

Influence of frequent magnetic field on chlorophyll content in leaves of sugar beet plants

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Abstract Chlorophyll content in plant leaves is correlated with the yield and nitrogen content in plants. Non-destructive investigations of chlorophyll content in leaves of 3 varieties of sugar beet grown from seeds revealed that a low frequent magnetic field, acting independently or in combination with other methods of seed improvement, increased chlorophyll content in leaves of the investigated plants. The treatment with the magnetic field increased nitrogen content in the examined plants. The effect was not connected with environmental conditions during vegetation seasons.

Key words magnetic field • chlorophyll • nitrogen • seed quality improvement • sugar beet

Introduction

Green plants are the only living organisms on the Earth, which could use the sun light as an energy source. Plants use the sun light for changing inorganic molecules: CO₂ and H₂O into carbohydrates, fundamental food compounds for plants and animals. This process, named photosynthesis, is possible because of the presence in plants of the specific green pigment – chlorophyll. Chlorophyll content has a basic importance for plant productivity, the most important issue for farmers. Low chlorophyll content, below 2 mg/dm² of leaf surface, causes insufficient absorption of the sun light and low plant productivity. About 3 mg of chlorophyll/dm² of leaf surface ensures the optimal (95–97%) consumption of sun light absorbed by plants.

Chlorophyll content is correlated with nitrogen content in plants and the gathering from soil of nitrogen, and other macro- and microelements important for plant metabolism. This is also correlated with the content of low-molecular proteins, mainly enzymes [11]. Thus chlorophyll content is a marker of plant health and productivity and helps to elaborate proper fertilization. In the case of nitrogen and microelement deficiency, productivity of plants decreased. Scientists try to help farmers to get the highest and best quality yield. Plants grown from conditioned seeds produce a high and good quality yield. One of the methods of seed improvement is the treatment with a frequent magnetic field. Plants grown from such treated seeds also produced a higher yield [5, 7]. It was interesting to know if their chlorophyll content was also higher.

In the past, when the only method for the examination of chlorophyll content was chemical analysis destroying plants, it was difficult to determine this parameter in a single plant during the vegetation season.

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Now, using non-destructive methods, it is possible to measure the changes of chlorophyll content in a single plant during the whole vegetation period.

Materials and methods

Chlorophyll contents were examined in the leaves of 3 varieties of sugar beet: triploid Jamira and diploid Jastra and PN Mono 1. The chlorophyll content was measured in the leaves of living plants in the field, from the end of June till the beginning of September during 3 successive years: 1999, 2000, 2001. Dates of sowing and dates of measurements, in particular years, were approximately similar and differed by 2–4 days.

Seeds were treated with 16 Hz homogeneous magnetic field, using a magnetic flux density of 5 mT and treatment time of 2 hours. The equipment used to produce the alternating magnetic field was constructed from two Helmholtz coils reel arranged in different directions. This guaranteed a pure magnetic field without any electric component in the cavity of the apparatus. Before treatment with the magnetic field, seeds of sugar beet were rubbed with a sand-paper or conditioned by keeping for 24 hours at the temperature and water condition optimal for germination and then dried. Seeds were sown nineteen days after treatment.

The chlorophyll content was measured with a chlorophyll meter SPAD-520 produced by Minolta Co. Ltd. It is an optical instrument which measures the relative chlorophyll content using a colorimetric, non-destructive method. This way of measurements allowed to estimate health conditions of the plant and its status of nitrogen nutrition. SPAD results are strictly correlated with the content of chlorophyll in the leaves of different plant species [3] and with the nitrogen content in plants [4].

The measurements were made at the same times of the day (early mornings) in sunny weather. Every year the field stand of plants, as well as the used agricultural methods and fertilization were the same. There was no use of herbicides destroying leaves.

The chlorophyll content was measured in the relative SPAD units. The dependence of SPAD indications on the total chlorophyll content in leaves is not linear. Therefore, the results were counted as mg of chlorophyll/dm² of leaf surface. The results were counted on the basis of calibration curves. Calibration curves showed the dependence between SPAD units and the colorimetrically measured contents of the chlorophyll extracted from the examined sugar beet leaves.

Results and discussion

Weather conditions during particular years of the experiment were different. The most profitable weather conditions for the proper development of sugar beet plants were in the year 2000, the less profitable weather conditions were in 2001.

During particular years of the experiment, air temperatures and rainfalls varied. It allowed to define

the influence of the magnetic field under the different environmental conditions. Every plant species needs a different level of rainfall and temperatures during vegetation season to grow, develop and produce the highest yield.

Table 1 presents chlorophyll contents in leaves of 3 varieties of sugar beet: Jamira, Jastra and PN Mono 1.

Data in Table 1 represent mean values for each variety in 3 years of the experiment. The chlorophyll content in the leaves of sugar beet ranged from 2.57 to 3.14 mg/dm² of leaf surface and in particular years of the experiment differed by 5–10%. The highest content of the green pigment was measured in the year 2000 when the weather conditions were most favorable for sugar beet plants.

Data presented in Fig. 1 indicate that the chlorophyll content in the leaves of sugar beet plants changes during the vegetation season with respect to the phases of plant development. In the time period from 60 to 86 days after seed sowing, the chlorophyll content quickly increased. From the day 86 to the day 113, the chlorophyll content slowly decreased and then (until 130 days after seed sowing) it decreased quickly. Presented changes were correlated with particular stages of development of sugar beet plants. From the first 60 days after sowing of seeds, the plants developed the aboveground parts and began the formation of the secondary roots. From the 80–85 days, the sugar beet plants developed a large leaves with a large photosynthetic surface and formed a secondary root. Between the 86 and 120 days, the growth of the secondary root was limited, and the process of carbohydrates accumulation started. From the day 120 till the harvest, the roots changed weight only by transforming water into sugar.

Thus, around the 85 day of life, the sugar beet plants were completely developed and ready for fully intensive photosynthesis and other metabolic processes. This status lasted to approximately 120 days after seed sowing [8]. Simultaneously with ageing of the plant, the chlorophyll content in leaves decreased more and more quickly, because the green pigment was synthesized less intensively and metabolized more intensively.

The presented methods of seed quality improvement changed the chlorophyll content in sugar beet plants during vegetation season in different ways. The lowest chlorophyll content in leaves was observed in

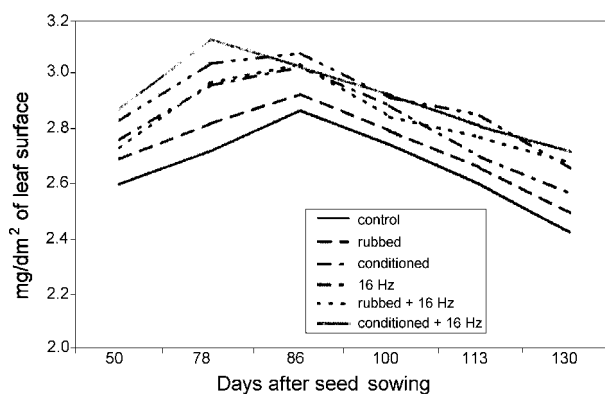


Fig. 1. Chlorophyll content in the leaves of sugar beet plants. Mean values for 3 varieties and 3 years of experiment.

Table 1. Chlorophyll content in the leaves of sugar beet plants

Variety and way of seed treatment Day after sowing	Chlorophyll content [mg/dm ² of leaf surface] mean values for 3 years of experiment					
	60	76	86	100	113	130
Jamira						
Control	2.57	2.63	2.87	2.79	2.56	2.43
Rubbed	2.61	2.81	2.95	2.82	2.69	2.53
Conditioned	2.74	2.93	3.03	2.89	2.68	2.55
Treated with 16 Hz magnetic field	2.76	3.00	3.05	2.92	2.87	2.70
Rubbed and treated with magnetic field	2.71	2.95	2.93	2.79	2.78	2.75
Conditioned and treated with magnetic field	2.85	3.13	2.92	2.85	2.88	2.81
LSD	0.40	0.29	0.16	0.12	0.13	0.31
Jastra						
Control	2.62	2.80	2.83	2.73	2.61	2.41
Rubbed	2.73	2.77	2.90	2.77	2.59	2.54
Conditioned	2.78	2.94	3.01	2.88	2.72	2.62
Treated with 16 Hz magnetic field	2.91	3.04	3.06	2.88	2.86	2.70
Rubbed and treated with magnetic field	2.70	2.95	3.05	2.83	2.75	2.67
Conditioned and treated with magnetic field	2.89	3.14	3.07	2.97	2.77	2.64
LSD	0.30	0.31	0.16	0.15	0.16	0.19
PN Mono 1						
Control	2.61	2.73	2.90	2.72	2.66	2.48
Rubbed	2.74	2.88	2.93	2.81	2.74	2.45
Conditioned	2.76	3.02	3.15	2.90	2.73	2.57
Treated with 16 Hz magnetic field	2.82	3.07	3.13	2.97	2.84	2.58
Rubbed and treated with magnetic field	2.79	3.00	3.15	2.93	2.80	2.66
Conditioned and treated with magnetic field	2.86	3.12	3.09	2.98	2.80	2.74
LSD	0.30	0.20	0.22	0.27	0.12	0.30

LSD – the lowest significant differences.

the plants grown from untreated (control) seeds. Rubbing of seeds decreased the thickness of seed coats and made germination easier, but did not significantly increase the content of chlorophyll. Conditioning carry the seeds through the first two steps of germination, accelerated germination and in the first period of seedling growth, significantly increased chlorophyll content in the leaves of sugar beet plants till the 100 days of the plant life. Later on, differences in the chlorophyll contents between the plants growing from improved and untreated seeds decreased.

The 16 Hz frequent magnetic field increased the content of chlorophyll in the leaves of sugar beet plants, in comparison with control plants, during the whole vegetation period. These differences were the highest at the beginning of plant vegetation, till the 76 days after seed sowing. Frequent magnetic field, in combination with seed rubbing did not increase the content of chlorophyll in comparison to rubbing and treatment with the magnetic field independently. Conditioning increased the content of chlorophyll in the leaves of sugar beet plants, both independently and in combina-

tion with treatment with the magnetic field. At the end of vegetation period, the chlorophyll content in the leaves of plants grown from different kinds of seeds became equal. The examined sugar beet varieties reacted differently in the used improvement methods. The most visible reaction was in the variety Jamira, the lowest reaction was in Jastra. It was probably the result of the differences in the level of polyploidy.

The highest chlorophyll content was attained early in the plant development. This results showed that the plants grown from seeds conditioned and treated with the frequent magnetic field developed more quickly and more early the full intensity of metabolic processes. Then, the plants had more time for yield production. In reality, these plants produced higher leaf and root yield. Conditioning and treatment with the frequent magnetic field significantly intensified and accelerated plant metabolism.

The yield of sugar beet plants depended on absorption of the sun light and the use of it in metabolic reactions. In the favorable environmental conditions, the most productive were the plants which were able to

spread solar energy evenly through the foliage surface. Solar energy evenly saturated leaf chlorophyll, and plants attained a high level of photosynthetic intensity, even less intensive sun light.

Plants grown from seeds treated with the frequent magnetic field or from seeds conditioned and treated with the magnetic field attained the fullness of physiological activity earlier than other plants. These plants could longer keep the high photosynthetic intensity and could produce a higher yield of roots with a higher content of sugar. This is very profitable for agricultural practice.

The chlorophyll meter (SPAD-520) also measured the content of nitrogen in plants and the level of nitrogen uptake from the soil [1]. The measurement of nitrogen content during plant growth made it possible to establish proper doses of nitrogen fertilizers [2, 9].

The results presented in Table 1 and Fig. 1 show that plants grown from seeds treated with the frequent magnetic field, used independently or in combination with other methods of improvement, had a higher nitrogen content. Because all the examined plants grew under the same agricultural conditions a higher content of nitrogen probably resulted from the better uptake and the use of soil nitrogen. Better nitrogen uptake can improve physiological conditions, growth, development and the yield of the plant.

The 16 Hz frequent magnetic field increased the content of chlorophyll and nitrogen in plants independently of weather conditions during vegetation. It may be assumed that the examined factor attended at some internal features of plants, which were not correlated with environmental conditions. Thus, the frequent magnetic field affected the productivity of sugar beet plants better than other traditional methods of seed quality improvement.

Conclusions

1. The low frequent magnetic field, used independently or in combination with other methods of post-harvest improvement of seed quality (rubbing and conditioning) influenced the chlorophyll content in the leaves of sugar beet plants independently of the

examined varieties of sugar beet and weather conditions during the vegetation season. The best results were obtained using the magnetic field together with conditioning.

2. Magnetic field treatment increased the content of nitrogen in plants of the sugar beet through the better uptake of nitrogen from the soil.

References

1. Argenta S, Silva PR, da Bartolini CG (2001) Leaf chlorophyll as an index of nitrogen status in cereal. *Cincia Rural* 31:715–722
2. Costa C, Dwyer LM, Dutilleul P, Stewart DW, Ma BL, Smith DL (2001) Interrelationships of applied nitrogen SPAD and yield of leafy and non-leafy maize genotypes. *J Plant Nutrition* 24:1173–1194
3. Evans JR (1983) Nitrogen and photosynthesis in the leaf of wheat. *Plant Physiol* 72:297–302
4. Minotti PL, Halseth DE, Sieczka JB (1994) Field chlorophyll measurement to assess the nitrogen status to potato varieties. *Hort Science* 27:69–71
5. Pietruszewski S (2000) Influence of magnetic field on the crop of sugar beet of the Kalwia and Polko varieties. *Inżynieria Rolnicza* 5:207–210 (in Polish)
6. Pittman UJ (1977) Effect of magnetic seeds treatment on yield of barley, wheat and oats in Southern Alberta. *Can J Plant Sci* 57:37–45
7. Rochalska M (2002) Amelioration of the quality of seed material by means of changeable magnetic field – field experiments. *Acta Agrophysica* 62:113–126 (in Polish)
8. Rudnicki F, Wasilewski P, Kotwica K (1993) Cultivation of sugar beet. *Fragmenta Agronomica* 2;38:63–75 (in Polish)
9. Treder W (2001) Use of the SPAD-502 gauge to measure the nitrogen nutrition level of apple tree. In: *Proc of the Conf on New Technologies in Agriculture*, Spała, Poland, pp 65–67 (in Polish)
10. Tugulea L, Micleus S, Pascanu S (2000) Chlorophyll A – a suitable biomaterial for monitoring the electromagnetic influence at molecular level. In: *22 Annual Meeting Eur Bioelectromagnetics Association*, Munich, Germany, p 161
11. Watanabe NJ, Evans P, Chen WS (1994) Changes in the photosynthetic properties of wheat cultivars over the last century. *Acta Physiol* 21169–21183