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Short Communication

Agro-technique studies on foliage and seed production of some *Amaranthus* cultivars from the Somesan Plateau, Romania

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The *Amaranthus* species are cultivated as "pseudo cereals" because of their high content of carbohydrates, proteins and fats, comparable or even superior to cereals. In this backdrop, the present study aims to test the vegetative development of *Amaranthus* cultivars, in order to integrate the research results with the agricultural technologies, adapted to the climatic conditions from Somesan Plateau. The cultivars tested were: Alegria, Amont, Pleisman, Golden, Mercado, Burgundi, Hopi Red Dye, Chihuahn, Opopeo, MT3 (parent material of the cultivar Amont), Plenitude and Intense Purpure. The results obtained in seed production of the *Amaranthus* cultivars shows very significant positive production of variants with densities of 100,000 plants/ha. Interaction of the cultivars of *Amaranthus* upon density is much more diversified on the yields obtained and shows in case of density 70,000 plants/ha superiority of the cultivars: Alegria, Amont, Golden and Plenitude, and in case of 100,000 plants/ha cultivars: Amont, Golden, Hopi Red Dye, Plenitude and Intense Purpure. Influence of variety of *Amaranthus* on biomass production shows the cultivars with the highest productivity as follows: Plenitude, Alegria, Amont, Intense Purpure. Influence of density on biomass productivity of *Amaranthus* is similar with the seeds productivity, namely 100,000 plants/ha provides very significant positive production compared with the average of the variants.

Keywords: *Amaranthus* cultivars, seed, biomass

Introduction

Genus Amaranthus contains about 60 species, but only a few cultivated, most are considered weeds. Species cultivated for seeds are (Marin et al., 2008; Law-Ogbomo and Ajayi, 2009): *Amaranthus hypochondriacus, Amaranthus cruentus* and *Amaranthus caudatus.* Species cultivated for leaves are: *Amaranthus tricolor, Amaranthus dubius, Amaranthus lividus, Amaranthus creuntus*, *Amaranthus palmeri* and *Amaranthus hybridus* were used by ancient populations in the southern U.S. *Amaranthus retroflexus* is considered one of the most common and dangerous weed.

Amaranthus are species with high value of proteins in seeds. The *Amaranthus* genotype species are cultivated as „pseudo cereals" because of their high content of carbohydrates, proteins and fats, comparable or even superior to cereals themselves (Rusu et al., 2009; Toader and Roman, 2009). The seed of *Amaranthus* has a high value in proteins (12-18%) and higher content of lysine. This high content in lysine makes *Amaranthus* to be used mainly in improving the biological value of processed food. Flour protein value of *Amaranthus* is enhanced when it is mixed with cereal flour. When flour of *Amaranthus* is mixed in a ratio of 30:70 with the rice, corn or wheat flour, protein quality (based on casein) increases from 72 to 90, 58 to 81, respectively from 32 to 50. Protein from *Amaranthus* differs from the grain by the fact that 65% is found in germ and 35% in the endosperm; 15% protein is found in germ and 85% in the endosperm of cereals. *Amaranthus* are annual plants that prefer a warm / temperate climate and multiply by self-

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Table 1. Seeds production of *Amaranthus* cultivars obtained on Stagnic argic phaeozem in Cluj Napoca, 2008-2009

Variant	Production (kg/ha)	Production (%)	Difference (±)	Significance of differences
Witness (average)	2,530.36	100	0	Witness
V_1 - Alegria	2,425.83 c	95.9	-104.53	000
V_2 - Amont	2,670.17 j	105.5	139.81	***
V_3 - Pleisman	2,497.17 g	98.7	-33.19	000
V_4 - Golden	2,727.17 k	107.8	196.81	***
V_5 - Mercado	2,411.00 b	95.3	-119.36	000
V_6 - Burgundi	2,511.00 h	99.2	-19.36	000
V_7 - Hopi Red Dye	2,549.33 i	100.7	18.97	***
V_8 - Chihuahan	2,472.83 d	97.7	-57.53	000
V_9 - Opopeo	2,488.83 f	98.4	-41.53	000
V_{10} - MT3	2,404.17 a	95.0	-126.19	000
V_{11} - Plenitude	2,727.00 k	107.8	196.64	***
V_{12} - Intense Purpure	2,479.83 e	98.0	-50.53	000

LSD 5%= 6.77 kg/ha, LSD 1% = 9.22 kg/ha, LSD 0.1% = 12.40 kg/ha
* signification positives, ^{0} signification negatives
a, b, c……j, k – classification by Duncan test

pollination. There are a variety of species. Some have the characteristic to tolerate drought, which makes them in semi-arid areas, and some species in irrigated areas, as an alternative for farmers that are trying to reduce the cost of irrigation and soil salinization.

Researches conducted currently focuses in three directions: germplasm conservation and utilization, developed and improved technological lines and an increased awareness regarding the qualities of this plant.

Materials and Methods

Testing of 12 cultivars of *Amaranthus* for the purpose of their integration in the agricultural technologies of Somesan Plateau, was done on stagnic argic phaeozem, in the following climatic conditions: annual precipitations value of 523 mm and annual average temperature of 9.4℃. Stagnic argic phaeozem (SRTS, 2003) from the experimental field is loam clay / clay loam soil (45.7 / 55.7% clay), weak acidic (pH 6.02 to 6.42), rich in humus (3.27 to 4.33%) and nutrients. Varieties tested are:

Alegria (*Amaranthus cruenthus)*
Amont (*Amaranthus cruenthus*)
Pleisman (*Amaranthus hypochondriacus x Amaranthus hybridus*)
Golden (*Amaranthus hypochondriacus*)
Mercado (*Amaranthus hypochondriacus*)
Burgundi (*Amaranthus hypochondriacus*)
Hopi Red Dye (*Amaranthus hypochondriacus*)
Chihuahan (*Amaranthus cruenthus*)
Opopeo (*Amaranthus hypochondriacus*)
MT3 (*Amaranthus cruenthus,* parent material of the cultivar Amont)
Plenitude (*Amaranthus hypochondriacus*)
Intense Purpure (*Amaranthus hypochondriacus*)

The study aims to test the vegetative development of *Amaranthus*, in order to integrate it in the agricultural technologies, adaptated to climatic conditions from Somesan Plateau. Determinations followed the vegetative development of the plants every 15 days, number of leaves, green biomass and seed production. Varieties were cultivated in two types of density: D_1 = 70,000 harvestable plants/ha, D_2 = 100,000 harvestable plants/ha, in 3 repetitions, and the experimental plot size was 210 m^2. It was sown at 0.5 cm depth; distance between rows being 70 cm, experimental data processing was done by ANOVA and Duncan test (Polifact, 2010).

Results and Discussion

Vegetative development of *Amaranthus* cultivars determined every 15 days show an increase in height, in terms of Cluj-Napoca, approximately 85-99 centimeters, the increase being faster in the first part of the vegetation. Number of leaves per plant reaches, an average, at harvest from 24 to 30 leaves. Green biomass at harvest is 197-317 grams per plant. Related traits were determined in bloom and seed maturity, considering that 50% of seed maturity is achieved after 15 September.

Statistical processing of the results concerning the seed production shows the influence of the cultivated variety on the obtained yields. Influence of variety of *Amaranthus* cultivars on the obtained seed production is shown in Table 1. Duncan Test rank first cultivars: Golden, Plenitude and Amont, indicating that yields are the average of densities, so they are smaller than varieties productions grown in D_2. The average of 2,530.36 kg/ha, shows very significant positive production for all varieties at density of 100,000 plants/ha, except the cultivars Alegria (with positive differences between 193.97 to 581.31 kg/ha). Multiple comparison of variants show the productivity order of the interactions, the most productive being: Golden x D_2, Plenitude x D_2 and Amont x D_2.

Variance analysis for factor density shows very distinct

Table 2. Influence of density of *Amaranthus* cultivars on seeds production obtained on Stagnic argic phaeozem in Cluj-Napoca, 2008-2009

Variant	Production (kg/ha)	Production (%)	Difference (±)	Significance of differences
Witness (average)	2,530.36	100	0	Witness
D_1, 70,000 plants/ha	2,223.33 a	87.9	-307.03	000
D_2, 100,000 plants/ha	2,837.39 b	112.1	307.03	***

LSD 5%= 2.35 kg/ha, LSD 1% = 3.19 kg/ha, LSD 0.1% = 4.28 kg/ha
* signification positives, ^{0} signification negatives
a, b – classification by Duncan test

Table 3. Biomass production of *Amaranthus* cultivars obtained on Stagnic argic phaeozem in Cluj-Napoca, 2008-2009

Variant	Production (kg/ha)	Production (%)	Difference (±)	Significance of differences
Witness (average)	22,668.26	100	0	Witness
V_1 - Alegria	25,988.67 e	114.6	3,320.40	***
V_2 - Amont	25,720.17 e	113.5	3,051.90	***
V_3 - Pleisman	16,743.5 a	73.9	-5,924.76	000
V_4 - Golden	20,899.83 bc	92.2	-1,768.43	0
V_5 - Mercado	19,453.17 b	85.8	-3,215.10	000
V_6 - Burgundi	22,153 cd	97.7	-515.26	ns
V_7 - Hopi Red Dye	22,673.33 d	100	5.07	ns
V_8 - Chihuahan	22,707.5 d	100.2	39.24	ns
V_9 - Opopeo	22,855.5 d	100.8	187.24	ns
V_{10} - MT3	20,559.17 b	90.7	-2,109.10	00
V_{11} - Plenitude	26,859.33 e	118.5	4,191.07	***
V_{12} - Intense Purpure	25,406 e	112.1	2,737.74	***

LSD 5%= 1,412.41 kg/ha, LSD 1% = 1,924.41 kg/ha, LSD 0.1% = 2,586.01 kg/ha
ns – not significant, * signification positives, ^{0} signification negatives
a, b...d, e – classification by Duncan test

significantly positive differences for all variants for D_2 (100,000 plants/ha, table 2), positive differences being 307.03 kg/ha. Multiple processing with Duncan test classifies density variants in the following order: D_2, D_1.

Interaction of density variants on productivity of *Amaranthus* cultivars varieties, show for all variants higher production values and positive significance for D_2 variants, compared with the witness - average. Processing with Duncan test classify variants: D_2 x Golden, D_2 x Plenitude, D_2 x Amont, D_2 x Hopi Red Dye etc.

Interaction variety of *Amaranthus* cultivars, upon density is much more diverse, as influence on the obtained yields and shows, at density D_1 (70,000 plants/ha) superiority of the cultivars: Alegria, Amont, Golden and Plenitude, and at D_2 (100,000 plants/ha) cultivars: Amont, Golden, Hopi Red Dye and Intende Purpure.

Influence of variety of *Amaranthus* cultivars on the biomass production is shown in Table 3, variants with the highest productivity being (e): Plenitude, Alegria, Amont, Intense purpure, production averages are between 25,406 to 26,859.33 kg/ha. The results obtained in biomass production of Amaranthus sp., through the interaction between variety and density, compared to the average experience of 22,668.26 kg/ha, variants classified by Duncan test first, are as follows: Plenitude x D_2, Amont x D_2, Alegria x D_2, Intense Purpure x D_2 (j), with biomass production between 29,847.33 to 31,503.67 kg/ha.

Influence of density (Table 4) on biomass productivity of *Amaranthus* cultivars is similar with the seeds productivity, namely, D_2 (100,000 plants/ha) provides very significant positive production compared with the average of the variants.

The interaction density × cultivars and cultivars x density interaction show similar situations with the results of seeds production. Thus in terms of density, the best combinations (k) are: D_2 x Plenitude, D_2 x Alegria, D_2 x Amont, D_2 x Intense Purpure, which at the same time shows that at D_1 best results are: Alegria, Amont, Golden and Plenitude, and at D_2 the best results are: Amont,

Table 4. Influence of density of *Amaranthus* cultivars upon biomass production obtained on Stagnic argic phaeozem in Cluj-Napoca, 2008-2009

Variant	Production (kg/ha)	Production (%)	Difference (±)	Significance of differences
Witness (average)	22,668.26	100	0	Witness
D_1, 70000 pl/ha	18,832.61 b	83.1	-3,835.65	000
D_2, 100000 pl/ha	26,503.92 a	116.9	3,835.65	***

LSD 5%= 583.31 kg/ha, LSD 1% = 792.85 kg/ha, LSD 0.1% = 1,061.85 kg/ha
* signification positives, ^{0} signification negatives
a, b – classification by Duncan test

Golden, Hopi Red Dye, Plenitude and Intense Purpure.

Conclusions

Results obtained in seeds production of *Amaranthus* cultivars shows an average of 2,530.36 kg/ha, ascertaining very significant positive production of variants with densities of 100,000 plants/ha. Interaction of density variants on productivity variants of *Amaranthus* cultivars is classified by the Duncan test as follows: D_2 x Golden, D_2 x Plenitude, D_2 x Amont, D_2 x Hopi Red Dye etc. Interaction of the variety of *Amaranthus* cultivars upon density is much more diversified on the yields obtained and shows in case of density D_1 (70,000 plants/ha) superiority of the cultivars: Alegria, Amont, Golden and Plenitude, and in case of D_2 (100,000 plants/ha) cultivars: Amont, Golden, Hopi Red Dye, Plenitude and Intense Purpure. Comparison of multiple variants show the productivity order of the variants, the most productive being: Golden x D_2, Plenitude x D_2 and Amont x D_2.

The results obtained in biomass production of *Amaranthus* cultivars towards the average experience of 22,668.26 kg/ha, yields classified by Duncan test, first place are: Plenitude x D_2, Amont x D_2, Alegria x D_2, Plenitude x D_2 (j), with biomass production between 29,847.33 and 31,503.67 kg/ha. Influence of *Amaranthus* cultivars on biomass production shows the variants with the highest productivity as follows (e): Plenitude, Alegria, Amont, Intense Purpure, average productions are between 25,406 and 26,859.33 kg/ha. Influence of density on biomass productivity of *Amaranthus* cultivars is similar with the seeds productivity, namely D_2 (100,000 plants/ha) provides very significant positive production compared with the average of the variants. The interaction density × cultivars and cultivars x density interaction show similar situations with the results of seeds production. Thus, in terms of density, the best combinations (k) are: D_2 x Plenitude, D_2 x Alegria, D_2 x Amont, D_2 x Intense Purpure. At the same time it was found that at D_1 the best results are at: Plenitude, Alegria, Amont and Intense Purpure, and at D_2 the best results are at: Plenitude, Alegria, Amont and Intense Purpure.

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