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THE EFFECTS OF WATER DEFICIT AND AIR TEMPERATURE ON SEED PRODUCTION OF ALFAALFA (*Medicago sativa* L.) UNDER THE CONDITIONS OF ARDS SECUIENI, NEAMȚ

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Abstract

Good quality of alfalfa seed variety is very important to meet the farmers` requirements for feed production. Testing of new alfalfa varieties is important for assessing their seed production potential, which also influences their commercial value. The purpose of our research was to test the seeds production potential of new alfalfa varieties, under the pedoclimaic conditions of ARDS Secuieni, Neamț, Romania. The experiment was organized between 2020 and 2022 o a chernozem-type soil and aimed to evaluate the quality of some new varieties of alfalfa. An important aspect pursued in this study referred to the effects of climate change on new alfalfa varieties, in the absence of irrigation. Within the study, 17 Romanian alfalfa varieties were analyzed regarding seed productiion potential, based on multi-annual testing, to recommend the best-adapted ones in culture, to make these results available to farmers, and to expand in culture. Of the 17 alfalfa genotypes tested in our study, five (F 2907-20, F 2910-20, F 2905-20, F 2906-20, Catinca) showed a high adaptability to the pedo-climatic conditions of ARDS Secuieni, Neamț, Romania.

Key words*: alfalfa, new varieties, seed production, climatic conditions.*

INTRODUCTION

Alfalfa (*Medicago sativa* L.) is of particular importance as a good fodder plant, but also as a soil improver, as it enriches the soil in nitrogen due to its symbiosis with the *Rhizobium meliloti* Dangeard bacteria, thus saving important amounts of nitrogen fertilizer during the whole growing season. The highest amount of nitrogen fixing symbiotic nodules is formed in the 0-15 cm soil layer (Oliveira et al., 2004).
For seed production, alfalfa is usually sown in late fall or early spring. With the global warming, the water and thermal regime after sowing is highly fluctuating and thus cold and heat stress of the plants has also occurred (Gharoobi et al., 2012).
In general, weather fluctuations represented byan intense increase in monthly mean air temperature, a decrease in the amount of precipitation, uneven rainfall distribution and a prolonged period of drought in summer further limit legume seed productivity (Brouwer et al., 2000; Tyshchenko et al., 2020; Mîrzan et al., 2024; Lykhovyd, 2018). The air temperature is crucial in early sowing of alfalfa, and improving seed germination ability under low temperature conditions by modern breeding approaches could be beneficial for seed production (Zhao et al., 2024).
Alfalfa reacts negatively to drought and, in order to adapt and survive under stress conditions, undergoes morphological, physiological, biochemical or molecular changes, which need to be taken into account when breeding drought-tolerant varieties while increasing yields and quality of the products (Vozhehova et al., 2021).
During the dry season, alfalfa (*Medicago sativa* L.) plants reduce aboveground vegetative mass (Bellague et al., 2016; Durand, 2007), which limits the leaf area index and consequently reduces biomass productivity. Therefore, to stabilize and increase the productivity of

alfalfa, it is necessary to increase the drought resistance of alfalfa plants, and the study of this trait is an important step in plant breeding programs (Yu, 2017).

The potential for seed production of a new alfalfa variety induces its commercial potential (Varga et al., 1998; Ualiyeva et al., 2022). It has been established that species and varieties differ by seed germination under stress conditions (Budakli & Erdel, 2015; Molor et al., 2016). One of the most important steps in the plant breeding process is a preliminary evaluation of the drought tolerance of a large set of populations to choose the best primary material. The correct choice of primary material is a prerequisite for further success in plant breeding.

Breeding new alfalfa varieties with superior seed yield and high forage quality is one of the biggest challenges for alfalfa breeders and seed producers both abroad (Julier et al., 2000; Bolanos-Aguilar, 2002; Tucak et al., 2017; 2023) and in Romania (Schitea et al., 2007; 2020a; 2020b; 2022).

Alfalfa seed can be obtained from regular forage crops, or from crops specially established for this purpose, but it is recommended to obtain seed production from specially established crops (Moisa et al., 2018; Muscalu et al., 2022).

The purpose of the research was to test the seeds production potential of new alfalfa varieties, under the pedoclimaic conditions of ARDS Secuieni, Neamț.

MATERIALS AND METHODS

The research was carried out in the experimental field of the Fodder Plant Culture Laboratory of the Agricultural Research and Development Station (ARDS), Secuieni, Neamț, Romania, between 2020 and 2022.

The experiments were laid out according to the randomized block method, in four replications, with a harvestable plot area of 10 m^2, with a row spacing of 25 cm, and the seed density was 500/m^2. The cultivation technology specific to the forest steppe pedoclimatic conditions area was followed, and the obtained data were statistically processed according to the analysis of variance method and interpreted accordingly (Jităreanu, 1999). The experiment was stationary and was located on a medium-textured, acidic, chernozemic soil. The main characterstics of soil are $pH_{(H2O)}$ - 5.98; well supplied in phosphorus (77.6 ppm P_{AL}); Ca - 13.6 meq/100 g soil; Mg -1.8 meq/100 g soil Mg; poorly supplied in active humus (1.88 %) and nitrogen (16.2 ppm $N\text{-}NO_3$) and poorly supplied in potassium (124.6 ppm K_2O).

Alfalfa sowing was carried out in the third decade of March (20.03.2020) with the SCE-8 Haldrup experimental seed drill. During the growing season, bentazone 480 g/l + imazamox 22.4 g/l herbicide (1.25 l/ha) was administered to control annual dicotyledonous and some monocotyledonous weeds in the experimental field. Harvesting of the seedlings for seed was done with the Wintersteiger combine when 80% of the pods had browned (Photo 1.). Alfalfa seed is produced at the first or second harvest, depending on the climatic conditions of the year.

Photo 1. Pictures from the experimental field of ARDS Secuieni - mechanized harvesting

Average plant height (cm) was determined in the 100% flowering fenophase of alfalfa plants by measuring the height of the plants in the middle of each experimental plot.

The average number of racemes/shoot was determined by counting the racemes on 100 shoots from each experimental plot, then calculating the average value.

The average number of seeds/racema was determined by counting the seeds in the racemes of 10 shoots on each experimental plot, then calculating the average value.

Seed production ($kg \cdot ha^{-1}$) was determined by mechanized harvesting of each experimental plot, weighing seeds, and then reporting the amount of seeds to the surface unit.

The climatic conditions recorded in the 2019-2022 crop years were highly variable, and the

years studied were characterized as hot and very dry.

In terms of the temperatures recorded at the unit's own weather station, the studied agricultural years were characterized as atypical, warm years, registering deviations ranging from 1°C to 1.5°C from the multi-year average of 8.9°C (Figure 1).

In terms of precipitation, the analyzed period was characterized as dry, compared to the multiannual sum of 544.3 mm, the deviations recorded were 168.3 mm in the 2019/2020 agricultural year, 144.5 mm in the 2020/2021 agricultural year and 283.5 mm in the 2021/2022 agricultural year (Figure 2).

Research was carried out on the behavior of 17 varieties and synthetic varieties of alfalfa for sowing, all of them of autochthonous origin, created at National Institute for Agricultural Research and Development Fundulea, thus aiming to introduce in the culture of genotypes that show high adaptability to the conditions of ARDS Secuieni Neamț.

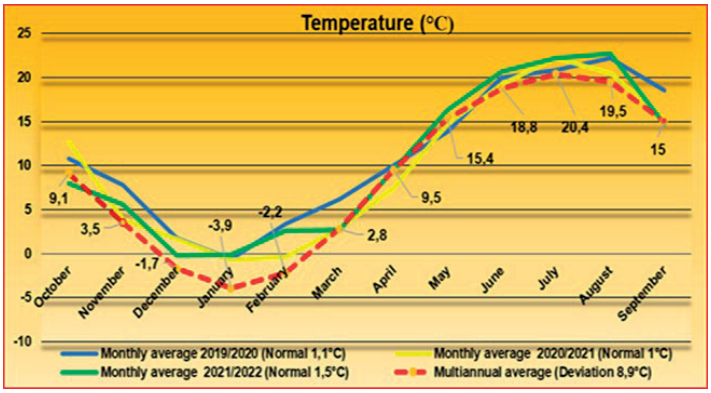

Figure 1 Monthly temperatures recorded at A.R.D.S. Secuieni, in the period 2019-2022

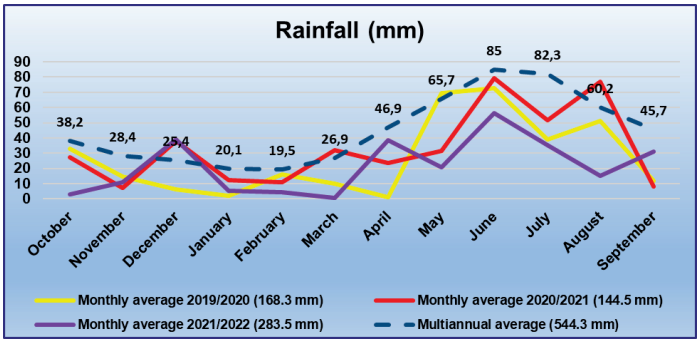

Figure 2. Monthly precipitation recorded at A.R.D.S. Secuieni, in the period 2019-2022

RESULTS AND DISCUSSIONS

In order to be able to characterize the studied varieties, a series of morpho-physiological determinations were made on the samples harvested in the experiment during the growing season.

As a result of the research carried out, on average over the three years studied (2020, 2021, 2022) it was observed that the average plant height ranged between 76.4 cm for the Catinca variety and 88.6 cm for the synthetic variety F 2909 - 1 - 20 (Table 1).

The average number of racemes per shoot ranged from 6.8 in the synthetic variety F 2814 - 19 to 16.5 in the synthetic variety F 2020 - 20, but the highest number of racemes per shoot was observed in the synthetic varieties F 2910 - 20 (15.4) and F 2020 - 20 (16.5).

The average number of seeds/raceme ranged from 14.5 for the synthetic variety F 2811 - 19 to 27.1 for Ileana.

Table 1. Biometric determinations of alfalfa (*Medicago sativa* L.), 2020-2022

No.	Varieties	Average plant height (cm)	Average number of racemes/shoot	Average number of seeds/raceme	Disease resistance*	Regeneration after mowing*
1	Catinca	76.4	9.6	18.6	1.5	3.51
2	Liliana	73.5	8.5	19.2	2.0	2.51
3	Pompilia	80.5	8.5	21.6	2.0	2.90
4	Ileana	81.0	10.6	27.1	1.5	1.53
5	F 2809 -19	81.8	13.7	26.8	1.0	2.31
6	F 2810 - 19	86.8	7.9	18.8	2.5	3.22
7	F 2811 - 19	85.5	10.7	14.5	1.0	254
8	F 2812 - 19	81.3	7.0	20.2	1.0	2.00
9	F 2814 - 19	78.8	6.8	21.9	2.5	2.59
10	F 2905 - 20	83.5	11.3	19.8	2.0	3.13
11	F 2906 - 20	79.3	11.8	16.7	1.0	2.58
12	F 2907 - 20	81.0	13.5	17.5	1.5	3.21
13	F 2908 - 20	79.3	7.8	19.2	1.0	2.54
14	F 2909 - 1 - 20	88.6	13.6	18.9	1.5	3.52
15	F 2909 - 2 - 20	78.3	10.7	19.0	1.5	2.57
16	F 2910 - 20	86.8	15.5	17.1	3.0	3.28
17	F 2020 - 20	88.3	16.5	18.6	2.0	3.51

*)Notes 1-9; 1 = very good, 9 = very poor.

Photo 2. Pictures from the experimental field of ARDS Secuieni - vegetation period

During the growing season, alfalfa was attacked by a complex of foliar diseases, thus the diseases alfalfa rust (*Uromyces striatus*) and alfalfa mealy bug (*Erysiphe pisi*) were identified. The disease resistance of the genotypes studied was scored on a 1-9 scale and values between 1 and 3 were recorded. From these data, the resistance of the analyzed genotypes under the conditions of Secuieni was determined.

From the data obtained, the regeneration after mowing was rated with scores ranging from 1.53 for the Ileana variety and 3.52 for the synthetic variety F 2909 - 1 - 20.

As for the correlation between the number of racemes per plant and the number of seeds in the raceme, in the three experimental years, it was observed that it was direct and the correlation coefficient (r) was statistically assured and interpreted as distinctly significant (Figure 3).

The thousand kernel mass values ranged widely by genotype from 1.61 g (Catinca) to 1.96 g (F 2907 - 20). The highest MMB values were 1.91, 1.92 g and 1.96 g, recorded in the synthetic varieties F 2909 - 2 - 20, F 2809 -19 and F 2907 - 20 (Figure 4).

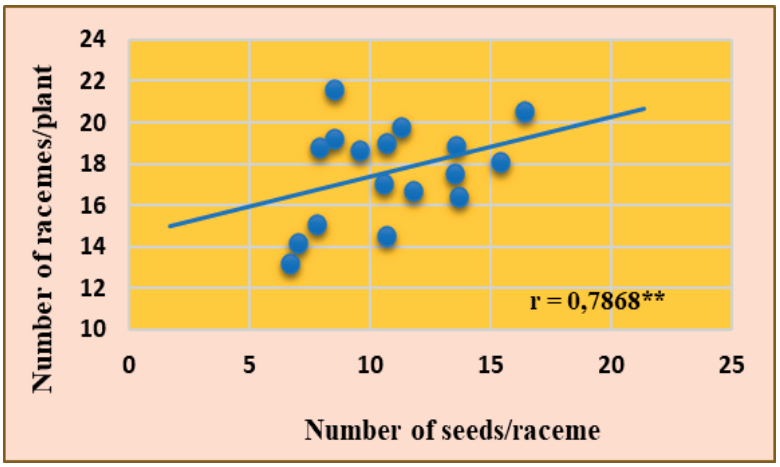

Figure 3. Correlation between number of racemes per plant and number of seeds per raceme

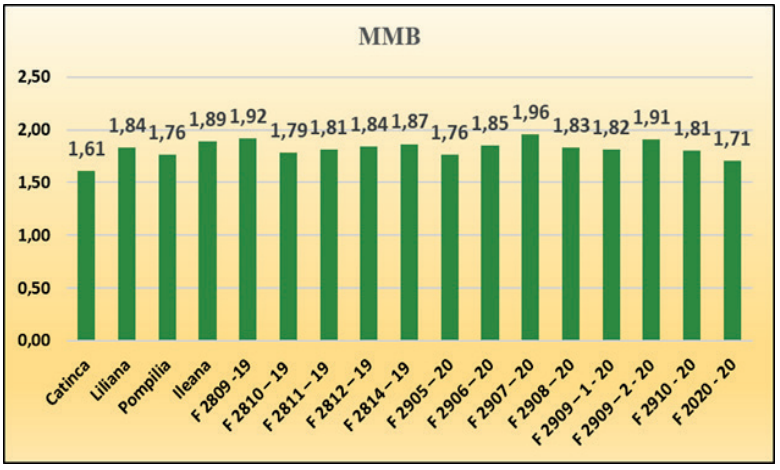

Figure 4. Weight of one thousand grains in the studied alfalfa genotypes

The experimental results obtained during the analyzed period indicate a significant difference in the production of the studied alfalfa varieties. Average alfalfa yields ranged from 416 kg/ha (synthetic variety F 2809-19) to 753 kg/ha (synthetic variety F 2907-20). Compared to the yield recorded in the control variant (mean of the experiment - 524 kg/ha), of the 17 alfalfa genotypes studied, very significant yield increases were recorded for the synthetic varieties F 2907-20, F 2910-20, and distinctly significant for Catinca and the synthetic varieties F 2905-20 and F 2906-20. The synthetic variety F 2809 - 19 with a very significant negative yield difference, the synthetic variety F 2810 - 19 with a distinctly significant negative yield difference, and the synthetic varieties Liliana and F 2811 - 19, F 2812 - 19, F 2909 - 1 - 20 and F 2020 - 20 with distinctly significant negative yields, were identified as having a lower adaptability to the conditions of the area (Table 2).

CONCLUSIONS

On average, during the three years of experimentation, the yields obtained from the 17 alfalfa genotypes tested at S.C.D.A. Secuieni, varied within very wide limits, from 416 kg/ha (F 2809 -19) to 753 kg/ha (F 2907 - 20).

Compared to the control (average of experience), very significant yield increases

Table 2. Production recorded for alfalfa varieties under soil and climatic conditions at ARDS Secuieni

Varieties	Average yield (kg·ha^{-1})	Relative output (%)	Diff. (kg/ha)	Significance
Catinca	584	111	60	**
Liliana	466	89	-58	o
Pompilia	546	104	22	-
Ileana	550	105	26	-
F 2809 -19	416	79	-108	ooo
F 2810 - 19	462	88	-62	oo
F 2811 - 19	465	89	-60	o
F 2812 - 19	482	92	-43	o
F 2814 - 19	555	106	31	-
F 2905 - 20	589	112	65	**
F 2906 - 20	587	112	62	**
F 2907 - 20	753	144	229	***
F 2908 - 20	553	105	29	-
F 2909 - 1 - 20	469	89	-55	o
F 2909 - 2 - 20	501	96	-23	-
F 2910 - 20	601	115	77	***
F 2020 - 20	478	91	-46	o
Average	524 ^{Control}	100	Control	-
LSD (kg/ha)	5% = 35; 1% = 63; 0.1% = 71			

were recorded for the synthetic varieties F 2910-20 and F 2907-20.

The highest plant height was recorded for the synthetic variety F 2909 - 1 - 20 (88.6 cm), the highest number of racemes per shoot was recorded for the synthetic varieties F 2910 - 20 (15.4) and F 2020 - 20 (16.5), and the average number of seeds/raceme ranged from 14.5 for the synthetic variety F 2811 - 19 to 27.1 for the synthetic variety Ileana.

Of the 17 alfalfa genotypes tested at ARDS Secuieni five showed a high adaptability to the pedo-climatic conditions without irrigation.

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