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SPECTRAL EVALUATION OF THE EFFECT OF POULTRY MANURE PELLETS ON PIGMENT CONTENT OF MAIZE *(ZEA MAYS L.)* AND WHEAT *(TRITICUM AESTIVUM L.)* SEEDLINGS

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Abstract

In my research I observed the effects of different poultry manure pellets on germination and pigment changes in maize and wheat with breeding test. At the end of the experiments I measured the pigment and spectral data. The effect of the pellets on the pigment content was also studied by Tukey's variance analysis and I evaluated the connection between pigment content and reflectance. Then based on the spectral data, principal component analysis was performed to select the appropriate wavelength ranges.

In the case of maize, the Natur extra and Nitro-plusz poultry manure pellets produced outstanding results on sandy soil and we can raise. In the case of wheat, the P+K manure pellets produced outstanding results. The absorption of chlorophyll can be measured at 678 nm and chlorophyll b at 650 nm. When we carried out the principal componenet analysis, we could select the 520-650 nm wavelength range and 700 nm wavelength for maize. For wheat the wavelengths were 540-650 nm and 702 nm. The priority ranges and their proximity ranges may be suitable for spectral monitoring of the pigment content.

Key words: wheat, maize, germ test, spectral monitoring

INTRODUCTION

Nowadays, proper emphasis must be placed on the proper nutrient supply of plants in plant cultivation, because the good fertilization increases soil fertility, thereby increasing the quantity and quality of yields. In recent years, the use of organic fertilizers has come to the forefront in agriculture, and the certification of these products is mainly tested in germ cell cultures in pot. Studying germination is a difficult project, because germination processes vary widely between different seeds (Bewlely, 1997), while it is a cheap technology for measuring the nutritional quality of cereals (Paucar-Menacho et al., 2016).

The disadvantage is that most experiments are chemical, material and time-consuming. Spectral measurements can also be used to measure the content of the plants in the pots without sampling, in addition more economical and with the large area, the chlorophyll concentration of the leaf can be measured (Filella et al., 1995) In the past two decades, spectral material testing has also been introduced as a tool for agricultural drought, agricultural water flow factors and the resulting yield and quality assessment (Tamás et al., 2015; Nagy et al., 2018).

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The spectral analysis of the plant is a generally suitable for measuring the combination of plant pigments, especially chlorophyll and biomass (Hall et al., 2002; Huang et al., 2007). With this method, can be measured electromagnetic waves between 400-7500 nm, and in plants the photosynthetic pigments of the leaves are absorbed in the red band. Water, nutrients, carbon and plant pigments can be measured between 400-2500 nm in the spectrum (Nagy, 2014).

In my research, because of my role in food, I chose the two most important cereal crops in the world, corn and wheat, which must meet the growing needs of the world's population (Antal, 2005; Nagy, 2007; Bandici et al., 2011). I investigated the maize *(Zea mays L.)* and wheat *(Triticum aestivum L.)* on the germination of different poultry manure pellets method of spectrophotometrically and spectrally.

First of all, the change in the content of pigment (chlorophyll and carotenoid) in test plants was important, because chlorophyll content provides information on the nitrogen content of the plant, which is related to photosynthesis (Nagy, 2014). Tóth et al., 2002 reported that the concentration of chlorophyll in the agricultural maize leaf decreased while carotenoid increased by reducing the amount of nitrogen.

Water demand of maize increases as plants forward in growth, this period during this time, soil moisture will ensure the connection between fertilization and grain formation and the transport of minerals to the right place (Domuța, 2015). Wheat is a far more feasible version of remote sensing for analyzing nitrogen than using other laboratory tests (Filella et al., 1995).

The main objective of the research was the effect of the examined poultry manure pellets on the change of maize and wheat seed pigment content, the spectral detection and correlation of the pigment content with the spectrophotometric measurement method and the selection of the spectral wavelength for the pigment content measurement.

MATERIAL AND METHOD

We used 8 kinds of soil improvers were examined for maize seedlings and for 6 weeks on maize plants (provided by the Institute of Agrochemical and Soil Science (ATI)) and wheat seedlings on the basis of changes in plant pigment content during my research. In addition, I made a preliminary assessment of whether the pigment content could be determined by non-invasive spectral measurements, which could determine the effect of pellets on plants with material-energy and time-saving.

During the experiment with maize and wheat germ I used 7 fermented poultry manure pellets and one type of fertilizer were applied at a dose of 1 t / ha and 1.5 t / ha with 4 x set repetition. At the setting of the experiment, have been filled 1 l of pots of 1 kg of undisturbed sand soil and added to which the pellets of poultry manure were at 700 grams.

The used poultry manure pellets are: Natur (100 % fermented poultry manure), Natur extra (Fermented poultry manure + meat flour), Kali - sulf (Fermented poultry manure + potassium sulphate), Kali - plus (Fermented poultry manure + Potassium chloride), Phosphorus - plus (Fermented Poultry Fertilizer + Phosphorus), P + K (Fermented Poultry Fertilizer + Phosphorus + Potassium), Nitro - plus (Fermented Poultry Fertilizer + Urea), Nitro - plus 2 (Fermented Poultry Fertilizer + Diammonium Phosphate) they were.

Soil moisture content was set at 60 % of the soil's open ground water capacity (CW) and daily irrigation replaced the missing water. We sown 5 seeds in maize and 10 seeds in wheat at every pots on 2 cm depth and after 14 days we weighed the plants pigment content and spectral characteristics.

Spectral measurements of our seedlings were carried out under laboratory conditions with AVASPEC 2048 spectrometer at a wavelength range of 400-1000 nm with an accuracy of 0.6 nm.

To determine the total content of chlorophyll and carotenoid we need fresh plant samples always. Samples should be destroyed in a mortar with quartz sand and acetone until a homogeneous state is reached, then settled in a Hettich ROTOFIX 32A centrifuge. The absorbance of the samples was measured in a glass cuvette at a wavelength of 470 nm, 644 nm and 663 nm in a spectrophotometer.

The values we have obtained are described by Droppa et al., 2003 can be converted to chlorophyll values and Lichtenthaler et al., 1983 can be used to determine the content of carotenoids, chlorophyll a and chlorophyll b.

The obtained chlorophyll, carotenoid and chlorophyll results were grouped and did statistical analysis with SPSS software. We calculated the statistical differences between control and treatment pigment results with 5 % significance by Tukey's variance analysis. In order to identify the wavelengths that can be used to determine the most important and pigment content, spectral data were grouped according to their chlorophyll content. I analyzed the average and standard deviation of the groups. In addition, the most sensitive wavelength ranges change of pigment content were selected by the main component analysis of spectral data.

RESULTS AND DISCUSSION

Effect of poultry manure pellets on corn pigment content

The chlorophyll content of maize seedlings was 1683 ± 319 µg / g, and the chlorophyll content of our maize plant for 6 weeks gave 1530 ± 405 µg / g taking into account all added poultry manure pellets. Chlorophyll content of the maize seedlings used for the control, which did not contain added soil improvers was 1472 ± 385 µg / g and in the other case 1478 ± 213 µg / g. The carotenoid content of maize seedlings during treatment was 305 ± 50 µg / g and the maize plant for 6 weeks gave 416 ± 88 µg / g which is higher than the control at 267 ± 63 µg / g and 442 ± 34 µg / g.

It can be stated that poultry manure pellets have a positive effect on the physiological processes of corn. During the treatments, the NH_4NO_3 proved to be the most effective, and organic matter can be highlighted in terms of supply Natur extra and Nitro - plus 1-2 addition.

Both abiotic and biotic stress effects have an effect on both chlorophyll and carotenoid concentrations, the plant pigments begin to decline. This statement is closely related to the maize seedlings, the concentration of chlorophyll was decreased, while the carotenoid increases proportionally with the reduction of nitrogen (R^2 = 0.9088, $p < 0.05$).

The pigment changes resulting from the stress effects are significantly correlated between the carotenoid -chlorophyll ratio and the chlorophyll content, there was a weak correlation between values (R^2 = 0.267, $p < 0.05$).

Different effects of different treatments on the change of the content of maize seedlings in the chlorophyll can be distinguished by different effects on the basis of multivariate analysis of variance (p = 0.000). We got higher levels of control yielded 1 t / ha and 1.5 t / ha NH_4NO_3, Natur extra, Nitro - plus, Phospho - plus, and P + K treatments.

The ratio of carotenoid and chlorophyll to maize seed 0.182 ± 0.012 µg / g is the treatment, which is not significantly different from the chlorophyll value of 0.185 ± 0.009 µg / g in the control, the treatments generally gave a control value. Differential effects can be distinguished from multiple variance analysis during statistical analysis (p = 0.000) (Table 1).

The value of R^2 was also significant in the corn grown for 6 weeks in the case of the chlorophyll carotenoid ratio was R^2 = 0.88844, $p < 0.05$.

The correlation between the carotenoid - chlorophyll ratio and the chlorophyll content in the pigment change due to the stress effects gave a value of R^2 = 0.5268, $p < 0.05$ so the correlation is medium.

Different chlorophyll containing treatments can be separated based on multivariate variance analysis (p = 0.027). The Nitro - plus 1, Nitro - plus 2 and P + K treatments was given statistically higher result for the control, while the other used pellets produced nearly the same results as the control. The ratio of carotenoids to chlorophyll during treatments was 0.299 ± 0.021 µg / g so gave a positive result compared to 0.296 ± 0.016 µg / g of chlorophyll. Differential effects can be distinguished from multiple variance analysis during statistical analysis (p = 0.000) (Table 2).

Table 1

Differences in chlorophyll content differences and carotenoid / chlorophyll ratio between treatments

	Mean	Stand. deviat	Min	Max	Mean	Stand. deviat	Min	Max
NH_4NO_3 1 t/ha	2163 c	375	1603	2638	0.181 b	0.006	0.174	0.188
NH_4NO_3 1.5 t/ha	2007 c	154	1824	2249	0.171 a	0.005	0.165	0.179
phospho plus 1 t/ha	1508 ab	226	1208	1845	0.198 c	0.013	0.183	0.218
phospho plus 1.5 t/ha	1848 bc	145	1674	2066	0.177 ab	0.004	0.171	0.181
kali plus 1 t/ha	1398 a	132	1260	1609	0.176 ab	0.009	0.162	0.186
kali plus 1.5 t/ha	1518 ab	181	1259	1715	0.173 a	0.007	0.163	0.181
kali sulf 1 t/ha	1321 a	181	1044	1549	0.190 bc	0.007	0.18	0.197
kali sulf 1.5 t/ha	1755 bc	98	1658	1909	0.169 a	0.002	0.166	0.172
natur 1 t/ha	1570 ab	173	1403	1810	0.187 bc	0.006	0.18	0.197
natur 1.5 t/ha	1332 a	147	1126	1539	0.199 c	0.018	0.182	0.225
natur extra 1.5 t/ha	1852 bc	471	1104	2398	0.178 ab	0.004	0.173	0.183
natur extra 1 t/ha	1805 bc	229	1623	2196	0.179 ab	0.007	0.175	0.191
nitro plus 1 t/ha	1829 bc	310	1360	2149	0.177 ab	0.013	0.156	0.19
nitro plus 1.5 t/ha	1829 bc	185	1645	2097	0.183 b	0.01	0.173	0.2
P+K 1 t/ha	1521 ab	183	1210	1678	0.197 c	0.012	0.188	0.217
P+K 1.5 t/ha	1629 bc	300	1354	2030	0.182 b	0.005	0.177	0.188
control	1472 a	352	1106	1871	0.183 b	0.007	0.179	0.2

* where there is no statistical difference between treatments with the same letter value

Table 2

Differences in chlorophyll content and carotenoid / chlorophyll ratio between treatments during 6 weeks of cultivation in corn

	Mean	Stand. deviation	Min	Max	Mean	Stand. deviation	Min	Max
control	1528 ab	173	1327	1629	0.296 c	0.016	0.286	0.315
natur	1292 ab	234	1106	1556	0.286 c	0.009	0.281	0.296
natur extra	1390 a	259	1098	1594	0.271 abc	0.022	0.25	0.294
kali sulf	1430 ab	285	1177	1741	0.290 c	0.026	0.267	0.318
kali plus	1214 a	187	1080	1428	0.291 c	0.016	0.282	0.31
nitro plus 1	2209 b	200	1986	2372	0.237 a	0.005	0.232	0.242
phospho plus	1330 ab	190	1191	1547	0.279 bc	0.009	0.27	0.287
P+K	1701 ab	325	1439	2065	0.308 c	0.007	0.303	0.317
nitro plus 2	1888 b	519	1379	2418	0.244 a	0.011	0.232	0.253

* where there is no statistical difference between treatments with the same letter value

Effect of poultry manure pellets on the pigment content of wheat plants

The chlorophyll content of wheat seedling with the added soil improvers was 1917 ± 266 µg / g and the control shows a positive increase compared to the content of 1770 ± 235 µg / g chlorophyll. The wheat seedling carotenoid content after treatment was 318 ± 56 µg / g and the control value was 295 ± 63 µg / g.

On the basis of our values, it can be stated that the added soil improvers have a positive effect on the development and physiological processes of wheat seedlings. P + K proved to be the most effective during the treatments and the NH_4NO_3, Kali - sulf, Kali - plus and Nitro - plus granules were the most important in terms of results.

Various abiotic and biotic stress effects on wheat seedlings also influence the change in pigment content. There is a moderately close contest between the reduction in chlorophyll and carotenoid content ($R^2 = 0.604$, $p < 0.05$).

The resulting pigment changes were not significant in the case of wheat seedlings in relation to the correlations between the carotenoid - chlorophyll ratio and the chlorophyll content.

The effects of the chlorophyll content can be statistically separated from the wheat seedlings in the multivariate variance analysis ($p = 0.001$). The NH_4NO_3, P + K, Nitro - plus and Kali - plus treatments gave higher results compared to control for both doses. Calculating the carotenoid and chlorophyll ratios on all treatments were 0.16 ± 0.019 µg / g, which is no significant difference compared to 0.16 ± 0.012 µg / g of control. We can be separated statistically different groups according to the carotenoid chlorophyll ratio based on the multivariate variance analysis ($p = 0.000$) (Table 3).

Evaluation of the spectral measurement of pigment content in maize and wheat foliage

In order to investigate the spectral properties of maize and wheat, the reflectance standard deviations calculated for chlorophyll content were compared by proportioning the given reflectance averages. The examined groups cover intervals containing spectral data of all plants from the scattering of low chlorophyll-containing reflectance data.

There was a high standard deviation from 510 to 530 nm, the standard deviation of reflectance increased with the chlorophyll content, there is a high standard of variation in high chlorophyll-containing maize in germ and breeding plants and in wheat seedlings, this range may be suitable for determining plant maturity tests. The peak of the scatter is outstanding due to the absorption properties of chlorophyll measured in the given wavelength range and sensitive to low chlorophyll content at 680 nm.

The groups have to give an almost equal value of the standard deviation of the reflectance measured at 680 nm on the basis of the literature, which is not justified for wheat seedlings. The reflectance values measured at wavelength ranges from 678 nm to 30 nm showed high variability, so this wavelength range can be used to measure pigment content values. The reflectance values measured in the NIR range showed low variability, this wavelength range can be used to measure pigment content values. The reflectance scatter values measured at 525-575 nm and 700 nm wavelengths are pigment sensitive for both plants in our chart.

Table 3

Differences in chlorophyll content differences and carotenoid / chlorophyll ratio between treatments

	Mean	Stand deviation	Min	Max	Mean	Stand deviation	Min
NH_4NO_3 1 t/ha	1978 c	242	1568	2130	0.162 bc	0.154	0.173
NH_4NO_3 1.5 t/ha	2180 cd	304	1838	2670	0.164 bc	0.162	0.202
phospho plus 1 t/ha	1853 b	93	1758	1996	0.143 a	0.124	0.157
phospho plus 1.5 t/ha	1849 b	118	1666	1979	0.179 d	0.169	0.185
kali plus 1 t/ha	1860 b	302	1400	2226	0.142 a	0.135	0.147
kali plus 1.5 t/ha	2067 c	322	1534	2329	0.166 bc	0.168	0.182
kali sulf 1 t/ha	2056 cd	142	1861	2223	0.138 a	0.127	0.152
kali sulf 1.5 t/ha	1637 a	111	1523	1770	0.178 cd	0.173	0.187
natur 1 t/ha	1759 ab	80	1649	1837	0.153 ab	0.135	0.169
natur 1.5 t/ha	1889 b	326	1344	2195	0.186 d	0.174	0.201
natur extra 1 t/ha	1676 ab	145	1455	1815	0.161 bc	0.145	0.17
natur extra 1.5 t/ha	1843 b	291	1416	2172	0.179 d	0.173	0.184
nitro plus 1 t/ha	1888 b	300	1676	2404	0.175 cd	0.163	0.194
nitro plus 1.5 t/ha	1986 c	155	1849	2234	0.148 a	0.168	0.197
P+K 1 t/ha	2336 cd	236	2040	2595	0.143 a	0.09	0.162
P+K 1.5 t/ha	1959 c	175	1721	2215	0.146 a	0.173	0.197
control	1770 ab	204	1569	2110	0.165 bc	0.154	0.183

* where there is no statistical difference between treatments with the same letter value

The maize and wheat main component analysis can be used to raise 3 wavelengths: 520 nm, 650 nm and 700 nm (Fig. 1).

CONCLUSIONS

The studied soil fertilizer pellets have a positive effect on the physiological processes of maize based on the analysis of maize pigment content. For maize production, the use of Phosphorus- plus, Kali-sulf soil improvers is recommended for poultry manure pellets at doses of Natur extra, Nitro-plus 1 and Nitro-plus 2 and 1.5 t / ha. Based on these, it can be that high-nitrogen pellets produce positive results in maize production, including additives that are supplemented with urea and DAP. During the development of potassium additive, maize will be added and utilized later.

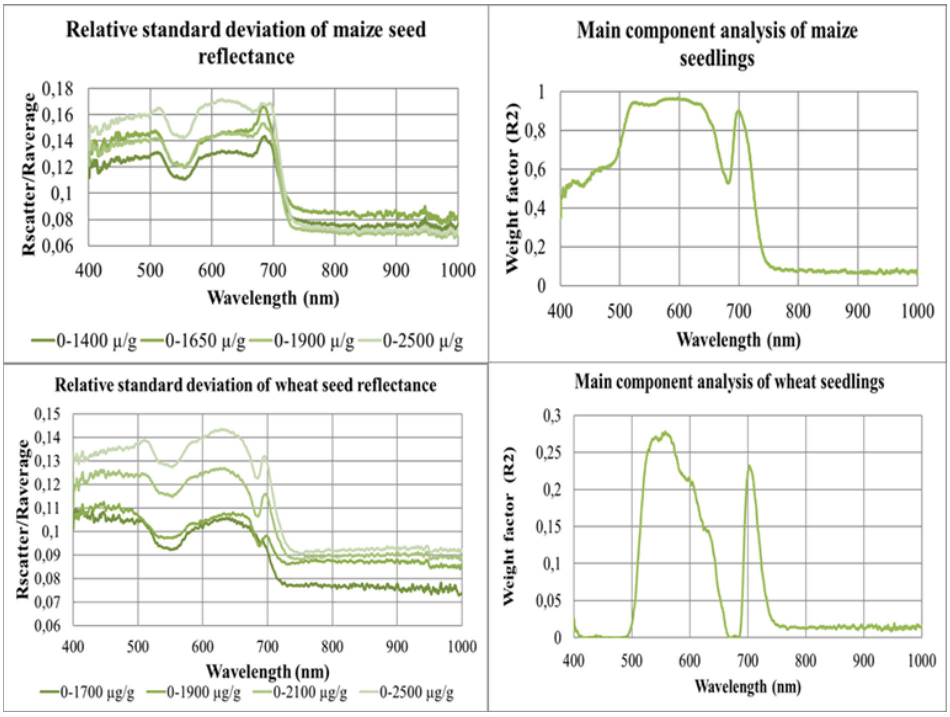

Fig. 1. Relative standard deviation and main component analysis of the reflectance of maize and wheat

The use of KCl as an additive is to be avoided due to the presumed sensitivity of the chloride to the plant.

The wheat seed pigment content confirmed the positive effect of poultry manure pellets on physiological processes like maize. According to the treatments, the used of the P + K in wheat production is the most suitable, and the used of Kali- sulf, Kali-plus and Nitro-plus poultry manure pellets is also recommended. Based on these, it is recommended to use higher nitrogen and potassium-containing organic additives in pellet production in the future.

The non-invasive determination of chlorophyll content can be suggested in the carotenoid -sensitive 520-580 nm wavelength range, as well as the reflectance values measured at 650 nm and 700 nm. Spectral measurement can be used to examine changes in pigment content in products therefore, it is recommended that the spectrophotometric method be supplemented with spectral measurements in the future. The use of spectral measurements can provide a basis for the development of field methodology as well, since the given test parameters can be measured without destruction in the field.

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REFERENCES

1. Antal J., 2005, Basics of cropproduction. Cereals (in Hungarian: A növénytermesztéstan alapjai. Gabonafélék.) Mezőgazda kiadó, Budapest, pp.383;
2. Bandici Gh.E., Ardelean I., Stanciu A., 2011, Researches regarding the influence of crop rotation and fertilization level on the dynamics of total dry phytomass accumulation in winter wheat. Natural Resources and Sustainable Development;
3. Bewley D.J., 1997, Seed Germination and Dormancy. American Society of Plant Physiologists. The Plant Cell, Vol. 9, pp.1055-1066;
4. Domuța Cr., 2015, Water consumption of irrigated and unirrigated maize crop and irrigation influence on yields obtained in different areas from Romania. Natural Resources and Sustainable Development;
5. Droppa M., Erdei S., Horváth G., Kissimon J., Mészáros A., Szalai J., Kosáry J., 2003, Plant Biochemistry and Physiology Exercises (in Hungarian: Növénybiokémiai és élettani gyakorlatok). Budapesti Közgazdaságtudományi és Államigazgatási Egyetem, Budapest, pp.88;
6. Filella I., Serrano L., Serra J., Penuelas J., 1995, Evaluating wheat nitrogen status with canopy reflectance indices and discriminate analysis. Crop Science, 35, pp.1400–1405;
7. Hall A., Lamb D.W., Holzapfel B., Louis J., 2002, Optical remote sensing applications for viticulture a review. Australian Journal of Grape & Wine Research, 8, pp.36–47;
8. Huang W., Lamb W.D., Niu Z., Zhang Y., Liu L., Wang J., 2007, Identification of yellow rust in wheat using in-situ spectral reflectance measurements and airborne hyperspectral imaging. Precision Agriculture. 8, pp.187–197;
9. Lichtenthaler H.K., Wellbum A.R., 1983, Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents. Biochem Soc Trans, 603, pp.591-592;
10. Nagy A., 2014., Spectral testing methods for drought and stress monitoring, irrigation planning (in Hungarian: Spektrális vizsgálati módszerek aszály és stressz monitorozásában, öntözéstervezésben). Debreceni Egyetem, Debrecen, TÁMOP 4.2.4.A/2-11-1-2012-0001, pp.27;
11. Nagy A., Fehér J., Tamás J., 2018., Wheat and maize yield forecasting for the Tisza river catchment using MODIS NDVI time series and reported crop statistics. Computers and Electronics in Agriculture, 151 (2018), pp.41–49;
12. Nagy J., 2007, Maize cultivation (in Hungarian: Kukoricatermesztés). Akadémiai kiadó, Budapest, pp.395;
13. Paucar-Menacho M.L., Martinez-Villaluenga C., Duenas M., Frias J., Penas E., 2016, Optimization of germination time and temperature to maximize the content of bioactive compounds and the antioxidant activity of purple corn (Zea mays L.) by response surface methodology. Food Science and Technology, 76, pp.236-244;
14. Tamás J., Nagy A., Fehér J., 2015, Agricultural biomass monitoring on watersheds based on remotely sensed data. Water Science & Technology, | 72.12 | 2015;

15. Tóth V.R., Mészáros I.,Veres S., Nagy J., 2002, Effects of the available nitrogen on the photosynthetic activity and xanthophylls cycle pool of maize in field. Journal of Plant Physiology, 159, pp.627–634.

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