USE OF SOIL AMENDMENTS - IMPORTANT MEASURE TO INCREASE YIELD IN SUGAR BEET

BĂRDAŞ MARIUS[1], ŞIMON ALINA[2], RUSSU FLORIN[3], CHEȚAN FELICIA[4],CECLAN OVIDIU ADRIAN[4]

AGRICULTURAL RESEARCH-DEVELOPMENT STATION TURDA, 27 AGRICULTURII STREET, TURDA, 401100, ROMÂNIA[1,2,3,4]

Corresponding author e-mail: maralys84@yahoo.com

Abstract:

The research where executed in 2021, at the Turda Agricultural Development Research Station, using the Vangelis sugar beet cultivar and followed the influence of Terracalco [95] soil amendments on physiological parameters and production at different stages of crop development. The granular soil amendment was applied in two doses of 500 and 1000 kg/ha^{-1}, during the vegetation period (beginning of root formation, 75 days after emergence, 105 days after emergence and 135 days after emergence), quantifying certain physiological parameters. Physiological parameters were monitored with the CIRAS-3 foliar gas analyzer, simultaneously determining: reference carbon dioxide (CO2r- µmolm-s^{-1}), assimilation (A- µmol m^{-2}s^{-1}), transpiration rate (E- mmolm^{-2}s^{-1}), leaf water deficit (VPD- kPa) and leaf temperature (Tfr. ^{o}C). By applying the granulated soil amendment, the absorption of nutrients is maximized, in most cases stimulating the analyzed physiological parameters, obtaining in the variant that applied 1000 kg/ha^{-1}an increase in production of over 950 kg/ha^{-1}.

Key words: *soil amendment, assimilation, sugar beet, yield*

Clasificare JEL: *Q 01, Q 15, Q 16*

INTRODUCTION

Sugar beet is a crop of particular economic importance, being the only plant that provides the raw material for sugar production, in the temperate continental climate, especially in European countries (Muntean et al., 2014). The long duration of sunshine of at least 850 hours during the growing season in August, September, October qualifies it as a long-day plant and leads to the provision of large amounts of sugar (Velican, 1965).

In sugar beet culture, an important role is played by photosynthesis, a process by which the first organic compounds are synthesized from inorganic substances (carbon dioxide, water and mineral salts) in the presence of light radiation captured by assimilating pigments (especially chlorophyll), in after which oxygen is released (Delian Elena, 2010).

By applying Terracalco [95], the structure of the soil is improved and the absorption of nutrients from the soil by plants is maximized, creating an environment favorable to biological activity, it sets the cycle of living things and microorganisms in motion, it raises the pH and last but not least, it increases production. (Chețan Felicia, 2021).

The product Terracalco [95] is administered with the machine for spreading chemical fertilizers, on the stubble and is incorporated into the soil through the basic works (ploughing, scarification, etc.) or it can be incorporated superficially into the soil through disc works followed by plowing.

The research looked at the influence of Terracalco [95] soil amendment in the sugar beet crop on physiological and environmental parameters, yield and quality.

MATERIALS AND METHODS

In the experiment, the sugar beet cultivar Vangelis Strube Dieckmann was used, which shows tolerance to cercosporiosis and rhizomania, the culture being included in a rotation with a 4-year rotation: corn - soybean - winter wheat - sugar beet.

The studies were carried out on a vertic clay-iluvial chernozem type soil, with a pH of 7.0 - 7.2, with a humus content at the depth of 0 - 30 cm between 2.14 - 3.12% and of clay between 51.8 - 55.5 % (clay texture), the preceding plant being winter wheat. After harvesting the wheat in the variants in which Terracalco [95] was used, it was applied by spreading, after plowing at a depth of 30 cm on the entire surface, already in the fall in the third decade of September.The leveling was executed with the rotary harrow since autumn to achieve better water management.

The basic fertilization was realized with 700 kg/ha NPK 16:16:16 in the third decade of March for all variants and an additional fertilization on the vegetation with 150 kg/ha N.

Herbicide where administrated pre-emergent on the ground at the end of March with the products Venzar 1.2 l/ha + Spectrum 1.0 l/ha, being incorporated at a depth of 3-4 cm, with the combiner.

Sowing was done at the end of March at 45 cm distance between rows and 18 cm between grains/row. The quantity of seed/ha being 1.4 UG (140000 b.g).

After sowing, the land was rolled with the ring roller for a better contact of the seed with the soil, and after about 21 days after sowing, the emergence of the crop took place.

The treatments on vegetation to combat weeds, diseases and pests were executed as follows: treatment I was applied in the first decade of May, with the products Powertwin (2.0 l/ha) and Cloe (0.25 l/ha) ; treatment II was applied at the beginning of the second decade of May, with Safari 50 WG (30 g/ha) and Sherpa (0.2 l/ha); treatment III was aplied at the beginning of the third decade of May, with the herbicides Safari (30 g/ha) and Agil (1.5 l/ha) + Lithovit (1.0 kg/ha) (foliar fertilizer) + Mospilan (0 .2 l/ha) (systemic insecticide); treatments IV and V were aplied in the first decades of July and August with Sfera (0.35 l/ha) (fungicide) + Dafcobor (2.0 l/ha) (foliar fertilizer) + Aphis (0.15 l /ha) (systemic insecticide) and Yamato (1.5 l/ha) (fungicide) + Aphis (0.15 l/ha) (systemic insecticide).

The harvest took place at the end of the second decade of October.

The measurement of the physiological parameters were executed in three phases of development, the root formation phase, 75 days after emergence, which corresponds to the first decade of July, the root thickening phase, in the first decade of August, at 105 days from emergence and the root maturity phase, 135 days after emergence, in the first decade of September. The research method used was non-destructive (the leaves were not detached from the plant) and was based on the use of the leaf gas analyzer CIRAS-3, (PP System USA,-2014), the determinations being realized under semi- controlled conditions for normal CO2 (390 μmolm-s^{-1}). It simultaneously reads several physiological and environmental parameters such as: reference carbon dioxide (CO2 r-μmolm-s^{-1}), assimilation (A- μmol $m^{-2}s^{-1}$), transpiration rate (E- mmolm$^{-2}s^{-1}$), water deficit in the leaf (VPD-kPa), active photosynthetic internal radiation (PARi- μmolm$^{-2}s^{-1}$) and leaf temperature (Tfr. - ^{o}C), (table 2).

The beet sugar percentage was determined using the KRUSS DR201-95-OE dual-scale portable refractometer, which reads in degrees brix 0 – 95% for invert sugar (for glucose, fructose, invert sugar).

RESULTS AND DISCUSSIONS

During the vegetation period (March - October) in sugar beet, the rate of growth, development and accumulation of sugar are influenced by environmental conditions, temperature and precipitation.

Temperature is a particularly important factor, so that Radke and Bauer (1969) found that the rate of root growth intensifies between the temperature limits of 10-20^{o}C, becomes stagnant in the limits of 20-30^{o}C and decreases at temperatures exceeding 30^{o}C. Also, leaf formation is slower at temperatures below 15^{o}C, has maximum values between 15 and 30^{o}C and decreases greatly in intensity at temperatures above 30^{o}C (Thorne, 1967).

Regarding the meteorological conditions in 2021 for the sugar beet crop, during the vegetation period (March - October) it can be observed that the average temperature was 14.6^{o}C, and the amount of precipitation fell was 418 mm.

The thermal regime during the vegetation period (March - October) was cooler in the months of March-April-May, the deviations being negative, which led to a slower development of the beet in the first phases.

The highest temperatures were recorded in June and July, with a deviation from the multiannual average of +1.9^{o}C and +3.0^{o}C respectively, and the months of August, September and October had normal monthly average values compared to the multiannual average, sugar beet having normal development and sugar accumulation (Figure 1).

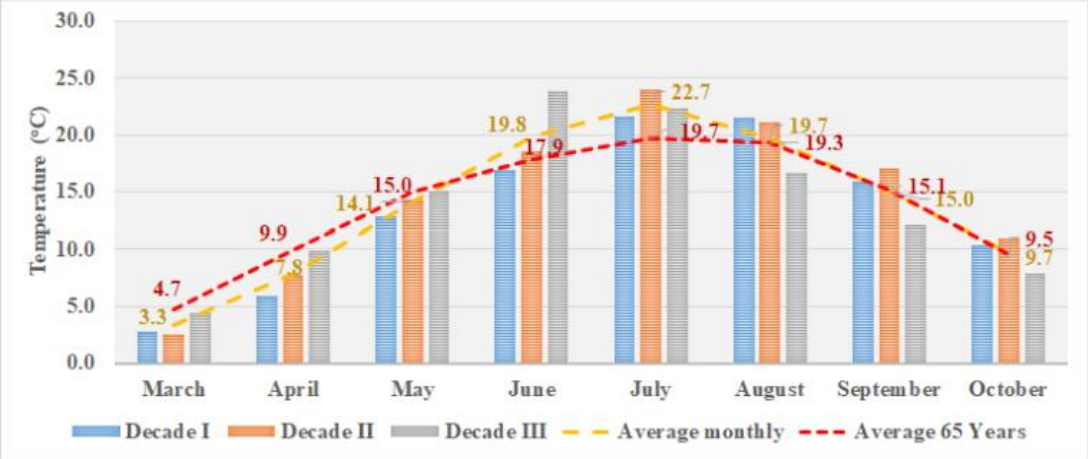

Figure 1. The average monthly temperature recorded during March 1st, - October 31st, 2021
Primary data source: meteorological station Turda (longitude: 23° 47' latitude 46° 35')

Regarding the rainfall regime during the beet vegetation period, it recorded an amount of 418.3 mm, the deviation from the multi-annual average being -16.4 mm. Precipitation in the spring months ranged from a little rainy in March, during the sowing period, to a little dry during the emergence period, and to a little rainy in the phase of the beginning of root formation.

Precipitation in the summer months ranged from excessively dry in June with a deviation of -39.8 mm, to excessively rainy in July with a deviation of +46 mm, then to normal in August.

In September the rainfall was near to normal, so the sugar beet was able to develop normally and accumulate reserve substances. For this crop, the 2021 agricultural year was favorable according to temperature, but dry for precipitation (this is where the lack of precipitation in April, June and October left its mark) (Figure 2). But sugar beet tolerates long periods of drought quite well and can

quickly recover water after a rainy period, with the maximum water requirements being in early July and mid-August, a fact also highlighted by Burzo et al. in 1999.

At the beginning of the vegetation period, the growth rate of the leaves is slower, after which their development intensifies in July and reaches its maximum in August, gradually decreasing during the months of September and October (Demazure et al. 1992).

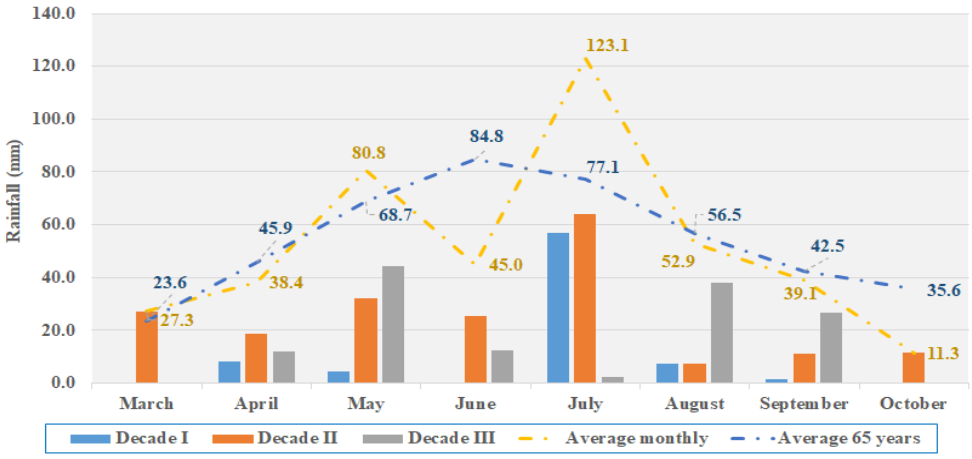

Figure 2. The average monthly rainfall recorded during March 1st, - October 31st, 2021 Source of primary data: Turda meteorological station (longitude: 23 ° 47 'latitude 46 ° 35');

In the sugar beet cultivar Vangelis, assimilation (A) was more intense in all development phases, where the Terracalco[95] amendment was applied, in all three temperature ranges I1 (24-27ºC), I2 (27-30ºC) and I3 (30-33ºC), as can be seen from table 1.We can note that where 1000 kg/ha Terracalco [95] was used the differences compared to the control are statistically ensured at different thresholds (table 1).

Table 1 The influence of the Terracalco [95] amendment on assimilation in sugar beet

	Temperature (ºC)	July (75 days after germination)			August (105 days after germination)			September (135 days after germination)		
	Variant	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3
Assimilation (A-µmolm^{-2}s^{-1})	24-27ºC	20.4	21,2	22.8	23,8	23,6	24,7	19.9	20,5	21.8
	Significant	Cv.	ns	***	Cv.	ns	*	Cv.	*	***
	27-30ºC	21,5	22,3	23,2	23,7	24,4	24,9	21,4	22,4	23,2
	Significant	Cv	ns	***	Cv.	ns	**	Cv	*	***
	30-33ºC	23,3	23,3	24,4	24,2	24,9	25,3	21,9	22,7	23,1
	Significant	Cv	ns	**	Cv.	ns	*	Cv.	ns	**
LDS (p 5%)-0,84; LDS (p 1%)-1,13; LDS (p 0,1%) - 1,52;										

,* = Significant at 1% and 0.1% probability levels, positive values; Cv. = control variant: ns= not significant

Transpiration at leaf level has oscillating values in the climatic conditions of the experimental year 2021 (Figure 3) with grouped values, and the regression curve obtained indicates a decrease in potential yield from values of 58500 kg/ha^{-1} to a transpiration level of 2.2 mmol^{-2} s^{-1} CO2 up to values of 58000 kg/ha going down to 57500 kg/ha^{-1} under transpiration conditions of 3.0 mmol^{-2} s^{-1} CO_2 and 3.8 mmol^{-2} s^{-1} CO_2. Superior yields are obtained in the range of these transpiration values in the Vangelis sugar beet cultivar (Figure 3)

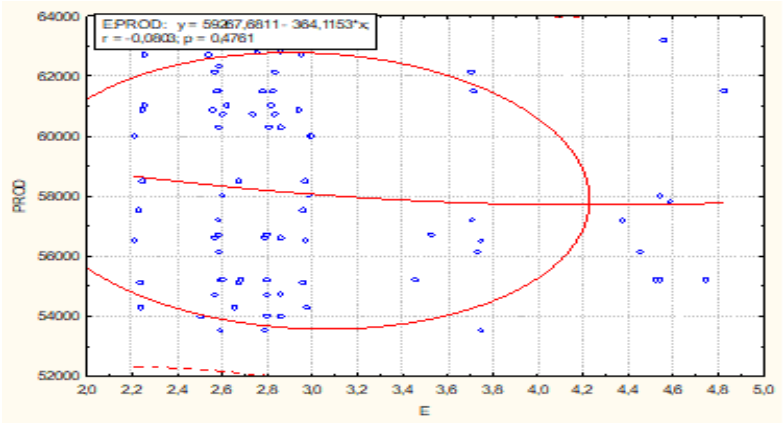

Figure 3. Interaction between yield (kg/ha^{-1}) and transpiration (mmolm^{-2}s^{-1})

As it presented in figure 4, the water deficit in the leaf is closely connected with the climate of the year 2021, the regression line indicating an increase in potential production from the range of 58200 to 58500 kg/ha^{-1}, at values of the water vapor pressure deficit of leaf (VPD) from 0.8 to 1.2 kPa (optimum year), after which it decreases to 56000 kg/ha^{-1} at a deficit of water vapor pressure from 1.8 to 2.0 kPa (climatic stress).

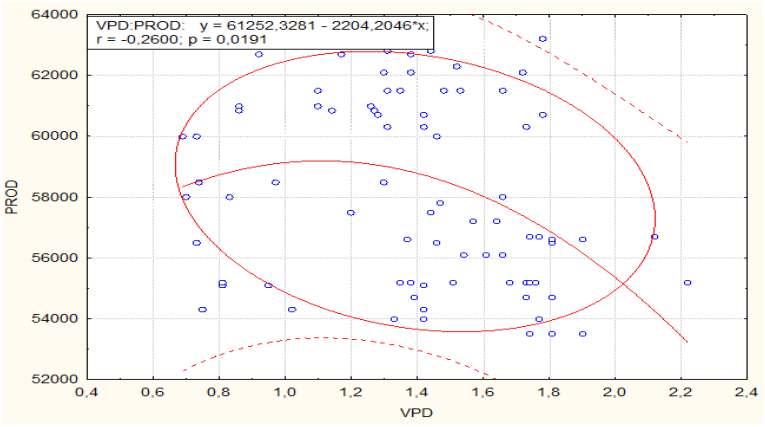

Figure 4. Interaction between production (kg/ha^{-1}) and leaf vapor pressure deficit (kPa)

The interaction between leaf transpiration (Evap - mmolm^{-2}s^{-1}) and the sugar beet development period was more intense in the first two phases of root formation and thickening (July and August) in the V3 variant where 1000 kg/ha of Terracalco 95 was applied the values obtained being statistically very significantly positive compared to the control treated only with basic fertilization (table 2).

The interaction of leaf water vapor pressure deficit (VPD) and plant development period was lower in July and August from 0.79 to 0.99 kPa when plants had the fastest growth and leaf development rate.higher, being statistically assured compared to the control as can be seen from table 4.

Malnou et al. 2006 and Jaradat and Riske 2012 point out that newer genotypes have a higher capacity to cover the soil with leaves of up to 90% to make maximum use of solar radiation. With the beginning of September, the active photosynthetic radiation of the leaf drops below 1000 µmolm^{-2}s^{-1} and the temperature of 26.7^{o}C, sugar beet roots reaching the maturity phase when the number of leaves decreases and the accumulation of sugar in the root is quite high (table 2).

Table 2 The influence of the amendment on physiological parameters in sugar beet

Physiological parameters	July (75 days after germination)			August (105 days after germination)			September (135 days after germination)		
	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3
reference CO_2 r (µmolm-s^{-1})	390	390	390	390	390	390	390	390	390
Transpiration at leaf level ($mmolm^{-2}s^{-1}$)	2,85	3,48	3,46	2,98	3,25	3,43	2,47	2,48	2,46
Significant	Cv.	***	***	Cv.	*	***	Cv.	ns	ns
LDS (p 5%)-0,22; LDS (p 1%)-0,31; LDS (p 0,1%) - 0,44;									
Leaf vapor pressure deficit (VPD – kPa)	1,35	1,17	1,16	1,66	1,18	1,32	1,58	1,50	1,63
Significant	Cv.	0	00	Cv.	000	000	Cv.	ns	ns
LDS (p 5%)-0,13; LDS (p 1%)-1,19; LDS (p 0,1%) - 0,26;									

,* = Significant at 1% and 0.1% probability levels, positive values; 000 = Significant at 0.1% probability levels, negative values;Cv = control variant: ns= not significant

The yield obtained in the Vangelis sugar beet cultivar increased slightly by applying 1000 kg/ha of Terracalco^{95} granulated fertilizer, the increase in yield being over 950 kg/ha^{-1}, the differences obtained being statistically very significantly positive compared to the control treated only with the fertilization of base (table 3)..

Not signifiant differences in yield were obtained but, the application of this soil amendment (a granular fertilizer) contributes to a very easy absorption, loosening and improvement of the soil. It also makes agricultural work more efficient, allowing water, oxygen and carbon dioxide to circulate freely in the soil, and improving its microbial activity.

The increase in yield in the variant where 1000 kg/ha^{-1} of Terracalco^{95} was applied was followed by a decrease in the sugar content from 19.5% to 18.7%, the differences compared to the control being very significant. Even though the application of the Terracalco 95 soil amendment reduced the percentage of sugar, still the yield of sugar per hectare increases.

Table 3 Influence of Terracalco ^{95} application on yield and sugar concentration.

Granular soil amendment, Terracalco ^{95}	Yield (kg/ha^{-1})	Difference (kg/ha^{-1})	Significant
V_1-control variant	57754	0,00	Cv
V_2- 500 kg/ha Terracalco ^{95}	58150	396	ns
V_3- 1000 kg/ha Terracalco ^{95}	58712	958	***
LDS (p 5%) 397,0; LDS (p 1%) 557,3; LDS (p 0,1%) 786,8			
Granular soil amendment, Terracalco ^{95}	Sugar concentration (%)	Difference (%)	Significant
V_1-control variant	19,50	0,00	Cv
V_2- 500 kg/ha^{-1}Terracalco ^{95}	19,22	-0,28	0
V_3- 1000 kg/ha^{-1}Terracalco ^{95}	18,69	-0,81	000
LDS (p 5%) 0,28; LDS (p 1%) 0,39 ; LDS (p 0,1%) 0,55.			

,* = Significant at 1% and 0.1% probability levels, positive values; 000 = Significant at 0.1% probability levels, negative values; Cv = control variant: ns= not significant

CONCLUSIONS

- In the sugar beet cultivar Vangelis, by applying the Terracalco 95 soil amendment in the phases of root formation 75 days after emergence, and root thickening 105 days after emergence, the physiological parameters had more positive values high, except for the leaf vapor pressure deficit (VPD), which is inversely proportional, registering negative values.
- Following the application of the amendment, the absorption of nutrients by plants increases, achieving higher yields, over 58150 kg/ha, and a higher amount of sugar. per unit area

REFERENCES

1. Burzo I.,Toma S.,Aurelia Dobrescu,Livia Ungurean, Ştefan Victor, (1999). Fiziologia plantelor de cultură,vol.2, Editura Poligrafică Stiinţa, Chisinău, Republica Moldova.
2. Chețan Felicia, (2021). Agricultura Transilvană, Buletin informativ, Nr.35, Septembrie, 44-54.
3. Delian Elena,(2010). Fiziologia plantelor, Editura Universitară București.
4. Demazure L și colab. (1992). Le bettravier francais1992, 600, 15-17.
5. Jaradat, A.A.; Rinke, J. Modeling sugar content of farmer-managed sugar beets (Beta vulgaris L.). Commun. Biometry Crop Sci. 2012, 7, 23–34.
6. Malnou, C.S.; Jaggard, K.W.; Sparkes, D.L. A canopy approach to nitrogen fertilizer recommendations for the sugar beet crop. Eur. J. Agron. 2006, 25, 254–263.
7. Muntean L.S, Cernea S, Morar G, Duda M.M, Vârban D.I, Muntean S, Moldovan C, (2014). Phytotehnics, ediția III-a, 6.2 Sfecla pentru zahăr (*Beta Vulgaris* L.,) Risoprint Publishing House, Cluj-Napoca, 4,4: 582-623.
8. Radke, J.K și Bauer, R.E.- Agron J (1969). 61, 860-863.
9. Thorne, G.N. 1967 Ann. Bot. 31, 71-101.
10. Velican V.,(1965). Fitotehnie, vol II,ed. Agro-Silvică, București.
11. PP System (SUA), (2014). Technical manual for CIRAS 3.
12. *Staţia meteorologică Turda (2017). Centrul Meteorologic Regional Transilvania Nord Cluj.*