Dependence of the buffer capacity on the chemical composition of dry matter of alfalfa

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Annotation. It is shown that the buffer capacity of dry matter of alfalfa of the first cut in the flowering phase is 5.66 - 5.94 mol / liter. With an increase in the content of crude protein and crude ash by 1%, it increases by 0.14 - 0.40 and 0.49 - 0.86 mol / liter, respectively, with an increase in the content of soluble carbohydrates by 1%, it decreases by 1.44 mol / liter ... The dry matter of the second cut alfalfa has a high forage quality. The content of crude protein from the stemming - beginning of budding phase to the flowering phase is in the range of 23.44-20.20%, crude ash 9.24-8.10%, while the content of crude fiber is reduced to 22.92-29.01%, dry matter - up to 20.84-26.00%. The buffer capacity of dry matter reaches 9.69-7.23 mol / liter. The main influence on the buffer capacity is exerted by the mineral composition of the dry matter. An increase in the content of crude ash by 1% increases the buffer capacity of dry matter by 0.55 ± 0.16 - 1.36 ± 0.14 mol / l, an increase in the content of crude protein by 1% increases the buffer capacity by 0.15 ± 0.06 - 0.39 ± 0.14 mol / liter.

Keywords: alfalfa, crude protein, crude ash, dry matter, buffer capacity

1. Introduction
Alfalfa is the most widespread forage crop in the world, characterized by high yield of dry matter in combination with long-term productivity, good forage quality, high adaptive ability to cultivate in various climatic zones. For forage, alfalfa is used in green form, in the form of hay, haylage, silage and concentrated forage prepared from leaf mass [1; 2]. In many climatic zones of alfalfa cultivation, it is very difficult to produce high quality hay due to unfavorable weather conditions. In this case, silage and silage take the first place in the preparation of forage. According to Yu. A. Pobedniy and V. M. Kosolapov (2018), “... dry matter of alfalfa silage is consumed by cattle in greater quantities than dry matter of silage from cereal grasses, as a result of which the intake of nutrients into the body of animals and their productivity ”[3]. The high fodder value of haylage and alfalfa silage is associated with a high protein content in the silage mass. However, making high quality alfalfa silage or silage is extremely difficult. According to a number of researchers, alfalfa belongs to non-silting grass species due to the composition of the epiphytic microflora on the surface of the aboveground part of plants, and most importantly, because of the high buffer capacity of the green mass of alfalfa [4; five]. F. Weisbach (2012) writes: “Comparing the buffering capacity of various plant species with the content of crude protein, calcium and magnesium in them, the researchers found that the richer the plants in these compounds, the higher their buffer capacity” [6]. Many researchers believe that the main role in increasing the buffer capacity is played not by nitrogenous substances, but by mineral compounds.
Alfalfa is rich in minerals with pronounced basic properties. The high buffering capacity of alfalfa necessitates the accumulation of a much larger amount of lactic acid than is required for acidification of cereal grasses and meadow clover, which in conditions of sugar deficiency is very difficult to provide during ordinary ensiling, even in dried form [3; five; 7; eight]. In recent years, it has been shown that, along with the sugar-buffer ratio, the sugar content in the natural mass of plants also has a significant effect on the result of ensiling. The combined influence of both factors is not the same and depends on their specific values. It was found that the direction of microbiological processes and the yield of lactic acid from sugar is significantly influenced by the content of dry matter in the green mass. An increase in the dry matter content in plants leads to an increase in the yield of lactic acid from sugar only when harvesting silage from grasses that are not silted and difficult to absorb [3-5; 7-9]. Analysis of domestic and foreign literature on the preparation of silage and haylage from alfalfa showed that overcoming the lack of silage of alfalfa is solved mainly by improving the methods of silage [9-11], and there is no research on the agricultural technology of cultivation of alfalfa and the creation of new varieties suitable for silage and silage.

The purpose of the research is to analyze the effect of the chemical composition of dry matter of alfalfa on its buffer capacity in the first and second cuttings.

2. Methods of the research
The studies were carried out at the FWRC FPA experimental base in 2018-2020. The soil and climatic conditions of the research site are typical for the forest zone. The soil of the experimental plots is podzolic, medium loamy, medium cultivated. Soil fertility indicators: pH 5.17-5.65, humus 1.82-2.09%, total nitrogen content 0.140-0.152%, phosphorus 202-210, potassium 198-210 mg per kg of soil. We studied the chemical composition of dry matter and the buffer capacity of two varieties of alfalfa (Medicago sativa L. nothosubsp. Varia) close in origin: Taisiya and Agniya VIK. The dry matter of alfalfa from the first and second cut was analyzed. The dry matter content was determined by drying at a temperature of 130 °C, the content of crude fiber - according to the Henneberg and Shtoman method, crude fat - on a Soxhlet apparatus using petroleum ether, crude ash - by burning at a temperature of 500 °C, total nitrogen - according to Kuldahl, the content of soluble carbohydrates - according to the Bertrand method [12]. The buffer capacity was determined by the Weisbach method [13]. Correlation-regression analysis of the dependence of the buffer capacity of dry matter of alfalfa on the specific content of dry matter and its chemical composition - according to B.A. Dospekhov [14].

3. Results of the research
Analyzed the chemical composition of the dry matter of freshly cut alfalfa, without wilting the green mass. It is known that drying for 4-6 hours increases the content of soluble carbohydrates and reduces the required amount of lactic acid for acidifying the silage to pH 4.2-4.3, that is, the buffer capacity. This is a technique for silage of alfalfa, and our task is to study the biochemical characteristics of alfalfa, to accumulate new knowledge to create specialized varieties of alfalfa suitable for successful ensiling and silage.

The buffer capacity of dry matter of alfalfa in the first cut in the flowering phase varied over the years of research from 5.66 to 5.94 mol / liter. Crude ash and crude protein had a statistically significant (P <0.05) direct effect on buffering capacity. The crude ash content ranged from 8.12 to 9.58%, and the protein content - from 15.17 to 15.59%. The correlation coefficients (r) between the ash content and the buffer capacity were 0.65-0.77, the regression coefficients (b_yx) were in the range of 0.49-0.86. Consequently, an increase in the content of crude ash by 1% leads to an increase in the buffer capacity by 0.49-0.86 mol / l. Crude protein content had a relatively high positive effect on buffering capacity. Correlation coefficients r = 0.56-0.72, regression coefficients b_yx = 0.14-0.40 (P> 0.05). Increasing the crude protein content by 1% can increase the buffer capacity by 0.14-0.40 mol / liter. A close to statistically significant inverse relationship was found between the content of soluble carbohydrates and the buffer capacity: r = -0.72; b_yx = -1.44. The average soluble carbohydrate
content, determined by the Bertrand method, was 2.45% dry matter. A 1% increase in carbohydrate content can reduce the dry matter buffering capacity of alfalfa by 1.44 mol / liter.

The grass stand of alfalfa of the second or third hay is formed more slowly than the first, therefore the plants have close internodes, and as a result - higher leafiness, increased content of crude protein, crude fat, ash, reduced content of crude fiber and dry matter. At the end of the growing season, the epiphytic microflora changes for the worse, the lesion by phyllospheric diseases significantly increases, which significantly reduces the quality of feed. This is confirmed by Chinese researchers [5].

In 2020, the height of the grass stand of alfalfa of the second cycle of use in the phase of steming - beginning of budding reached 40-60 cm. The grass stand was quite suitable for economic use. A slight brown spot lesion was observed. The intensity of the development of the disease did not exceed 10-15%. The feed quality indicators were high: the content of crude fiber was 22.92%, crude protein 23.44%, crude fat 3.28%, crude ash 9.24%, buffer capacity reached 9.69 mol / l (table 1).

Table 1. The effect of the chemical composition of the dry matter of alfalfa (X) on the buffer capacity (Y) in different phases of development, the second cut in 2020

| Indicator of the chemical composition of dry matter (X) | Mean X | Mean Y | Correlation coefficient, $r \pm S_r$ | Regression coefficient, $b_{yx} \pm S_b$ | Actual criterion of significance, $t_r$
|-------------------------------------------------------|--------|--------|----------------------------------|----------------------------------|-------------------|
| Stalking - the beginning of budding $^a$                |        |        |                                  |                                  |                   |
| 1. Crude fiber, %                                      | 22.92  | 9.69   | -0.25$\pm$0.28                  | -0.14$\pm$0.16                  | -0.89             |
| 2. Crude fat, %                                        | 3.28   | 9.69   | 0.12$\pm$0.29                   | 0.12$\pm$0.29                   | 0.42              |
| 3. Crude protein, %                                    | 23.44  | 9.69   | 0.62$\pm$0.23*$                 | 0.39$\pm$0.14                  | 2.73              |
| 4. Crude ash, %                                        | 9.24   | 9.69   | 0.51$\pm$0.25                   | 0.68$\pm$0.33                   | 2.04              |
| 5. Dry matter, %                                       | 20.84  | 9.69   | 0.24$\pm$0.28                   | 0.29$\pm$0.33                   | 0.86              |
| Budding $^b$                                           |        |        |                                  |                                  |                   |
| 1. Crude fiber, %                                      | 26.52  | 7.70   | -0.23$\pm$0.24                  | -0.08$\pm$0.06                  | -0.94             |
| 2. Crude fat, %                                        | 3.09   | 7.70   | 0.49$\pm$0.22*                  | 0.31$\pm$0.14                   | 2.26              |
| 3. Crude protein, %                                    | 21.18  | 7.70   | 0.56$\pm$0.20*                  | 0.15$\pm$0.06                   | 2.68              |
| 4. Crude ash, %                                        | 8.81   | 7.70   | 0.66$\pm$0.19**                 | 0.55$\pm$0.16                   | 3.48              |
| 5. Dry matter, %                                       | 22.15  | 7.70   | 0.34$\pm$0.23                   | 0.13$\pm$0.09                   | 1.46              |
| Bloom $^c$                                             |        |        |                                  |                                  |                   |
| 1. Crude fiber, %                                      | 29.01  | 7.23   | -0.44$\pm$0.16*                 | -0.16$\pm$0.06                  | -2.67             |
| 2. Crude fat, %                                        | 2.90   | 7.23   | 0.65$\pm$0.14**                 | 1.18$\pm$0.25                   | 4.62              |
| 3. Crude protein, %                                    | 20.20  | 7.23   | 0.22$\pm$0.18                   | 0.15$\pm$0.12                   | 1.22              |
| 4. Crude ash, %                                        | 8.10   | 7.23   | 0.74$\pm$0.12**                 | 1.36$\pm$0.23                   | 5.90              |
| 5. Dry matter, %                                       | 26.00  | 7.23   | 0.22$\pm$0.20                   | 0.17$\pm$0.15                   | 1.09              |

*P<0.05; **P<0.01

Theoretical significance criterion $^a$stalking phase $t_{0.05} = 2.18; t_{0.01} = 3.06$

$^b$budding phase $t_{0.05} = 2.12; t_{0.01} = 2.92$

$^c$blomm phase $t_{0.05} = 2.05; t_{0.01} = 2.76$

A statistically significant ($P<0.05$) positive correlation was observed between the crude protein content and the buffer capacity $r = 0.62 \pm 0.23; b_{yx} = 0.39 \pm 0.14; t_r = 2.73 > t_{0.05}$. However, calculations show that a high content of crude ash (9.24%) has a more noticeable effect on the buffer capacity. Correlation coefficient $r = 0.51 \pm 0.25; b_{yx} = 0.68 \pm 0.33; t_r = 2.04 < t_{0.05}$. Although the correlation dependence is not statistically significant, the regression coefficient shows that an increase in the crude ash content by 1% increases the buffer capacity by 0.68 $\pm$ 0.33 mol / L, and an increase in the crude protein content by 1% increases the buffer capacity only by 0.39 $\pm$ 0.14 mol / liter. Crude
fiber slightly reduces the buffer capacity: \( r = -0.25 \pm 0.28; \) \( b_{xy} = -0.14 \pm 0.16. \) However, in this case, the low fiber content does not have any noticeable effect on the buffering capacity (table).

Obviously, for ensiling such raw materials, it is necessary to add a significant amount of lactic acid or other preservatives. It is better to use this green mass of alfalfa for hay production, if the weather permits. Stems and leaves of alfalfa plants in the steming-beginning of budding phase dry more evenly compared to the flowering phase, the leaves do not dry out and do not crumble, high-quality hay is obtained.

In the budding phase, the average content of crude fiber increased to 26.52%, the content of crude protein decreased to 21.18%, and the content of crude fat (3.09%) and ash (8.81%) remained at a fairly significant level. The dry matter content was low, 22.15%, and the buffer capacity was very high, 7.70 mol / liter (table). When harvesting alfalfa in the budding phase, there is a statistically significant (P <0.05) positive relationship between the content of crude fat \( (r = 0.49 \pm 0.22) \) and crude protein \( (r = 0.56 \pm 0.20) \), as well as crude ash \( (r = 0.66 \pm 0.19; \) P <0.01) with a buffer tank. However, only a change in the content of crude ash \( (b_{xy} = 0.55 \pm 0.16) \) can have any noticeable effect on the buffer capacity, that is, a decrease in the content of crude ash in dry matter by 1% can reduce the buffer capacity by 0.55 ± 0.16 mol / liter (table).

During the flowering phase, the nutritional value of the dry matter of the second cut alfalfa remained quite high. The content of crude fiber and protein was 29.01 and 20.20%, the content of crude ash decreased slightly (up to 8.10%), compared with the budding phase (8.81%), the dry matter content increased by 3.75% compared with the budding phase. The average value of the buffer capacity remained high (7.23 mol / l) (table). A highly significant (P <0.01) linear positive relationship was found between the content of crude fat, crude ash and buffer capacity. The correlation coefficients were 0.65 ± 0.14 and 0.74 ± 0.12, the regression coefficients indicated that an increase in the content of crude fat and crude ash by 1% can increase the buffer capacity of dry matter of second cut alfalfa by 1.18 ± 0.25 and 1.36 ± 0.23 mol / liter. The crude fiber content in the flowering phase increased to 29.01% and had a significant inverse relationship with the buffer capacity index: \( r = -0.44 \pm 0.16, \) but this dependence was insignificant, an increase in fiber content by 1% reduced the buffer capacity by 0 , 16 ± 0.06 mol / liter (table).

4. Conclusion
It was found that the buffer capacity of dry matter of alfalfa of the first cut in the flowering phase is 5.66-5.94 mol / liter. The buffer capacity increases with an increase in the content of crude protein and crude ash by 1%, respectively, by 0.14-0.40 and 0.49-0.86 mol / l and decreases by 1.44 mol / l with an increase in the content of soluble carbohydrates by 1 %.

The dry matter of alfalfa of the second cut from the steming-beginning of budding phase to the flowering phase is distinguished by a high content of crude protein (23.44-20.20%), crude ash (9.24-8.10%), a low content of crude fiber (22, 92-29.01%), dry matter (20.84-26.00%) and a very high buffer capacity (9.69-7.23 mol / liter). The main influence on the buffer capacity is exerted by the mineral composition of the dry matter. An increase in the content of crude ash by 1% increases the buffer capacity of dry matter by 0.55 ± 0.16 - 1.36 ± 0.14 mol / l, an increase in the content of crude protein by 1% increases the buffer capacity by 0.15 ± 0.06 - 0.39 ± 0.14 mol / liter.

Consequently, the green mass of modern alfalfa varieties is suitable for ensiling, mowed in the first half of the growing season (first mowing), dried for 4-6 hours and with the use of lactic acid bacteria or other preservatives.

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