NUTRIENT MANAGEMENT FOR PROPER ALFALFA STAND ESTABLISHMENT

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ABSTRACT

Alfalfa (Medicago sativa L.), is a perennial legume that grows best on deep, well-drained, friable soils. For a good stand establishment, the seedbed must be smooth, free of weeds and residues and contain readily available nutrients and adequate moisture for germination and emergence. The study emphasizes the importance of the soil analysis for alfalfa crop. Soil samples were collected in 2020 from farm fields located in Hălchiu, Brașov department. Results show that even for weak acidic soils high in organic matter content, the soil's available phosphorous is 3 - 5 times lower than the recommended guidelines, due to its retrogradation with the soil's cations – various fertilizing techniques and the use of phosphorous protected fertilizers are required to reach the desired soil levels and to achieve an improved stand establishment and higher yields.

INTRODUCTION

Alfalfa *(Medicago sativa L.*) is one of the major forage crops in dairy and livestock production and an expensive crop to establish. Therefore, it's important to establish alfalfa successfully by following important steps, from the variety selection to the planting (M.S.U., 2020).

For an optimum stand establishment and maximized production, alfalfa requires well-drained soils. Excess humidity in the poorly-drained soils can cause soil crusting and ponding, poor soil aeration, very limited movement of soil's oxygen to the roots, micronutrient toxicity, high rates of denitrification and disease conditions - all of these are reducing the yield and, finally, can destroy the established crop (even over the winter due to the frost/ice conditions).

Soils should be deep enough to have adequate water-holding capacity. Alfalfa has a long taproot that penetrates more deeply into the soil than crops such as corn or wheat which have more fibrous, shallow roots. Under favorable conditions, alfalfa roots may penetrate over 6 meters deep – this great rooting depth gives alfalfa excellent drought tolerance. Sloping fields where erosion is a problem may require erosion control practices such as planting with a companion crop or reduced tillage to keep soil and seed in place until seedlings are well rooted. Sloping fields may have low spots where water is standing, making it difficult to maintain alfalfa stands, so proper field levelling is required (A.S.A, 2020).

The yield of agricultural crops is the result of a combination of the genetic potential of the genotype, the management of the crop and the environmental conditions (soil, drought, heat) from the local cultivation area (Bonea, 2016; Bonea, 2020).

For optimal alfalfa growth, a balanced fertilization is required - balanced fertilization does not mean a balanced fertilizer formula *(*Popescu C.V., 2018*).*

Proper alfalfa fertilizer management allows good stand establishment by promoting early rooting and vegetative growth, increasing yield and quality, and improving winterhardiness and stand persistence. Including an adequate liming program, is essential to reach optimized, economic yields.

The yield's level and quality can be maintained or improved by implementing the correct technological steps - qualitative genotypes' selection and, most important, a comprehensive set of biochemical analysis on the soil before the crop establishment and during the vegetation period.

Most soil testing programs make recommendations for pH and lime, phosphorus, potassium, and several of the secondary nutrients and micronutrients.

Optimal soil test levels for alfalfa differ due to varying subsoil fertility, nutrient buffering capacities, soil yield potentials, and different management assumptions. Soil testing is the most convenient and economical method of evaluating the fertility levels of a soil and accurately assessing nutrient requirements (A.S.A., 2020).

For this reason, the study was initiated to fill-in the information deficit by evaluating the available soil nutrients, before an alfalfa crop establishment.

MATERIAL AND METHOD

The studied field is situated in Hălchiu, Brașov department. There were manually collected five soil samples, according to the standardized soil sampling methodologies, from an area of 28 ha designated for the establishment of the alfalfa crop.

Soil analysis was performed using the laboratory standardized methodologies - nitrogen by Kjeldahl distillation / CNS analyzer, organic matter by Dumas, phosphorous by Olsen method and 1 M ammonium nitrate /solution spectrophotometry/ICP for most of the other elements.

The samples have been analyzed for available nitrate (NO_3) and ammonia (NH_3) nitrogen which are quoted in parts per million (ppm). These figures have been used to calculate/estimate the level of soil mineral nitrogen in kg/ha in the profile submitted. Previous cropping, manure applications, rainfall and soil type must be taken into account when assessing future nitrogen applications.

RESULTS AND DISCUSSIONS

The alfalfa crop has to get an adequate supply of all the essential nutrients - the critical nutritional requirements of the alfalfa plants according to the growth and development stages are represented by the calcium, boron, molybdenum and potassium elements, along with the continuous supply with nitrogen and phosphorous. Each harvested dry matter ton of alfalfa removes approximately 5 kg of P_2O_5 and 25 kg of K_2O (M.S.U., 2020).

Alfalfa is typically getting the required nitrogen from its symbiotic relationship with nitrogen-fixing Rhizobium bacteria and from soil organic matter, that is releasing nitrogen as it decomposes. On well-inoculated, established stands, top-dressed nitrogen does not improve yields, quality, or stand vigor. Normally, adding nitrogen may lower yield and/or quality by stimulating growth of grasses and weeds. But in some cases, such as where soils have not been adequately limed, an application of 35 to 55 kg/ha of nitrogen can be used as a stop-gap measure to increase yields (A.S.A., 2020).

The involvement of phosphorus in the plant's metabolism is essential. Phosphorus acts as a fundamental support in all phenological development stages of the crops, becomes essential in the formation and development of the radicular system especially in the early vegetative stages, being the most important element for stand/plant development and the accumulation of reserve substances.

In addition to its low mobility on the soil's profile, phosphorus that is applied from the conventional fertilizers will be limited once it reaches the soil - the possibility of being more or less absorbed by the plant is depending on the soil's reaction and its compounds - up to 75% becomes insoluble / readily unavailable (Popescu C.V. et al., 2018).

In acid soils, the phosphorus is forming insoluble complexes with the iron hydroxide and aluminum (Iron phosphates and AL) and in alkaline soils, rich in calcareous, it reacts with Calcium turning into Dicalcium phosphate or Tricalcium phosphate (through retrogradation), and, in both cases, the phosphorus is no longer easily available for the crop.

There were analyzed the main soil available macro and micronutrients - results are presented in table 1 and their interpretation in table 2. It can be observed from these tables that:

- soil is slightly acidic - pH values are between 6,1 – 6,3;
- available nitrogen content is variable considering that there were applied high quantities of organic bovine manure and nitrogen fertilizers - the soil mineral nitrogen figures should not be used in isolation as there are a number of factors which will affect the accuracy of assessing the soil nitrogen supply. Previous cropping, manure applications, rainfall and soil type must be taken into account when assessing future nitrogen applications. Quality nitrogen fertilizers based on urease and nitrification inhibitors are required in order to prevent nitrogen losses by leaching and denitrification and environment pollution;
- for the studied area, the available phosphorous is 3 - 5 times lower than the alfalfa soil guidelines, due to its retrogradation with the soil cations. It is compulsory to adapt phosphorous nutritional schemes by using technological fertilizers based on a new generation of polymers designed to protect phosphorous from retrogradation (they are acting by binding to the cations before they can reach the phosphates) and by using beneficial PGPR's - phosphate solubilizing bacteria;
- available potassium content is low – potassium is to be applied according to the crop's requirements and soil's further analysis which is recommended to be done yearly in the case of alfalfa;
- generally speaking, for this plot, magnesium, calcium and manganese most probably will not present deficiencies but leaf analysis will be required further during the vegetation period to determine their level – as in the case of other nutrients, leaf analysis is one of the most important tools to determine crop's deficiencies and prevent them using combinations of base and foliar treatments;
- high calcium and copper values can determine possible interference with the availability of Mg, Mn, Zn, B, P, K, Fe;
- sulfur soil level is low. Elemental sulfur and/or sulphates as potassium sulphate may be applied at seedbed preparation and/or in the vegetation period by foliar and/or fertigation products;
- boron is slightly low – an appropriate quality boron fertilizer can be used in the nutritional schemes considering alfalfa requirements to avoid high doses;
- zinc application should be considered after foliar analysis like in the case of other deficient micronutrients;
- sodium level is not an issue for this plot for the moment;
- although the cation exchange capacity and organic matter levels are showing high values, the availability of nutrients, especially of the phosphorous, can be lower than expected and the micronutrients may present toxic levels.

CONCLUSIONS

Liming is essential in order for the alfalfa stand to be established and to provide high quantitative and qualitative yields. For good results, acid soils have to be limed to a pH interval of 6.7 to 6.9. The main benefits of liming alfalfa are: improved crop stand establishment, enhanced activity of nitrogen-fixing Rhizobium bacteria, improved soil structure, increased phosphorus availability and decreased iron and aluminum toxicity.

Lime is a slowly reacting material, which is influencing the applications for improved results. Lime should be applied one year or preferably longer before seeding alfalfa, allowing sufficient time for reacting with the soil acidity. Also, tillage within the cropping rotation will better mix/remix lime with soil so, by the time alfalfa is established, the soil pH value should be at the desired level.

It is recommended to spread lime on the surface of the soil, to disk and/or plow the soil for an improved maximized lime distribution and neutralization of acidity in the entire plow layer. When high amounts of lime are to be applied, it is recommended that half of the rate to be applied before tilling the fields and the remaining half to be mixed into the soil after plowing or by other field preparation. The lime purity and its grounding fineness are influencing the lime’s effectiveness so, in order to reach the desired pH soil values, coarse lime has to be applied earlier and at raised rates than the fine lime (A.S.A., 2020).

Manure is one of the best sources of macronutrients and micronutrients and can be used to meet the nutrient needs of alfalfa. Manure should be tested before any application. For an improved impact, manure application is to be done before alfalfa seeding and should be thoroughly mixed with the soil. Also, the rates should be limited to a maximum of 15 tons/ha of solid dairy manure or 200 m^3/ha of liquid dairy manure (environmental national requirements lower the recommended rates). The efficiency of manure is higher if it is administered together with mineral fertilizers, especially phosphate fertilizers. This reduces the dose of nitrogen by 20-50%, without the production to decrease (I.C.P.A., 2020).

Some research has shown that small additions of nitrogen may enhance stand establishment and yields - 25 to 35 kg/ha nitrogen when alfalfa is directly seeded on coarse-textured soils with low organic matter content (less than 2%); 20 to 40 kg/ha nitrogen when seeding alfalfa with a companion crop and 45 to 60 kg/ha nitrogen if the companion crop will be harvested as silage.

Phosphorus is very immobile in most of the soils. Most of the research confirms that at low to medium soil test levels, incorporated phosphorus is more than twice as efficient as top-dressed phosphorus. Even the weak acid soils are causing interferences on the availability of phosphorous - good quality fertilizers protected from retrogradation are required.

As an example, the NUTRI TOP AMESAL NPK product range developed by CiCh Năvodari is including AMESAL - polymer with a high cationic exchange capacity (its specific molecular structure enhances phosphorous availability and absorption by doubling fertilizer efficiency when coated onto phosphate fertilizers - due to its phosphorus enhancement technology, the phosphorus no longer gets retrograded into the soils, regardless of the soil's reaction (CiCh Romania, 2020).

Although potassium has relatively little influence on improving stand establishment, yield and stand survival are highly dependent on an adequate potassium supply. When soil tests are in the medium range or below, sufficient potassium should be added to meet the needs of the year crop (including the companion crop if the case).

Elemental sulfur, can be used as the sulfur source and may be applied at seeding - it has to be converted to sulfate-sulfur before being used by plants. The process is relatively slow, especially when sulfur is top-dressed.

Therefore, incorporating moderately - high rates (50-60 kg/ha) of elemental sulfur at establishment will usually satisfy alfalfa sulfur requirements for the life of the stand. Due to the ease of application, usually, sulfur is typically top-dressed annually rather than incorporated at planting with the mineral fertilizers (A.S.A., 2020).

Leaf/tissue analysis will be required further during the vegetation period to determine the nutrients’ level – leaf analysis is one of the most important tools to determine crop’s deficiencies.

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Table 1

Soil available nutrient content analysis

Analysis / Sample no.	1	2	3	4	5
pH	6,2	6,2	6,3	6,1	6,1
Nitrogen (Kg/ha)	78	130	77	105	63
Ammonium N (ppm)	4,2	6,0	4,3	4,8	5,0
Nitrate N (ppm)	21,8	37,4	21,2	30,3	16,1
P (ppm)	9	7	9	6	6
K (ppm)	89	83	87	90	96
Mg (ppm)	103	108	95	92	95
Ca (ppm)	5166	4762	5101	6393	5928
Mn (ppm)	51	72	33	4	13
S (ppm)	4	4	4	10	4
Cu (ppm)	10,1	10,4	9,1	14,5	11,7
B (ppm)	1,30	1,27	1,14	1,27	1,18
Zn (ppm)	1,8	1,7	1,5	1,6	2,1
Mo (ppm)	0,08	0,07	0,07	0,10	0,07
Fe (ppm)	367	309	309	741	464
Na (ppm)	41	33	36	43	42
C.E.C. (meq/100g)	22,7	20,9	22,3	28,1	26,0
Org/ Matter (%)	7,9	6,5	7,7	13,7	8,2

Normal | *Very low* | *Low / Slightly low* | *High / Very high*

Table 2

Soil available nutrients – sample no. 1

Analysis	Result	Guideline	Interpretation	Comments
pH	6,2	6,50	**Slightly low**	Liming requirements - 4 t $CaCO_3$/ha
SMN (Kg/ha)	**78**	-	**Medium**	The estimated or additional (SMN/soil mineral nitrogen) figures should not be used in isolation - previous cropping, manure applications, rainfall and soil type must be taken into account when assessing future nitrogen applications.
N – NH_3 (ppm)	4,2	-		
N - NO_3 (ppm)	21,8	-		
P (ppm)	**9**	26	**Very low**	Apply phosphorous retrogradation protected solid fertilizers, foliar fertilizers with high quality phosphorous content and nutrient solubilization PGPR's.
K (ppm)	**89**	241	**Low**	Apply potassium solid fertilizers, foliar fertilizers with high quality potassium content and nutrient solubilization PGPR's.
Mg (ppm)	103	50	Normal	Adequate level.
Ca (ppm)	5166	1600	Normal	Adequate level.
Mn (ppm)	51	30	Normal	Adequate level.
S (ppm)	**4**	10	**Very low**	Average priority. Apply sulphur content fertilizers (e.g., potassium sulphate) at seedbed preparation and/or in the vegetation period by foliar/fertigation products.
Cu (ppm)	10,1	2,1	Normal	Adequate level.
B (ppm)	**1,30**	1,6	**Slightly low**	Low priority. Apply boron content fertilizers at seedbed preparation and/or in the vegetation period by foliar/fertigation products (leaf/tissue analysis is required).
Zn (ppm)	**1,8**	2,1	**Slightly low**	Low priority. Apply zinc content fertilizers at seedbed preparation and/or in the vegetation period by foliar/fertigation products (leaf/tissue analysis is required).
Mo (ppm)	**0,08**	0,60	**Very low**	Average priority. Apply molybdenum fertilizers in the vegetation period by foliar/fertigation products (leaf/tissue analysis is required).
Fe (ppm)	367	50	Normal	Adequate level.
Na (ppm)	41	90	Very low	No restrictions for crop growth and development.
C.E.C (meq/100g)	22,7	15,0	Normal	Cation Exchange Capacity indicates a soil with a good nutrient holding ability.
Org. Mat. (%)	**7,9**	3,0	**Normal**	Adequate level. Humic soil.

Table 2

Soil available nutrients – sample no. 2

Analysis	Result	Guideline	Interpretation	Comments
pH	6,2	6,50	**Slightly low**	Liming requirements - 4 t $CaCO_3$/ha
SMN (Kg/ha)	**130**	-	**High**	The estimated or additional (SMN/soil mineral nitrogen) figures should not be used in isolation - previous cropping, manure applications, rainfall and soil type must be taken into account when assessing future nitrogen applications.
N – NH_3 (ppm)	6,0	-		
N - NO_3 (ppm)	37,4	-		
P (ppm)	**7**	26	**Very low**	Apply phosphorous retrogradation protected solid fertilizers, foliar fertilizers with high quality phosphorous content and nutrient solubilization PGPR's.
K (ppm)	**83**	241	**Low**	Apply potassium solid fertilizers, foliar fertilizers with high quality potassium content and nutrient solubilization PGPR's.
Mg (ppm)	108	50	Normal	Adequate level.
Ca (ppm)	4762	1600	Normal	Adequate level.
Mn (ppm)	72	30	Normal	Adequate level.
S (ppm)	**4**	10	**Very low**	Average priority. Apply sulphur content fertilizers (e.g., potassium sulphate) at seedbed preparation and/or in the vegetation period by foliar/fertigation products (leaf/tissue analysis is required).
Cu (ppm)	10,4	2,1	Normal	Adequate level.
B (ppm)	**1,27**	1,6	**Slightly low**	Low priority. Apply boron content fertilizers at seedbed preparation and/or in the vegetation period by foliar/fertigation products (leaf/tissue analysis is required).
Zn (ppm)	**1,7**	2,1	**Slightly low**	Low priority. Apply zinc content fertilizers at seedbed preparation and/or in the vegetation period by foliar/fertigation products (leaf/tissue analysis is required).
Mo (ppm)	**0,07**	0,60	**Very low**	Average priority. Apply molybdenum fertilizers in the vegetation period by foliar/fertigation products (leaf/tissue analysis is required).
Fe (ppm)	309	50	Normal	Adequate level.
Na (ppm)	33	90	Very low	No restrictions for crop growth and development.
C.E.C (meq/100g)	20,9	15,0	Normal	Cation Exchange Capacity indicates a soil with a good nutrient holding ability.
Org. Mat. (%)	**6,5**	3,0	**Normal**	Adequate level. Humic soil.

Table 2

Soil available nutrients – sample no. 4

Analysis	Result	Guideline	Interpretation	Comments
pH	6,1	6,50	**Slightly low**	Liming requirements - 5 t $CaCO_3$/ha
SMN (Kg/ha)	**105**	-	**High**	The estimated or additional (SMN/soil mineral nitrogen) figures should not be used in isolation - previous cropping, manure applications, rainfall and soil type must be taken into account when assessing future nitrogen applications.
$N - NH_3$ (ppm)	4,8	-		
$N - NO_3$ (ppm)	30,3	-		
P (ppm)	**6**	26	**Very low**	Apply phosphorous retrogradation protected solid fertilizers, foliar fertilizers with high quality phosphorous content and nutrient solubilization PGPR's.
K (ppm)	**90**	241	**Low**	Apply potassium solid fertilizers, foliar fertilizers with high quality potassium content and nutrient solubilization PGPR's.
Mg (ppm)	92	50	Normal	Adequate level.
Ca (ppm)	**6393**	1600	**High**	Possible interference on availability of Mg, Mn, Zn, B, P, K, Fe.
Mn (ppm)	**4**	25	**Very low**	Apply manganese fertilizers in the vegetation period by foliar/fertigation products (leaf/tissue analysis is required).
S (ppm)	**10**	10	Normal	Adequate level.
Cu (ppm)	**14,5**	2,1	**High**	Possible interference with the availability of Manganese.
B (ppm)	**1,27**	1,6	**Slightly low**	Low priority. Apply boron content fertilizers at seedbed preparation and/or in the vegetation period by foliar/fertigation products (leaf/tissue analysis is required).
Zn (ppm)	**1,6**	2,1	**Slightly low**	Low priority. Apply zinc content fertilizers at seedbed preparation and/or in the vegetation period by foliar/fertigation products (leaf/tissue analysis is required).
Mo (ppm)	**0,10**	0,60	**Very low**	Average priority. Apply molybdenum fertilizers in the vegetation period by foliar/fertigation products (leaf/tissue analysis is required).
Fe (ppm)	741	50	Normal	Adequate level.
Na (ppm)	43	90	Very low	No restrictions for crop growth and development.
C.E.C (meq/100g)	28,1	15,0	Normal	Cation Exchange Capacity indicates a soil with a good nutrient holding ability.
Org. Mat. (%)	**13,7**	3,0	**Very high**	Humic soil. Above 16% peaty soil.