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Variability examination of photosynthetic pigment content and specific leaf area in individual maize (*Zea mays* L.) plants

Attila Simkó – Szilvia Veres
University of Debrecen, Faculty of Agricultural and Food Sciences and Environmental Management,
Institute of Plant Sciences, Debrecen
simko.attila@agr.unideb.hu

SUMMARY

Currently, maize is one of the most important crops (Zea mays L.) both globally and in Hungary. We compared physiological parameters of a maize genotype – p9903 – at two different experimental sites in a field experiment. Furthermore, we examined these parameters' variability in individual plants on the leaves with different ages. Absolute chlorophyll content of the leaves were analysed, separately that of chlorophyll a and chlorophyll b. We also measured the absolute carotenoid contents of leaves. Furthermore, we calculated these photosynthetic pigments' content ratio. Specific leaf area (SLA) and dry matter weight were also measured in order to characterise plant production. The results obviously reflect the decreasing in the efficiency of photosynthetic apparatus on the low yield site. Otherwise, we identify significant differences only in certain cases of leaves.

Keywords*: chlorophyll, carotenoid, SLA, dry weight, maize*

INTRODUCTION

Recently maize *(Zea mays* L.) is one of the most important crops both globally and in Hungary. The harvested area of maize was 184 800 969 ha worldwide (FAOSTAT 2014). Currently, the most important objective of agriculture is to maintain the principles of sustainability and to perform production in deteriorating environmental conditions. The usage of the precision technologies gives an opportunity to reduce the negative effects of environmental stresses. Precision agricultural technologies are mostly based on sensor measurements – NDVI, SPAD-values – but before using these sensors, it is necessary to make calibration measurements as precisely as possible. Recently the fast, precise, *in vivo* determination of photosynthetic pigments is increasingly the base of the appropriate crop management. The precise determination of the photosynthetic pigment is the base of the relative chlorophyll metres. The environmental stress factors influenced the contents of photosynthetic pigments. Salt and heat stress induced a decreasing of chlorophyll a and chlorophyll b content but it also induced an increasing of carotenoid content (Aliu et al. 2015, Yüzbaşioğlu et al. 2017). Different nutrients affect differently the leaves photosynthetic pigment contents. Taban and Alpasaln (1996) revealed that the zinc concentration causes a decreasing of iron, copper and manganese contents of maize plant whereas the chlorophyll contents increased. Amujoyegbe et al. (2007) evinced a positive impact of a mixture which contains poultry manure and inorganic fertilizer to the total chlorophyll content of maize. Water stress also reduced the total chlorophyll content (Sanchez et al. 1983). According to Gitelson et al. (2014) the canopy chlorophyll content depends on the ages of leaves.

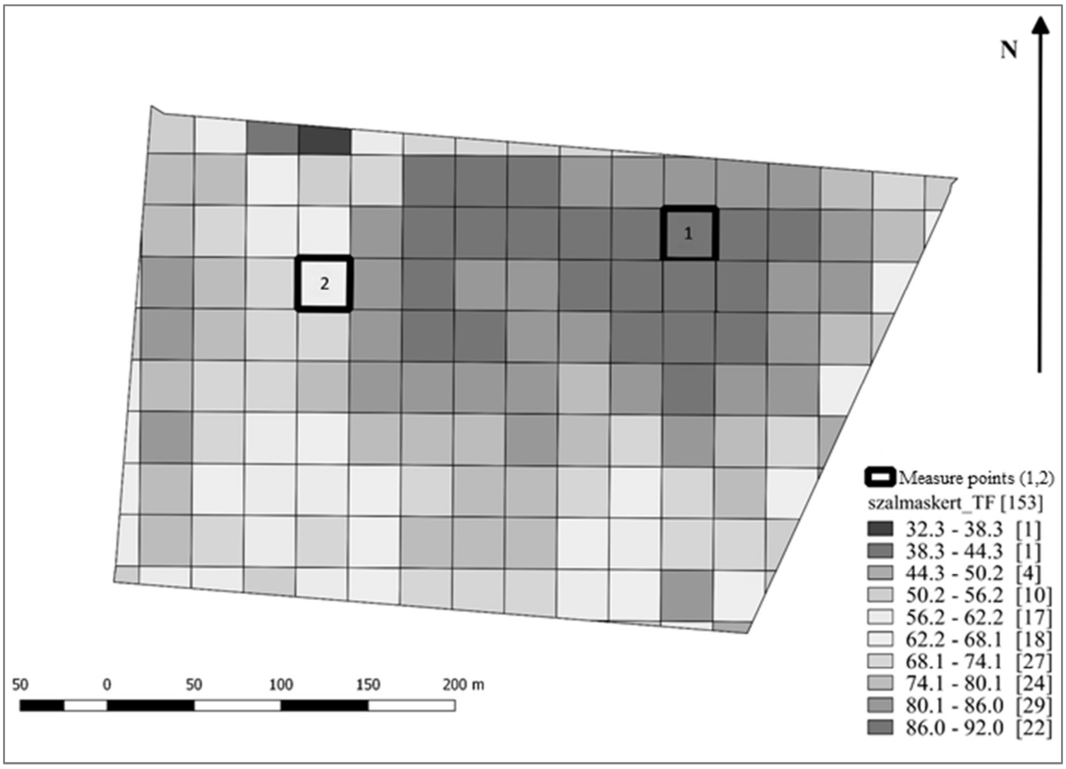
The dry matter content is also an important parameter. The specific leaf area (SLA) is available to characterize the leaves structure (Garnier et al. 2001). The increasing of this value can be observed for the bigger rate of nitrogen supply in winter wheat (*Triticum aestivum* L.) (Veres et al. 2016). Amanullah et al. (2007) also reflects this statement in the case of maize. Salinity also have a negative influence on the SLA (Cramer et al. 1994). The low temperature negatively correlated to the SLA in inbred lines of maize (Hund et al. 2005). The environmental and the anthropogenic factors both effect the leaves dry matter content. The late sowing date caused a decreasing of the dry matter content in maze (Cirilo and Andrade 1993). McCullough et al. (1994) revealed that the dry matter content of an older and a newer maize hybrid was decreased for the effect of lower nitrogen supply, but the older hybrid was more sensitive. In contrast, the leaves dry matter content did not change during the grain fill for the nitrogen rates (Anderson et al. 1982). The total dry matter content which contains the leaves and the stalk was significantly affected by the water deficit of soil (Çakir 2004). The salinity and high temperature also influenced negatively the dry weight of the shoot (Ashraf and Hafeez 2004, Eker et al. 2006).

The main objective of this study was variability examination of photosynthetic pigment content and specific leaf area in individual maize (*Zea mays* L.) plants. These parameters and their changes in individual level can help the precision agriculture technologies for establishing right technology steps towards the smart production.

MATERIAL AND METHODS

The base of our examination was a yield map which was provided by the KITE Zrt. This map signed the different sites with altered yield with different colours. The base of this map is a value which was calculated from the NDVI values of the sites, relief data, harvest results and data from the soil examination. Site (1) has 87.3791 unit and Site (2) has 63.5714 unit *Figure 1* (Kite Zrt. pers. comm.)

Figure 1: **The map of the field (Tépe, Szalmáskert) with two experimental site**



Note: 1 – dark grey, high yield; 2 – grey, low yield.

The experimental plant was a maize (*Zea mays* L.) hybrid P9903. Both sites had the same agrotechnology. Plants were in tasselling (VT) stage (Hanway, 1963) at sampling time (11/07/2017 at 10h). Six samples were collected from each area and were chosen randomly. Leaves with different ages were collected separately, started from the bottom to the top: 1. under-cob leaf, 2. cob-leaf, 3. above the cob leaf, 4. the last fully expanded leaf. The concentration of photosynthetic pigment was investigated according to Moran and Porath (1980). The data obtained after the spectro-photometrically determination was mathematically processed based on the equation of Lichtenthaler and Wellburne (1983). We also determined the specific leaf area (SLA). The SLA is the quotient of the area of the sample and the dry weight of the sample. The dry matter content was rendered by percent format.

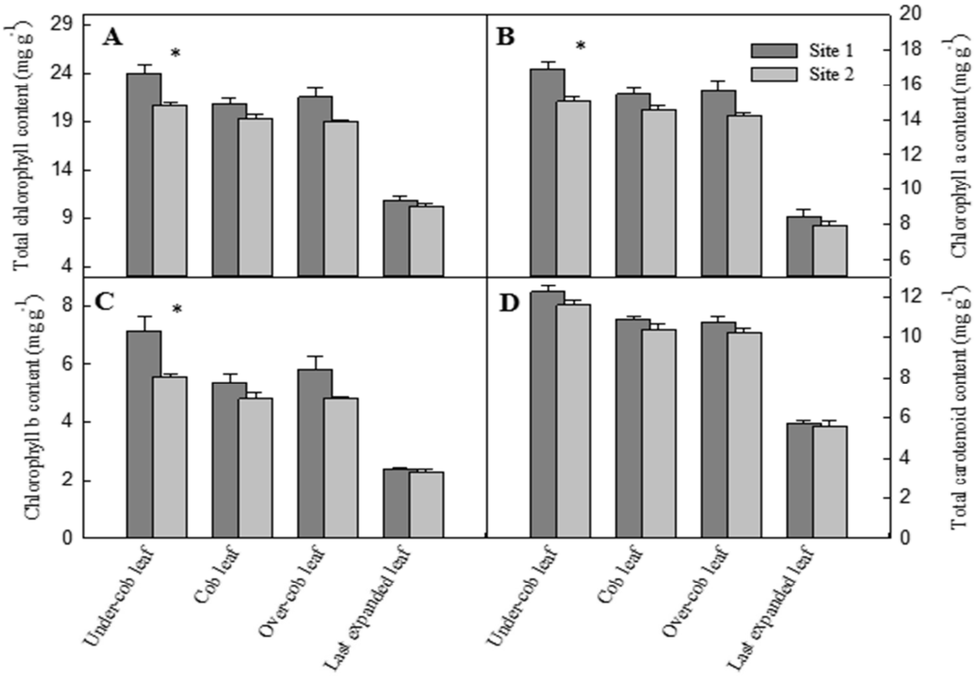
RESULTS AND DISCUSSION

The quantitative examination of the photosynthetic pigments can provide information about the effects of the different stresses on the plants (Taban and Alpasaln 1996, Aliu et al. 2015, Yüzbaşioğlu et al. 2017). According to our comparison of photosynthetic pigment contents significant differences was observed in the case of the under-cob leaves except for carotenoid content *Figure 2*.

The difference of the total chlorophyll content between site (1) and site (2) was 14.2% and 11.1% was in the case of chlorophyll a, furthermore 21.7% in the chlorophyll b content. The total chlorophyll content decreased from the older leaves to the younger in both sites. Malagoli et al. (2005) revealed that the nitrogen requirements for seed filling were satisfied mainly by N mobilized from vegetative parts in winter oilseed rape (*Brassica napus*). We measured the lowest pigment content in every case at the last fully expanded leaf at site (2). That was 7.93 ±0.43 mg g^{-1} in the case of chlorophyll a content, 2.3±0.18 mg g^{-1} in the case of chlorophyll b, 10.2±0.61 mg g^{-1} in the case of total chlorophyll content and 5.59±0.46 mg g^{-1} in the case of carotenoid content. The highest concentration of pigments was measured on the under-cob leaves at site (1). The chlorophyll a concentration was 16.9±0.71 mg g^{-1} and the chlorophyll b was 7.1±0.87 mg g^{-1} on these leaves. The total chlorophyll concentration was 24±1.59 mg g^{-1} and the total carotenoid content was 12.2±0.51 mg g^{-1}.

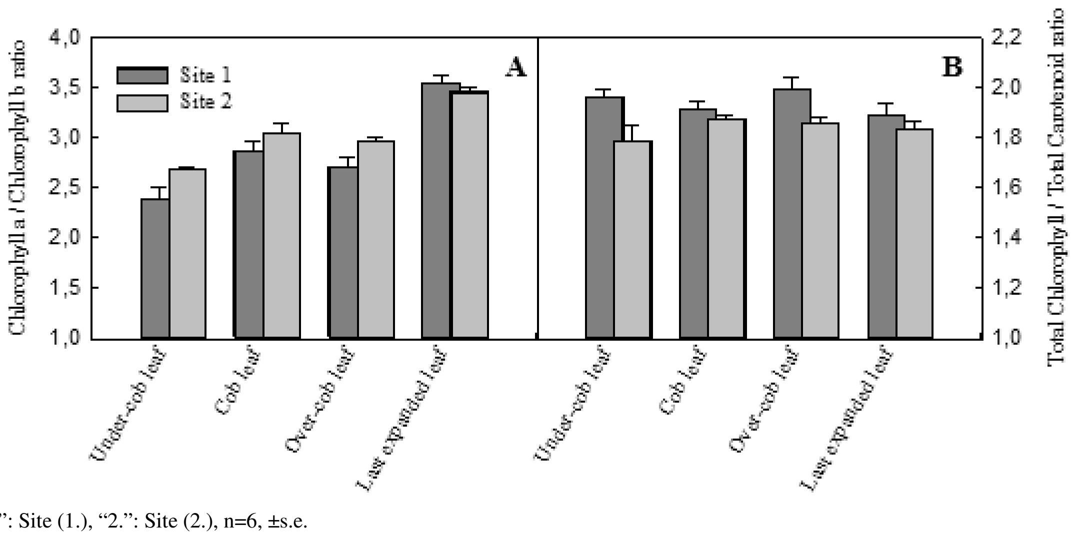
The changes of the chlorophyll a to chlorophyll b ratio and the total chlorophyll to total carotenoid ratio were shown on *Figure 3*. We weren't observed any significant differences at these parameters. But at the total chlorophyll to total carotenoid ratio was lower at site (2) yielded unequivocal. The changes of the chlorophyll a to chlorophyll b ratio for the effect of atmospheric CO_2 concentration was observed by Keutgen et al. (1997).

Figure 2: **Changes of the "A" total chlorophyll content (mg g^{-1}), "B" chlorophyll a content (mg g^{-1}), "C" chlorophyll b content (mg g^{-1}) and "D" total carotenoid content (mg g^{-1}) of maize leaves (under-cob leaf, cob leaf, over-cob leaf, last-expanded leaf) growing different area**



Note: "1.": Site (1.), "2.": Site (2.). n=6, ±s.e. (differences between sites $p<0.05$*).

Figure 3: **Changes of the "A" chlorophyll a to chlorophyll b ratio and "B" total chlorophyll to total carotenoid content of maize leaves (under-cob leaf, cob leaf, over-cob leaf, last-expanded leaf) growing different area**

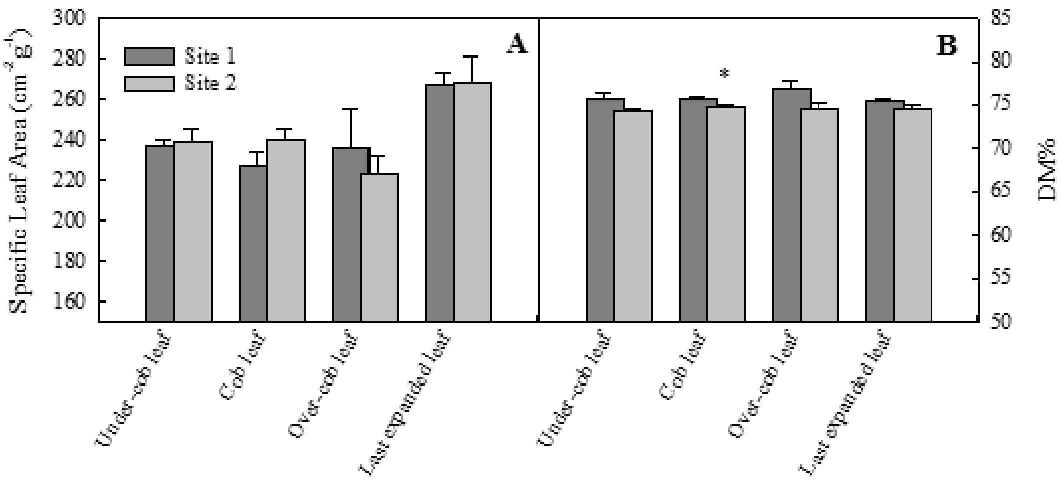


Note: "1.": Site (1.), "2.": Site (2.), n=6, ±s.e.

The *Figure 4* presents the values of Specific Leaf Area (SLA) and the dry matter production. The highest SLA was measured on the last expanded leaves 268.4±22.5 cm^{-2} g^{-1} at site (2) and 267.4±9.4 cm^{-2} g^{-1} at site (1). The lowest (SLA) was of the over cob leaves at site (2) (223.4±14.8 cm^{-2} g^{-1}). The differences between the two experimental sites were not significant.

We are showing the results of the dry matter accumulation of the leaves as percent format (DM %). If we observed these results we can conclude that, the rates of DM % were similar at site (2) in the case of every examined leaves. The lowest DM % on the site (2) was measured on the under-cob leaves. That was 74.4±0.5%. The values of site (1) were higher than the values of site (2). But if we compared the results of the two sites we observed significant difference just in one case, on the cob leaf. In this case the difference between site (1) and site (2) was up to 1%.

Figure 4: **Changes of the "A" Specific Leaf Area (cm^{-2} g^{-1}), "B" Dry matter content (cm^{-2} g^{-1}) of maize leaves (under-cob leaf, cob leaf, over-cob leaf, last-expanded leaf) growing different area**



Note: "1.": Site (1.), "2.": Site (2.), n=6, ±s.e., differences between sites $p<0.05$*.

CONCLUSION

In our experiment, we compared two experimental sites with different yields. Agronomical treatments were the same on both sites. We collect data of plant-physiological parameters. We have done the data collection on older and younger leaves separately. The photosynthetic pigment content which contains the chlorophyll a, chlorophyll b, total chlorophyll and carotenoid contents, a difference was observed between the two sites. Site (1) had higher pigment concentration in every pigment and every leaves case. But statistically significant difference was appreciable just in the case of under cob leaf. We weren't revealed any statistically significant difference at the ratios of chlorophyll a/ chlorophyll b and total chlorophyll/ total carotenoids. As well the examination of SLA values weren't revealed any significant differences. The dry matter accumulation was higher at site (1) in every leaves case but the difference was statistically significant just on the cob leaf.

Summarized the results we can conclude that the quantitative examination can be suitable to the stress research in maize, but there are differences between the pigment contents of different aged leaves. So, care must be taken about the choosing of the examined leaves if we made an absolute or relative measurement of photosynthetic pigments.

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