PhD THESIS

The impact of soil type on morpho-productive traits in *Amaranthus* sp.

SUMMARY OF Ph.D THESIS

PhD student **Alexandru Mătieș**

Scientific coordinator **Professor Ioan Păcurar Ph.D.**

CONTENTS

1. General considerations concerning *Amaranthus sp.*

Plants belonging to the genus Amaranthus are annual or perennial herbaceous plants with a wide variation in height, from dwarf species to taller shrubs. They can have straight or branched stems, sometimes with a red or purple appearance (Matieș *et al*., 2023). Plants in the genus Amaranthus have a number of distinct morphological characteristics that make them easy to identify (BATLLA ET AL., 2000; BRAINARD ET AL., 200; YESHITILA ET AL., 2023).

2. The soil types and crops mainataining

Soil structure refers to how soil particles are arranged and linked together. The argic faecium is a type of soil characterized by the presence of a significant amount of clay in its composition, which gives it certain distinct qualities and characteristics. Albic Luvosol is a type of soil with distinct characteristics that can vary depending on the exact composition and specific environmental conditions. Little research is known on the influence of soil type on *Amaranthus* sp. crops. (AUFHAMMER ET AL., 1994; MATIEȘ ET AL., 2023; MATIEȘ ET AL., 2024; PACURAR, 1999).

3. Research objectives

The objectives pursued in the doctoral thesis refer to: testing the influence of the type of soil on the morpho-productive performances in the cultivation of *Amaranthus* sp., the evaluation of the productivity of green mass and seeds in the cultivation of *Amaranthus* sp. depending on the type of soil on which the crops are maintained, the qualitative study of the seeds from the cultivation of *Amaranthus* sp. depending on the type of soil on which the crops are maintained, as well as the comparative evaluation of the qualitative characteristics of the seeds from the cultivation of *Amaranthus* sp. depending on the type of soil on which the crops are maintained.

4. Environmental pecularities of the experimental site

The research was carried out in a private farm in the Someșului meadow, located in the area of Mireșu Mare commune (47º29′16″ N, 23º21′26″ E), Maramureș county. The main rivers that pass through Mireșu Mare commune are Someșul Mare, which flow in the eastern part of the commune, and the Tur river, which runs through the central area. Summers are moderate and winters are cold and long with the possibility of heavy snowfall. Precipitation is relatively evenly distributed throughout the year, favoring the development of agriculture. Winters are not extreme, but thermal inversions and late frosts are frequent (https://miresu-mare.ro/articles/prezentare).

5. Material and method

In order to test the influence of the type of soil on which the crops are installed in obtaining the different morpho-productive and qualitative cultivation performances belonging to Amaranthus sp., experimental protocols were put into practice in the years 2022 and 2023. The biological material under study is represented by six cultivation of *Amaranthus* sp., belonging to two species: Alegria, Amont, Golden, Mercado, Hopi Red Dye and Opopeo. The study was organized as a bifactorial experience, in which Factor A represents the cultivar (with seven gradations: a1: Control, a2: Alegria, a3: Amont, a4: Golden, a5: Mercado, a6: Hopy Red Dye and a7: Opopeo) , and Factor B is the type of soil (with two gradations: b1: argic faeosium, b2: albic luvosol). The combination of the two factors A and B resulted in 14 experimental variants organized in randomized blocks, each in two repetitions, with five plants/repetition. Fertilization was carried out with cattle manure in a dose of 20 t/ha, applied directly, by mixing with the soil, in the autumn of 2021 and 2022. No action against diseases and weeds was necessary. The content in nutrients and the total content in polyphenols in the seeds of *Amaranthus* sp. (Li *et al*., 2015; Șara & Odagiu, 2002). SPSS Statistics v28, STATISTICA v. 8.0 and XLSTAT Version 2022.2.1 were the programs used for statistical data processing. The Least Difference Test (LSD5%) was used to compare the morpho-productive and quantitative performances of cultivars of Amaranthus sp. studied, depending on the type of soil. Multiple regression analysis and multivariate analysis, through its components cluster analysis and principal component analysis (PCA) were implemented to highlight the complex interrelationships between fresh and dry biomass productions and the influence of morphological and quantitative traits on fresh and dry biomass productivities, depending on the type of soil.

6. Results and discussions

Results concerning the morpho-productive traits of the studied *Amaranthus* sp. studiate

The study of the multiple interrelationships between dry biomass production, plant height and number of leaves carried out for each of the six cultivars studied and also for the Control, under the conditions of maintaining the crops on albic luvosol, indicates that they are characterized by multiple correlations weak, weak to moderate and moderate (Table 6.22). In the case of cultivars Golden, Mercado, Hop Red Dye and

Opopeo, dry biomass production is moderately correlated with plant height and number of leaves (R = 0.397; R = 0.402; R = 0.400; R = 0.313). Weak to moderate multiple correlations are reported in the case of the cultivar Amont and in the case of the Martor (R = 0.236; R = 0.236), while in the case of the cultivar Alegria a weak multiple correlation is observed, equal to R = 0.155 (Tabelul 6.22).

Table6.21

The multiple regression analysis of dry biomass yield, plants heights and leaves number of varieties in *Amaranthus* sp. grown on argic phaeozem

Variety	Regression line	R	R^2	p
V1 – Martor	Y = 1002.021-0.074X1+0.387X2	0.355	0.126	0.811
V2 – Alegria	Y = 6312.343-0.223X1+0.264X2	0.265	0.070	0.956
V3 – Amont	Y = 7555.559-0.043X1+0.533X2	0.284	0.081	0.833
V4 – Golden	Y = 9167.051-0.153X1+0.465X2	0.435	0.189	0.865
V5 – Mercado	Y = 8476.946-0.154X1+0.526X2	0.465	0.216	0.713
V6 – Hopi Red Dye	Y = 9197.162-0.232X1+0.555X2	0.411	0.169	0.865
V7 – Opopeo	Y = 1001.021-0.031X1+0.387X2	0.376	0.141	0.822

Y – dry biomass yield, g/plantă/plant; X1 – plant height, cm; X2 – number of leavesş R – coefficient of multiple correlation; R^2 – oefficient of determination; p – probability.

Table 6.22

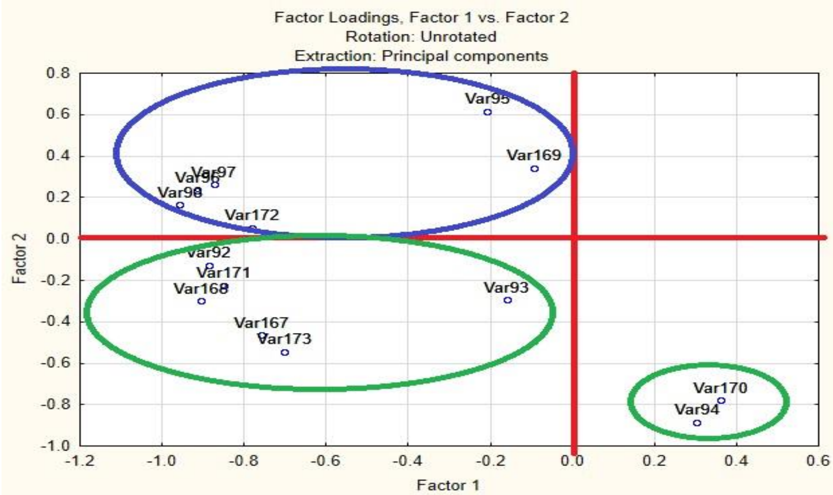
The multiple regression analysis of dry biomass yield, plants heights and leaves number of varieties in *Amaranthus* sp. grown on albic luvisol

Variety	Regression line	R	R^2	p
V1 – Martor/Control	Y = 1023.056-0.066X1+0.364X2	0.236	0.056	0.823
V2 – Alegria	Y = 6345.348-0.333X1+0.213X2	0.155	0.024	0.911
V3 – Amont	Y = 7436.556-0.083X1+0.535X2	0.236	0.056	0.861
V4 – Golden	Y = 9369.046-0.135X1+0.495X2	0.397	0.158	0.827
V5 – Mercado	Y = 8694.985-0.135X1+0.525X2	0.402	0.162	0.746
V6 – Hopi Red Dye	Y = 9037.125-0.252X1+0.584X2	0.400	0.160	0.839
V7 – Opopeo	Y = 1169.026-0.0148X1+0.385X2	0.313	0.098	0.762

Y – dry biomass yield, g/plantă/plant; X1 – plant height, cm; X2 – number of leavesş R – coefficient of multiple correlation; R^2 – oefficient of determination; p – probability.

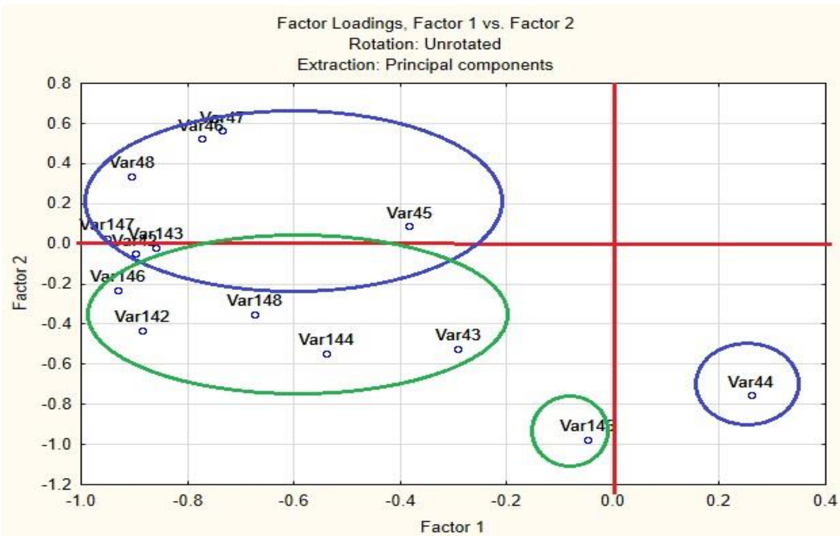
Results concerning the yields recorded in studied *Amaranthus* sp. varieties

Following the application of principal component analysis for the six cultivars of *Amaranthus* sp. and Control maintained on argic phaeosiom and albic luvosol, two main factors were identified, namely production (Factor 1) and cultivar (Factor 2). Factor 1, production, is responsible for 62.04% of the variance and Factor 2, Cultivator, for 37.96% of the variance (Fig. 6.5, Fig. 6.7). According to the dendrograms, seed yields, fresh mass and dry mass are grouped into two main clusters, A and B, respectively (Fig. 6.6 and Fig. 6.7). Cluster A groups the cultivars Alegria and Opopeo, which show a high degree of similarity and include the highest seed yields (fresh mass).



Var 92, 167-Control, Var 93, 168-Alegria, Var 94, 169-Amont, Var 95, 170-Golden, Var 96, 171-Mercado, Var 97, 172-Hopi Red Dye, Var 98, 173-Opopeo.

Figura 6.5. The biplot representation in projection plans PC1 x PC2 of dry biomass and dry grain yields (dry biomass), from varieties cultivated on phaeozem argic

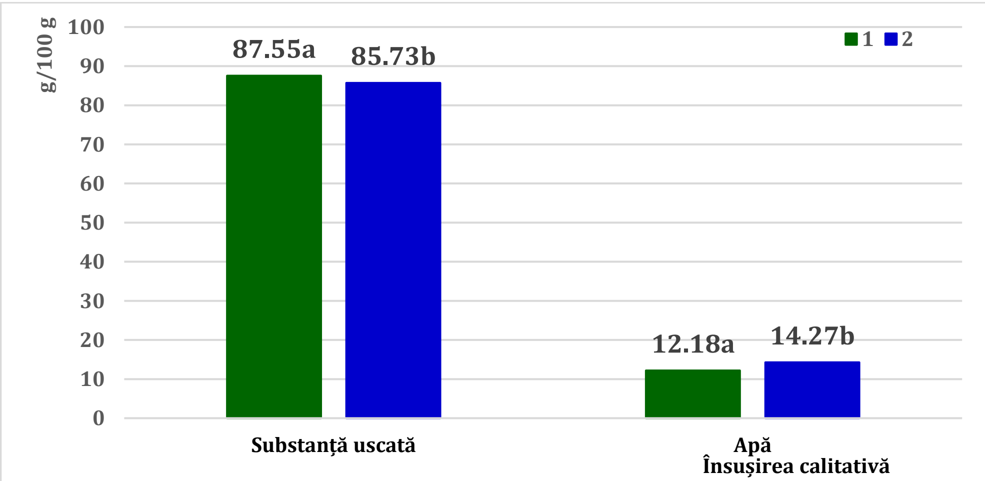


Var 42, 142- Control,, Var 43, 143-Alegria, Var 44, 144-Amont, Var 45, 145-Golden, Var 46, 146-Mercado, Var 47, 147-Hopi Red Dye, Var 48, 148-Opopeo.

Figure 6.7. The biplot representation in projection plans PC1 x PC2 of dry biomass and dry grain yields(dry biomass), from varieties cultivated on luvosol

Results concerning the qualitative study of the seeds from *Amaranthus* sp.

Comparative analysis of the dry matter content of Amaranthus sp. belonging to the six cultivars analyzed and the control, shows, according to the test of the smallest differences (LSD5%), the fact that, according to the values of the Fisher coefficient, on the set of cultivars the resulting averages differ significantly between the different cultivars, in the case of both types of soil on which crops were placed.



1 – Culture grwoth on phaeozem argic; 2 – Culture growth on luvisol albic; 1 – Dry matter: $LSD_{5\%}$ = 5,114, F = 7,691*; 2 – Dry matter: $LSD_{5\%}$ = 5,739, F = 8,596*; 1 – Moisture: $LSD_{5\%}$ = 4,999, F = 6,937*; 2 – Dry matter: $LSD_{5\%}$ = 5,912, F = 7,262*; the differences between any two variants are significant if their values are followed by different letters or gropup of letters.
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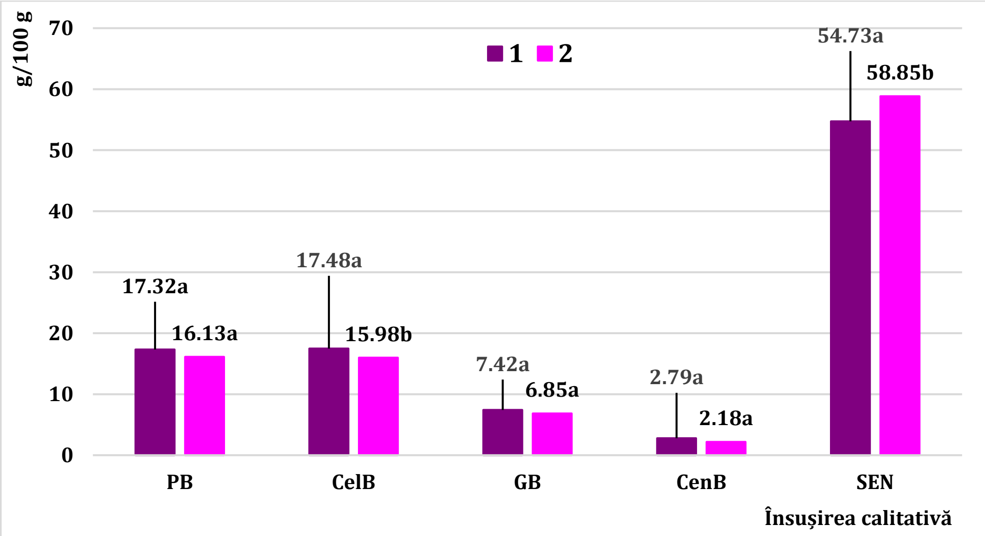
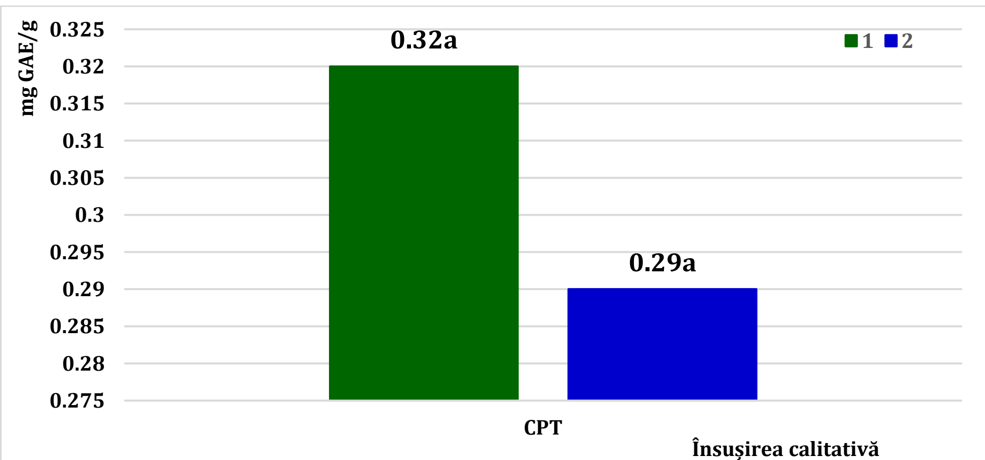
Figure 6.9. The dry matter and moisture content of *Amaranthus* sp. varieties and control growth on different types of soil

With regard to the nutrient content of the studied cultivars, maintained on the two types of soil, different developments are highlighted. The test of the smallest differences shows that in the case of crude protein, crude fat and crude ash contents, the resulting means do not differ significantly between the different cultivations, in the case of both types of soil on which the crops were placed (Fig. 6.10). Regarding the content in total polyphenols, there are no significant differences ($p > 0.05\%$) between the averages considered on the set of cultivars corresponding to each type of soil, they take values equal to 0.32 mg GAE/g in the case of the culture on argic phaeozoum and 20.9 mg GAE/g in the case of culture on albic luvosol. The Least Difference Test also indicates that the resulting means do not differ significantly between the different cultivars for both soil types on which the cultivars were placed (Fig. 6.11).



1 – Culture grwoth on phaeozem argic; 2 – Culture growth on luvisol albic; 1 – Crude protein, CP: $LSD_{5\%}$ = 4,999, F = $2,305^{ns}$; 2 – Crude protein, CP: $LSD_{5\%}$ = 5,611, F = $2,682^{ns}$; 1 – Crude fiber: $LSD_{5\%}$ = 5,631, F = 7,812*; 2 – Crude fiber, CF: $LSD_{5\%}$ = 5,428, F = 8,254; 1 – Crude fat, CFat: $LSD_{5\%}$ = 5,333, F = $2,922^{ns}$; 2 – Crude fat, CFat: $LSD_{5\%}$ = 6,085, F = $2,086^{ns}$; 1 – Crude ash, CA: $LSD_{5\%}$ = 6,588, F = $2,832^{ns}$; 2 – Crude ash, CA: $LSD_{5\%}$ = 5,159, F = $2,362^{ns}$; 1 – Nitrogen Free Extracts, NFE: $LSD_{5\%}$ = 3,514, F = 14,389**; 2 – Nitrogen Free Extracts, NFE: $LSD_{5\%}$ = 2,739, F = 15,821**; the differences between any two variants are significant if their values are followed by different letters or gropup of letters.

The nutritional content of *Amaranthus* sp. varieties and control growth on different types of soil



1 – Cultura întreținută pe faeoziom argic; 2 – Cultura întreținută pe luvosol albic; 1 – Conținutul în polifenoli totalii, CPT, TPC: $LSD_{5\%}$ = 5,369, F = $2,397^{ns}$; 2 – Conținutul în polifenoli totalii, CPT, TPC: $LSD_{5\%}$ = 5,935, F = $2,146^{ns}$; diferențele dintre oricare două variante sunt semnificative, dacă valorile lor sunt urmate de litere, sau grup de litere diferite.

Figure 6.11. Conținutul în polifenoli totali al cultivarelor de *Amaranthus* sp. și Martorului întreținute pe diferite tipuri de sol

7. Concluzii și recomandări

The study of the interrelationships analyzed provides a good perspective on the complexity of the relationships between the morphological characteristics and the productivity of the cultivars of *Amaranthus* sp. studied. For both soil types, plant height exerts a negative influence on dry biomass production (R_S = -0.245 corresponding to crops maintained on argic phaeozoum and R_S = -0.525 corresponding to crops maintained on albic luvosol), while the number of leaves positively influences production (R_S = 0.750 corresponding to cultures maintained on argic phaeosium and R_S = 0.625 corresponding to cultures maintained on albic luvosol). Multiple correlations between plant height, dry biomass production, and leaf number are generally weak to moderate, and in no case are they statistically significant. Crops grown on Argic Phaeozoum show stronger multiple correlations than those on Albic Luvosol, indicating a stronger association between plant height, dry biomass production and leaf number in this soil type.

Cluster analysis revealed distinct groupings of fresh and dry seed yields, indicating diversity and similarities between different cultivars. Regardless of the type of soil on which the crops are planted, two main clusters can be distinguished, one corresponding to the cultivars Alegria and Opopeo, with the highest productions of fresh seeds, and the other much more branched, subdivided into two subclusters corresponding to the productions of the other cultivars. Both cluster analysis and PCA show that the best dry seed productions correspond to cultivars Alegria and Mercado installed on argic phaeosium. These results suggest that these cultivars show the best adaptability to the conditions of maintenance of crops on argic phaeozoum compared to those of maintenance on albic luvosol.

The present study shows that soil type can influence the seed composition of *Amaranthus* sp., with some significant differences between crops grown on argic phaeozoum and those on albic Luvosol. However, essential nutrient values remain consistent in both soil types.

In the context of climate change and environmental concerns, it is important to promote sustainable agricultural practices. Selection and promotion of cultivars of *Amaranthus* sp. that adapt well to local conditions and soil needs can contribute to more sustainable agriculture and long-term food security.

The study highlights that some cultivars, such as Alegria and Mercado, showed superior adaptability to Argic phaeosiom soil type conditions. Continuing research to identify and develop cultivars with increased adaptability to different soil types may be useful for improving the yield and sustainability of *Amaranthus* sp. crops. Detailed studies on the nutritional composition and health benefits of seeds belonging to cultivars of *Amaranthus* sp. analyzed should continue to identify their full potential in nutrition and health promotion. This research could lead to new discoveries and innovations in food and health.

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