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THE PERFORMANS OF NEW ROMANIAN ALFALAFA (*MEDICAGO SATIVA)* GENOTYPES

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Abstract

Alfalfa (Medicago sativa), known as „Queen of the forages" is important for its biomass yield and it is the fourth most widely grown crop in the world behind corn, wheat and soybean. Therefore, alfalfa breeding targets forage yield and quality, as well as tolerance to biotic and abiotic stresses. The alfalfa genotypes have been tested in natural conditions to Agricultural and Research Station Caracal in 2020-2021 for assessing their yielding treats. Thus, the biomass yield ranged between 63,5 for F 2909-2 and 72,2 t/ha for F 2910, while dry matter emphasized significant values comparatively with the control (3-11%), only for the genotypes F2907, F2909-1, F2910. The genotypes Ileana and F2910 performed the best in all assessed traits and they are recommended for extended cropping system.

***Key words**: alfalfa, synthetic cultivars, adaptability, fodder, yielding treats*

INTRODUCTION

Alfalfa (*Medicago sativa* L., 2n = 4x = 32) is native from the Middle East and a member of the *M. sativa–falcata* complex, being an open-pollinated, tetraploid perennial legume with polysomic inheritance. Because of its high protein content, high nutritional value, and distinct summer availability over other forage crops, alfalfa is considered as "*the queen of the forage crops*". In Romania, alfalfa is the main source of protein used in animal feed, especially in the form of green fodder and hay.

Modern cultivars alfalfa can be harvested for up to 4-5 years before the stand deteriorates, though it is typical to rotate to other crops after 2-3 years. As many other natural vegetation and crops, alfalfa production is limited by different stressful environments, which represent a serious threat to global food security (Ilie et al., 2023; Răduțoiu, 2023; Răduţoiu and Băloniu, 2021; Răduţoiu and Stan, 2022; Răduţoiu and Ștefănescu, 2022; Răduțoiu et al., 2023). Alfalfa suffers from various severe abiotic stresses during its growth, such as salinity, drought, extreme temperature, heavy metals and also from biotic factors such as pets, diseases, weeds (Song et al., 2019; Lu et al., 2020). These stresses may cause a decline in the global feed production from alfalfa due to harmful effects resulting from stresses at the physiological, biochemical and histological levels. Gradual adjustments to perennial crop management (planting dates, harvest dates, number of harvests, crop genetics, and pest control) will be required in order to adapt to and possibly even benefit from the future climate (Durău et al., 2021; Velea et al., 2021). Advances in bioengineering and genetic biotechnology have direct implications in stress management and plant protection and at the same time also of the environment (Bonciu, 2023). A key feature and industrial benefit of these technologies is the possibility to include different genetic targets in each cell of the delivery system, thereby reducing or eliminating the potential of pathogens to develop different types of resistance (Bonciu et al., 2021; De Souza and Bonciu, 2022 a, b). The plant protection strategy in organic farming is based on preventive measures, which enhance the natural regulation potential of the system (Bonciu, 2022 a). Only in the case of an imminent infestation are measures that act directly against specific pathogens used. The application of prevention strategies in the ecological system requires a good knowledge of the biology of diseases, pests and beneficial organisms, as well as the specific effectiveness of individual measures and their side effects (Bonciu, 2022 b). Thus, understanding how alfalfa plants respond to stress, as well as the mechanisms of tolerance and available management options, is essential to improving alfalfa productivity under these conditions (El-Ramady et al, 2020). The Romanian's forage legume breeding initiative aims to increase the efficiency of cultivar development through the development of molecular technologies and the identification of genetic remedies for biotic and abiotic constraints on forage legume yield (Petcu et al., 2019; Petcu et al., 2021; Petcu et al., 2022). Therefore, continued research on alfalfa breeding and management is necessary to expand adaptation of alfalfa to hostile environments with less-than-optimal soil conditions, limited water availability, and resistant to insect pests and diseases to maximize yield and economic return.

Because alfalfa is set to become one of the most important components in the bio-fuel industry driven by new cultivars with higher biomass yields and enhanced nitrogen use efficiency in agricultural production systems, the aim of the current research was to investigate the main components related to alfalfa production under hydric stress, useful for the alfalfa breeding program.

MATERIALS AND METHODS

The alfalfa genotypes have been tested in natural conditions to The Agricultural Research Station Caracal, Romania (44°11'N and 24°37'E) in 2021-2022 (the second year of cultivation) for assessing their yielding treats the trial was conducted in a split–plot design with the main plots (10 m2) arranged in a randomized complete block with three replicates. All recommended cultural practices (pests' control with Decis 0,15 l/ha and Mospilan 5 g/10 l water and fertilizing with Aminofed 20 g/10 l water, etc.) and other management were applied. The local long term average rainfall amount was 541,7 mm, while long term average temperature was +11,6^{o}C. Severe summer drought was avoided by providing three irrigations of 55 mm each before harvest. Harvest took place when plants approached 10% blooming for every genotype and hay was collected in bales (16% moisture). On each replication the traits evaluated were:(a) stems elongation (cm), b) number of internodes c) growth rhythm, d) average yield on 10 stems with and without leaves. Total biomass and total dry matter yield on a plot basis was recorded.

RESULTS AND DISCUSSIONS

In general, in Romania alfalfa cultivation is gaining ground as a result of the EU Common Agricultural Policies (CAP) which provides subsidies for this crop and supports the increase in livestock numbers, but drought stress on perennial forages reduces forage yield and limits persistence. Annually, the forage yield per cut varies with climatic conditions and genotype.

The average monthly temperature on 2021 year (+12,65^{o}C) that was +1,05^{o}C higher than multiannual temperature (+11,6^{o}C) follows the global trend in planet warming accordingly with a report of National Oceanic and Atmospheric Administration (NOAA, September 2020).

Rainfall amount for evaluated period was with 56,3 mm less than multiannual amount for Caracal area (541 mm), drought being considered the most important cause of yield reduction in alfalfa plants (Bohnert and Jensen, 1996) (Figure 1).

Figure 1. Climatic conditions during the study period (2021 year)

Currently, the using of biotechnology to enhance drought tolerance in alfalfa is feasible (Diatta et al., 2021; Hrbáčková et al., 2020; Inès et al., 2022; Samac and Temple, 2021). The experiment was based on the comparison of ten alfalfa genotypes performance as expressed by total biomass during the second year of cultivation 2020-2021. Also, some morphological characters were considered.

The present study revealed that alfalfa yield can vary significantly based on factors like climate, genotype and management practices.

Thus, in the second year of cultivation (2021) four hay crops were recorded for each genotype and the best total biomass yield was recorded in F 2910, F 2909-1, F 2907, F Ileana ranging between 67,7 t/ha and 77,2 t/ha (Table 1). The yield increase ranged between 5 and 12% comparatively with the control Catinca genotype. Among all meadows for all alfalfa genotypes the first one was the greatest in terms of total biomass yield.

Annicchiarico et al. (2015) highlighted that lower rate of genetic yield improvement in alfalfa compared to cereals, such maize or wheat, which have gained importance as feed crops in recent decades, pose a danger to the economic viability of alfalfa.

Also, the greatest performance as total dry matter yield was recorded by the genotypes F 2910, F 2909-1, F 2907, F Ileana and ranged between 13,56 t/ha and 14,59 t/ha (Table 1), which represents yield increases between 3% and 11% comparatively with the control genotype.

The correlation between total biomass yield and total dry matter yield was positively significant (r^2 = 0,8532***).

The alfalfa genotype F 2909-1 showed the greatest yield among all tested ones.

The genotypes F 2906 and F 2909-2 showed the lowest yields with 9% less comparatively with the control yield for total dry matter yield and

The results revealed that for increasing alfalfa productivity it is of great significance to cultivate new alfalfa (*Medicago sativa* L.) types with high yield and quality.

Table 1. New alfalfa genotypes yield during 2020-2021 in ARDS Caracal, Romania

No.	Variant	Total biomass yield t/ha					Rel. yield %	Total dry matter yield t/ha					Rel. yield %
		meadow						meadow					
		I	II	III	IV	Total		I	II	III	IV	Total	
1	**Catinca***	28,3	24,6	6,0	5,4	**64,3**	**100**	5,82	5,0	1,2	1,1	**13,12**	**100**
2	**F Ileana**	33	22,3	6,8	5,6	**67,7**	**105**	6,53	4,54	1,36	1,13	**13,56**	**103**
3	**F 2020**	30,5	21,3	6,1	5,6	**63,5**	**98,7**	6,22	4,42	1,23	1,10	**12,97**	**98**
4	**F 2905**	29,6	23,3	5,5	5,4	**63,8**	**99**	6,09	4,47	1,14	1,08	**12,78**	**97**
5	**F 2906**	30,8	22,3	6,5	5,6	**65,2**	**101**	5,35	4,46	1,18	1,04	**12,03**	**91**
6	**F 2907**	32,5	23,6	6,7	5,7	**68,5**	**106**	6,37	5,05	1,35	1,17	**13,94**	**106**
7	**F 2908**	30,8	22,3	5,8	5,2	**64,1**	**99**	6,16	4,63	1,14	1,06	**12,99**	**99**
8	**F 2909-1**	33	26	6,1	6,1	**71,2**	**110**	6,79	5,35	1,22	1,23	**14,59**	**111**
9	**F 2909-2**	31,6	21,6	5,2	5,1	**63,5**	**98**	6,69	4,44	1,08	1,03	**12,01**	**91**
10	**F 2910**	34,8	24,6	7,2	5,6	**72,2**	**112**	6,89	4,82	1,39	1,10	**14,20**	**108**

Source: own data/*Control

Cai et al. (2017) showed that he most significant external component that positively affects the buildup of dry matter and raises crop production is light. Also, previous research demonstrated that gibberellin (GA) which can induce internode elongation, is the most significant hormone responsible for controlling plant height (Wang et al., 2017).

The results showed that stem elongation values ranged between 241,4 cm for alfalfa line F2020 and 265,1 cm for alfalfa line F Ileana. Only the lines F 2905, F2910 and F Ileana recorded slightly higher values of stem elongation that the control genotype Catinca, while all the others assessed alfalfa genotypes exhibited lower values (Table 2).

Table 2. Alfalfa stem elongation values (2020-2021)

No	Genotype	Stems length (10 stems / variant) (cm)					Rel. length %
		mower					
		I	II	III	IV	Total cm	
1	Catinca - Control	75,8	85,8	46,6	43,9	**252,1**	**100**
2	F Ileana	77	88,5	52,6	47	**265,1**	**105**
3	F 2020	75,3	75,8	48,9	41,4	**241,4**	**95**
4	F 2905	71,7	82,4	56,7	46,7	**257,5**	**102**
5	F 2906	73,1	88,1	51	41,8	**254**	**100**
6	F 2907	74,4	88,2	48,8	43,9	**255,3**	**101**
7	F 2908	74,5	85,1	47,8	46,5	**253,9**	**100**
8	F 2909-1	76	85,2	49,3	41,1	**251,6**	**99**
9	F 2909-2	77,4	85,0	49,9	39,6	**251,9**	**99**
10	F 2910	77,4	89,2	51	43,7	**261,3**	**103**

Source: own data

However, as a typical example of forage, alfalfa has received minimal attention in terms of the process underlying stem elongation, with the majority of studies concentrating on the nutritional value of the stem. The genetic regulatory mechanism and the underlying reasons for the variability in alfalfa plant height require additional research.

The total internode number ranged between 39 for F 2909-2 and 52,9 for F2020 (Table 3). The genotypes F2907, F2908 and F2910 have the same total internodes number (39,8). The only alfalfa genotypes that recorded higher number of internodes were F Ileana with 4% more than the control and F2020 with 29% more than Catinca. There was a significant and positive correlation between stem elongation and internode number (r^2 = 0,59443*).

Table 3. Alfalfa number of internodes (2020-2021)

No	Genotype	Internodes number (10 stems / variant)					Rel. length %
		mower					
		I	II	III	IV	Total	
1	Catinca - Control	11,1	11,5	9,7	8,4	**40,7**	**100**
2	F Ileana	11,1	11,6	10,5	9,2	**42,4**	**104**
3	F 2020	10,6	11	23,1	8,2	**52,9**	**129**
4	F 2905	10,1	11,5	9,6	8,7	**39,9**	**98**
5	F 2906	10,7	11,5	10,2	8,2	**40,6**	**99**
6	F 2907	10,0	11,7	9,7	8,4	**39,8**	**97**
7	F 2908	10,4	10,9	9,1	9,2	**39,6**	**97**
8	F 2909-1	10,3	11,0	9,4	8,5	**39,2**	**96**
9	F 2909-2	10,4	10,9	9,7	8,0	**39**	**95**
10	F 2910	10,3	11,0	9,7	8,8	**39,8**	**97**

Source: own data

Jing et al. (2023) found that the growing rhythm seems to be particular for each alfalfa genotype depending on climatic conditions and genetic background. Thus, the fastest growing rhythm was observed to the genotype F2905 and the lowest to F2910 (Table 4).

Table 4. Alfalfa growing rhythm (cm) (2020-2021)

No.	Genotype	Growth rhythm (cm)		
		*RI	RII	RIII
1	Catinca - Control	1,5	1,5	3,5
2	F Ileana	1,5	1,5	1,5
3	F 2020	2,5	1,5	1
4	F 2905	3,0	2	3,5
5	F 2906	1,0	2	3,5
6	F 2907	1,0	1,5	1,5
7	F 2908	1,5	3	2
8	F 2909-1	1,0	2	1
9	F 2909-2	1,0	3	1
10	F 2910	1,0	1	1

Source: own data

Research results show that there are differences in the production of total biomass and hay in alfalfa genotypes analysed according to the genetic background and specific climatic conditions. However, under optimal conditions, alfalfa has shown remarkable yield potential, often surpassing other forage crops.

CONCLUSIONS

Alfalfa is set to become important components in the bio-fuel industry driven by new cultivars with higher biomass yields and enhanced nitrogen use efficiency in agricultural production systems. Integration of molecular breeding approaches and the latest technologies will contribute to the sustainability of profitable forage crop production systems to meet current and future demands for these crops.

The present study revealed that alfalfa yield can vary significantly based on factors like climate, genotype and management practices. In the second year of cultivation (2021) the best total biomass yields were recorded in F 2910, F 2909-1, F 2907, F Ileana ranging between 67,7 t/ha and 77,2 t/ha. The yield increase ranged between 5 and 12% comparatively with the control Catinca genotype. Also, the greatest performance as total dry matter yield was recorded by the genotypes F 2910, F 2909-1, F 2907, F Ileana and ranged between 13,56 t/ha and 14,59 t/ha (Table 1), which represents yield increases between 3% and 11% comparatively with the control genotype. The alfalfa genotype F 2909-1 showed the greatest yield among all tested ones. The only alfalfa genotypes that recorded higher number of internodes were F Ileana with 4% more than the control and F2020 with 29% more than Catinca. Only the lines F 2905, F2910 and F Ileana recorded slightly higher values of stem elongation that the control genotype Catinca, while all the others assessed alfalfa genotypes exhibited lower values.

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