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Effect of the Pătârlagele Diatomite on Seed Germination and Growth of Sunflower Plants

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ABSTRACT

Sunflower (*Helianthus annuus* L.) is the third largest agricultural crop in Romania, after corn and wheat. In 2021 Romania cultivated 1112 thousand ha of sunflower with a production of 2818 thousand tons, ranking first among EU countries both in terms of production and cultivated area. Diatomite, also called diatomaceous earth or kieselguhr, is a natural sedimentary rock with a high content of silicon dioxide and clay minerals, widely used in agriculture for its insecticidal and fungicidal properties, stimulating the process of seed germination and plant growth, as well as the ability to absorb and retain nutrients and water. The paper presents preliminary results regarding the effect of diatomite from Pătârlagele deposit (Buzău County) on seed germination and growth of young sunflower plants in laboratory conditions and on seeds production in the field at three sowing dates as well. A semi-early hybrid P64LE99 was used in experiments. Our data showed that the Pătârlagele diatomite improves sunflower seed performances both in laboratory and field conditions. In the laboratory, an increase in seed germination and stimulation of plant growth and development were observed in the diatomite treated samples compared to the untreated control. In the field under climatic and soil conditions of the Moara Domnească area (Southern Romania), the diatomite treated samples performed better than the control, both in terms of plant growth and development as well as production elements, in three sowing dates, middle and late April and early May. The highest yields were when sowing was in the first week of May for both variants.

Keywords: diatomite, sunflower, seed germination, production.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is the third largest agricultural crop in Romania, after corn and wheat. According to the data of the National Institute of Statistics (INS, 2022), Romania cultivated an area of 1112 thousand ha with sunflower in 2021 and achieved a production of 2818 thousand tons, occupying first place among EU countries both in terms of production and cultivated area. The area cultivated with sunflowers in an ecological system, in conversion or certified, experienced an increase of 37.8% in Romania in the period 2017-2019, the largest area (30%) being cultivated in Tulcea County (Brumă et al., 2021).

The uses of the sunflower are multiple, in human and animal nutrition, and in industry, due to the rich content of the seeds in oil, proteins and vitamins. Sunflower is the main plant producing high quality edible oil. Romania is one of the main suppliers of sunflower seeds on the foreign market (Chiriac et al., 2018). The agronomic and melliferous importance of sunflower plants further increase the value of this crop. Honey production from sunflower can reach up to 115 kg/ha depending on the hybrid and climatic conditions (Ion and Basa, 2021). Due to the high oleic acid content (approx. 80%), sunflower seeds are used in the petroleum and biofuel industries (Adeleke and Babalola, 2020).

Diatomite, also called celite, diatomaceous earth or kieselguhr, is a natural sedimentary rock with a high content of silicon dioxide and clay minerals widely used in agriculture for its insecticidal and fungicidal properties, stimulating the process of seed germination and plant growth, as well as the ability to absorb and retain nutrients and water.

In recent years in Romania, the advance of sowing sunflowers earlier than the optimal time is increasingly promoted. Early sowing can avoid the dry atmosphere and lack of water during the flowering and seed-filling

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stages, but on the other hand, the emergence of plants can be prolonged and uneven, the young plants are susceptible to diseases and pests attack; early weeds such as *Poygonum convolvulus* L., *Sinapis arvenis* L. or *Chenopodium album* compete strongly with sunflower plants with obvious repercussions on production (Vrânceanu, 1974). With a delayed sowing, the moisture accumulated in the soil may be inefficiently used during the winter evapotranspiration, the crop may not have had enough time to fill the achenes (Killi and Altunbay, 2005), and yield will be reduced because of high temperature during flowering (Ahmed et al., 2020), the composition of fatty acids also being affected (Petcu et al., 2010; Popa et al., 2017; Conţescu and Anton, 2023).

The paper presents preliminary results regarding the effect of diatomaceous earth from the Pătârlagele deposit (Buzău County, Romania) on seed germination and growth of young and mature sunflower plants as well as on seed production.

MATERIAL AND METHODS

The experience under laboratory conditions. It was used sunflower hybrid P64LE99 (the semi-early hybrid), and diatomite from Pătârlagele, Buzău County, Romania. A number of 100 seeds (approx. 6.5 g, selected to be uniform in terms of size and morphological appearance) were mixed with 300 mg of diatomite powder in a container and shaken for uniform distribution of the diatomite on the seeds surface. Treated seeds were sown in ventilated Petri dishes (90 x 16.2 mm) on filter paper moistened with an amount of distilled water equal to 1.5 times its weight. The control consisted in used the seeds without treatment with diatomite. The seeds were germinated in the growth chamber at a temperature of 22°C, 16/8 hours, RH 60%. Seed germination was observed at 3, 4 and 6 days. At the end of the germination period, the germinated seeds were transferred to sterilized natural substrate in four batches in trays of 42 x 30 x 10 cm for a period of 24 days. Seedling emergence and length were monitored, and at the end of the experiment, length and green and dry weight of plants and parts of plants were evaluated.

The experience under field conditions. The experiment in the field was carried out at the Moara Domnească Experimental Farm (44°30'10.8"N/26°15'25.6"E) in Ilfov County (Vlăsia Plain, Southern Romania) belonging to University of Agronomic Sciences and Veterinary Medicine of Bucharest. In this experiment, the semi-early sunflower hybrid P64LE99 was evaluated regarding the morphological characteristics of plants and production elements in two variants: seeds treated with diatomite from the Pătârlagele deposit and untreated control at three sowing dates. The P64LE99 hybrid is characterized by a high production potential, resistance to the herbicide Express®, good plasticity and pedo-climatic adaptability. The plants have a very well-developed root system with good resistance to breaking and falling and high tolerance to drought and heat.

Sowing in the experiment was carried out on three calendar dates conditioned by the unstable climatic conditions that occurred during the spring period, dominated by precipitation and low temperature (Figure 1), as follows: (1) 12.04.2021, (2) 26.04.2021 and (3) 07.05.2021. The surface of a plot corresponding to a sowing date was 357.6 m² and the surface of a variant (with three replicates) was 179.2 m² (5.6 x 32 m). The number of leaves per plant as well as the height of the plants were evaluated by measurements taken two months after sowing. Forty plants per repetition were evaluated. Yield elements were assessed at harvest by counting and weighing individually per plant the seeds from the calathidium of forty plants. The diameter of a calathidium resulted from the average of the measurements of two diagonals.

Moara Domnească area is characterized by a humid climate, with hot summers and harsh winters, average annual precipitation of 580 mm, reddish luvosol with a generally low organic matter content and low availability of nutrients for plants (Dogaru and Dragomir, 2021). The climate of the area in the 2021 study year was characterized by precipitation in the period from April to the first and second decade of June that varied from 1.2 to

40.1 mm, and average maximum and minimum temperatures below 24°C and 15°C, respectively. After this period, precipitation was limited because of the high maximum temperatures above 25°C.

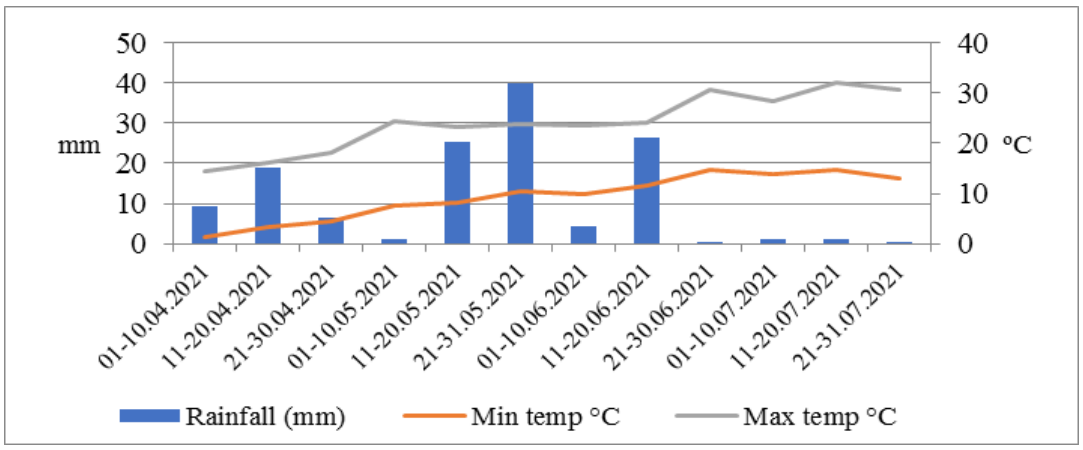

Figure 1. Climatic parameters for the period April-July 2021 at the M.D. Experimental Station

Statistical analysis. Collected data were statistically analyzed by ARM-9 software using ANOVA test analysis of variance and means obtained were compared using the least significant difference (LSD) at 5%.

RESULTS AND DISCUSSION

In the laboratory, the germination of sunflower seeds treated with diatomite from Pătârlagele was 99%, 1% higher than the control sample three days after the experiment was initiated, this difference being held until the end of the 6-day evaluation period. The average length of the plants stem from the soil to cotyledons, both for the diatomite treated and control plants was measured at 10, 12, 14, 16, 21 and 24 days after treatment (DAT) meaning 4, 6, 8, 10 and 15 days after the germinated seeds were transferred in organic substrate under controlled conditions. Diatomite treated samples had a stem higher compared to the control, of 2.05 times at 10 DAT, 1.32 times at 12 DAT, 1.36 times at 14 and 16 DAT, 1.3 times at 21 DAT and 1.29 times at 24 DAT. The difference is statistically significant for the last three assessments (Figure 2).

The assessments at the end of experiment (30 days) consisted in measuring the length of root, shoot and entire plant from the soil level to the top. The average length of plants and shoots was slightly higher for the diatomite treated variant than the control which had a longer root length (Figure 3).

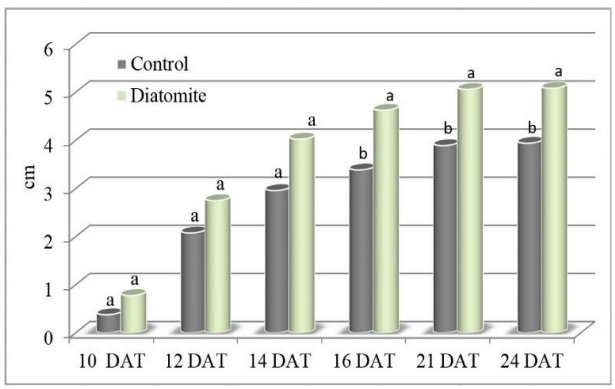

Figure 2. Average length of the stem (from soil to cotyledons) of plants grown in organic substrate (Different letters in columns differ at significant difference according to Tukey's HSD test; P<0.05)

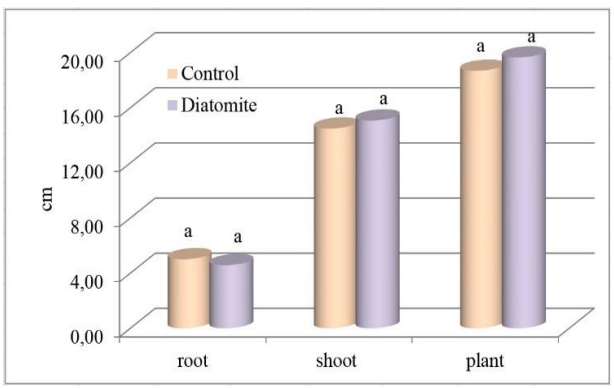

Figure 3. Average length (after 30 days) of the roots, shoots and whole plants grown in organic substrate (Different letters in columns differ at significant difference according to Tukey's HSD test; P<0.05)

Fresh and dry weight of roots, shoots and leaves together and whole plants were measured at the end of laboratory experiment, 30 days. Both fresh and dry weight for shoots and leaves together as well as for whole plants were superior in diatomite treatment compared to the control. The average fresh and dry weight of whole plants and shoots + leaves together was higher for diatomite than the control, 1.28 and 1.29 times and 1.33 and 1.46 times, respectively. The differences from the control plants were, in general, statistically significant, with the exception of the plant roots, which remained almost unchanged (Figures 4 and 5). The results in literature presented by Escobar et al. (2014) reveal significantly increased fresh and dry weight for maize, bean, yellow potato and carrot plants resulted from diatomite treated seeds compared to the control. Other studies show that treatments with diatomaceous earth had a significant positive influence on the fresh and dry shoot and root mass of sweet potato seedlings in vitro cultivation (Oliviera Junior et al., 2023).

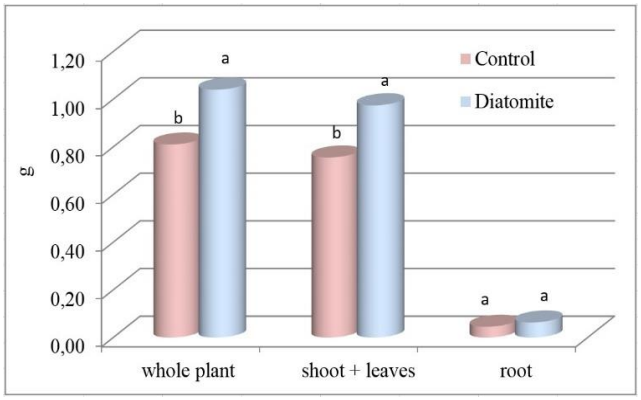

Figure 4. Average fresh weigh per plant, shoot and leaves, and root in diatomite and control samples (Different letters in columns differ at significant difference according to Tukey's HSD test; P<0.05)

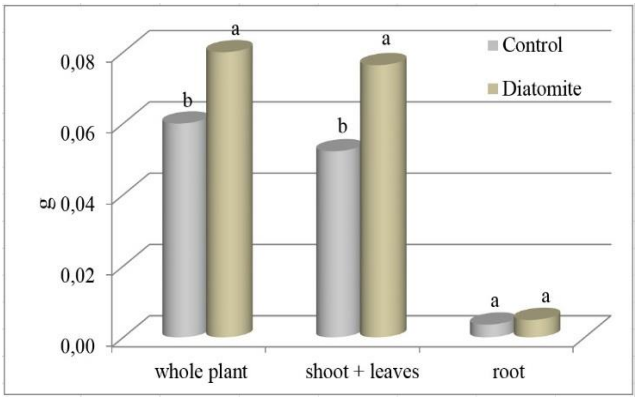

Figure 5. Average dry weight per plant, shoot and leaves, and root in diatomite and control samples (Different letters in columns differ at significant difference according to Tukey's HSD test; P<0.05)

In the field experiment the seeds were sown on three dates two weeks apart. In order to mitigate the shortcoming during early sowing caused by the soil temperature lower than optimum, seed stimulating with diatomite treatment may be an alternative to be considered. The assessments for morphological characteristics (plant height and number of leaves) were performed in the field during growing season and the yield components were analyzed after harvest (Table 1). The results reveal the dependence of all characteristics on the sowing date.

The plants in the diatomite treated variant had a taller stature with more leaves at all three sowing dates (Table 1) compared to the control variant. The two traits characteristics showed similar statistical distribution, the highest values being in plots sown at the end of April and the lower in plots sown in mid-April.

The average for head diameter recorded the highest values in plants from the plot sown on 26.04.2021 and 07.05.2021. The difference between sowing date was especially significant for the earliest sowing date. The results are in concordance with those of Radu et al. (2022) in conditions of Tulcea County (South-Eastern Romania). In studies performed in climatic conditions different from those in Romania, the largest head diameters were in the early sowing date (Miller et al., 1984; Allam et al., 2003; Lawal et al., 2011; Demir, 2019).

In our study, measurement data sets showed that the yield components were superior in the plots where sowing carried out on 26.04.2021 and 07.05.2021. Number of seeds per head increased constant alongside with the delay of sowing. This trait is influenced by the level of temperature and radiation conditions around anthesis during

and immediately after floral differentiation stage (Cantagallo and Hall, 2000; Chimenti et al., 2001). The highest yield over 3300 kg/ha was obtained when sowing was in late April and over 3700 kg/ha when sowing was in early May. For seeds sown on 12 April, the yield from diatomite treated seeds was on average 60% higher than the control. The difference was reduced to 6 and 2% for the seeds sown in late-April and early-May, respectively. The highest yield in plots sown in May can be attributed to the maximum atmospheric temperature under 30°C during the flowering stage (Figure 1) favorable for seed development. Temperatures during the flowering stage is a key natural factor with direct consequences on development and viability of germ cells and seeds production. Previous studies on sunflower have shown that the extreme temperatures strongly negatively affect the weight and filling of seeds (Rondanini et al., 2006). Balalić et al. (2016) found a direct correlation between the diameter of the sunflower head and number of flowers and seeds per head, with consequence on the seeds production. The optimal sowing time for sunflowers varies greatly across different climatic regions in the sunflower cultivation zone, from February (El-Saied et al., 1989) and August (Lawal et al., 2011) to November (Ahmed et al., 2015).

Table 1. Effect of sowing date and diatomite on morphological characteristics and yield components during 2021 sunflower growing season

Sowing date	Variant	Plant height (cm)	Number of leaves/plant	Head diameter (cm)	Head weight (with seeds) (g)	No. of seeds/head	Seed weight/head (g)	1000-seed weight (g)	Seed yield (kg ha^{-1})
12.04.2021	Control	68.84 b	18.19 b	14.00 c	82.42 c	622.95 d	44.07 c	71.83 b	1828.21 c
	Diatomite	109.89 a	21.69 a	16.61 b	127.41 b	832.26 c	70.37 b	85.61 a	2919.14 b
26.04.2021	Control	106.51 a	22.84 a	17.29 ab	141.20 ab	999.52 b	81.07 ab	81.70 a	3362.62 ab
	Diatomite	110.31 a	23.00 a	18.95 a	174.29 a	969.49 b	85.45 a	87.71 a	3544.55 a
07.05.2021	Control	96.95 a	21.90 a	18.76 a	167.40 a	1117.48 b	90.96 a	81.05 a	3773.17 a
	Diatomite	101.88 a	22.01 a	18.48 a	149.83 ab	1310.86 a	92.59 a	69.98 b	3840.50 a
LSD P=.05		1.359	10.429	1.192	24.745	129.907	5.571	11.828	490.629
Standard Deviation		0.902	6.919	0.791	16.418	86.193	3.697	7.848	325.531

Different letters in columns differ at significant difference according to Tukey's HSD test; P<0.05

CONCLUSIONS

The experimental results in this research showed that the diatomaceous earth from Pătârlagele (Buzău County) determined a beneficial effect on seeds and sunflower plants both in laboratory and field conditions.

A stimulation effect of the growth and development of young plants resulting from diatomite-treated seeds in laboratory was appreciated compared to the untreated control.

In the field, under climatic and soil conditions characteristic to the Moara Domnească area (Southern Romania), the diatomite treated variant performed better than the control, both in terms of plant growth and development as well as production elements, in three sowing dates, middle and late April and early May. The highest yield was at sowing in the first week of May for both variants.

Our data support the use of diatomite in sunflower culture technology in both conventional and ecological systems due to its beneficial effects of agronomic importance.

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REFERENCES

Adeleke, B.S., and Babalola, O.O., 2020. *Oilseed crop sunflower (Helianthus annuus) as a source of food: Nutritional and health benefits*. Food Science & Nutrition, 8(9): 4666-4684. https://doi.org/10.1002/fsn3.1783

Ahmed, B., Sultana, M., Zaman, J., Paul, S.K., Rahman, M.M., Islam, M.R., Majumdar, F., 2015. *Effect of sowing dates on the yield of sunflower*. Bangladesh Agronomy Journal, 18(1): 1-5.

Ahmed, M.A., Abd-Elsaber, A., Abdelsatar, M.A., 2020. *Effect of sowing dates on yield and yield attributes of some sunflower hybrids.* Agricultura, 113(1-2): 131-144.

Allam, A.Y., El-Nagar, G.R., Galal, A.H., 2003. *Response of two sunflower hybrids to planting dates and densities*. Acta Agronomica Hungarica, 51(1): 25-35.

Brumă, I.S., Rodino, S., Petcu, V., Micu, M.M., 2021. *An overview of organic sunflower production in Romania*. Romanian Agriculture Research, 38: 495-504. https://doi.org/10.59665/rar3852

Balalic, I., Crnobarac, J., Jocic, S., Miklic, V., 2016. *Variability of head diameter in sunflower hybrids depending on planting date*. Genetika, 48(3): 983-990.

Cantagallo, J.E., and Hall, A.J., 2000. *Reduction in the number of filled seed in sunflower (Helianthus annuus L.) by light stress*. Proceedings of the 15th International Sunflower Conference, Tolouse, France: 35-40.

Chimenti, C.A., Hall, A.J., Lopez, M.S., 2001. *Embryo-growth rate and duration in sunflower as affected by temperature*. Field Crops Research, 69(1): 81-88.

Chiriac, A.R., Cristea, S., Popescu, M., Rîşnoveanu, L., 2018. *The evolution of sunflower crops in Romania in the context of the pre- and post accession to the European Union*. Agrarian Economy and Rural Development - Realities and Perspectives for Romania, 9th Edition of the International Symposium, November 2018, Bucharest. The Research Institute for Agricultural Economy and Rural Development (ICEADR), Bucharest: 156-162.

Conțescu, E.L., and Anton, F.G., 2023. *Study of the genetic diversity of some wild sunflower species using ISSR markers*. Romanian Agricultural Research, 40: 31-37. https://doi.org/10.59665/rar4004

Demir, I., 2019. *The effects of sowing date on growth, seed yield and oil content of sunflower (Helianthus annuus L.) cultivars under rainfed conditions.* Fresenius Environmental Bulletin, 28(9): 6849-6857.

Dogaru, M., and Dragomir, D., 2021. *Research on soil fertility in the experimental field at the Moara Domnească Experimental Station*. Scientific Papers, Series A, Agronomy, 64(2): 34-39.

Escobar, N., Espejo, J., Rodríguez, L., 2014. *Evaluation of the effect of diatomaceous earth as a sustainable alternative in commercial interest crops in Colombia*. WIT Transactions on Ecology and the Environment, 181: 409-419.

El-Saied, S.K., El-Ahmer, B.A., El-Sergani, D.Z., Guirguis, N.R., 1989. *Response of sunflower varieties to different sowing dates*. Minia Journal of Agricultural Research and Development, 11: 1485-1504.

INS, 2022. *Comunicat de presă, nr. 79. Producția vegetală la principalele culturi în anul 2021 (date provizorii*): 1-4. https://insse.ro/cms/sites/default/files/com_presa/com_pdf/prod_veg_r21.pdf

Ion, V., and Basa, A.G., 2021. *Fitotehnie - Plante Oleaginoase*. Ex Terra Aurum Publishing House, Bucharest: 27-28.

Killi, F., and Altunbay, S.G., 2005. *Seed yield, oil content and yield components of confection and oilseed sunflower (Helianthus annuus L.) cultivars planted in different dates*. International Journal of Agriculture and Biology, 7: 21-24.

Lawal, B.A., Obigbesan, G.O., Akanbi, W.B., Kolawole, G.O., 2011. *Effect of planting time on sunflower (Helianthus annuus L.) productivity in Ibadan, Nigeria*. African Journal of Agricultural Research, 6(13): 3049-3054.

Miller, B., Oplinger, E., Rand, R., Peters, J., Weis, G., 1984. *Effect of planting date and plant population on sunflower performance*. Agronomy Journal, 76: 511-515.

Oliveira Júnior, A.M., Rangel Junior, I.V.A.N., Rodrigues, F.A., Martins, A.D., Cavalcanti, V.P., Dória, J., Pasqual, M., 2023. *Acclimatization of Sweet Potatoes under In vitro Application of Diatomaceous Earth*. Anais da Academia Brasileira de Ciências, 95, e20200021.

Petcu, E., Băbeanu, N., Popa, O., Partal, E., Pricop, S., 2010. *Effect of planting date, plant population and genotype on oil content and fatty acid composition in sunflower*. Romanian Agricultural Research, 27: 53-57.

Popa, M., Anton, F.G., Rîşnoveanu, L., Petcu, E., Băbeanu, N., 2017. *The effect of planting date and climatic condition on oil content and fatty acid composition in some Romanian sunflower hybrids*. Agrolife Scientific Journal, 6: 212-217.

Radu, I., Gurau, L.R., Florescu, I., Teodoru, A., Chireceanu, C., 2022. *Influence of sowing date on the morphological characters and yield components on sunflower hybrids*. Scientific Papers, Series A, Agronomy, 65(1): 509-513.

Rondanini, D., Mantese, A., Savin, R., Hall, A.J., 2006. *Responses of sunflower yield and grain quality to alternating day/night high temperature regimes during grain filling: effects of timing, duration and intensity of exposure to stress*. Field Crops Research, 96: 48-62.

Vrânceanu, A.V., 1974. *Floarea-soarelui*. The Academy of the Socialist Republic of Romania Publishing House, Bucharest.