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Eligibility criteria for joint ensilage of maize and yellow lupine on poorly productive lands of the Upper Volga region

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ABSTRACT

In the modern conditions of RF agro-industrial complex development, the transfer of animal husbandry to an industrial basis is possible only with high-grade vegetable protein production increase. Silage of the aboveground mass of pure corn during all phases of plant growth and development does not provide the content of nutrients in the feed unit according to the zootechnical requirements. Therefore, to optimize the finished feed in terms of the carbohydrate-protein ratio, green mass of legumes should be added to its composition during the preparation of silage from corn. The selection of the legume component should be carried out taking into account the following main criteria: coincidence with corn by the growing season duration, the same attitude to soil and climatic resources and insolation conditions, high provision of the legume component with digestible protein, dry matter, starch and exchange energy during the ensiling period. It has been established that the joint ensiling of corn with yellow lupine is expedient when the corn is in waxy ripeness, and the lupine is in the phase of shiny beans with the component ratio of 55:45%. In this case, the content of digestible protein in 1 feed unit of finished silage is 100.2 g at reliable feed supply with both irreplaceable (36.0 g) and critical (7.2 g) amino acids.

Key words: Corn, Yellow lupine, Silage components, Digestible protein, Metabolic energy, Amino acid composition.
Article type: Research Article.

INTRODUCTION

Corn is the most important fodder crop in our country. In conditions of limited thermal resources of the northern regions of the Non-Chernozem zone, it is cultivated mainly for silage harvesting, which has good digestibility and dietary properties (Shevchenko *et al.* 2018). With the normal development of early maturing maize hybrids, the proportion of ears in the structure of the aboveground mass yield by the time of harvesting for silage reaches more than 45%, and the concentration of metabolic energy makes 9.6-11.3 MJ kg^{-1} of dry matter (Khlopyanikov 2010). However, the provision of one feed unit with digestible protein of corn silage harvested in the phase of milky-wax ripeness makes only 70 g at a zootechnical norm of 105-110 g. To improve the quality of corn silage, it is necessary to introduce green mass of legumes into its composition. Joint sowing of corn and soybeans is of great importance to improve the quality of corn silage, reduce feed consumption, increase animal productivity and reduce production costs (Fedotov 2002). In joint crops of 100 - 150 kg per hectare the collection of digestible protein is increased, and its content increases from 54 - 55 to 66 - 67 g per feed unit (Righer & Bedilo 2017). To stabilize corn silage during ensiling in the phase of milky-wax ripeness to the required amount of digestible protein in one feed unit (108 g), it is necessary to introduce 35% of the aboveground soybean mass into its composition (Shevchenko *et al.* 2019). The priority direction for the protein problem solution in the fodder production of the Non-Black Earth Zone, along with joint sowing of corn with soybeans, is the expansion of perennial and annual grass sowing, as well as the cultivation of corn with various types of leguminous crops (Novoselov *et al.* 2004). There are many reports about plant production studies around the world (Vladimirovna Demina *et al.* 2020; Omidipour *et al.* 2021; Abolhasani *et al.* 2021). The purpose of our research was to study the compatibility criteria of economic and biological traits and amino acid composition of corn and yellow lupine to optimize the finished feed at their joint ensiling.

MATERIALS AND METHODS

The experiments in fodder crop rotation were carried out on the developed lands of LLC "Ruchevskoe-1", Rzhevsky district, Tver region during 2012-2019. The predecessor is spring barley for grain fodder. The soil of the experimental

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site is sod-podzolic light loamy, the thickness of the arable layer is 16-18 cm, drained by open drainage. Initial content in soil (2012) included humus 1.69-1.83%; P_2O_5 106-109 mg kg^{-1}; K_2O 90-100 mg kg^{-1}; pH_{KCl} 4.78-4.83. The soil was in a state of fallow from 1994 to 2010. In 2011, cultural and technical works were carried out, and the cultivation of agricultural crops began in 2012. As the main fertilizer, we used liquid livestock runoff, which was applied in the spring before sowing the silage components using the soft rubber hose technology. The content of mineral nutrition elements in liquid runoff is the following (in %): N 0.1; P_2O_5 0.03; and K_2O 0.28. The reaction of liquid runoff is slightly alkaline: pH_{KCl} 7.3 units. Solid fraction: N 0.54%; P_2O_5 0.25%; K_2O 0.60%; pH_{KCl} 7.8 units. We used an early ripe corn hybrid Voronezh 158 CB and yellow lupine variety Druzhny 165 for sowing, which were approved for use in the second region of the Russian Federation. Simultaneously with sowing, 10 kg/a.r. of P_2O_5 was introduced for each component. The missing amount of nutrients were used in top dressing when performing inter-row cultivation to obtain the planned yield of the silage mass of corn up to 35 ton ha^{-1} and lupine up to 30 ton ha^{-1} (a.r. - N48 kg for corn crops and N25 kg for lupine crops). The meteorological conditions during the years of experimental work differed significantly both in temperature regime and in the amount of precipitation and their distribution over decades and months. According to the moisture content, all growing seasons can be divided into three groups: 1) relatively dry (hydrothermal coefficient is less than 1 according to G.T. Selyaninov) 2014 and 2018; 2) wet (HTC 1.3 - 1.6) 2012, 2013 and 2016; 3) waterlogged (HTC > 1.6) 2015, 2017 and 2019. Nevertheless, the moisture deficit in relatively dry years was not a limiting reason for the cultivation of programming yields, since when 100 m^3 ha^{-1} of liquid wastes were applied, 10 mm of moisture was added to the amount of precipitation per hectare, which was immediately embedded in the soil simultaneously with the application. The area of the scientific plot was 140 m^2; the sowing area was 280 m^2. Variant placement: by the method of randomized repetitions; repetition: 4 times. Sowing was carried out at the onset of soil physical moisture in 1-2 days after the introduction of liquid runoff. The sowing depth of corn seeds makes 5-7 cm, lupine 3-4 cm. A model experiment for silage of corn and yellow lupine at different harvesting periods was carried out in 3-liter glass jars. The cutting length and the tamping density were 3-5 cm and 0.75 g cm^{-3} rspectively. Forage ensiling during the waxy phase and by the end of the waxy phase (at the beginning of full ripeness) was carried out with the addition of the preservative Biotrof with the consumption rate of 0.5 mL per 3 liters. All analyzes by the quality characteristics and energy value of the ensiling components in various ratios both during harvesting and in finished feed (two months after canning) were performed according to generally accepted methods used in agricultural establishments (Mineev *et al*. 2001).

RESULTS AND ITS DISCUSSION

Joint ensiling of corn with legumes is most effective when both components are selected taking into account the criteria of their economic and biological compatibility. When growing components in different areas, it is very important that the rates of growth and development of plants at the time of laying the silage coincide and, at the same time, differ in optimal indicators both in terms of the aboveground mass yield and of the grown product quality. The economic and biological characteristics of maize and yellow lupine at different times of harvest are presented in Table 1. It was found that for the entry of maize plants into the phase of milky-wax ripeness, the sum of active temperatures over the years of the experiments was 1717 ºC on average, while for the middle of the wax phase was 1822 and for the end of wax (the beginning of full ripeness) was 1946. In similar soil and climatic conditions, yellow lupine needed 1695 ºC to reach the beginning of bean filling, 1811 for wax and 1924 for the beginning of full ripeness, which is 22, 11 and 22 days less than corn, respectively. However, the difference in the required sum of active temperatures between corn and yellow lupine was insignificant at HCP_{05} = 126 days. Based on these data, it can be concluded that maize and yellow lupine are suitable for joint ensiling, since their biological requirements for temperature regime are approximately the same. However, in order to combine lupine harvesting within the same dates as corn, lupines should be sown on the same calendar dates as corn. Under the conditions of the Non-Chernozem zone with enough moisture, later sowing dates for lupine are quite justified, especially when liquid runoff are applied at the dose of 80 - 100 m^3 ha^{-1}, additional 8 - 10 mm of moisture are applied per area unit. The height of maize and yellow lupine plants reaches maximum values by the phase of milky-wax ripeness, since at the end of wax - the beginning of full ripeness, both components increase the stem size only by 2-3 cm at HCP_{05} = 12 cm. Based on the analysis of the data obtained, Notably, the joint sowing of corn and yellow lupine is not very effective both in one row and in several rows, since corns are 2.1 times higher than yellow lupine in height. Therefore, shading of the legume component is inevitable, which will negatively affect the yield of digestible protein per hectare. For this reason, it is advisable to cultivate the components of silage on different lands. In terms of the growing season length, yellow lupine grows 1-5 days faster than early-ripening maize hybrids, but this difference was insignificant by the onset of phenological phases of plant growth and development at HCP_{05} = 8 days.

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Table 1. Economic - biological characteristics of silage components in different harvesting periods.

Item №	Compliance criteria	Milky-wax ripeness		Wax ripeness		End of waxy - beginning of full ripeness		On average	HCP_{05}
		corn	lupine	corn	lupine	corn	lupine		
1	Sum of active temperatures >10 ºC	1717	1695	1822	1811	1946	1924	1819	126
2	Plant height before harvesting (cm)	212	102	215	104	215	104	159	12
3	The height of lower ear or bean from soil (cm)	43	39	45	40	45	40	42	3
4	Leaf area before harvesting (thousand m^2 ha^{-1})	50.5	40.3	45.6	36.7	43.7	35.1	42.0	3.1
5	Above ground mass yield (ton ha^{-1})	36.1	31.9	28.1	24.3	20.1	20.4	26.8	2.1
6	Harvest structure (%): leaves	33	39	26	31	23	26	30	3
	Stems	28	30	27	26	19	20	25	2
	Ears or beans	39	31	47	43	58	54	45	4
7	SM content (%)	22.9	24.5	32.3	34.4	36.8	37.2	31.4	2.5
8	SM harvesting (c ha^{-1})	82.67	78.16	90.76	83.59	73.97	75.89	80.84	7.11
9	Content of feed units in 1 kg of aboveground mass	0.19	0.16	0.32	0.34	0.43	0.40	0.31	0.03
10	Harvesting of feed units from 1 hectare (c)	68.59	51.04	89.92	82.62	86.43	81.60	76.70	6.14
11	Content of digested protein in 1 kg of aboveground mass (g)	14	19	28	57	34	65	36	3
12	Harvesting of digested protein from 1 ha (kg)	505.4	606.1	786.8	1385.1	683.4	1326.0	822.1	69.5
13	Collection of starch from 1 ha (kg)	845.8	722.7	1747.4	2420.1	1721.0	2460.1	1652.9	132.2
14	OE collection from 1 ha (GJ)	66.79	66.35	103.98	107.40	99.94	106.07	91.8	7.4
15	SM content in 1 c.u. (kg)	1.21	1.53	1.01	1.01	0.86	0.93	1.09	0.09
16	Content of digested protein in 1 c.u. (g)	74	119	87	167	79	162	115	9
17	Starch content in 1 c.u. (g)	123	142	211	293	199	301	212	17
18	OE content in 1 c.u, (MJ)	9.7	12.9	11.6	13.0	11.5	12.9	11.9	1.0
19	Starch content in 1 kg of SM (g)	102.3	92.5	192.5	289.5	232.7	324.2	205.6	14.8
20	Growing season length (days)	97	98	103	106	112	117	106	8

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The most reliable indicator of ensiling component entry into the next phase of growth and development is the dry matter content, which gradually increased and at the end of wax - the beginning of full ripeness was as follows (in %): for corn 36.8, and for yellow lupine 37.2%, which is 13.9 - 12.7% higher than during the milky-wax phase. Thus, in both maize and yellow lupine, the maximum dry matter yield was noted during the phase of wax ripeness of seeds. So, in corn, the excess of dry matter yield was 8.09 centners ha^{-1} relative to milky-wax ripeness, and as compared to the end of wax - the beginning of full ripeness was 16.79 centners ha^{-1} with HCP_{05} = 7.11 centners. In yellow lupine, this tendency in the collection of dry matter remained. However, the differences as compared to the phase of waxy ripeness were 5.43 and 7.70 c ha^{-1}, respectively, which was significant only between the end of waxy (the beginning of full ripeness) and waxy ripeness. As the plants age, there is a significant increase of fodder unit content in 1 kg of aboveground mass, which is explained by the decreased proportion of leafy mass and by elevated cobs or beans proportion in the ensiling components. However, the collection of fodder units per 1 ha of sowing for both components remains the maximum in the phase of wax ripeness. A slight decrease in the collection of feed units (minus 3.49 and 1.02 c ha^{-1} at HCP_{05} = 6.14 c respectively) is explained by the fact that at the end of the wax (the beginning of full ripeness), the leafy mass becomes coarse, affected by diseases and therefore, loses its fodder advantages, which is especially clearly manifested in maize agrocenose. For the same reason, at the end of waxy (the beginning of full ripeness), there is a decreased collection of digestible protein, starch and metabolic energy for both components compared to the phase of waxy ripeness. Notably, the content of digestible protein in 1 feed unit at all times of harvesting the aboveground mass of corn does not meet the requirements of the zootechnical norm, since it makes 74-89 g at the required amount of 105-110 g. At the same time, the aboveground mass of lupine in all phases of plant growth and development contains an excess of digestible protein (119-167), which is also undesirable when feeding animals, since additional energy is spent on its digestion. Dry matter content in 1 feed unit decreased gradually with the aging of the plant organism. So that, during the phase of milky-wax ripeness, it was 1.21 kg for corn, 1.53 kg for yellow lupine. In the phase of waxy ripeness, it was the same (1.01 kg), while at the end of waxy (the beginning of full ripeness) it dropped to 0.86 kg in corn and to 0.93 kg in yellow lupine. The optimal starch content for animal feeding is considered to be 250 g kg^{-1} of dry matter. During the phase of milky-wax ripeness, it was 2.4-2.7 times lower than the norm. In the phase of waxy ripeness, it reached 192.5 g in corn and 289.5 g in yellow lupine, while at the end of waxy (the beginning of full ripeness) elevated to 232.7 and 324.2 g kg^{-1} of dry matter, respectively. Thus, during all phases of growth and development, the aboveground mass of maize accumulates a significantly smaller amount of starch in its composition than it is necessary at the norm, while the concentration of this organic matter in the green mass of yellow lupine exceeds the optimal value by 15.8-29.7%, starting from the phase of waxy ripeness. Given this circumstance, the joint ensiling of corn and yellow lupine should be recognized as an expedient technological method for nutritional value of forage increase during their harvesting. The accumulation of metabolic energy in the yield of silage components is determined by the collection of dry matter and fiber. In the experiment, when harvesting during the phase of milky-wax ripeness, the content of metabolizable energy in 1 feed unit was 9.7 MJ in corn, and 12.9 MJ in yellow lupine, while reached maximum values in the wax ripeness phase, 11.6 and 13.0 MJ, respectively, with an optimal value of 10.5 MJ. At the end of the wax (the beginning of full ripeness), both components for this indicator remained at the level of the previous phase. It is known that the nutritional value of vegetable feed is determined by the quality of protein, and primarily by its saturation with essential amino acids, as well as by the high content of an easily digestible fraction. The fractional composition of protein is one of the most important indicators of the protein complex quality, since the upraised specific gravity of readily soluble fractions improves the digestibility and assimilability of feed. In order to establish the optimal period of corn and yellow lupine use as the components for joint ensiling, we studied the amino acid composition of essential, critical and nonessential amino acids, and also calculated their collection from the entire aboveground mass at the stages of plant growth and development. It was found that in the phase of milky-wax ripeness of corn, which coincides with the beginning of bean filling in yellow lupine, the seed protein in both components is characterized by a relatively low content of essential amino acids (32.0% in corn and 33.2% in yellow lupine), including critical ones (lysine, tryptophan and methionine), as 5.7 and 7.0%, respectively. That is, according to the requirements of the zootechnical norm, both components provide only the minimum permissible level of essential amino acids (32%) in this phase, while the concentration of critical amino acids corresponds only to the lower limit of the permissible value (7%) in yellow lupine. In terms of the content of nonessential amino acids, the vegetable protein of corn exceeded the concentration of essential ones by 2.1 times, and that of yellow lupine by 2.0 times. In addition, the differences in the accumulation of essential amino acids at a given harvesting period for both ensiling components were insignificant and amounted to 66.8 - 68 0%, and the ratio of essential amino acids to nonessential was equal to 0.47-0.50. The total harvest of essential amino acids from the yield of the entire aboveground mass of corn in the phase of milky-wax ripeness was

161.7 kg ha^{-1}, and critical was 28.8 kg ha^{-1}. In the case of yellow lupine it made 201.2 and 42.4 kg ha^{-1}, respectively. Also, in terms of the total collection of essential amino acids, yellow lupine significantly surpasses corn (606.1 and 505.4 kg ha^{-1}, respectively at HCP_{05} = 69.5 kg). Therefore, to improve the nutritional value of corn silage harvested in the phase of milky-wax ripeness, it is advisable to introduce the above-ground mass of yellow lupine in its composition, which at this time is at the beginning of the bean filling. Comparative analyses of the amino acid composition of the aboveground mass of maize and yellow lupine, harvested in the phase of waxy ripeness, reveal a significant elevated content of essential amino acids for both components. So, in the case of corn, their concentration increased by 3.6% on average, while in yellow lupine by 16.0%, with HCP_{05} = 3.3%. At the same time, the amount of critical amino acids in the composition of essential amino acids increased by 0.6 - 3.2%, respectively, with HCP_{05} = 0.7%. Consequently, a significant elevated critical amino acids is characteristic only of the aboveground mass of yellow lupine, since the upraised content of these organic compounds in maize is within the statistical error of the experiment. The total amount of nonessential amino acids in the aboveground mass of both components during their harvesting in the phase of waxy ripeness decreased relative to the milky-wax phase, but this decrease occurred with different intensities. So, in the case of corn, the decrease in this indicator was 3.6%, while in yellow lupine was 16.0% with HCP_{05} = 4.7%. At the same time, during the phase of wax ripeness, the ratio of essential to nonessential amino acids increased significantly, which amounted to 0.55 and 0.97 units, respectively. The total collection of amino acids in the phase of waxy ripeness, as compared with the phase of milky-waxy ripeness, increased by 55.7% in corn and reached 786.8 kg ha^{-1}, while in yellow lupine by 128.5% and amounted to 1385.1 kg ha^{-1}; irreplaceable by 73.2 and 238.7%, respectively, of which the share of critical increased by 72.2 and 233.3%. When harvesting silage components at the end of wax (the beginning of full ripeness), an insignificant increase of essential amino acids in the protein structure was noted (by 2.8-4.4% at HCP_{05} = 4.8). However, the total collection of amino acids decreased in the corn crop by 103.4 kg ha^{-1}, and in the yield of the aboveground mass of yellow lupine by 59.1 kg ha^{-1} with HCP_{05} = 69.5 kg. Equal dependence was also established for the accumulation of nonessential amino acids: -96.7 and -67.1 kg ha^{-1}, respectively, with HCP_{05} = 44.8 kg. Nevertheless, no difference was found for the collection of critical amino acids at the end of the growing season for both components, since deviations from the wax ripeness phase ranged from - 1.1 to +1.9 kg ha^{-1} with HCP_{05} = 6.6 kg. Thus, on the basis of the analyzes carried out, it can be concluded that the joint ensiling of maize and yellow lupine is most expedient to carry out in the phase of waxy ripeness of maize, when the dry matter content in the aboveground mass is 31-33%. While lupine yellow is in the lustrous bean phase, the dry matter content ranges from 32 to 35%, and the seeds are filled with a mushy mass. When harvesting silage components at a given time, the maximum collection of feed units, dry mass, digestible protein and metabolic energy from 1 hectare is ensured, and the fodder unit contains the maximum concentration of protein and metabolic energy. At the same time, in the phase of waxy ripeness, the concentration of essential and critical amino acids in the protein complex of yellow lupine significantly elevated, which made it possible to upraise the content of digestible protein into 1 feed units up to 167 g and use this leguminous crop to optimize the feed value when silaging it together with corn. In 2015-2019 we carried out an experiment on the joint ensiling of corn and yellow lupine in different ratios and at different times of harvesting (Table 2). It was found that when ensiling pure corn, 1 feed units of finished silage contained only 76.9 g of digestible protein and 23 g of essential amino acids in the phase of milky-wax ripeness, of which only 4 g were critical amino acids. As the proportion of yellow lupine in the silage mass increases, the quality of the finished silage gradually increases. Thus, the normalization of the feed in terms of the protein complex was observed when the ratio of corn and legume component was 40:60%. According to the content of the lower limit of the permissible level of essential amino acids (32 g per 1 feed unit) with the ratio of silage components (70:30%) and a reliable supply of 36 g with the ratio of cereal and legume components of 60:40%. At the same time, Noteworthy the content of critical amino acids reached the required value of 7 g per 1 feed units at the ratio of 65:35%. Silage prepared from pure corn in the phase of waxy ripeness contained 88.8 g of digestible protein, 26.6 g of essential amino acids in 1 feed unit of ready-made feed, of which the share of critical amino acids was 4.6 g, which is significantly higher in all respects than in the phase of milky-wax ripeness. The silage mass provided allowable content mark in 1 feed unit of 101.1 g of digestible protein at a component ratio of 60:40%. The lower permissible redistribution is noted at 80:20%, and the reliable one is at 55:45%. Sufficient amount of critical amino acids per feed unit is provided at the ratio of 60:40%. In general, the joint ensiling of corn and yellow lupine is most expedient during the phase of waxy ripeness of corn and shiny yellow lupine beans. At the same time, according to the experience, the content of digestible protein in 1 feed unit increased by 7.5 g on average, and irreplaceable by 1.0 g. Joint ensiling of corn and yellow lupine at the end of waxy (the beginning of full ripeness) is impractical, since the aboveground mass of lupine, although it does not coarse, but the quality indicators of 1 feed unit of combined silage are inferior to the characteristics of the finished feed, harvested at an earlier date: for digestible protein by 1.9 - 10.5%, for essential amino acids by 9.4 - 12.8% and for critical by 14.3 - 19.6%.

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Table 2. Content of digestible protein and essential amino acids in 1 feed unit of finished silage during joint ensiling of corn and yellow lupine at different harvesting periods (2015-2019).

The ratio of silage components (%): in the numerator: corn; in the denominator: yellow lupine	**Milky-wax ripeness**			**Wax ripeness**			**The end of the wax (The beginning of full ripeness)**		
	digestible protein (g)	**Essential amino acids (g)**		**Digestible protein (g)**	**Essential amino acids (g)**		**Digestible protein (g)**	**Essential amino acids (g)**	
		Total	**Including critical**		**Total**	**Including critical**		**Total**	**Including critical**
$\frac{100}{0}$ control	76.9	23.0	4.0	88.8	26.6	4.6	79.2	23.8	4.1
$\frac{95}{5}$	78.8	24.3	4.4	90.4	27.9	4.9	80.8	24.4	4.4
$\frac{90}{10}$	80.8	25.7	4.8	92.0	29.8	5.2	82.3	26.1	4.9
$\frac{85}{15}$	82.8	27.2	5.2	93.5	31.6	5.5	83.5	27.6	5.0
$\frac{80}{20}$	84.8	28.7	5.7	95.1	33.5	5.9	84.9	29.1	5.2
$\frac{75}{25}$	87.0	30.3	6.2	96.4	34.1	6.3	86.1	30.0	5.4
$\frac{70}{30}$	89.3	32.1	6.6	96.6	34.2	6.5	87.2	30.6	5.5
$\frac{65}{35}$	91.3	33.6	7.2	98.8	35.1	6.8	88.3	31.2	5.7
$\frac{60}{40}$	93.6	36.5	7.9	100.1	35.7	7.1	89.3	31.7	5.9
$\frac{55}{45}$	96.0	38.2	8.5	100.2	36.0	7.2	90.2	32.2	6.0
$\frac{50}{50}$	98.3	39.6	8.7	102.2	36.9	7.6	91.2	32.7	6.3
$\frac{45}{55}$	100.7	41.3	9.1	103.1	37.6	7.7	92.1	33.3	6.8
$\frac{40}{60}$	103.1	42.8	9.3	104.0	38.4	8.1	92.8	34.1	7.1
On average	89.5	32.6	6.7	97.0	33.6	6.4	87.8	29.8	5.6
HCP_{05}	5.1	2.2	0.5	6.4	2.2	0.4	5.9	2.0	0.4

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CONCLUSIONS

1. Silage of the aboveground mass of pure corn during all phases of plant growth and development does not provide the concentration of nutrients in the feed unit to the level of the zootechnical norm. Therefore, green mass of legumes should be added to it to optimize the finished feed in terms of the carbohydrate-protein ratio during harvesting of silage from corn.
2. The selection of a legume component for joint ensiling with corn should be carried out taking into account the following criteria: the same attitude to the soil and climatic resources of the region, equal or close demands on the sum of active temperatures to complete the growing season, coincidence of the growing season by length when industrial plants enter the growth and development phase, a high supply of 1 fodder unit of the legume component with digestible protein, dry matter, starch and the metabolic energy during the ensiling period.
3. It has been established that joint ensiling of corn with yellow lupine is expedient when the corn is in waxy ripeness, and the legume component is in the shiny legume phase with the component ratio of 55:45%. In this case, the content of digestible protein in the finished silage is 100.2 g per 1 feed unit at a reliable feed supply with both irreplaceable (36.0 g) and critical (7.2 g) amino acids.

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