Scientific Papers. Series A. Agronomy, Vol. LXVII, No. 2, 2024
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE INFLUENCE OF ORGANIC AND MINERAL FERTILIZATION ON SUGAR BEET CULTURE IN COVASNA COUNTY

Bianca-Ana Maria POPA, Mircea MIHALACHE

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: popa.bianca22@yahoo.com

Abstract

Sugar beet is a species whose importance contradicts the current situation of its cultivation at the national level, namely its increasingly low presence in the crop. The crop technology and the increased attention that the plant needs during the vegetation period, transform the sugar beet crop into a `niche` crop. The work is based on the analysis of the data obtained in the agricultural year 2022-2023 following the establishment of an experimental sugar beet field trial. After fertilizing the variants with the established doses of organic, mineral, or organo-mineral fertilizers, different morphological characters were analyzed, such as the plant length, plant diameter, the length of the parcel, the diameter of the parcel, the weight of the plant, but also the main elements of production, such as the percentage content of sugar, root production per hectare and total sugar content/ha.

Key words*: sugar beet, area, sugar production, correlations, technology.*

INTRODUCTION

Beta vulgaris is a member of the *Chenopodiaceae* and, like many others in the family is a halophyte. It is a highly variable species containing four main groups of agricultural significance: leaf beets (such as Swiss chard), garden beets (such as beetroot), fodder beets (including mangolds), and sugar beet. The storage organ of the sugar-beet plant is usually called the root, although only about 90% is root-derived, the upper 10% (the crown) being derived from the hypocotyl (Elliott et al., 1993).

Sugar beet is a recent crop developed solely to extract the sweetener, sucrose. Breeding and improvement of *Beta vulgaris* for sugar has a rich historical record. Sugar beet originated from fodder beet in the 1800s, and selection increased its sugar content from 4 to 6% to over 18% today. The development of vegetable beets-namely table beet and leaf beet (chard)-predates the creation of sugar beet. Each of these likely shares a common ancestor in the wild relative *B. vulgaris* spp. *maritima*. Beets of all crop types share common disease pressures. Germplasm for breeding and improvement, mostly for disease resistance, is accessible from each of the crop types and wild relatives, as there are no barriers to sexual hybridization. All cultivated types are biennial, with a basic chromosome number of 9, and most new cultivars are diploid. Most sugar beets are hybrids, facilitated by a complex system of cytoplasmic male sterility - CMS (Bohra et al., 2016). Hybrids are typically monogerm, which reduces the labour required for thinning. Genomics and molecular markers are rapidly improving our understanding of the genetic characters controlling sugar beet phenotypes, particularly concerning bolting. Such understanding may allow an expansion of the range of sugar beet cultivation and may help improve yield through earlier planting. Developing beets for new uses, as an energy resource, and for bio-based industrial feedstock, for instance, may further expand the range of beet production for human uses (McGrath et al., 2018).

Mechanical harvest and cleaning of sugar beet, followed by transport, often result in substantial root tip breakage and surface damage through mechanical impact (Gorzelany et al., 2003). The extent of damages from topping or defoliation and root tip breakage highly depends on the harvester settings, and therefore, on the driver (Hoffmann et al., 2018a). In addition to the yield loss through damage, it has been shown that the sugar loss during beet storage is influenced mostly by the amount of damage (Hoffmann & Schnepel, 2016). Furthermore, this and other

observations suggest, that the damage susceptibility depends on the sugar beet variety (van Swaaij et al. 2003; Hoffmann et al., 2018b). This can probably be attributed to the stability of the root tissue.

The importance of fertilizing with mineral fertilizers lies in the fact that they intensify physiological processes such as: breathing, transpiration, opening of stomata and photosynthesis. At the same time, mineral fertilizers increase the osmotic pressure and the suction force. They cause a stronger growth of the aerial parts of the sugar beet, especially those based on nitrogen.

It is considered that manure is a complex and inexpensive fertilizer that is available to many sugar beet growers. The application of manure for the sugar beet crop is very beneficial due to the maximum production increases it achieves.

The study's objective is finding the most suitable fertilization method, exclusively mineral, organic or organo-mineral, for the sugar beet crop.

MATERIALS AND METHODS

The research was carried out in Covasna county, Zăbala village, in a demonstration plot of 1.5 ha. Three sugar beet hybrids were taken into study namely: Darvas, Deseda and Tatry and different doses of organic, mineral, or organo-mineral fertilizer were applied, as follows: 20 t/ha manure, 20 t/ha manure + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K, 10 t/ha manure, 10 t/ha manure + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K, only mineral fertilization with 150 kg/ha N + 150 kg/ha P + 150 kg/ha K and the control (unfertilized) (Table 1).

Table 1. The experimental factors

Fertilizer/ Hybrid	a1: DARVAS	a2: DESEDA	a3: TATRY
b1: 20 t manure/ ha	a1b1	a2b1	a3b1
b2: 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K	a1b2	a2b2	a3b2
b3: 10 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K	a1b3	a2b3	a3b3
b4: 10 t manure/ ha	a1b4	a2b4	a3b4
b5: 150 kg/ha N + 150 kg/ha P + 150 kg/ha K	a1b5	a2b5	a3b5
b6: control (unfertilized)	a1b6	a2b6	a3b6

The climatic conditions of the area can be characterised by an average annual temperature of 10.64°C, and 500-600 mm/year precipitations.

The soil on which the experiment was located showed a pH value of 6.13, being classified as acidic soil. Low values were identified for Potassium (K), Phosphorus (P), Calcium (Ca), Magnesium (Mg), and Zinc (Zn), normal values for Nitrogen (N), Sodium (Na), Manganese (Mn), and Boron (B) and high values were identified for Iron (Fe) and Copper (Cu).

To assess the efficiency of mineral and organic fertilizers, the variants are compared with the control (unfertilized).

The variants were placed systematically, in four repetitions. The hybrids were sown on May 13, 2023, and harvested on November 13, 2023. The preceding crop was maize. The sowing was carried out mechanized, at a distance of 45 cm between rows and a density of 90,000 germinable seeds/ha.

Darvas hybrid is a new, robust hybrid with a high tolerance to foliar diseases but also to drought.

Deseda hybrid provides high sugar production, high productivity per hectare and excellent tolerance to *Cercospora*.

Tatry hybrid promises a high sugar content, above the usual root yield, with a high juice purity coefficient and a high tolerance to beet Cercosporiosis and abiotic stress.

The morphological characteristics and production elements measurements were carried out in the sugar beet laboratory within the National Research and Development Institute for Potato and Sugar Beet, Braşov.

RESULTS AND DISCUSSIONS

Plant length (cm)

Darvas hybrid fertilized with 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K (a1b2) had the highest length, with a value of 29.50 cm in the second repetition. At the variant level, the best average was recorded for Tatry fertilized with 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K, i.e 27.08 cm, 28.26% above the lowest average recorded for the a3b6 (Tatry control variant) (Table 2).

Table 2. Plant length (cm)

	R1	R2	R3	R4	Average
a1b1	24.00	25.70	21.40	23.20	23.58
a1b2	22.00	29.50	23.70	26.40	25.40
a1b3	21.00	29.00	22.30	24.80	24.28
a1b4	21.80	24.50	22.40	23.10	22.95
a1b5	20.00	20.90	26.30	22.10	22.33
a1b6	20.00	20.60	17.20	18.10	18.98
Average a1	21.47	25.03	22.22	22.95	22.92
a2b1	26.20	23.00	24.10	22.70	24.00
a2b2	23.50	26.40	27.10	25.90	25.73
a2b3	19.80	27.50	21.40	22.30	22.75
a2b4	21.00	19.00	21.20	20.40	20.40
a2b5	18.40	16.50	16.20	17.10	17.05
a2b6	17.20	14.40	14.00	15.60	15.30
Average a2	21.02	21.13	20.67	20.67	20.87
a3b1	24.00	28.40	25.90	26.30	26.15
a3b2	28.50	25.80	27.10	26.90	27.08
a3b3	26.50	23.50	22.80	25.10	24.48
a3b4	24.00	20.60	21.30	22.10	22.00
a3b5	26.50	21.50	23.30	23.40	23.68
a3b6	19.50	20.40	18.20	20.00	19.53
Average a3	24.83	23.37	23.10	23.97	23.82
Average	22.44	23.18	21.99	22.53	22.54

Plant diameter (cm)

The highest value for plant diameter was registered for Deseda variant fertilized with 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K, i.e 10.70 cm and in the second repetition. At the average level, the best value/ variant was recorded at Tatry variant fertilized with 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K, i.e 10.18 cm, 25.54% above the lowest average value recorded at a3b6 (Tatry control variant) (Table 3).

Table 3. Plant diameter (cm)

	R1	R2	R3	R4	Average
a1b1	10.40	9.70	10.10	9.80	10.00
a1b2	8.80	8.70	8.60	8.70	8.70
a1b3	8.30	10.00	9.60	8.80	9.18
a1b4	9.10	9.70	9.00	9.20	9.25
a1b5	6.80	7.40	7.60	7.30	7.28
a1b6	6.40	5.70	6.20	6.00	6.08
Average a1	8.30	8.53	8.52	8.30	8.41
a2b1	9.10	8.80	8.80	9.00	8.93
a2b2	8.60	10.70	9.40	10.20	9.73
a2b3	9.00	8.90	9.10	9.20	9.05
a2b4	7.50	7.60	7.80	7.70	7.65
a2b5	8.10	6.60	8.00	6.60	7.33
a2b6	7.80	7.90	6.80	7.80	7.58
Average a2	8.35	8.42	8.32	8.42	8.38
a3b1	9.80	8.20	9.20	9.10	9.08
a3b2	10.50	9.80	10.30	10.10	10.18
a3b3	9.00	8.60	8.90	8.50	8.75
a3b4	9.80	8.50	9.20	9.40	9.23
a3b5	8.80	8.20	8.00	8.00	8.25
a3b6	8.30	7.00	7.60	7.40	7.58
Average a3	9.37	8.38	8.87	8.75	8.84
Average	8.67	8.44	8.57	8.49	8.55

Neck length (cm)

The recorded average values for the neck length were between 2.48 cm at a1b6 (Darvas control variant) and 4.58 cm at Darvas variant fertilized with 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K. The difference between the maximum and the minimum average values was45.84% (Table 4).

Table 4. Neck length (cm)

	R1	R2	R3	R4	Average
a1b1	4.00	4.50	4.80	4.60	4.48
a1b2	3.90	4.80	4.90	4.70	4.58
a1b3	3.00	5.30	4.20	4.10	4.15
a1b4	4.00	3.20	4.20	3.80	3.80
a1b5	3.20	2.40	3.10	2.70	2.85
a1b6	2.10	2.60	2.40	2.80	2.48
Average a1	3.37	3.80	3.93	3.78	3.72
a2b1	2.90	2.80	2.30	2.70	2.68
a2b2	2.90	3.50	3.10	3.00	3.13
a2b3	3.50	3.00	2.80	2.90	3.05
a2b4	2.00	2.30	2.90	2.60	2.45
a2b5	2.70	2.80	2.50	2.50	2.63
a2b6	2.20	3.60	2.10	2.30	2.55
Average a2	2.70	3.00	2.62	2.67	2.75
a3b1	3.60	4.20	3.80	3.90	3.88
a3b2	4.50	3.90	4.10	4.10	4.15
a3b3	3.80	3.50	3.00	3.30	3.40
a3b4	3.00	3.10	3.00	3.20	3.08
a3b5	4.00	3.70	3.10	3.50	3.58
a3b6	3.00	2.40	2.70	2.90	2.75
Average a3	3.65	3.47	3.28	3.48	3.47
Average	3.24	3.42	3.28	3.31	3.31

Neck diameter (cm)

Regarding the neck diameter, in the Tatry variant fertilized with 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K was registered the highest value of 5.90 cm, in the second repetition. The best average value at the variant level was recorded for Tatry variant fertilized with 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K, i.e 5.53 cm, 47.55% above the lowest average value recorded for a1b6 (Darvas control variant) (Table 5).

Table 5. Neck diameter (cm)

	R1	R2	R3	R4	Average
a1b1	5.20	5.30	5.60	5.10	5.30
a1b2	5.60	5.20	5.80	5.40	5.50
a1b3	5.20	4.80	5.30	5.10	5.10
a1b4	4.10	5.00	4.50	4.60	4.55
a1b5	4.10	3.80	3.90	4.00	3.95
a1b6	3.10	2.90	2.70	2.90	2.90
Average a1	4.55	4.50	4.63	4.52	4.55
a2b1	4.40	4.60	4.90	4.70	4.65
a2b2	4.60	4.70	5.10	5.00	4.85
a2b3	4.30	4.80	4.20	4.50	4.45
a2b4	3.40	3.60	3.70	3.60	3.58

a2b5	3.70	3.70	3.90	3.90	3.80
a2b6	3.00	3.10	3.10	3.20	3.10
Average a2	3.90	4.08	4.15	4.15	4.07
a3b1	4.80	4.70	4.40	4.70	4.65
a3b2	5.30	5.90	5.40	5.50	5.53
a3b3	4.50	5.10	4.80	4.30	4.68
a3b4	4.70	4.10	4.10	4.30	4.30
a3b5	4.10	4.30	3.90	4.00	4.08
a3b6	3.80	3.40	3.90	3.60	3.68
Average a3	4.53	4.58	4.42	4.40	4.48
Average	4.33	4.39	4.40	4.36	4.37

Plant weight (g)

The plant weight recorded the highest value for Darvas variant fertilized with 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K variant, i.e. 1341.21 g, in the fourth repetition. At the average level, the best value/variant was recorded at Darvas variant fertilized with 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K, namely 1,318.20 g, 77.08% above the lowest average value recorded at a1b6 (Darvas control variant) (Table 6).

Table 6. Plant weight (g)

	R1	R2	R3	R4	Average
a1b1	1021.60	1292.20	1274.30	1185.30	1193.35
a1b2	1361.40	1239.50	1330.70	1341.21	1318.20
a1b3	908.30	626.10	821.60	863.74	804.94
a1b4	731.50	775.10	698.20	726.31	732.78
a1b5	533.10	486.70	465.50	520.64	501.49
a1b6	317.80	226.00	302.50	362.12	302.11
Average a1	812.28	774.27	815.47	833.22	808.81
a2b1	835.50	820.00	877.30	852.66	846.37
a2b2	942.80	1078.80	1110.40	1123.52	1063.88
a2b3	796.50	691.30	772.20	718.49	744.62
a2b4	561.80	541.50	469.30	522.37	523.74
a2b5	494.40	450.40	478.80	487.87	477.87
a2b6	499.30	481.90	420.10	440.27	460.39
Average a2	688.38	677.32	688.02	690.86	686.15
a3b1	1040.00	1116.80	865.30	1002.02	1006.03
a3b2	994.10	1284.70	1129.10	1098.45	1126.59
a3b3	905.50	884.60	901.20	896.35	896.91
a3b4	828.60	784.30	809.90	799.42	805.56
a3b5	622.80	699.30	774.20	710.87	701.79
a3b6	521.70	584.60	503.20	543.91	538.35
Average a3	818.78	892.38	830.48	841.84	845.87
Average	773.15	781.32	777.99	788.64	780.28

Sugar content (%)

Regarding the sugar content, the variant with the best value registered was Tatry fertilized with 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K, i.e 18.408%, in the first repetition. The best average at the variant level was recorded for Tatry fertilized with 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K variant, namely 18.270%, 23.21% above the lowest average value recorded for a1b6 (Darvas control variant) (Table 7).

Table 7. Sugar content (%)

	R1	R2	R3	R4	Average
a1b1	17.196	16.988	17.022	16.952	17.04
a1b2	17.386	17.402	17.320	17.296	17.351
a1b3	16.690	16.503	16.466	16.557	16.554
a1b4	16.404	16.200	16.112	16.331	16.262
a1b5	15.346	15.236	15.047	15.029	15.165
a1b6	14.086	14.021	13.866	14.140	14.028
Average a1	16.185	16.058	15.972	16.051	16.067
a2b1	18.114	18.033	18.102	18.023	18.068
a2b2	17.450	17.384	17.416	17.295	17.386
a2b3	16.630	16.694	16.273	16.334	16.483
a2b4	15.566	15.403	15.742	15.648	15.590
a2b5	15.136	15.016	14.981	15.084	15.054
a2b6	14.144	13.921	14.069	14.032	14.042
Average a2	16.173	16.075	16.097	16.069	16.104
a3b1	17.512	17.436	17.220	17.361	17.382
a3b2	18.408	18.347	18.112	18.214	18.270
a3b3	17.200	17.416	17.118	17.374	17.277
a3b4	16.224	16.339	16.347	16.263	16.293
a3b5	15.316	15.441	15.130	15.120	15.252
a3b6	14.784	14.226	14.297	14.343	14.413
Average a3	16.574	16.534	16.371	16.446	16.493
Average	16.311	16.223	16.147	16.189	16.217

Root production (t/ha)

The production of roots (t/ha) recorded average values between 49.25 t/ha at Tatry control variant and 60.05 t/ha at Tatry fertilized with 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K. The difference between the maximum and minimum average was of 17.98% (Table 8).

Table 8. Root production (t/ha)

	R1	R2	R3	R4	Average
a1b1	58.40	59.30	54.70	59.10	57.88
a1b2	60.70	60.10	59.30	57.60	59.43
a1b3	54.30	52.60	55.10	58.90	55.23
a1b4	52.80	53.10	52.40	52.50	52.70
a1b5	50.20	51.30	53.30	52.70	51.88
a1b6	49.60	48.90	50.10	48.70	49.33
Average a1	54.33	54.22	54.15	54.92	54.40
a2b1	59.70	59.30	58.00	50.20	56.80
a2b2	59.90	60.30	58.70	59.80	59.68
a2b3	56.80	58.10	57.80	54.90	56.90
a2b4	54.60	53.70	53.10	52.90	53.58
a2b5	52.30	52.80	51.60	52.00	52.18
a2b6	50.30	51.40	50.80	50.70	50.80
Average a2	55.60	55.93	55.00	53.42	54.99
a3b1	59.10	58.70	58.40	58.90	58.78
a3b2	60.60	59.50	60.20	59.90	60.05
a3b3	58.40	57.30	58.60	58.40	58.18
a3b4	54.60	52.90	53.80	54.20	53.88
a3b5	53.80	52.40	51.30	53.20	52.68
a3b6	49.30	47.20	51.30	49.20	49.25
Average a3	55.97	54.67	55.60	55.63	55.47
Average	55.30	54.94	54.92	54.66	54.95

Sugar production (t/ha)

Sugar production is strongly influenced by all previously analyzed characteristics, and results from the sugar content percentage and the root production of the plot. The highest average sugar production was recorded at Tatry fertilized with 20 t manure/ ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K variant, with a value of 10.971 t/ha of sugar, and the lowest average value was recorded at Darvas control variant (a1b6), i.e. 6.919 t/ha of sugar. The difference between the maximum and minimum average value was of 36.93% (Table 9)

Table 9. Sugar production (t/ha)

	R1	R2	R3	R4	Average
a1b1	10.04	10.07	9.31	10.02	9.86
a1b2	10.55	10.46	10.27	9.96	10.31
a1b3	9.06	8.68	9.07	9.75	9.14
a1b4	8.66	8.60	8.44	8.57	8.57
a1b5	7.70	7.82	8.02	7.92	7.87
a1b6	6.99	6.86	6.95	6.87	6.92
Average a1	8.84	8.75	8.68	8.85	8.78
a2b1	10.81	10.69	10.50	9.05	10.26
a2b2	10.45	10.48	10.22	10.34	10.38
a2b3	9.45	9.70	9.41	8.97	9.38
a2b4	8.50	8.27	8.36	8.28	8.35
a2b5	7.92	7.93	7.73	7.84	7.86
a2b6	7.11	7.16	7.15	7.11	7.13
Average a2	9.04	9.04	8.89	8.60	8.89
a3b1	10.35	10.24	10.06	10.23	10.22
a3b2	11.16	10.92	10.90	10.91	10.97
a3b3	10.05	9.98	10.03	10.15	10.05
a3b4	8.86	8.64	8.79	8.82	8.78
a3b5	8.240	8.091	7.762	8.044	8.034
a3b6	7.29	6.72	7.33	7.06	7.10
Average a3	9.32	9.09	9.15	9.20	9.19
Average	9.06	8.96	8.91	8.88	8.95

CONCLUSIONS

Following the measurements, Darvas (a1b2), Deseda (a2b2) and Tatry (a3b2) variants registered the highest values, being fertilized with 20 t manure/ha + 150 kg/ha N + 150 kg/ha P + 150 kg/ha K.

The importance of mineral fertilization is related to the intensification of the physiological processes such as: breathing, transpiration, stomata opening and photosynthesis.

The importance of organic fertilization results from the fact that manure is a complex and inexpensive fertilizer that is available to many sugar beet growers. The application of manure for the sugar beet crop is very beneficial through the maximum production increases, as long as it is administered in optimal quantities and periods.

The combination of the two types of fertilizers leads to the harmonious development of the plant and to superior production and sugar content values than individual fertilizations, only with mineral fertilizers or only with organic fertilizers.

In conclusion, sugar beet is an intensive, very profitable crop, that efficiently capitalizes on fertilization, soil, or irrigation water, and is also a good preceding plant for most crops.

ACKNOWLEDGEMENTS

This research work was carried out with the support of the University of Agronomic Sciences and Veterinary Medicine Bucharest and The National Research and Development Institute for Potato and Sugar Beet, Braşov.

REFERENCES

Bohra, A., Jha, U. C., Adhimoolam, P., Bisht, D., & Singh, N. P. (2016). Cytoplasmic male sterility (CMS) in hybrid breeding in field crops. *Plant Cell Reports*, *35*, 967-993.

Elliott, M.C., & Weston, G.D. (1993). Biology and physiology of the sugar-beet plant. In: *The sugar beet crop* (pp. 37-66). Dordrecht: Springer Netherlands.

Gorzelany, J., & Puchalski, C. (2000). Mechanical properties of sugar beet roots during harvest and storage. *International Agrophysics*, *14*(2).

Hoffmann, C. M., Engelhardt, M., Gallmeier, M., Gruber, M., Märländer, B. (2018a). Importance of harvesting system and variety for storage losses of sugar beet. In: *Sugar Ind*. 143 (8), S. 474–484. DOI: 10.36961/si19782.

Hoffmann, C.M., Leijdekkers, M., Ekelöf, J., & Vancutsem, F. (2018). Patterns for improved storability of sugar beet–importance of marc content and damage susceptibility of varieties in different environments. *European Journal of Agronomy*, *101*, 30-37.

McGrath, J. M., & Panella, L. (2018). Sugar beet breeding. *Plant breeding reviews*, *42*, 167-218.

Schnepel, K., & Hoffmann, C.M. (2016). Genotypic differences in storage losses of sugar beet–causes and indirect criteria for selection. *Plant breeding*, *135*(1), 130-137.

Van SwaijJ, A. M., Van der Linden, J. P., & Vandergeten, J. P. (2003). Effect of growth conditions and variety on damage susceptibility of sugarbeet. *Zuckerindustrie*, *128*(12), 888-891.