

DENSITY INFLUENCE ON PLANT GROWTH AND PRODUCTION OF SOME MANGOLD VARIETIES

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Abstract: Mangold (*Beta vulgaris* ssp. *cicla* L.) is cultivated for leaf petiole but can also be consumed in different dishes. It is called petiole beetroot and leafy beet, since this species is mainly consumed for these vegetative parts either for human nutrition, cooked different ways or for animal feed (depreciated leaves, with no commercial appearance). Mangold is a plant cultivated less than other vegetables in the group green vegetables (lettuce, spinach), but with the same importance as other green vegetables. It is considered a vegetable with a vital impact in healthy nutrition due to the rich content of leaves in nutrients, especially vitamin A, vitamin C, vitamin E, folic acid, calcium, iron and dietary fiber.

Experience was carried out in 2018, in a vegetable microfarm, in the locality of Săcueni, Bihor County, favorable for the cultivation of the mangold due to the specific pedoclimatic conditions. Three cultivars of mangold have been studied, which have been cultivated in the field at different densities and the objectives were to follow plant growth and production.

Keywords: mangold, cultivar, density, plant growth, production

INTRODUCTION

Mangold is part of *Beta* genus, *Chenopodiaceae* family, which includes several species: sugar beet (*Beta vulgaris* L., var. *saccharata*), feed beet (*Beta vulgaris* L., var. *rapacea* subvar. *crassa*), beet for petiole and leaves (*Beta vulgaris* L., ssp. *cicla*) and red beet (*Beta vulgaris* L., var. *conditiva*, f. *rubra* Alef.), (Cristea, 2014). Chard or mangold beet (*Beta vulgaris* L., ssp. *vulgaris* (sin. ssp. *cycla*), convar. *vulgaris*, var. *flavescens* DC., is grown for whole leaves or only for petiole which is pleasant to taste, tender and succulent (Ciofu et al., 2004).

In Romania, is a less cultivated species, present in some areas of Transylvania. Being a species with lower requirements for temperature can be cultivated in all areas, except mountain areas. It has resistance to high temperatures (over 35°C), thus being for the southern areas a great summer vegetable (Lagunovschi-Luchian and Vânătoru, 2016).

Leaves of mangold can be a good choice for a healthy diet because they do not contain cholesterol and are naturally low in calories and sodium. Increasing the consumption of leaf vegetables reduces body weight, reduces cholesterol and blood pressure and helps slow absorption of carbohydrates in the blood, which reduces the risk of cardiovascular disease and type 2 diabetes (Rana, 2016).

Leaves petiole is white in most varieties but there are varieties of petiole colored in different shades of red, yellow-orange or violet, which also have a distinctive decorative aspect (Apahidean and Apahidean, 2000, Cristea, 2014).

Mangold has a special economic importance being cultivated since ancient times. It is spread on all continents, on large surfaces, allowing for a significant harvest of over 40 t/ha. Culture is quite affordable, price varies depending on the cost of seeds, herbicides,

fertilizers, pest and pest control agents, and the use of labor for technological works (Ciofu et al., 2004).

Culture is established by sowing directly in the field, in spring from second decade of April. Depending on the period we want to sell it, sowing can take place until July 15th. However, spring crop production may be double compared to autumn culture (Kolota et al., 2010). It is ready to be harvested after 60-70 days after crop establishment due to its characteristic short period of vegetation.

MATERIALS AND METHODS

Experience was carried out in 2018, being located in a vegetable microfarm, in Săcueni village, Bihor County, in the western part of Romania. Average monthly multiannual temperature in experimental area has positive values from February (0.3°C), then reaches 5.0°C in March, at 10.5°C in April, and in May 15.8°C. Average annual temperature is 8-10 °C. In 2018, the precipitation value was 636 mm compared to the multiannual average (1880-2018) which is 580 mm. Soil on which the experience was placed was alluvial.

Purpose of the experience was to determine how some mangold cultivars, cultivated in the field at different densities, behave in conventional culture system.

Three varieties of mangold were used in the experience (*Carde Blanche Ampuis*, *Lucullus*, *Couleurs Rainbow*) cultivated at different densities: 41.6 thousand plants/ha (0.60 m x 0.40 m), 55.5 thousand plants/ha (0.60 m x 0.30 m) and 83.3 thousand plants/ha (0.60 m x 0.20 m), resulting in 9 variants that were placed in four rehearsals.

Carde Blanche d'Ampuis is a variety that has leaf petioles with a width of 10-12 cm, white in color. It is a rustic variety, of special quality, with leaves in a vertical position, with dark green leaves.

Lucullus is a kind of mangold that forms well-developed petioles of medium length, white, leaves are dark green with white veins, harvested after about 60 days after emergence, is resistant to high temperatures during the summer.

Couleurs Rainbow is a variety of chard with well-developed red-orange petioles. Leaves are lightly embossed with orange red ribbons, which ensures an ornamental appearance of the plants. It is adapted to a warm climate, harvested after at least 45 days after emergence.

Experience was placed in the field and was set up by direct sowing in last decade of April on a properly prepared land (fertilized from autumn with 40 t/ha semi-compound manure). After emergence, thinning was done, at distances of 40 cm, 30 cm and 20 cm respectively, to achieve the densities proposed by experimental protocol, then the usual maintenance work was carried out. Leaves harvesting began in July and lasted until November, with six harvests.

Observations on plant growth, plant height, leaf rosette diameter, leaf length, leaf/plant number, petiole length and thickness at plant base, and production were made at each variant.

RESULTS AND DISCUSSIONS

After 60 days from emergence it was found that height of mangold plants was influenced by the cultivar used as well as by the number of plants per unit area and was

between 40.33 cm and 59.00 cm (Table 1). Smallest plant size, after 60 days of emergence, was recorded at Carde Blanche Ampuis variety, at which plants had between 40.33 cm and 55.50 cm, depending on density used. Plant height was higher for Couleurs Rainbow variety, where the height was between 44.66 cm and 59.00 cm. Compared to average height of the 9 experimental variants, which was 50.36 cm, Couleurs Rainbow variety at a density of 41.6 thousand plants/ha exceeded average value by 17.15%, the difference being significant. Higher values of plant heights were also recorded for Carde Blanche Ampuis and Lucullus varieties, cultivated at a density of 41.6 thousand plants/ha, differences compared to average being distinctly significant or significant.

Table 1

Influence of cultivar and plant density on plant height
after 60 days from emergence

Variant		Plant height		± d cm	Difference significance
Cultivar	Density thousand plants/ha	cm	%		
Carde Blanche Ampuis	41.6	55.50	110.42	5.14	x
	55.5	47.00	93.32	-3.36	o
	83.3	40.33	80.08	-10.03	ooo
Lucullus	41.6	57.00	113.18	6.64	xx
	55.5	53.16	105.55	2.80	-
	83.3	47.66	94.63	-2.70	-
Couleurs Rainbow	41.6	59.00	117.15	8.64	xxx
	55.5	49.00	97.30	-1.36	-
	83.3	44.66	88.68	-5.70	oo
Average		50.36	100.00	-	-

DL (P 5 %)

2.95

DL (P 1 %)

4.37

DL (P 0.1 %)

6.82

Degree of leaf petiole development after 60 days of plant emergence was influenced by experimental factors as shown in Table 2. Petioles length was on average 60 days after emergence of 13.90 cm, being between 10.37 cm and 20.52 cm and thickness of petioles averaging 2.69 cm, with variations between 1.94 cm and 3.56 cm. In all varieties leaf petiole was better developed at a density of 41.6 thousand plants/ha.

Table 2

Cultivar and plant growth influence upon mangold petiole development,
60 days after emergence

Variant		Petiole length		Petiole thickness	
Cultivar	Density thousand plants/ha	cm	%	cm	%
Carde Blanche Ampuis	41.6	15.42	110.93	3.56	132.34
	55.5	13.40	96.40	3.24	120.44
	83.3	12.28	98.34	1.94	72.12

Lucullus	41.6	12.31	88.56	3.12	115.98
	55.5	11.87	85.39	2.79	103.71
	83.3	10.37	74.60	2.30	85.50
Couleurs Rainbow	41.6	20.52	147.62	3.51	130.48
	55.5	14.97	107.69	2.75	102.23
	83.3	13.27	100.50	2.03	75.46
Average		13.90	100.00	2.69	100.00

Table 3

Cultivar and plant density influence upon mangold leaf characters
after 60 days from emergence

Variant		Leaf rosette diameter		Leaf length		No. of leaf/plant	
Cultivar	Density thousand plants/ha	cm	%	cm	%	pieces	%
Carde Blanche Ampuis	41.6	87.00	113.80	45.17	97.66	10.50	131.74
	55.5	60.16	80.79	38.27	82.74	10.33	129.61
	83.3	56.83	74.32	38.54	83.33	7.66	96.11
Lucullus	41.6	101.00	132.09	50.54	109.37	7.00	87.82
	55.5	82.00	107.24	49.25	106.48	6.50	81.55
	83.3	63.00	82.39	44.65	96.54	6.50	81.55
Couleurs Rainbow	41.6	97.16	127.07	54.85	118.59	8.33	104.51
	55.5	75.50	98.74	48.03	103.84	8.66	108.65
	83.3	65.50	85.66	44.97	97.23	6.33	71.42
Average		76.46	100.00	46.25	100.00	7.97	100.00

After 60 days of emergence, development of mangold leaves (rosette diameter, length of leaves, average leaf/plant number) was different, depending on cultivar and distances between plants (Table 3). Thus, leaf rosette diameter had an average of 76.86 cm, 60 days after emergence, with variations of 56.83 cm (Carde Blanche Ampuis at the density of 83.3 thousand plants/ha) and 101.00 cm (Lucullus, at a density of 41.6 thousand plants/ha).

Leaf length after 60 days of emergence was on average 46.25 cm, with values ranging from 38.27 cm (Carde Blanche Ampuis, at a density of 55.5 thousand plants/ha) and 54.85 cm (Couleurs Rainbow, at a density of 41.6 thousand plants/ha). Average leaf/plant number was 7.97 pieces, ranging from 6.33 at Couleurs Rainbow, cultivated at a density of 83.3 thousand plants/ha and 10.50 at Carde Blanche Ampuis variety grown at 41.6 thousand plants/ha (Table 3).

In 2018, mangold was harvested 6 times, as shown in Table 4. First harvest took place on 16.07.2018 and last harvest on 17.11.2018. Generally, in all harvests production volume was higher at the level of 41.6 thousand pl/ha and 55.5 thousand plants/ha. At maximum density of 83.3 thousand plants/ha, production volume was lower at all three cultivars. Maximum volume of harvested production was recorded in August when two harvests took place in contrast to July, September, October and November, when only one harvest was carried out. P Production dynamics was better for all varieties, for variants with a density of 55.5 thousand plants/ha.

Table 4

Cultivar and plant growth influence on production dynamics of mangold (kg/m²)

Variant		Harvesting period						Total production
Cultivar	Density thousand plants/ha	16. VII	1. VIII	20. VIII	19. IX	25. X	17. XI	
Carde	41.6	3.10	4.72	5.12	6.83	4.10	2.85	26.52
Blanche Ampuis	55.5	5.62	7.65	7.38	10.10	7.88	5.22	43.85
Ampuis	83.3	3.21	4.07	3.46	3.26	3.15	3.07	20.40
Lucullus	41.6	6.46	6.53	4.73	5.60	3.03	3.62	29.97
	55.5	7.47	7.25	7.06	8.49	5.70	4.83	40.80
	83.3	5.79	4.44	3.63	3.10	2.92	2.81	22.69
Couleurs Rainbow	41.6	6.17	6.50	5.81	5.93	6.97	6.50	38.88
	55.5	8.61	7.33	8.98	10.22	8.25	4.00	47.39
	83.3	3.10	4.36	3.63	4.90	3.53	2.62	22.14

Analyzing the unilateral influence of the cultivar on the harvested leaf yield, it was found that production was 30.25 kg/m² at Carde Blanche Ampuis variety and 36.14 kg/m² at Couleurs Rainbow variety (Table 5). Couleurs Rainbow variety recorded a production increase of 11.16%, compared to experience average, production difference recorded (3.63 kg/m²) being significant. Carde Blanche Ampuis and Lucullus varieties had lower yields compared experience average, differences of production being not significant.

Table 5

Unilateral influence of cultivar on mangold production

Cultivar	Production		± d kg/m ²	Difference significance
	kg/m ²	%		
Carde Blanche Ampuis	30.25	93.05	-1.90	-
Lucullus	31.15	95.81	-1.36	-
Couleurs Rainbow	36.14	111.16	3.63	x
Average	32.51	100.00	-	-

DL (P 5 %) 2.38

DL (P 1 %) 3.75

DL (P 0.1 %) 5.12

Table 6

Unilateral influence of plant density on mangold production

Density thousand plants/ha	Production		± d kg/m ²	Difference significance
	kg/m ²	%		
41.6	31.79	97.78	-0.72	-
55.5	44.01	135.37	11.50	xxx
83.3	21.74	66.87	-10.77	ooo
Average	32.51	100.00	-	-

DL (P 5 %) 3.65

DL (P 1 %) 5.23

DL (P 0.1 %) 7.86

From analysis of the unilateral influence of practiced densities in experimental culture, result was that the production was 21.74 kg/m² at a density of 83.3 thousand plants/ha and 44.01 kg/m² at a density of 55.5 thousand plants/ha (Table 6). At a density of 55.5 thousand plants/ha, production was 35.37% above average, the difference in production of 11.50 kg/m² being very significant. At a density of 41.6 thousand plants/ha, production was 31.79 kg/m², difference from average being not statistically assured. At a density of 83.3 thousand plants/ha, production accounted for only 66.87% of the average and the production difference was very significantly negative.

Mangold production was influenced by both factors, variety and number of plants at the surface unit (Table 7). Total production was between 20.40 kg/m² recorded at Carde Blanche Ampuis variety, cultivated with 83.3 thousand plants/ha and 47.39 kg/m² at Couleurs Rainbow variety, at a density of 55.5 thousand plants/ha. All varieties achieved maximum yields at the density of 55.5 thousand plants/ha, with a production increase of 30.97% to 44.95%, production differences being very significant. At the density of 83.3 thousand plants/ha, yields were lower, production differences being very significantly negative, respectively distinctly significant.

Table 7
Combined influence of cultivar and plant density upon production of mangold

Variant		Production		± d kg/m ²	Difference significance
Cultivar	Density thousand plants/ha	kg/m ²	%		
Carde Blanche Ampuis	41.6	26.52	86.67	-3.73	-
	55.5	43.85	144.95	13.60	xxx
	83.3	20.40	67.43	-9.85	ooo
	Average	30.25	100.00	-	-
Lucullus	41.6	29.97	96.21	-1.18	-
	55.5	40.80	130.97	9.65	xxx
	83.3	22.69	72.84	-8.45	oo
	Average	31.15	100.00	-	-
Couleurs Rainbow	41.6	38.88	107.58	2.74	-
	55.5	47.39	131.12	11.25	xxx
	83.3	22.14	61.26	14.00	ooo
	Average	36.14	100.00	-	-

DL (P 5 %) 3.82

DL (P 1 %) 5.47

DL (P 0.1 %) 8.54

CONCLUSIONS

Based on results obtained from the field mangold research, under the specific conditions in West of Romania, using Carde Blanche d'Ampuis, Lucullus and Couleurs Rainbow varieties, cultivated at different densities, the following conclusions were drawn:

- After 60 days of emergence, it was found that the height of the mangold plants was influenced by the cultivar used as well as by plants number at surface unit;

- Petioles length was on average, 60 days after emergence, of 13.90 cm, ranging from 10.37 cm to 20.52 cm and petioles thickness averaged 2.69 cm. At all varieties the leaf petiole was better developed at a density of 41.6 thousand plants/ha;
- Maximum volume of harvested production was recorded in August when two harvests took place, compared to July, September, October and November, when only one harvest was carried out. Production dynamics was better for all varieties, for variants with a density of 55.5 thousand plants/ha
- All varieties achieved maximum yields at the density of 55.5 thousand plants/ha with production increase ranging from 30.97% to 44.95%.

REFERENCES

1. Apahidean Al. S. and M. Apahidean. (2000). Legumicultură specială-Vol.I, Ed.Risoprint, Cluj-Napoca.
2. Ciofu R., N. Stan, V. Popescu, P. Chilom, S. Apahidean, A. Horgoș, V. Berar, K.F. Lauer, N. Atanasiu. (2003). Tratat de Legumicultură, Ed.Ceres, București.
3. Cristea V. (2014). Plante vasculare-diversitate, sistematică, ecologie și importanță, Presa Universitară Clujeană.
4. Kolota E., K. Adamczewska-Sowinska, K. Czerniak. (2010). Yield and Nutritional Value of Swiss Chard Grown for Summer and Autumn Harvest, Journal of Agricultural Science, Vol.2, No.4, 120-124.
5. Lagunovschi-Luchian V., C. Vinătoru. (2016). Legumicultură, Ed.ALPHA MDN, Buzău.
6. Rana M.K.. (2016). Salad crops: Stem-type crops, Encyclopedia of Food and Health, 684–688.