the weed density increases. Other researchers also stated that plant height, leaf, stem, and cob ratios are closely related (Uremis et al., 2009; Vazin, 2012, Dogan et al., 2004). The great variation between leaf and cob ratios was related to weed density and also weed species (unpublished data). This is another reason for the significant year weed density interaction.

Inter-annual climatic variations are a natural phenomena, which directly affects plant production and quality. Weeds, as an environmental factor, could restrict the growth and genetical potential of the plants through competition, and thereby, great variations may occur in mineral contents such as Ca, Mg, and P (Carvalho et al., 2006; Abdelqader et al., 2009; Azevedo et al., 2011; Heuze et al., 2017). This might be the reason for the significant variation in Ca content of the silage among the weed densities in the study.

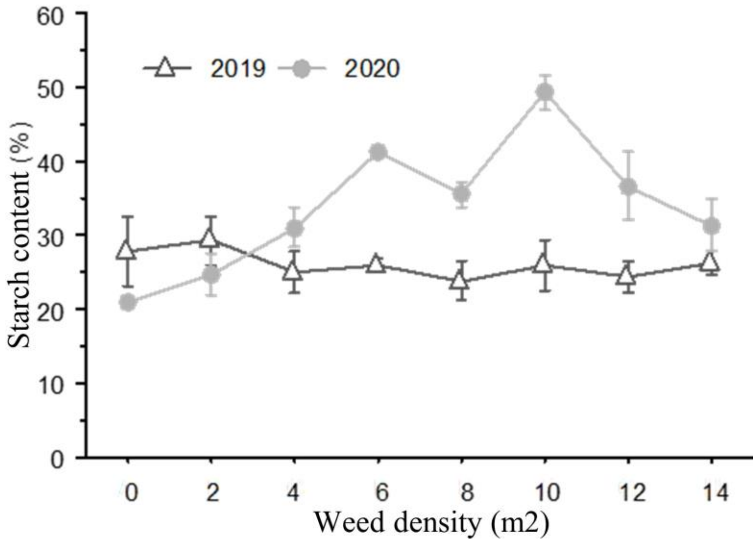

Figure 1. Variation of starch content in both years and at different weed densities

4. Conclusion

Ether extract, crude fiber, starch, Ca, and P contents of the additive-free corn silage, which was prepared using the silage corn grown at different weed densities, showed significant variations between the years. Weed density only affected the starch and Ca content of the silage. Although weed density did not affect some quality parameters of the corn silage, total production and the total amount of nutrients could be increased by weed struggle. The yield and silage quality of the plants could be increased by eliminating or alleviating the effects of weeds and decreasing their competitive ability.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Authorship contribution statement

All authors equally contributed to the study.

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