

Control of Corn Silage Quality on Farms for Milk Production in Kalesija area and Influence Climate Conditions on the Quality and Yield of Corn Silage

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ABSTRACT

The goal of the research was to monitor the quality of corn silage on farms in the period from 2017. to 2019th year, and to compare the quality of silage by years of research.

The analysis of corn silage has been done at 20 farms in the municipality Kalesija.

The following parameters of corn silage quality were determined: acidity (pH), crude protein (CP), crude fiber (SC) and moisture content (SV).

The quality of corn silage varies much more in one year, by the farms, than by years of production, although the agro-climatic conditions for production were different in the years of production.

The medium value of CP by years of research is in 2017 - 6.94 %, 2018 - 6.82 % and in 2019th was 6.31 %. The low level of protein indicates a bad choice of hybrids for sowing and storing silage at a later stage of corn development.

The acidity (pH), the medium value by year of research is in 2017 - 3.81, in 2018 - 4.03 and in 2019 - 4.01. The acidity is in the limits of optimal values for corn silage. The medium value of SC by years of research is in 2017th 31.69 %, 2018 - 31.9 % and in 2019 - 33.99 %. The high content of cellulose is an indicator of storing corn silage in later stage of corn maturation.

Moisture content, the medium value by years of the research is in 2017 - 68.48 %, 2018 - 68.75 % and in the 2019 - 68.43 %. The moisture content is within the optimum values for corn silage.

Keywords- silage, protein, cellulose, acidity, humidity.

High milk production can only be achieved with high quality forage because type and quality of forage affect the quantity and content of milk (Caput, 1996.).

Maize for forage production is relatively widely used, although we should cultivate a far more forage maize due to its high production potential of high-quality forage (Miskovic, 1986.).

Whole plant of silage corn is one of the most important energy source in the nutrition of dairy cows, since these plants gives a high yields of green mass, has a relatively high energy content of dry matter, it is characterized by high palatability and represents an indispensable component for the preparation of a fully mixed meal (Forouzmand et al., 2005.).

Usage of different corn hybrids increases the yield per unit area (Hunt et al., 1993.).

The content of nutrients and energy value of corn silage is biologically determined by the ratio of the stem, leaves and ears (grain) in the dry matter of hybrids, the level of fertilization, climatic conditions in the year of production, stage of maturity and silage technology, and content and digestibility of starch and fiber (Bal et al., 2000., Moss et al., 2001.).

Johnson et al. (1999.) indicate that the stage of maturity at the mowing time has the strongest effect on digestibility, energy value and suitability of whole corn silage plant.

Desired dry matter content of silage maize plant is about 35%, when is achieved an optimal ratio between the content of starch as a carrier of energy value and water soluble sugars needed to produce sufficient quantities of lactic acid that by lowering the acidity below pH 4 canned whole corn plant (Horrocks and Vallentine, 1999.).

Corn plant that contains less than 30 % of dry matter has a low content of starch, which increases nutrient losses with silage juice runoff, and reduces the consumption of silage. If the dry matter content is higher than 40%, it is difficult to achieve proper ensiling conditions due to poor compaction, which often leads to spoilage of silage mass (Kalivoda, 1990.).

Bal et al. (1997.) state that delaying of corn silage harvest from 35 to 45 % of dry matter

I. INTRODUCTION

Corn for silage production can be grown as a major, subsequent and after grain crops. In our country, we are mainly grown it as the major crop, but in the last few years there is a tendency of growing it as a subsequent crop (after fodder peas and vetch). Sowing of maize for silage production as the major crop is carried out at the same period as for production of grain (optimum April 10 to 25). Density of seeding should be higher by 15 to 20 % compared to the sowing of grain.

(physiological maturity of grain maize) does not affect the intake of dry matter silage, but due to declining digestibility of organic matter, acid detergent of fiber and starch, leads to reducing the production of milk and milk protein content.

The ripening of corn crop increases the dry matter content, the amount of starch, and in the dry matter reduces the amount of fiber (De Visser, 1993.).

In recent years, a lot of test of leafy maize hybrids for silage were performed. These hybrids are characterized by large amounts of leaves, higher moisture content in grain and softer texture of the corn cob. Dwyer et al. (1998.) reported that in North America about 16 % corn silage is produced from leafy hybrids.

In order to increase the nutritional value of corn silage, for this purpose hybrids with increased oil content are grown (Weiss and Wyatt, 2000.), waxy (Akay and Jackson, 2001.).

Stage of maturity of corn silage is an important factor that dictates digestibility. Ripening of corn increases the overall yield as well as percentage of participation of the cob (and grains) in total plant mass. However, the accumulation of starch in the grain parallel leads to reduction in the digestibility of the tree (Struik et al., 1985.).

One of the biggest problems for the practice of corn silage usage is the subsequent fermentation that occurs due to irregular spending of silage and prolonged exposure to the air. Subsequent fermentation occurs due to aerobic microbial activity (fungi) on a substrate consisting of residual sugars. The use of bacterial inoculants based on homo fermentative bacteria of lactic acid in silage maize may be even harmful because the fermentation ends for a short time and material was quickly acidified because of a larger amount of lactic acid and other minor products (acetic acid, ethyl alcohol, carbon dioxide). Because of the short duration of the fermentation, large amounts of sugar lag behind, which represent an excellent substrate for aerobic microbial activity at the opening of the silo. Years ago it was

confirmed that inoculation with *Lactobacillus Buchner* is improving aerobic stability of silage maize (Ranjit and Kung, 2000.), which is explained by the fact that it is a hetero fermentative bacteria of that transforms lactic acid into acetic (Oude Elferink et al., 2001.). Lactic acid, as the main product of homo fermentative fermentation of sugar in the ensiled mass, represents a high bactericidal but very low fungicidal means. In contrast, acetic, butyric and propionic acids have expressed high fungicidal effect, so minor amounts of these acids in corn silage, but also in other crops, are even desirable.

Corn silage can be used as the sole forage in the ration of dairy cows without negative consequences for the health of animals, but with the additions must be provided the required amount of protein, phosphorus and minerals (Chamberlain and Wilkinson, 1996.).

II. MATERIALS AND METHODS

The research includes samples of corn silage from 20 farms from Kalesija municipality. The farmers are classified as significant producers of milk with each farmer breeding more than 10 milking cows.

The following method of chemical quality of corn silage samples was used:

- Proteins - (sample preparation, digestion, distillation, titration), using Kjeldahl method;
- Cellulose (fiber) - Method manufacturers (Velp) - extractor for cellulose;
- Moisture (dry matter) - automatic hygrometer (Ohaus);
- Mineral matter - method of burning and annealing (burner and furnace annealing).

The results of research were analyzed in the statistical program SPSS 12.

Samples for analysis were taken every year (2017.-2019.).

III. RESULT AND DISCUSSION

Table 1: Chemical composition of corn silage samples

2017					2018					2019				
pH	M	P	C	MM	pH	M	P	C	MM	pH	M	P	C	MM
3,48	67,4	6,79	33,7	3,43	3,82	67,71	6,39	29,05	2,51	4,1	66,3	5,3	31,4	1,8
3,88	71,8	7,72	28,5	3,71	3,82	64,5	6,94	18,96	2,99	4,1	66,3	4,7	34,0	1,4
3,63	71,3	7,54	29,6	3,22	3,79	63,32	5,40	40,4	2,12	4,5	70,4	4,1	35,5	2,3
3,97	70,6	7,32	31,6	3,11	3,58	71,50	7,81	32,88	1,84	4,1	68,7	4,9	34,9	2,9
4,10	68,4	8,42	33,7	3,29	3,83	61,21	5,20	23,39	2,59	4,2	62,0	5,6	29,5	1,4
3,41	70,6	7,55	30,7	2,71	3,77	52,67	7,28	35,02	3,03	4,3	68,3	6,7	32,9	1,6
3,55	73,6	6,39	30,7	2,82	4,00	68,81	6,39	58,77	2,59	4,0	70,3	5,9	28,9	1,8
3,79	69,9	7,45	31,4	2,33	3,52	54,06	8,24	27,25	3,05	3,9	66,2	7,5	26,9	2,1
3,88	70,4	7,89	31,5	2,71	3,72	52,81	6,65	26,21	2,27	4,1	71,5	7,3	25,9	1,8
3,91	70,7	6,93	32,4	2,42	3,49	78,81	11,05	31,13	1,54	4,1	65,6	4,4	36,9	1,7

3,52	70,4	8,25	28,6	2,13	3,70	78,14	2,40	30,84	1,54	3,8	66,7	6,3	32,4	1,8
3,52	70,7	8,05	30,7	2,55	3,31	76,15	5,90	40,45	1,34	4,0	59,8	5,2	35,0	1,2
3,43	67,4	6,93	28,9	2,88	5,81	57,95	6,61	18,22	1,15	4,0	74,3	5,4	34,0	2,9
3,85	71,9	7,82	34,8	3,03	3,52	74,55	6,69	28,86	1,71	3,9	69,2	5,8	35,7	1,9
3,67	71,2	7,33	31,6	2,55	3,71	73,00	4,65	39,42	1,31	4,1	71,5	7,0	33,1	1,2
3,90	68,3	8,04	31,2	2,39	3,99	62,65	5,48	35,46	1,61	4,3	64,9	5,1	37,8	1,6
3,64	68,8	7,22	31,2	2,09	3,74	62,79	6,10	30,61	1,61	4,0	57,5	5,8	35,9	1,7
3,67	70,4	6,34	33,3	2,28	7,27	78,32	6,10	34,15	1,71	4,1	61,2	6,8	37,9	1,2
3,67	70,8	7,16	33,3	2,03	3,37	70,66	6,08	31,79	1,43	3,9	73,7	5,4	38,7	1,8
3,82	66,5	7,59	31,5	2,38	7,23	63,87	4,94	39,56	1,32	3,9	72,2	7,0	31,3	2,3

pH, P – protein, C – cellulose, M – moisture, MM – mineral matter

The pH value

Table 2: The pH value

	2017	2018	2019
Min.	3,39	3,31	3,71
Max.	4,12	7,36	4,86
Average	3,81	4,03	4,01

Table 3: F – Test of pH value

DEVIATION			d.f.	Variation	Analysis			
Source of Variation	Amount	%			F		d.f.	
					Calc.	Tab.	More	Less
Between mean treatments	1,96903	3,61	2	0,984518	3,485	2,99	2	186
Residual or sample errors	52,5473	96,39	186	0,282513				
Total	54,5163	100	188					

The determined value of average pH ranged from 3.81 to 4.03, indicating good fermentation of silage samples.

Statistically there is a significant difference in pH by years of testing. This was influenced by very

different agro-climatic conditions for production of silage.

The crude protein content (%)

Table 4: The crude protein content (%)

	2017	2018	2019
Min.	5,29	2,4	4,11
Max.	8,57	13,82	7,65
Average	6,94	6,82	6,31

Table 5: F – Test of crude protein content

DEVIATION			d.f.	Variation	Analysis			
Source of Variation	Amount	%			F		d.f.	
					Calc.	Tab.	More	Less
Between mean treatments	14,42419	5,39	2	7,212098	5,294	2,99	2	186
Residual or sample errors	253,37	94,61	186	1,362209				
Total	267,80	100	188					

The fortified low crude protein content in the tested corn silage averaged from 6.31 to 6.94%, and it was lower than the average of 8.0 to 8.5% for corn silage containing 40% dry matter according to NRC (2001.) and DLG (1997.).

Corn silage corn is quantitatively poor in content of crude protein.

Statistically there is a significant difference in the content of crude protein by years of research, and as a major factor in the differences of crude protein are agro climatic conditions of production.

The cellulose content (%)

Table 6: The cellulose content (%)

	2017	2018	2019
Min.	20,41	18,06	25,91
Max.	40,27	58,77	38,73
Average	31,69	31,9	33,99

Table 7: F – Test of cellulose content

DEVIATION			d.f.	Variation	Analysis			
					F		d.f.	
Source of Variation	Amount	%			Calc.	Tab.	More	Less
Between mean treatments	203,7221	3,82	2	101,8611	3,69	2,99	2	186
Residual or sample errors	5.132,95	96,18	186	27,5965				
Total	5.336,67	100	188					

Results show a high average content of cellulose in tested corn silage samples from 31.69% to 33.99%. The optimum content of cellulose in corn silage is 20% to 25%. The cause of the high content of cellulose of

prepared silage is agro-climatic conditions of production. Statistically there is a significant difference in terms of cellulose content by years of research.

The moisture content

Table 8: The moisture content

	2017	2018	2019
Min.	54,17	52,67	57,47
Max.	74,37	84,99	74,3
Average	68,48	68,75	68,43

Table 9: F – Test of moisture content

DEVIATION			d. f.	Variation	Analysis			
					F		d. f.	
Source of Variation	Amount	%			Calc.	Tab.	More	Less
Between mean treatments	3,69112	0,09	2	1,845562	0,084	2,99	2	186
Residual or sample errors	4.091,93	99,01	186	21,99965				
Total	4.095,62	100	188					

The fortified average moisture content ranged from 68.43 to 68.75% that indicates the preparation of silage at the optimum stage of maturity of maize, which is

very important. It is not noticed statistically significant difference in moisture content.

The mineral matter content

Table 10: The mineral matter content

	2017	2018	2019
Min.	1,54	1,15	1,11
Max.	3,83	3,51	3,34
Average	2,45	2,31	2,05

Table 11: F – Test of mineral matter content

DEVIATION			d.f.	Variation	Analysis			
Source of Variation	Amount	%			F		d.f.	
					Calc.	Tab.	More	Less
Between mean treatments	5,112585	9,73	2	2,556293	10,028	2,99	2	186
Residual or sample errors	47,41289	90,27	186	0,254908				
Total	52,52548	100	188					

The determined average mineral matter content from 2.05 to 2.45 indicating the proper preparation of corn silage, primarily the height of cut corn silage.

Agro-climatic conditions

The most important factor for changes in the quality of silage is agro-climatic conditions.

During the 2018 year we had a very good distribution of rainfall so in the same year yield and quality was the best.

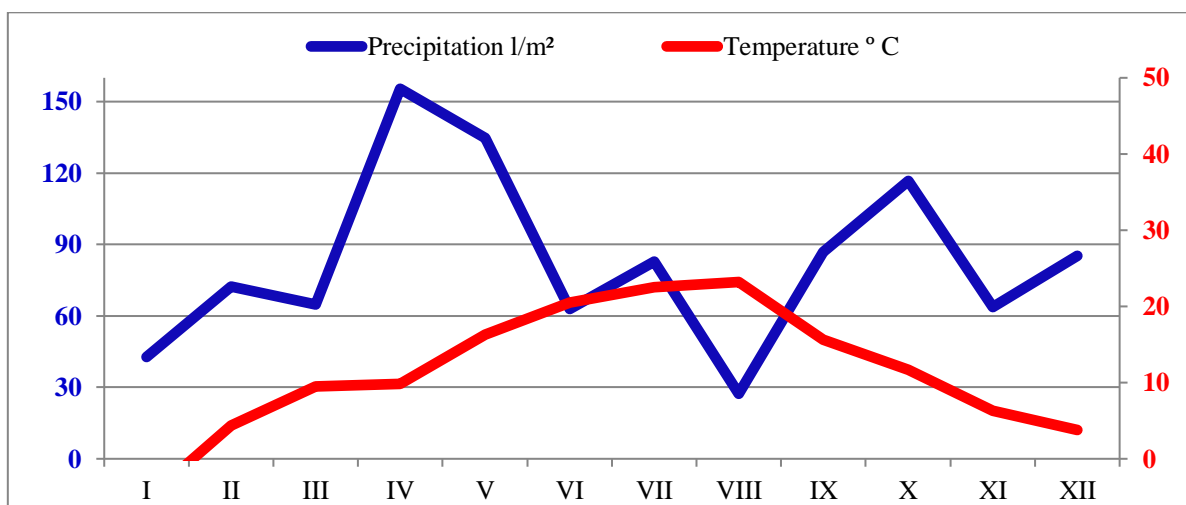
In the 2017 we had a over draught in August, which resulted in faster maturation of maize and a little less moisture content of the silage.

In the 2019 year throughout the growing season was a very much precipitation, and the sowing was delayed which affected the quality and yield of silage.

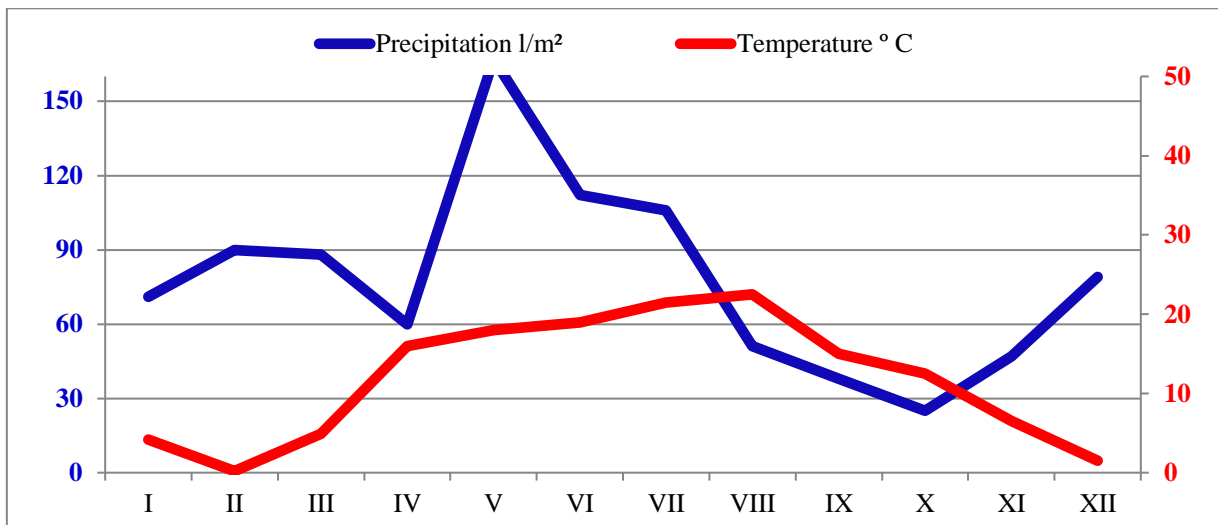
Table 12: Average yield of corn silage tons/Hectare (green mass)

	2017	2018	2019
Min.	18,4	23,6	17,5
Max.	41,8	51,6	37,9
Average	25,9	31,1	22,6

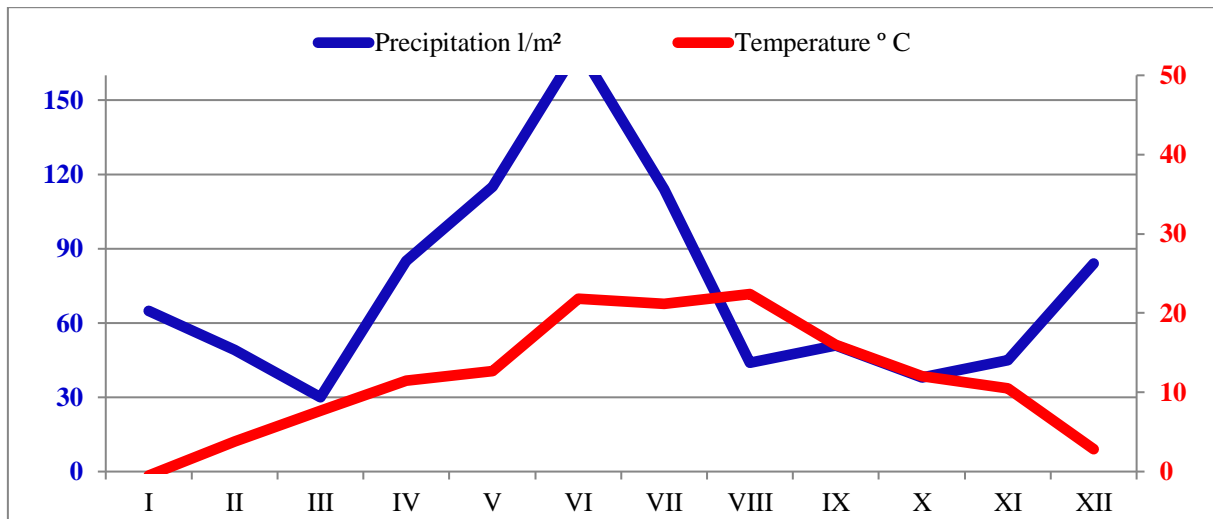
The highest yield was achieved in 2018, due to the good distribution of precipitation.



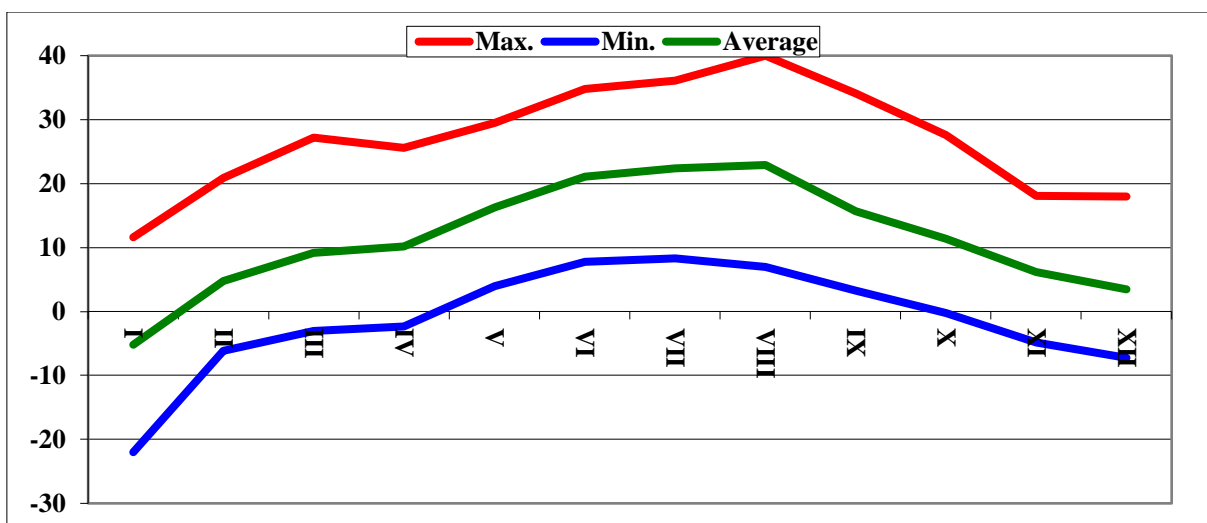
Graph 1: Climate chart at Walter and Lieth for 2017 year



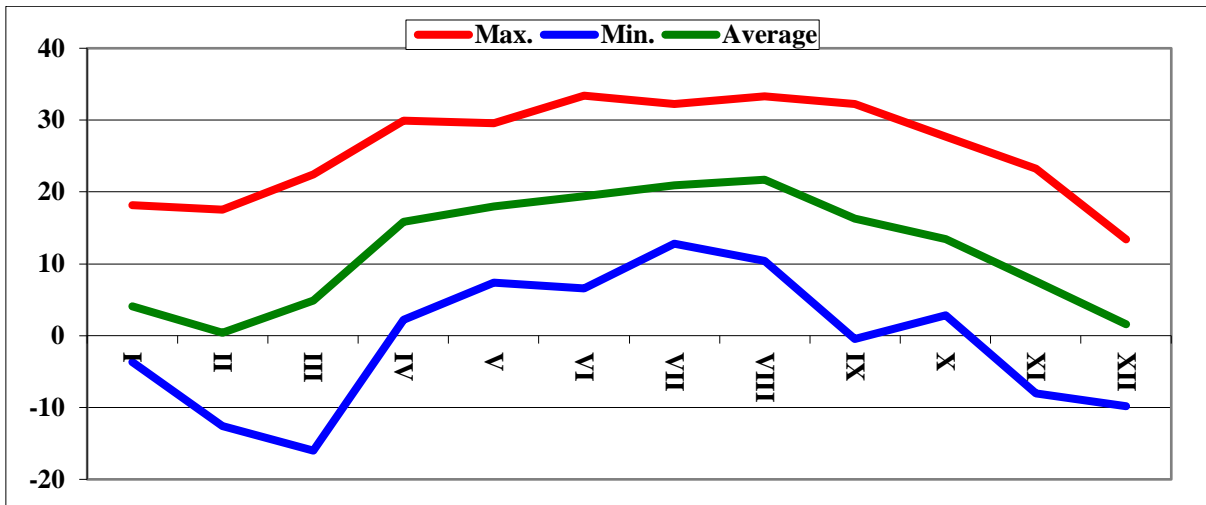
Graph 2: Climate chart at Walter and Lieth for 2018 year



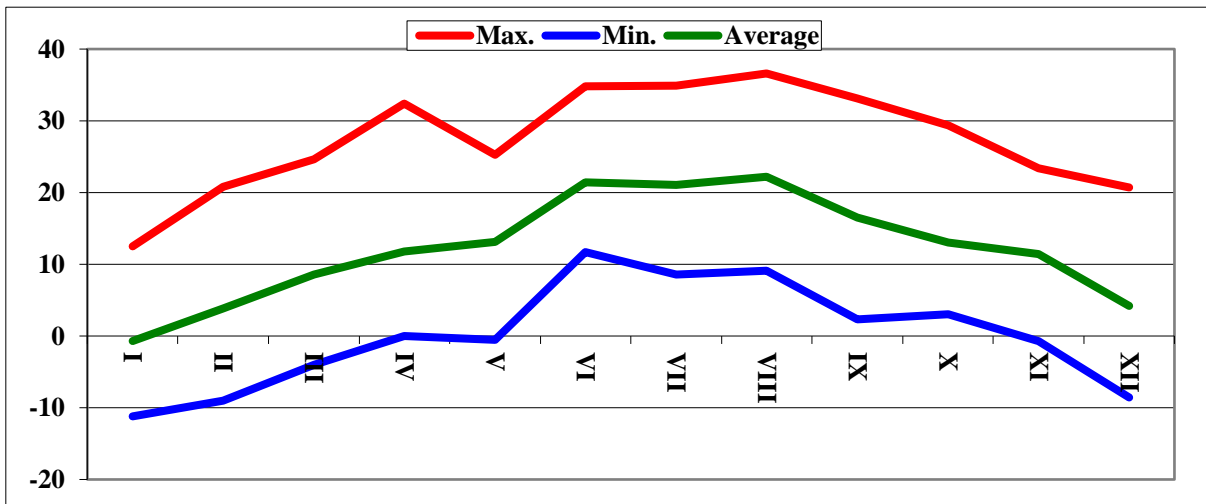
Graph 3: Climate chart at Walter and Lieth for 2019 year



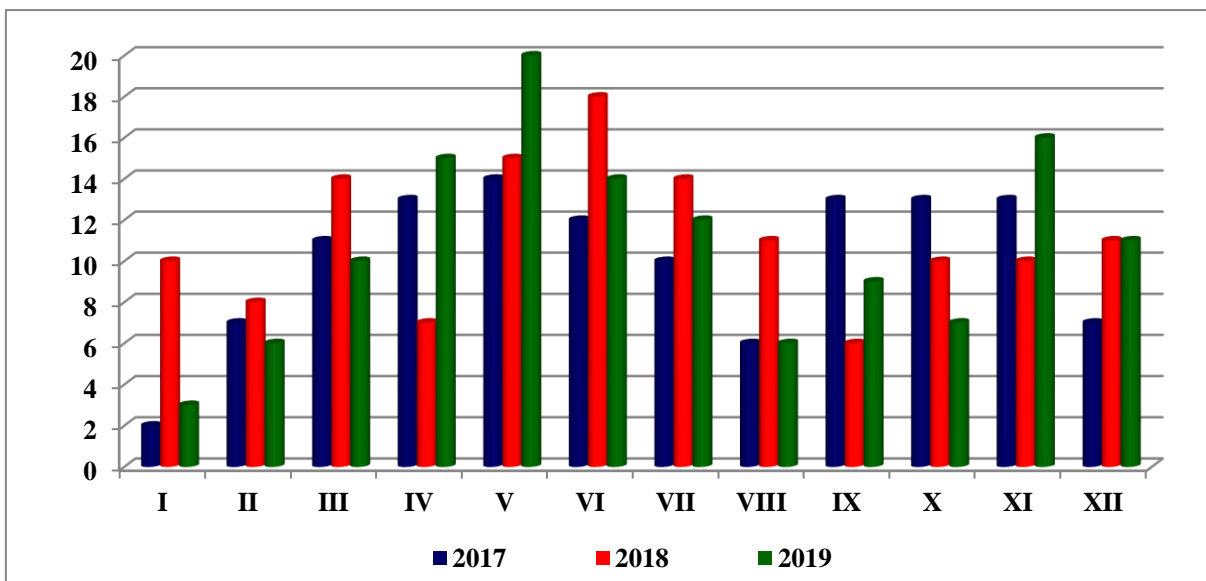
Graph 4: Minimum, maximum and average temperature for 2017 year



Graph 5: Minimum, maximum and average temperature for 2018 year



Graph 6: Minimum, maximum and average temperature for 2019 year



Graph 7: Number of days with precipitation

IV. CONCLUSIONS

According to the conventional chemical indicators of quality silage (pH, crude protein, cellulose, moisture and mineral matter) it can be concluded that all tested parameters are typical for silage that was prepared in the later stages of maize plant.

Great impact on the quality have agro climatic conditions, so we can conclude that agrotechnics of corn for silage must take into account the choice of hybrids for sowing (planting drought tolerant hybrids), and apply irrigation wherever possible.

As one of the factors is the lack of new and adequate mechanization for preparing corn silage.

REFERENCES

- [1] Akay, V., & Jackson, J. A. (2001). Effects of NutriDense and Waxy Corn Hybrids on the Rumen Fermentation, Digestibility and Lactational Performance of Dairy Cows. *Journal of Dairy Science*, 84(7), 1698–1706. [https://doi.org/10.3168/jds.S0022-0302\(01\)74605-X](https://doi.org/10.3168/jds.S0022-0302(01)74605-X)
- [2] Bal, M. A., Coors, J. G., & Shaver, R. D. (1997). Impact of the Maturity of Corn for Use as Silage in the Diets of Dairy Cows on Intake, Digestion, and Milk Production. *Journal of Dairy Science*, 80(10), 2497–2503. [https://doi.org/10.3168/jds.S0022-0302\(97\)76202-7](https://doi.org/10.3168/jds.S0022-0302(97)76202-7)
- [3] Caput, P. (1996.): Govodarstvo, Celeber d.o.o., Zagreb.
- [4] Chamberlain, A.T., Wilkinson, J. M. (1996). *Feeding the Dairy Cow*. Chalcombe Publications, Painshall, Ln2 3LT, UK.
- [5] De Visser, H. (1993). *Characterization of carbohydrates in concentrates for dairy cows. Recent advances in animal nutrition*. Nottingham University Press, Nottingham, pp. 19-38.
- [6] Deutsche Landwirtschafts-Gesellschaft (ab 1946), & Universität Hohenheim (Stuttgart). (1997). *DLG-Futterwerttabellen für Wiederkäuer*. Frankfurt am Main: DLG-Verlag. pp 212.
- [7] Dwyer, L. M., Stewart, D.W., Ma, B.L. Glenn, F. (1998): *Silage maize yield response to plant populations*. Proc. Of the 53rd Annu. Corn and Sorghum industry research conf. Chicago, IL. Am Seed trade Assoc., Washington, DC.
- [8] Forouzmand, M. A., . G. R. G., & . M. A. (2005). Influence of Hybrid and Maturity on the Nutritional Value of Corn Silage for Lactating Dairy Cows 1: Intake, Milk Production and Component Yield. *Pakistan Journal of Nutrition*, 4(6), 435–441. <https://doi.org/10.3923/pjn.2005.435.441>
- [9] Federalni hidrometeorolški zavod, (2017): Meterorolški godišnjak 2017, Sarajevo
- [10] Federalni hidrometeorolški zavod, (2018): Meterorolški godišnjak 2018, Sarajevo
- [11] Federalni hidrometeorolški zavod, (2019): Meterorolški godišnjak 2019, Sarajevo
- [12] Horrocks, R.D., Vallentine, J.F. (1999.): *Harvested Forages*. Academic Press. San Diego, pp. 426.
- [13] Hunt, C. W., Kezar, W., Hinman, D. D., Combs, J. J., Loesche, J. A., & Moen, T. (1993). Effects of hybrid and ensiling with and without a microbial inoculant on the nutritional characteristics of whole-plant corn. *Journal of Animal Science*, 77(1), 38–43. <https://doi.org/10.2527/1993.771138x>
- [14] Johnson, L., Harrison, J. H., Hunt, C., Shinnors, K., Doggett, C. G., & Sapienza, D. (1999). Nutritive Value of Corn Silage as Affected by Maturity and Mechanical Processing: A Contemporary Review. *Journal of Dairy Science*, 82(12), 2813–2825. [https://doi.org/10.3168/jds.S0022-0302\(99\)75540-2](https://doi.org/10.3168/jds.S0022-0302(99)75540-2)
- [15] Kalivoda, M. (1990). *Krmiva, Školska knjiga*, Zagreb.
- [16] Mišković, B. (1986). *Krmno bilje, Naučna knjiga*, Beograd.
- [17] Moss, B. R., Reeves, D. W., Lin, J. C., Torbert, H. A., McElhenney, W. H., Mask, P., & Kezar, W. (2001). Yield and quality of three corn hybrids as affected by broiler litter fertilization and crop maturity. *Animal Feed Science and Technology*, 94(1–2), 43–56. [https://doi.org/10.1016/S0377-8401\(01\)00303-0](https://doi.org/10.1016/S0377-8401(01)00303-0)
- [18] NRC - NATIONAL RESEARCH COUNCIL (2001). *Nutrient Requirements of Dairy Cattle. Seventh Revised Edition 2001*. National Academic Press, Washington, D.C. pp. 381.
- [19] Oude Elferink, S. J. W. H., Krooneman, J., Gottschal, J. C., Spoelstra, S. F., Faber, F., & Driehuis, F. (2001). Anaerobic Conversion of Lactic Acid to Acetic Acid and 1,2-Propanediol by *Lactobacillus buchneri*. *Applied and Environmental Microbiology*, 67(1), 125–132. <https://doi.org/10.1128/AEM.67.1.125-132.2001>
- [20] Ranjit, N. K., & Kung, L. (2000). The Effect of *Lactobacillus buchneri*, *Lactobacillus plantarum*, or a Chemical Preservative on the Fermentation and Aerobic Stability of Corn Silage. *Journal of Dairy Science*, 83(3), 526–535. [https://doi.org/10.3168/jds.S0022-0302\(00\)74912-5](https://doi.org/10.3168/jds.S0022-0302(00)74912-5)
- [21] Struik, P. C., Deinum, B., & Hoefsloot, J. M. P. (1985). Effects of temperature during different stages of development on growth and digestibility of forage maize (*Zea mays* L.). *Netherlands Journal of Agricultural Science*, 33(4), 405–420. <https://doi.org/10.18174/njas.v33i4.16832>
- [22] Weiss, W. P., & Wyatt, D. J. (2000). Effect of Oil Content and Kernel Processing of Corn Silage on Digestibility and Milk Production by Dairy Cows. *Journal of Dairy Science*, 83(2), 351–358. [https://doi.org/10.3168/jds.S0022-0302\(00\)74886-7](https://doi.org/10.3168/jds.S0022-0302(00)74886-7)