LITHUANIAN RESEARCH CENTRE FOR AGRICULTURE AND FORESTRY

2025 world alfalfa congress FRANCE-REIMS

Influence of mobile aluminium phytotoxicity on productivity of alfalfa genotypes in *Retisol*

Liatukienė Aurelija, Skuodienė Regina, Vida Danytė, Eglė Norkevičienė

Lithuanian Research Centre for Agriculture and Forestry, Instituto al. 1, Akademija, LT-58344 Kėdainiai distr., Lithuania

aurelija.liatukiene@lammc.lt

Introduction

Alfalfa is one of the most important forages crops due its excellent forage quality, high forage yield in a wide range of environments and high adaptability to different climatic conditions, and its capacity to fix nitrogen through symbiosis with rhizobia. Alfalfa varieties react differently to the growing environment factors such as soil characteristics, temperature and humidity.

The aim of this study was to evaluate the productivity traits of alfalfa on *Cambisol* and *Retisol*.

Materials and methods

The cultivars and populations of alfalfa were established in 2020 in two Lithuanian locations. The first experiment site was at the Vėžaičiai Branch and the second site was at the Institute of Agriculture of the Lithuanian Research Centre for Agriculture and Forestry. The cultivars and populations of alfalfa were evaluated during the study period of 2021–2024. The soil of experimental site I was *Bathygleyic Dystric Retisol* with pH_{KCl} ranged from 3.87–4.66 and mobile Al ranged from 2.07–95.00 mg kg^{-1}. The soil of experimental site II was *Endocalcari Epigleyic Cambisol* with pH_{KCl} 7.2–7.5. Agrochemical and physical properties of the soils at both sites were analysed prior to the establishment of the experiments and are presented in Table 1. The cultivars and populations of alfalfa of different origin were sown using a randomised block design with six replications to evaluate the productivity traits - the fresh and dry matter yields (FMY, DMY, t ha^{-1}), seed yield (SY, kg ha^{-1}), spring regrowth after wintering of plants (PHR, cm), plant height before flowering (PHF, cm), stem number (SN, m^2) and wintering (W, 1-9 score).

Table 1. Soil characteristics of experimental sites.

Pedological indices	Experimental site	
	Vėžaičiai Branch	Institute of Agriculture
Soil type	*Retisol*	*Cambisol*
Soil texture	Sandy light loam	Light loam
Sand, %	46.9±0.17	49.0±0.19
Silt, %	45.1±0.45	37.5±0.38
Clay, %	8.0±0.29	13.5±0.41
pH_{KCl}	3.87–4.66	7.2–7.5
Mobile Al, mg kg^{-1}	2.07–95.00	0.0
Mobile P_2O_5, mg kg^{-1}	118–195	176–224
Mobile K_2O, mg kg^{-1}	198–235	128–144
N_{total}, %	0.12–0.13	0.14–0.16

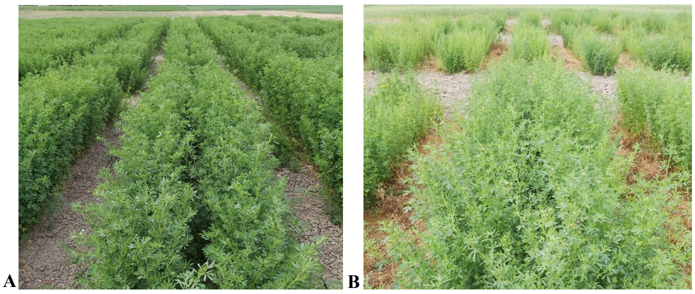

Figure 1. Cultivars and populations of alfalfa in *Cambisol* (A), and *Retisol* (B).

Table 2. Agro-biological traits of alfalfa in acidic soil, 2021–2024 (2020 sowing year)

Year	W (score)	PHR (cm)	PHF (cm)	DMY (t ha^{-1})	FMY (t ha^{-1})	SY (kg ha^{-1})	SN (m^2)
Mobile aluminium concentration 2.07–25.0 mg kg^{-1} (pH 4.22-4.66)							
2021 II	4.4a	25.0b	54.1a	4.8a	17.6b	276.3c	144.1a
2022 III	4.6a	34.0c	99.0c	4.8a	14.0ab	175.0b	215.9b
2023 IV	5.1b	18.1a	88.6b	3.4a	11.3a	47.5a	208.4b
2024 V	7.2c	21.9ab	101.3c	4.2a	15.5ab	–	210.3b
Mobile aluminium concentration 25.0–50.0 mg kg^{-1} (pH 4.02-4.34)							
2021 II	5.1a	19.0ab	51.8a	4.6b	17.0b	165.9b	114.2a
2022 III	4.9a	31.0c	88.1b	3.6ab	9.6a	119.0b	203.0b
2023 IV	5.6a	16.9a	81.7b	3.0a	9.8a	31.0a	199.8b
2024 V	7.2a	20.3b	91.9b	3.7ab	14.3b	–	195.5b
Mobile aluminium concentration 50.0-65.0 mg kg^{-1} (pH 3.96-4.26)							
2021 II	6.6a	18.4a	38.0a	1.5b	4.4b	41.0a	52.6a
2022 III	7.2ab	28.2b	81.4b	0.4a	1.2a	73.7b	114.2b
2023 IV	8.2b	–	–	–	–	–	–
2024 V	8.3b	–	–	–	–	–	–
Mobile aluminium concentration 65.0–95.0 mg kg^{-1} (pH 3.87-4.21)							
2021 II	8.2a	16.2	39.3	0.3	0.9	12.0	26.9
2022 III	8.6a	–	–	–	–	–	–
2023 IV	9.0a	–	–	–	–	–	–
2024 V	9.0a	–	–	–	–	–	–

Note: W–wintering, PHR–spring regrowth after wintering of plants, PHF–plant height before flowering, DMY–dry matter yield, FMY–fresh matter yield, SY–seed yield, SN–stem number, II, III, IV, V – the second, third, fourth and fifth year of growth.

Results

Changes in the agro-biological characteristics of alfalfa varieties and breeding material were influenced by the meteorological conditions of each year and the concentration of mobile aluminium, which increased steadily from 2.07 to 95.0 mg kg^{-1} in the experimental field. In the soil with a mobile Al concentration of 0.0–25.0 mg kg^{-1}, the wintering of alfalfa varieties and breeding material in the second and third years of growth was better compared to the fourth year of growth. The alfalfa grown in soil with a mobile Al concentration of 50.0–65.0 mg kg^{-1} showed poorer winter survival in the second year of growth. In soil with a mobile Al concentration of 65.0–95.0 mg kg^{-1}, the crops of alfalfa thinned out significantly after the first winter, with only a few plants remaining. The alfalfa plants grew taller and formed more stems in the third, fourth, and fifth years of growth compared to the second year of growth. The dry matter yield decreased consistently as the concentration of mobile aluminium in the soil increased. As, the crops of alfalfa aged, the dry matter yield was lower year after year as well. When the concentration of mobile Al in the soil was 0.0–25.0 mg kg^{-1}, the fresh matter yield was higher compared to a concentration of 25.0–50.0 mg kg^{-1} of mobile Al, 1.5 times higher in the third year of growth and 1.2 times higher in the fourth year of growth, as the crops of alfalfa were already thinned (Table 2). DMY and FMY of alfalfa genotypes were higher in *Cambisol* than in *Retisol* with mobile Al concentrations of 2.07–25.0 mg kg^{-1} – 8.6 times and 6.3 times, respectively, with 25.0–50.0 mg kg^{-1} – 12.5 times and 8.5 times, respectively. In *Cambisol*, SY and SN of alfalfa genotypes were higher than in *Retisol* with the 0.0–25.0 mg kg^{-1} concentration – 2.9 times and 3.7 times, respectively, with 25.0–50.0 mg kg^{-1} – 6.0 times and 4.3 times, respectively, with 50.0–65.0 mg kg^{-1} – 8.3 times and 7.8 times, respectively (Figure 2).

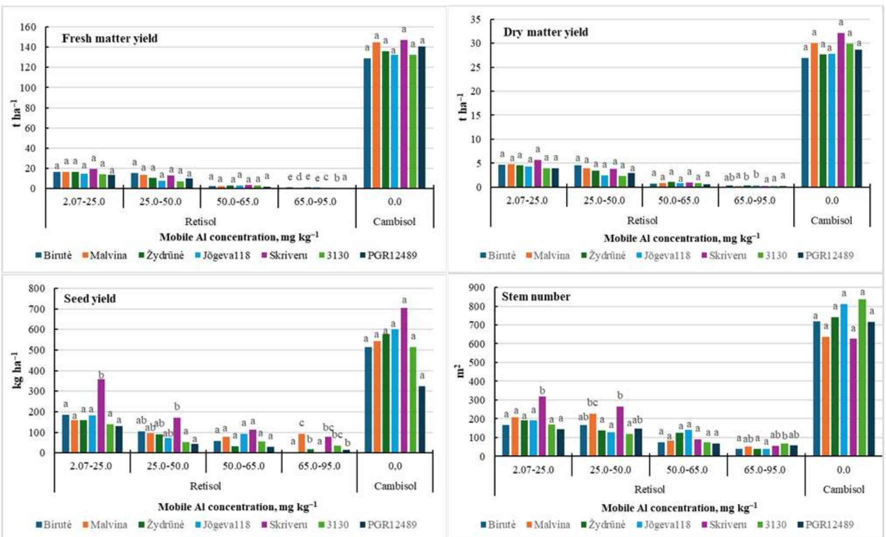

Figure 2. Productivity traits of alfalfa cultivars and populations in *Retisol* and *Cambisol*, 2021–2024.

Conclusion

The fresh matter, dry matter, and seed yields of the alfalfa cultivars and breeding material studied vary from year to year, depending on the pedoclimatic conditions in different regions of Lithuania. Lithuanian cultivars can also be grown in more acidic soils. The fresh matter, dry matter, and seed yields of the alfalfa cultivars and breeding material studied vary each year, depending on the pedoclimatic conditions in different regions of Lithuania. Lithuanian varieties can also be grown in more acidic soils. The results of the study also revealed that alfalfa cultivars and breeding material can grow and yield well in the soil with a mobile aluminium concentration of 0.0–25.0 mg kg^{-1}. The alfalfa varieties Birutė, Malvina, Žydrūnė, Jõgeva 118, Skriveru, PGR12489, and breeding material 3130 will be used for further research into the development of alfalfa varieties resistant to hydrogen and aluminium ions. Preliminary studies show that alfalfa varieties and breeding material can grow in the soil with a mobile Al concentration of up to 35.0–45.0 mg kg^{-1}. However, further research is needed to substantiate this claim.