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ALFALFA – THE QUEEN OF FORAGE CROPS A GUIDE FOR SUCCESSFUL PRODUCTION

*Good neighbours
creating
common future*



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ORIGIN, IMPORTANCE AND DISTRIBUTION OF ALFALFA

Perennial alfalfa (*Medicago sativa* L.) occurs in nature as cultivated or wild species. Alfalfa belongs to the order Fabales, family Fabaceae, tribe Trifolieae, and genus *Medicago*. It belongs to *Medicago sativa* complex with two dominant subspecies (*M. sativa* ssp. *sativa* and *M. sativa* ssp. *falcata*) and a less grown subspecies *M. sativa* ssp. *glutinosa*. Genus *Medicago* includes more than 60 species, and two-thirds of those are annual species.

The most important and widespread cultivated alfalfa is common alfalfa (*M. sativa* ssp. *sativa*), while subspecies *M. sativa* ssp. *falcata* is also grown on limited areas (steppes, desert areas and cold regions).

Historical records on alfalfa use reach back to 1300 BC in an area of Turkey today and 800 BC in Babylon. It was brought to Europe by Roman conquests from Central Asia.

According to the Vavilov theory, alfalfa originated from the Middle East gene centre that includes Iran, Transcaucasia, Asia Minor and the highlands of Turkmenistan. As endemic species, it is widespread in the Mediterranean area, Northern Africa, Middle East, large part of Europe, Siberia, and northern parts of India and China. As cultivated species, it is grown from 69°N to 55°S latitude, and from lowlands to 2,500 m.a.s.l.

Alfalfa is grown on about 33 million hectares worldwide. In Serbia, areas under alfalfa occupy about 170,000 ha with an average hay yield of 6.5 t/ha. It is grown on about 60,000 ha in the Vojvodina Province.

Alfalfa (*Medicago sativa* L.) is the most important forage crop that achieves high yields of biomass, has excellent nutritive values and multiple use in livestock nutrition (green forage, haylage, hay, briquettes). It successfully adapts to different soils and climate conditions. Alfalfa has high yields and nutritive value of green forage and hay, and protein yields of 2,000-2,500 kg/ha per unit area, which is more than in any other forage crop or grain legume.

This plant species is not only significant in livestock feeding, but also in crop rotation. When ploughing alfalfa fields, large quantities of organic matter remain in the soil. Organic matter decomposes and mineralizes, which improves physical, chemical and microbiological soil characteristics.

Alfalfa is a perennial legume that annually fixes 100-400 kgN/ha due to symbiotic fixation with bacteria of the genus *Rhizobium meliloti*. Symbiotic nitrogen fixation of alfalfa plants reduces the need for nitrogen fertilizers, both in alfalfa fields and the succeeding crop in crop rotation.



Recently, alfalfa sprouts have been used in human nutrition as an important source of minerals, proteins, and vitamins. Regarding digestibility, alfalfa sprouts are as good as lettuce. In medicine, alfalfa is important in treating gastric nausea, pains caused by gases, ulcer conditions and weak appetite, because it contains vitamin U.

Besides that, alfalfa is also used in pharmaceutical industry as a source for phytochemical preparation, because it contains significant quantities of vitamins, minerals and phytoestrogens.

ENVIRONMENTAL GROWING CONDITION

Soil requirements – Alfalfa difficultly tolerates heavy clay and compacted soils, but favours deep, fertile and loose soils, such as chernozem, black meadow soil, eutric cambisol and alluvium. Such soils allow tap root to easily grow in depth, and lateral roots to develop, which provides crop with sufficient supplies of water and nutrients.

Neutral reaction of soil solution (pH 6.6-7.5) is desirable for alfalfa development. Acidic soils (pH below 5.2) with low amounts of Ca are less favourable or completely unfavourable for alfalfa cultivation. Alfalfa can also be grown on low acidic soils if previously ameliorated by moisture regulation and liming, as well as application of organic and mineral fertilizers. Alfalfa cannot successfully be grown on very alkaline soils because it grows poorly, thins rapidly and withers on such soils. Alfalfa field should not have depressions where excess water collects. Alfalfa plants do not tolerate flooding in any stage of development, and after three days of waterlogging plants will die.

Temperature requirements – Alfalfa is a plant of moderately warm climate. The seeds begin germinating at 3-4 °C, and the optimum temperature for germination and growth is 20-25 °C. Alfalfa can successfully be grown in areas with average annual temperature of 10-12 °C and average summer temperature of 18-20 °C, where it yields

4-6 cuttings. It can also be grown at lower average annual temperatures (8-10 °C) with 3-4 cuttings.

At the stage of emergence, alfalfa can tolerate temperatures from -3 °C to -6 °C. Later, it increases its tolerance to low temperatures, so in years of its utilization it can withhold even -25 °C, owing to reserve nutrients in the root and ground plant parts.

Alfalfa tolerates high temperatures when provided with plenty water and nutrients. During very high temperatures (up to 40 °C) and lack of moisture, alfalfa slows down its growth, withers and eventually dries up.

Water requirements – Alfalfa requires and consumes large amounts of water for its growth and development, as well as for high production of green mass and hay. Its water requirements range from 540 mm to 580 mm in the first year of life, while in later years that amount is from 670 mm to 730 mm. During growing period, alfalfa consumes the largest amounts of water at the stage of intensive stem growth and formation of leaf mass. Alfalfa needs for water are 140-170 mm per cutting, except for the fifth cutting when alfalfa consumes 85-115 mm of water. Average daily water consumption is 5-6 mm.

Alfalfa consumes about 430 litres of water for the production of 1 kg of hay. In periods of drought, alfalfa vegetates due to its powerful root that penetrates deep into soil (in some cases over 7 m), which enables alfalfa to use moisture from the deeper layers. Young alfalfa is less resistant toward drought conditions because of underdeveloped root system.

Although alfalfa tolerates drought, it responds to irrigation very well, and in Serbia it is often watered after each cut. Water should not be left on soil surface for over 24 h because alfalfa does not tolerate excessive moisture and waterlogging.

Light requirements – Alfalfa is a long day crop with high requirements toward light. In long days, the elongation of internodes is increased, so length of daylight affects



the beginning of flowering, which is significant for determination of harvest, yield and quality of alfalfa. It requires 12-16 hours of daylight, while that number rises to over 14 hours for seed production.

Requirements toward mineral nutrition – Alfalfa is a perennial legume that has a luxuriant vegetative mass and gives high yields of dry matter. Therefore, it has high requirements toward nutritive elements, especially macroelements: N, P, K, Mg, S, Ca, C, O, H.

Nitrogen (N) is required for photosynthesis and the process of breathing because it is the integral part of chlorophyll. Nitrogen content in alfalfa dry matter ranges from 1.5% to 5.0%. Its content in alfalfa leaves is usually over 5.0%, and about 1.8% in stem. Alfalfa takes up nitrogen from the soil in form of ammonia, nitrate and nitrite, as well as from symbiotic nitrogen fixation from the air with the help of *Rhizobium mellioloti* bacteria, which can be found in nodes on plant root. Alfalfa plants can take up to 400 kgN/ha annually, depending on agro-ecological growing conditions.

Nitrogen deficiency causes leaf yellowing, thinner and elongated root, and underdeveloped plants. Excessive nitrogen results in dark-green, wider, longer and juicy leaves, and denser stand, which can lead to plant lodging.

Phosphorus (P) has an important role in alfalfa nutrition. Phosphorus content in alfalfa dry matter ranges from 0.2% to 0.4%. Most of it is located in vegetative points of growth and generative organs in the form of nucleotides. Alfalfa has high requirements toward phosphorus in the initial stages of growth, especially during 20-25 days after emergence until the appearance of 6-7 leaves. Phosphorus is mobile in a plant, and can move from older to younger tissue.

Phosphorus is important since it boosts the development of root system, intensifies tillering and plant leafing, enhances nutritional value and digestibility of forage, and increases protein content in forage.

Element deficiency results in slowed plant growth, weakly developed root, dark-green to brown coloured leaves, which leads to decreased plant resistance toward external factors and diseases.

Potassium (K) is present in quantities of about 5% in alfalfa dry matter, most in stems, then in leaves, and the least in root. Alfalfa has high requirements toward large quantities of potassium during the whole period of growth until the beginning of flowering, when potassium slowly withdraws to central parts of leaf, petiole and stem.

Potassium increases plant resistance toward low temperatures, drought and diseases. Potassium deficiency results in leaf yellowing, drying and fallout.

For alfalfa to yield 12 t/ha, it will remove 560 kgN/ha, 560 kgP₂O₅/ha, 560 kgK₂O/ha, 380 kgCaO/ha, 67 kgMg/ha, and 56 kgS/ha.

ALFALFA CULTIVATION PRACTICES FOR FORAGE PRODUCTION

Alfalfa growth and development

Alfalfa is a perennial forage crop. Its vegetative cycle repeats multiple times in a year and over several years. In the first year of life, alfalfa forms a deep root system,



side shoots and crown on root neck, so the vegetative cycle in the year of crop establishment is the longest one (120-130 days).

In the year of establishment, after the sowing, alfalfa goes through several development stages: the beginning of vegetative period (germination, emergence), rosette stage (7-8 true leaves), internode elongation, appearance of flower buds, the beginning of flowering, full flowering and pod ripening.

Emergence starts with the appearance of cotyledons (germ leaves) at the soil surface. Alfalfa has two large thick cotyledons, oval in shape and olive green in colour. The first simple leaf develops on the first node (knot), from the axil of cotyledon, and it is mostly roundly shaped.

The first true leaf (trifoliate leaf) appears about two weeks after the emergence. It is a complex leaf that consists of three ovoid blades. Nodules start appearing on crop root in this stage, and they contain symbiotic bacteria *Rhizobium meliloti* var. *medicaginis* that have the ability to fix elementary (air) nitrogen.

After the first trifoliate leaf, true leaves alternately form on the main stem and internodes elongate simultaneously.

The first buds on the root crown (root neck) are visible about 45 days after the crop emergence. This is the bud formation stage.

Crown is the part between the root and the aboveground part of the crop, from which stems start emerging after the cutting. As alfalfa develops, the root crown strengthens and aboveground mass constantly regenerates. Number of stems depends on the crop age. In the first year of its life, young alfalfa forms 2-3 stems, and it can have more than 30 stems in the following years. Root neck is located in the topsoil, at the depth of 2-4 cm, which protects young crown buds from frost, treading during grazing, and damage by harvest machines.



There are several developmental stages which begin in spring of each year of utilizing alfalfa crop: intensive crop growth, pod formation, flowering, pollination, fertilisation, and pod ripening.

Crop rotation

Alfalfa is a perennial crop that is harvested for 3-5 years, which is important

when considering crop rotation. Monoculture is not good for alfalfa, and it should only be sown at the same field after 3-4 years. The period should preferably be longer than that to limit issues such as “fatigued” soil, diseases and pests.

Good preceding crops for alfalfa are maize, potato, sunflower, brassicas, annual legumes, and small grains. It is necessary to pay attention to the herbicides applied to the preceding crops, because herbicides based on triazine unfavourably affect alfalfa growth and development. Alfalfa should not be sown after other perennial legumes since they share similar diseases and pests.

Alfalfa is a good preceding crop for most field crops, especially for row crops that remove large quantities of organic matter and nitrogen remaining after alfalfa ploughing. It is a poor preceding crop for maize in dry regions and years of drought, because alfalfa dries out the soil and leaves low amounts of reserve moisture.

Soil tillage

The depth of soil tillage depends on climate conditions and soil type. Deep primary tillage creates loose arable layer, which promotes water accumulation, good root development, intensive activities of micro flora and better activity of nodule bacteria. Primary tillage should be performed immediately after removal of the preceding crop, if possible. Early tillage enables the soil to settle naturally. Seedbed preparation includes levelling and crumbing. It is especially important that topsoil up to 5 cm is compact, so that the seed does not “fall in” to deeper layers. Well-prepared soil will provide easier sowing and good cultivation of alfalfa.

If alfalfa is sown in summer, preceding crops are small grains. In that case, disk (harrow) the topsoil at the depth of 10-12 cm, and later plough it at 30-40 cm depth. Plough the soil as soon as possible or at least 15 prior to sowing. Close the furrows after the ploughing, and prepare the seedbed in a favourable moment.

Harrow the field for spring sowing in order to chop up and introduce harvest residues of the preceding crop, and after that plough at the depth of 30-40 cm. It is recommended to close the furrows after the fall primary tillage, as well as to level the soil. Prepare the seedbed with seedbed conditioner at the depth 7-10 cm. If soil moisture allows, roll the field with light smooth rollers to compact the topsoil.

Fertilization

Adequate alfalfa fertilization accomplishes three goals: provide sufficient supply of nutrients in order to achieve maximum yields (15-20 t/ha of hay), provide favourable conditions for good activity of nodule bacteria, and create conditions for long utilization of alfalfa crop.

Chemical soil analysis is the first step of successful fertilization that reveals soil fertility and recommends fertilizers and rates. Analysis of plant material from the established crop is also of great importance for growing alfalfa, especially in determination of microelements content.

In symbiosis with bacteria, alfalfa fixes N from the atmosphere for its growth and development, but it is necessary to apply small amount of nitrogen fertilizer (30-50 kgN/ha) at the time of crop establishment and before the development of symbiotic bacteria. This amount of nitrogen is needed for acceleration of alfalfa seedling growth until the nitrogen fixation begins. Larger quantity of nitrogen at the time of crop establishment inhibits bacteria activity and can reduce the growth of young plants. It is not recommended to apply nitrogen fertilizers on the established alfalfa.

Alfalfa has high requirements toward PK nutrients. Phosphorus movement in soil is limited and it needs to be introduced into the root system zone at alfalfa establishment for the whole period of utilization.

Potassium is incorporated every year in order to avoid negative consequences of luxury consumption and excessive concentrations of potassium in alfalfa hay (<3%), which can result in health issues of livestock fed with such hay.

In medium-supply soils, it is recommended to incorporate 100-150 kgP₂O₅/ha and 60-100 kgK₂O/ha at the alfalfa establishment. Total of 2/3 of required phosphorus and potassium amounts should be introduced under primary tillage, and the rest before sowing, together with total planned nitrogen quantity. Fertilizers will then be properly distributed by depth of the arable layer.

Manure should not be applied directly to alfalfa due to possible soil infection with dodder and dock seed. Instead, apply manure to the preceding crop. If establishing alfalfa on acid soils, apply manure (30 t/ha) along with liming (2.5 tCaO/ha). Calcium neutralizes soil pH, accelerates alfalfa root development and is necessary for the formation of nodule bacteria.

Sowing

Sowing period: Alfalfa field can be established in spring or summer-fall terms. For spring sowing, late March and early April are recommended, with more precise optimum term from 1 to 10 April. Early sowing can be damaged due to later frosts. If sowing is late (after 15 April), young plants can be lost due to early drought period, because topsoil of 5 cm is drained and plants do not have sufficiently developed roots to reach deeper layers of soil with more moisture.

Alfalfa sowing in summer-fall period is recommended from 15 August to 5 September. If there is enough rain or irrigation is provided, this sowing date is more preferred.



Sowing methods: Alfalfa is most commonly sown with narrow-row seeders or manually on smaller areas. Priority is given to sowing with seeders for fine grain cultures or small grains seeders. The most frequent interrow distance is 12.5 cm, but it can also be 25 cm.

Sowing depth: Alfalfa seed is small, the germ is tender and sensitive. If the seed is sown shallow, the surrounding soil can dry up before the plant emerges. In case of deep sowing, seed does not have enough energy to emerge. This is why flat and finely prepared soil is very important for sowing alfalfa. It is sown at the depth of 0.5-3 cm, depending on soil type. Alfalfa should be sown on medium heavy soils at 1-2 cm depth, on heavy soils at 0.5-1 cm, and on easy soils at 2-3 cm depth. If the seed is sown on equal depth, uniform emergence, development and ripening are achieved, which facilitates weed and pest control, and utilization (time of cutting) of alfalfa fields.

Seed quantity needed for sowing: If the soil is well prepared and seeders can properly distribute the planned seed quantity, 15-18 kg/ha of quality seed is needed for sowing. Quantity of 25-35 kg/ha used to be recommended for sowing with seeders, and 40 kg/ha for manual sowing. In Serbia, alfalfa is still sown with 20 kg/ha of seed and more. Quantities of seed for sowing per unit area were reduced due to improved machines for soil preparation and sowing. The highest seed yield and successful alfalfa establishment is achieved by sowing 10 kg/ha of seed.



The most frequent problems in alfalfa sowing: The most frequent problem in alfalfa sowing is sowing too deep, which can occur due to poorly prepared soil. For quality soil preparation, primary tillage needs to be deep and careful, and to have enough time for soil compaction.

Seedbed preparation should be performed in order to transform the soil to crumbly structure. If the soil is not naturally compact, it should be rolled before sowing in order to obtain slightly compact topsoil layer up to 5 cm, so the seeder apparatus does not uncontrollably fall in. Soil compaction can be assessed by walking through the plot prepared for alfalfa sowing; footsteps should clearly be visible. However, deeper footsteps in the soil show that soil has not compacted sufficiently, and if footsteps are not visible, it shows that soil is not crumbly enough.

Faults in sowing depth can occur due to ill adjusted depth of the seeder apparatus. Adjust the seed depositors to the depth of 2 cm. If possible, avoid sowing alfalfa on soils infected with weed species (creeping thistle), and manage weed issues through crop rotation and herbicides.

Alfalfa cultivation

Breaking the crust: In case of showers after the sowing, crust will form on heavy and loosely structural soils. Therefore, the first measure is to break the crust using light star-shaped harrow. If the seed has already germinated, is not recommended to break the crust with rolls, because seedlings may be greatly damaged.

Rolling: It is necessary to roll the soil immediately after the sowing to additionally level the surface and compact the soil around the seed, aiming at a better contact between seeds and wet soil, which facilitates faster and uniform emergence. Rolling is not recommended on heavy and loosely structural soils due to possible crust formation.

Harrowing: Harrowing is recommended in early spring and after the first (forage) cutting in old alfalfa crop. It loosens the topsoil and removes crop residues, and help control weed, larvae and harmful insect and their nests.

Weed control: Young alfalfa is especially susceptible to weeds and develops slowly under large weed infestation. In addition, the crop thins out, which results in poor alfalfa stand establishment, and in severe cases – in complete crop loss. Among the most significant broadleaf weeds in the year of alfalfa field establishment are red-root amaranth (*Amaranthus retroflexus* L.), lamb's quarters (*Chenopodium album* L.), charlock mustard (*Sinapis arvensis* L.), creeping thistle (*Cirsium arvense* (L.) Scop.), spear saltbush (*Atriplex patula* L.), curlytop knotweed (*Polygonum lapathifolium* L.), dock (*Rumex* spp.), and common ragweed (*Ambrosia artemisiifolia* L.); while the most frequent grasses are Johnson grass (*Sorghum halepense* (L.) Pers.), dog's tooth grass (*Cynodon dactylon* Pers.), couch grass (*Agropyron repens* Beauv.), foxtail (*Setaria* spp.) and cockspur (*Echinochloa crus-galli* L.).



Crop rotation, all types of soil tillage, weed control in preceding crops and next to roads, channels, etc. have a significant role in weed control in alfalfa. Additionally, application of chemical preparations is necessary in establishment of alfalfa crop. Choice of herbicides and the time of their application are conditioned by the composition of weed flora, and crop and weed phenophase. Preparations based on bentazone, imazethapyr, imazamox and 2.4 DB can be used for broadleaf weed control after the emergence in the first year, as well as their combinations: bentazone + imazethapyr, bentazone + imazamox, 2.4 DB + imazethapyr.

Weed flora changes with alfalfa field getting old. The most distributed weed on an old alfalfa are shepherd's-purse (*Capsella bursa-pastoris* L.), plantains (*Plantago* spp.), dandelion (*Taraxacum officinale* Web.), chickweed (*Stellaria media* (L.) Vill.) and perennial broadleaf and narrow-leaf weeds.

Established alfalfa fields should be treated with herbicides at the stage of vegetative rest, which is in late fall, during winter or in early spring. Herbicide application at the stage of vegetative rest is especially recommended on crops for combined utilization (forage-grain), because enough time is left for herbicide degradation (necessary waiting period), and weed plants are destroyed at the stage of germination and emergence. In the second year and older alfalfa, preparations based on metribuzin and thifensulfuron-methyl can be applied before the growing starts. Preparations based on clethodim have market and application permits for grass control in alfalfa. In order to prevent antagonism and weaker efficiency in grass control, this preparation should not be mixed with preparations based on bentazone, imazamox and imazethapyr.

Dodder control: Dodder (*Cuscuta* sp.) is a parasitic flowering plant that forms many vines on infested plants.

Dodder control in alfalfa establishment is achieved by sowing uninfested alfalfa seeds on uninfested soil. However, when alfalfa plants reach height of 15-20 cm, the field should carefully be inspected because that is the moment when dodder can occur.

Dodder in alfalfa crop (*Cuscuta* sp.)



During inspection, attention should be paid to the border parts of the field, because dodder can be introduced from roads or neighbouring fields, by machines during tillage, animals, etc. If dodder hotspot is observed, it should immediately be removed. If that is done before it flowers, the problem will probably be solved permanently, but if dodder seeds mature, problem will multiply throughout the years of alfalfa utilization. Application of imazethapyr in quantity of 2 l/ha in the moment of dodder occurrence in young alfalfa can significantly manage this parasitic flowering plant.

Pests and diseases of alfalfa: Young alfalfa is rarely attacked by insects, unless it is sown near to old alfalfa fields. During alfalfa establishment in conditions of dry spring, weevils (*Otiorhynchus ligustici*, *Bothynoderes punctiventris*, *Tanimecus dilatipennis*) can cause serious damage. Control includes digging trap canals around young alfalfa fields. In addition, trap canals could be dug around older or ploughed fields. These canals should be 30-40 cm deep with smooth sides. After spotting the first insects in trap canals, they should be sprinkled with powdery insecticides that have the contact effect. Large space insulation between old and new alfalfa fields contribute to decreased pest attacks.

Pests on newly established fields can be managed by treating the whole area by preparations based on fenthion and fenitrothion or pyrethroids.

Lucerne beetle (*Phytodecta fornicata* Briig.)



Lucerne bug (*Adelphocoris lineolatus*)



The most damaging to the alfalfa in the first cutting is lucerne beetle (*Phytodecta fornicata* Briig.), which bites young leaves, so in the cases of strong attack, stems get leafless.

When cutting is late, crop can be treated at the stage of first cutting bud formation in order to control imago. In case of weaker attack or early cutting, crop is treated after the first cutting when larvae of lucerne beetle are managed. Preparations based on malathion, dimethoate, deltamethrin and other pyrethroids are used for treatment.

Common vole and hamster are the most significant rodents. They are managed by zinc phosphide baits or preparations based on phosphorus hydrogen. Alfalfa diseases rarely occur in the first year and management by chemical preparations is not recommended.



Cutting as cultivation measure: Early cutting is performed in order to control weed. In that case, alfalfa fields are cut at the stage of weed species bud formation, regardless of the alfalfa stage. Height of cutting should be 8-10 cm, so that alfalfa could regenerate faster, since it grows faster than most of the weed in the following upgrowth, which leads to decreased weediness. This measure emaciates the young plants, which results in weaker field establishment, i.e. it is better to apply herbicides in order to control weediness.

ALFALFA CUTTING

The following three methods are used to determine the optimal alfalfa cutting date:

1. Phenological plant development phase
2. Occurrence and development of buds on root and crown
3. Fixed dates or time intervals

1) Phenological plant development phase

Plant development phase at cutting time significantly affects crop longevity, productivity and alfalfa fodder quality. Depending on the alfalfa utilization (hay, silage, dehydration, biofuel, etc.) and purpose of growing (high yield/lower quality or low yield/better fodder quality) alfalfa is cut from early bud phase until mature pod phase. Aiming at achieving the best possible balance between fodder yield, its nutritive value



and stand longevity, producers cut most often at the early flowering phase. The flowering begins when 10% of plants have flowered, when maximum nutritional value is obtained per unit area, and when crops suddenly cease to grow fast.

Alfalfa leaf contains high amounts of crude protein, minerals and vitamins, so it is advisable that the total plant yield includes higher ratio of leaf weight. The largest leaf ratio is at the early developmental phases. As the plant grows, the stem ratio increases and leaf ratio decreases, which lowers fodder quality.

From the viewpoint of high yields and fodder quality, this method is significantly better than fixed dates or intervals. However, at low temperatures that hamper flowering, developmental phases cannot be used to determine optimal cutting time.

2) Occurrence and development of buds on crown and root

This method is mostly used at low temperatures or when days are short, meaning that in spring there is no flowering.

Shoots regenerate after each cut from the buds on the root crown or lateral buds on the stem.

Table 1. Phenological phase and bud development

Phenological phase	% root crown with buds	Bud length (cm)
Bud formation	10-45	1
Early flowering	50-70	2-3
Flowering	80	3-5

3) Fixed dates or intervals

Many producers use the method of fixed dates or intervals to determine alfalfa cutting time. Under our conditions, the first cut is most often dated in early May, coinciding with ethnic belief that the first cut should fall on St. George's Day. Serbian farmers achieve three, four or five cuts without irrigation, and five or six with irrigation.

Three-cut growing system includes cuts at the pod formation phase spaced 60 days apart. The first cut is in mid-May, the second in late July, and the third in late September or later, to allow higher sugar supply in crown prior to first frosts. This is extensive alfalfa growing system that does not fully use fodder potential and yields fodder of lower quality. The benefit of this system is that it allows extended stand longevity. This three-cut system is used in drier regions, on sandy soils and aged alfalfa stands (4-7 years).

Four-cut growing system is most often used in Serbia. This medium intensive production system entails four cuts at full flowering phase dated 40-45 days apart. The first cut is on 10-20 May. In comparison to three-cut system, this one yields more and better quality hay. In dry years, especially if summer is dry, four-cut growing system is preferred.

In years with ample precipitation and good distribution, or if crops are irrigated, farmers should utilize alfalfa stand potential to the full and apply the **five-cut** growing system. In such a regime, crops are cut at the early flowering phase; the first cut is dated in early May and each successive cut 30-35 days apart. This is a very intensive system that causes crop thinning and shorter life span due to frequent cuts. Yield ratio by cuts in total hay yield is as follows: 28%, 21%, 19%, 17% and 15%.

Disadvantage of this method is that it relies only on certain fixed dates or intervals, and does not take into account growth and development of alfalfa crop as affected by environmental conditions, site conditions and genotype.



Cutting in the establishment year

Our conditions allow three cuts in the stand establishment year. The first cut should be dated somewhat later than usual in order to enable plants to take roots better and redistribute root nutrients, which triggers its fast development. Very early cutting exhausts young plants decreasing later yields and stand longevity. The second cut should be around 20 August at the stage of early flowering, and the third at the end of growing season – late October.

First cut should be somewhat higher (7-10 cm) so that young plants can regenerate faster. The succeeding cuts should be at about 5-7 cm.

Cutting in spring (first cut)

Alfalfa stand reaches highest fodder yield (15-20 t/ha) in the second and third years, making optimal date of the first spring cut crucial. First spring cut determines total number of cuts per year, fodder yield and quality, plant recovery from adverse winter conditions and stand longevity.

Agro-ecological conditions of the Vojvodina Province, Serbia allow the first cut to be in early May at the early flowering phase, i.e. when 35-40% of total annual fresh fodder is attainable.

Earlier spring cut (early bud formation) negatively affects crop vitality, successive cuts and stand longevity. Low dry matter content and high water content in plants yield less fresh green mass. It is advisable for early cuts to be at 15 cm so that the remaining leaf area would ensure regeneration. Earlier first cut can prove to be a successful control measure for lucerne beetle.

Aging decreases protein content and increases cellulose content. Additionally, stems grow more intensively in comparison to leaves, causing full flowering stage leaf weight ratio to decrease to 40-45% of the total yield.

Cutting in fall (last cut)

Being a perennial plant species, alfalfa can be damaged by low temperatures in winter. Damage degree directly depends on root nutrient reserves. Cutting system in fall should provide renewal of nutrients supply to enable plants to survive even at the lowest temperatures.

Fall cutting affects alfalfa stand longevity and yield in the successive season. It is advisable that alfalfa is cut 4 to 6 weeks before permanent frosts (-2.2 °C). The optimum for the last cut is to be dated as late as possible at the very end of the growing period (early November), and the cut before last as early as possible, at least 45 days before the last cut.

Drawbacks of the fall cut can be decreased by growing alfalfa cultivars on fertile soil, which are resistant to low temperatures and tolerant to diseases. Unfavourable effect of fall cut can also be decreased if alfalfa fields are properly fertilized with potassium.

Cutting height

Cutting height can affect yields and fodder quality, as well as thinning of alfalfa stand, especially in intensive utilization system with five or six cuts a year.

Serbian farmers cut alfalfa at 3 to 5 cm. Lower cutting damages the crown and shoot regeneration is slower. On the other hand, higher cutting at over 10 cm leads to shoots from buds at lower parts of the stem, which is of lower quality and harbours insect larvae and numerous parasites that cause diseases. Cutting height is more important in fall. Higher canopy keeps snow for longer and decreases soil temperature fluctuations in fall and early spring. Higher cuts should be used only in intensive cutting system (six or more cuts per year).

Pests and cutting: Due to ample food during growing period, alfalfa stands are very attractive habitats for reproduction and development of numerous pests. Apart from chemical control (insecticides), insect abundance can be managed by adjusting cutting system. Early first cut during April destroys and removes insect larvae and eggs. Cutting height can also decrease insect abundance. Lower cutting, not above 5 cm, decreases the number of insects.

NUTRITIONAL VALUE OF ALFALFA

Alfalfa is a very valuable feed for livestock nutrition because it is rich in proteins, cellulose, minerals and vitamins. It gives higher yields of proteins than any other field crop, which is why it is widespread in production and necessary for livestock nutrition, especially ruminants.

The most important quality indicator of alfalfa is the content of crude proteins and fibres (cellulose). Quality, or alfalfa digestibility, mostly depends on crude protein content. Aging alfalfa results in decreased ratio of leaves in yield (proteins), and increased ratio of stem (cellulose). Lignin content increases in older stages of development, which is a significant cause of aged alfalfa quality decrease.

Plant development stage has the highest importance for quality, or digestibility of alfalfa. Crude protein content in early stage in stem is 23.84%, in leaves 39.87%, while at the early flowering stage it amounts to 9.81% in stem and 29.01% in leaves. Daily decrease of crude protein content from early vegetative phase to early flowering phase is 3.81 g/kg per day in stem, and 5.55 g/kg per day in leaves. Raw cellulose content increases with alfalfa age and it is higher in stem (32.49%) than in leaves (11.51%). Crude protein content is lower in dry part of a year, as well as in spring in cold and



exceptionally wet years, i.e. dry matter quality of alfalfa depends on environmental factors.

Alfalfa is rich in minerals, especially calcium, potassium, phosphorus, magnesium, chlorine, silicon. Moreover, alfalfa contains sodium, sulphur, manganese, iron, copper, zinc, selenium and others. Content of fatty substances in alfalfa is low, and averagely 1.88% and it slightly differs between years and cultivars. Proportion of nitrogen-free extracts (NEF) indicates the sugar content in alfalfa (about 40%), and it is higher in dry years. Alfalfa plants contain high concentration of vitamins A, B1, B2, C, D, K, and PP.

ALFALFA UTILIZATION

Alfalfa is primarily utilized by cuttings, and rarely by grazing. Cut alfalfa is suitable for livestock feed (when it is still green), hay preparation, haylage and silage, as well as for industrial processing by dehydration into alfalfa flour, for preparation of concentrated protein feed.

Green alfalfa is the cheapest source of proteins and can be used as harvested green mass and for grazing.

Freshly cut alfalfa is an excellent method of utilization as stable livestock feed, primarily because of its good quality and digestibility, especially during summer periods.

Alfalfa utilization by grazing is the simplest manner of use, but it is rarely practiced in our country due to dangers of ruminants bloating. When intended for grazing, alfalfa should be grown mixed with grasses to significantly decrease the flatulence in livestock.

Alfalfa hay: In Serbia, alfalfa is mostly cured by drying (naturally on sunlight) in order to obtain hay. Alfalfa lignifies relatively fast, so the optimum date for cutting lasts shortly and passes faster than in other plants. Stem strongly develops at the stage of

full flowering, with simultaneous increase of raw fibres content and decrease of crude protein content. Therefore, cutting should be performed at the stage of late bud formation or at early flowering.

Alfalfa should be cut in the morning in order to obtain quality hay – better drying and decrease in losses of carbohydrates during respiration. Drying on soil results in largest losses, while drying facilities or additional drying with fans can give far better quality. Hay is most often baled. Bales can be of different dimensions and shapes, take less storage space and are easy to transport.

Haylage of alfalfa has numerous benefits compared to hay preparation, which is mainly reflected in smaller losses, less dependence on weather conditions, savings in storage space and almost unlimited storage periods.

In non-irrigated conditions, first cutting of alfalfa is the most important, because its ratio is 40-60% compared to the annual yield. The largest problems in drying the first cut for hay are frequent rains in May, as well as high air humidity and soil moisture. In such conditions, leaves dry faster than stem, and too dried leaves crumble and fall more easily, and the most nutritious plant part with it. Additionally, retention of cut mass on alfalfa stands (due to unfavourable weather conditions) hinders plant regeneration, and if plants grow through cuttings, late collection of hay additionally harms young plants. Besides the first cut, the last (fall) cut is also used for haylage, because weather conditions in that period are also unfavourable for hay preparation.

Cut alfalfa, depending on weather conditions, should wither (dry) from 3-4 to 6-8 hours, and sometimes more, depending on weather factors and temperature. The aim is to reduce the moisture in cut mass to 45-55%. Withered mass is cut by forage harvester in segments 0.7-1.5 cm long and used for filling the facility for haylage (towers, pits, trenches). Haylage can be baled in big roll bales, as well as used for filling in so-called tubes or silage sausages.





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