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# INTERDEPENDENCE RELATIONSHIPS BETWEEN THE PRODUCTIVITY ELEMENTS IN WHEAT EAR AND THE PHOTOSYNTHETIC PIGMENTS IN LEAVES IN RELATION TO THEIR POSITION ON THE STEM

## SUMMARY

The study analyzed the interdependence relationships between the productivity elements of the wheat ear and the content of photosynthetic pigments in the leaves, and described the causal relationships based on equations and graphic models. The study took place in the Didactic and Experimental Resort of the Life Science University "King Michael I" from Timisoara, Romania. The biological material was represented by the Solehio wheat variety. The content of chlorophyll (Chl) and carotenoids (Car) was determined in the booting stage (45 – 47 BBCH code) in the five leaves on the stem (L1 to L5), according to the structural units (phytomers) specific to the Solehio variety. At physiological maturity (99 BBCH code), ear samples were taken and productivity elements were determined: spikelets number in ear, SN-E; fertile spikelets number in ear, FSN-E; grain number in spikelet, GN-S; grain number in ear, GN-E; grain weight in ear, GW-E; mean weight of a grain, MWG. Very strong and strong correlations were recorded between Chl and Car at the level of the studied leaves (e.g. $r=0.937$ in the case of L3, $p<0.001$; $r=0.859$ in the case of L5, $p<0.01$) and between the elements of productivity and leaves (e.g. between GN-E and Chl L5, $r=0.886$, $p<0.001$; between GN-S and Chl L5, $r=0.857$, $p<0.01$; between GW-E and Chl L5, $r=0.825$, $p<0.01$). The regression analysis facilitated obtaining an equation and 3D models and in the form of isoquants, which described the variation of the productivity elements in relation to Chl and Car at the level of the flag leaf (L5), under statistical safety conditions ($R^2$, p and RMSEP).

**Keywords**: correlations, chlorophyll, carotenoids, phytomers, wheat, ear, productivity elements

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## INTRODUCTION

Wheat is a plant of major importance within crop plants, for reasons of food resources, fodder, for industrialization, bakery, pastry, etc., and it is a crop plant with a long history in relation to humanity (Grote *et al.,* 2021; Erenstein *et al*., 2022).

As a result of its importance, wheat has been widely studied from the perspective of genetic aspects and breeding programs (Gao *et al.,* 2021; Govta *et al.,* 2022), physiological aspects (Mohan and Gupta, 2015), soil fertilization and plant nutrition aspects (Hirzel *et al.,* 2022; Jat *et al*., 2022), productivity elements (Datcu *et al.,* 2019; Jat *et al*., 2022), production quality, but also in relation to their interactions (Govta *et al*., 2022; Jat *et al.,* 2022).

Interaction "genotype x environment" or complex interactions of the type "genotype x environment x technological inputs" were studied and quantified in different experimental conditions regarding wheat culture (Tofighi *et al*., 2021; Todorova *et al*., 2022).

The leaves of wheat plants have a linear shape, with variations from juvenile to adult plant (Dornbusch *et al*., 2011) variable number in relation to the genotype and vegetation conditions, with a basal arrangement (the basal leaves, in the first stages of vegetation) but also an alternate arrangement, on the height of the stem, related to the repetitive structural units (phytomers) of the stem (Kirby, 2002).

The appearance, arrangement and formation / extension of wheat leaves has been studied in relation to genetic factors (Yang *et al.,* 2021; Mehla *et al*., 2022), but also to environmental and technological factors, such as fertilizers (Hay and Wilson, 1982; Kubar *et al.,* 2022; Merrium *et al*., 2022).

The content of photosynthetic pigments is important in relation to the photosynthesis process, in order to convert solar energy into biochemical energy and specific metabolic compounds (Lu *et al.,* 2001; Liu *et al*., 2020).

The content of photosynthetic pigments in wheat varies in relation to the genotype (Javed *et al.,* 2022), environmental factors and vegetation conditions (Xiong *et al.,* 2015), the position of the leaves on the plant (may much studied flag leaf) (Roy *et al.,* 2021; Yang *et al.,* 2022), with fertilization and plant nutrition status (Zhang *et al*., 2021), water regime (Yang *et al.*, 2022), the state of plant health (Cai *et al.,* 2021), vegetation stages of plants (Zhang *et al*., 2009; Li *et al*., 2022), stress factors (Roy *et al*., 2021), but also interactions of factors, such as "genotype x environment" or "genotype x environment x technological inputs".

At the same time, it was found in some studies the variation of the spatial distribution of the photosynthetic pigments (eg chlorophyll) in the leaves, in relation to the geometry of the leaf (especially the length) but also with various other factors (Borsuk and Brodersen, 2019; Huang *et al*., 2023).

Wheat is cultivated with a predilection for the production of grains, so that the productivity elements of the wheat ear present the main category of parameters at the level of the plant and the crops and have been studied in relation to the genotype (Wolde *et al.,* 2019), and vary in relationship with the complex interaction "genotype x environmental factors x culture technology" (Marcos-Barbero *et al.,* 2021; Nazarenko *et al*., 2022).

The present study analyzed the content of photosynthetic pigments in the leaves of wheat, the Solehio variety, in relation to the position of the leaves on the plant stem, productivity elements in the ear, and interdependence relationships between the productivity elements in relation to the content of photosynthetic pigments in the leaves.

## MATERIAL AND METHODS

The study evaluated the productivity elements in the wheat ear in relation to the content of photosynthetic pigments in the leaves on the stem of the wheat plants.

The study took place in the Didactic and Experimental Resort of the Life Science University "King Michael I" from Timisoara, Romania. The biological material was represented by the Solehio wheat variety, cultivated on a medium-fertility chernozem type soil, non-irrigated system, agricultural year 2021 – 2022, Figure 1 (ESRI, 2014).

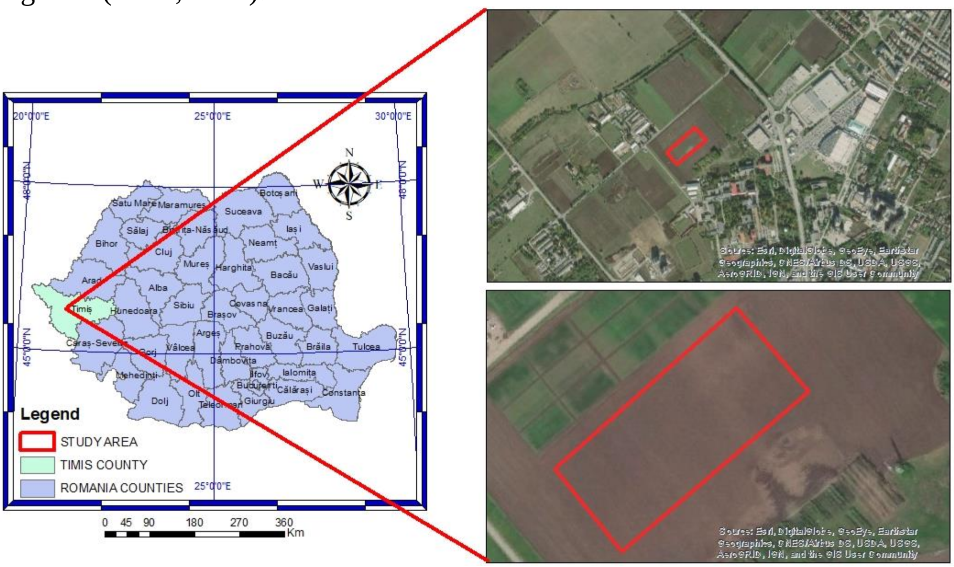
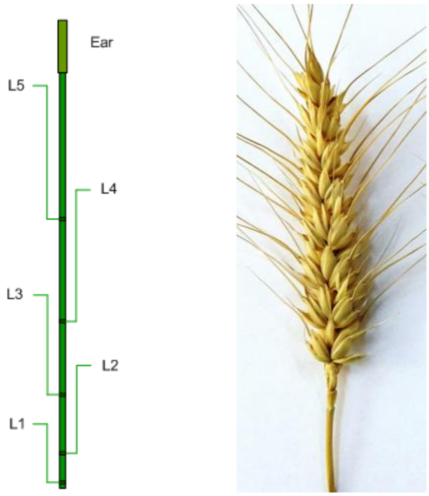



Figure 1. The location of the study

For the study, 10 wheat plants each (the main plant) were considered, randomly, from ten control points. The leaves related to the nodes arranged on the height of the stem of the wheat plants were analyzed, within the repetitive units (phytometers) of the formation of the stem of the wheat plant (Kirby, 2002; Gebbing, 2003). Between 6 and 16 such units, "phytomers or repeating units" (a node, a leaf, an elongated internode) were reported (Kirby, 2002).

In the case of the Solehio variety, 5 such units were identified, and the leaves were numbered starting from the base of the plants, in the order of the nodes and internodes (the units from the base to the top of the plant) - leaf 1 (L1), leaf 2 (L2), leaf 3 (L3), leaf 4 (L4), and Leaf 5 - flag leaf (L5), figure 2a. Determination of photosynthetic pigments was done at Principal growth stage 4: Booting (45 – 47 BBCH code) (Meier, 2001). The content of photosynthetic pigments was determined by non-destructive methods; chlorophyll (Chl) with a SPAD 502Plus portable chlorophyll meter (KONICA MINOLTA), and for the carotenoid content (Car) the ACM-200 plus device (OPTI-SCIENCES) was used.

At physiological maturity, Senescence (99 BBCH code), spike samples were collected from the studied plants (E1 to E10), the main plant, and the productivity elements were determined: spikelets number in ear, SN-E; fertile spikelets number in ear, FSN-E; grain number in spikelet, GN-S; grain number in ear, GN-E; grain weight in ear, GW-E; mean weight of a grain, MWG, figures 2(b), (c).




**Elements studied in the wheat ear**

spikelets number in the ear (SN-E)
number of fertile spikelets in the ear (FSN-E)
grain number in spikelet (GN-S)
grains number in the ear (GN-E)
grains weight in the ear (GW-E)
mean weight of a grain (MWG)

(a) (b) (c)

Figure 2. Plant and ear of wheat, Solehio variety; (a) layout scheme of analyzed leaves; (b) spike of the main plant; (d) productivity elements analyzed at the ear level

The interdependence relationships between the content of photosynthetic pigments (Chl, Car) at the level of leaves L1 – L5, and the productivity elements studied at the ear level (SN-E, FSN-E, GN-S, GN-E, GW-E, MWG) were evaluated.

Descriptive statistical analysis, correlation analysis, regression analysis were used, and for the significance of the results, the correlation coefficient (r), the regression coefficient ($R^2$), RMSEP, equation (1), and the statistical safety parameter (p , $^*p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$).

$$RMSEP = \sqrt{\frac{1}{n}\sum_{j=1}^{n}\left(y_j - \hat{y}_j\right)^2} \qquad (1)$$

The statistical processing and analysis of the experimental data was done with the calculation module in EXCEL, and with the softwares PAST (Hammer *et al.*, 2001), Wolfram Alpha (2020), and JASP (2022).

## RESULTS AND DISCUSSION

The photosynthetic pigments, chlorophyll (Chl) and carotenoids (Car) were determined at bootting stage (45 – 47 BBCH code) on each leaf (L1 to L5), on the five units of the stem, specific to the Solehio wheat variety. In the case of the L1 leaf, the chlorophyll content varied between 9.60-12.70±0.32 SPAD units, and the carotenoid content varied between 3.60-4.10±0.06 units. In the case of the L2 leaf, Chl varied between 30.80-49.65±1.91 SPAD units, and Car varied between 5.30-8.70±0.38 units. In the case of the L3 leaf, Chl varied between 43.70-60.80±1.58 SPAD units, and Car varied between 8.70-13.70±0.52 units. In the case of the L4 leaf, Chl varied between 49.90-58.80±1.05 SPAD units, and Car varied between 9.50-15.50±0.64 units. In the case of the L5 leaf, Chl varied between 46.70-55.20±0.86 SPAD units, and Car varied between 9.70-15.40±0.62 units. The complete series of values recorded at the foliar level, on the five floors of the stem of the wheat plants, at split (booting, 45 – 47 BBCH code) are presented in table 1.

Table 1. Photosynthetic pigments values in leaves of wheat plants, Solehio wheat variety

| Trial | Main stem plants | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Chl-L1 | Car-L1 | Chl-L2 | Car-L2 | Chl-L3 | Car-L3 | Chl-L4 | Car-L4 | Chl-L5 | Car-L5 |
| P1 | 10.10 | 3.75 | 41.60 | 6.85 | 48.90 | 10.60 | 51.20 | 11.60 | 47.70 | 9.70 |
| P2 | 12.40 | 4.00 | 48.10 | 7.60 | 54.30 | 10.80 | 52.50 | 11.20 | 54.90 | 15.40 |
| P3 | 11.90 | 4.10 | 45.10 | 7.70 | 57.60 | 13.70 | 51.90 | 13.20 | 55.20 | 15.20 |
| P4 | 12.70 | 3.90 | 49.65 | 8.70 | 60.80 | 13.70 | 58.80 | 15.50 | 52.40 | 12.60 |
| P5 | 10.80 | 4.10 | 38.50 | 5.30 | 52.50 | 11.70 | 49.90 | 10.80 | 51.90 | 11.10 |
| P6 | 10.60 | 3.70 | 33.90 | 5.60 | 53.40 | 11.10 | 58.10 | 14.00 | 52.50 | 10.60 |
| P7 | 11.00 | 3.60 | 43.80 | 6.40 | 47.00 | 9.10 | 56.80 | 15.20 | 52.80 | 12.50 |
| P8 | 9.60 | 4.00 | 30.80 | 5.30 | 53.10 | 10.80 | 50.30 | 9.50 | 46.70 | 10.05 |
| P9 | 11.10 | 3.70 | 46.10 | 7.90 | 43.70 | 8.70 | 55.70 | 14.60 | 51.60 | 11.90 |
| P10 | 10.30 | 3.80 | 42.60 | 6.20 | 50.10 | 10.50 | 51.70 | 12.10 | 50.75 | 11.30 |
| SE | ±0.32 | ±0.05 | ±1.91 | ±0.37 | ±1.57 | ±0.52 | ±1.05 | ±0.64 | ±0.86 | ±0.62 |

*Note: Chl – chlorophyll content and Car – carotenoid content; L1 to L5 - the position of the leaves on the plant; P1 to P10 – wheat plants samples studied; SE – Standard Error*

At the same plants, the ears were harvested at the moment of physiological maturity, and productivity elements were determined. The number of spikelets in the ear (SN-E) varied between 18.00-19.00±0.17. The number of fertile spikelets in the ear (FSN-E) varied between 16.00-17.00±0.16. The number of grains in the ear (GN-E) varied between 33.00-53.00±2.30. The average number of grains in the spikelet (GN-S) varied between 2.030-3.118±0.128. The average weight of the grains in the ear (GW-E) varied between 1.1360-2.1310±0.1109 g. The average weight of a grain in the ear (MGW) varied between 0.0034-0.0402±0.00078 g. The series of values recorded for the productivity elements in the ear, the Solehio wheat variety, are presented in table 2.

Table 2. Average values of the productivity elements in the ear, Solehio wheat variety

| Trial | | Main stem ear | | | | | |
|---|---|---|---|---|---|---|---|
| Plant | Spike | SN-E | FSN-E | GN-S | GN-E | GW-E | MWG |
| P1 | E1 | 19 | 16 | 2.13 | 34 | 1.140 | 0.03353 |
| P2 | E2 | 18 | 17 | 3.06 | 52 | 1.878 | 0.03612 |
| P3 | E3 | 19 | 17 | 3.12 | 53 | 2.131 | 0.04021 |
| P4 | E4 | 18 | 16 | 2.81 | 45 | 1.502 | 0.03338 |
| P5 | E5 | 19 | 17 | 2.11 | 38 | 1.276 | 0.03753 |
| P6 | E6 | 19 | 16 | 2.69 | 43 | 1.687 | 0.03923 |
| P7 | E7 | 18 | 17 | 2.95 | 51 | 1.933 | 0.03790 |
| P8 | E8 | 18 | 16 | 2.03 | 33 | 1.136 | 0.03442 |
| P9 | E9 | 19 | 17 | 2.78 | 49 | 1.887 | 0.03851 |
| P10 | E10 | 18 | 17 | 2.65 | 44 | 1.713 | 0.03893 |
| SE | | ±0.17 | ±0.16 | ±0.13 | ±2.30 | ±0.11 | ±0.00078 |

*Note: SN-E – spikelets number in ear; FSN-E – fertile spikelets number in ear; GN-S – grain number in spikelet; GN-E – grain number in ear; GW-E – grain weight in ear; MWG – mean weight of a grain (g); SE – Standard Error; E1 to E10 – ears sample corresponding to plant sample P1 – P10*

The graphic distribution of the data series recorded for the photosynthetic pigments in the analyzed L1-L5 leaves and the productivity elements at the level of the spike are shown graphically in figures 3 and 4, in boxplot format.

The content of photosynthetic pigments in the leaves of wheat, Solehio variety, at the time of determination (45 – 47 BBCH code) varied in relation to the position of the five leaves on the stem (L1 to L5), according to a model described by equation (2) in the case chlorophyll content (Chl, R2=0.976, p=0.0236), respectively equation (3) in the case of carotenoid content (Car, $R^2$=0.970, p=0.0296). The graphic distribution of Chl and Car values in relation to the position of the leaves L1 to L5 on the plant stem, and the graphic expressions of equations (2) and (3), are presented in figure 5.

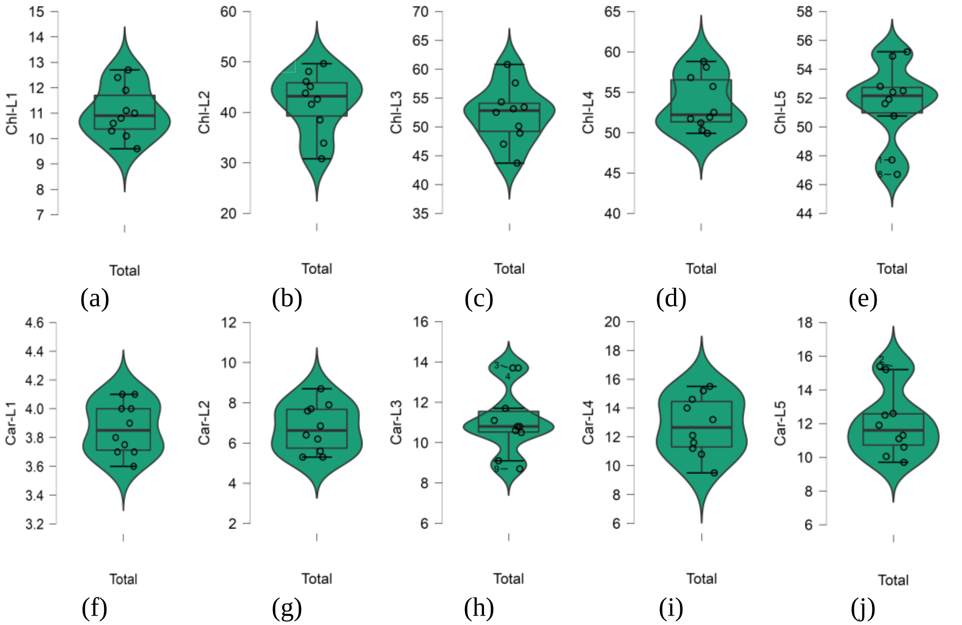



Figure 3. Distribution in boxplot format of photosynthetic pigments values in wheat leaves, Solehio variety; (a) Chl-L1; (b) Chl-L2; (c) Chl L-3; (d) Chl L-4; (e) Chl L-5; (f) Car L-1; (g) Car L-2; (h) Car L-3; (i) Car L-4; (j) Car L-5

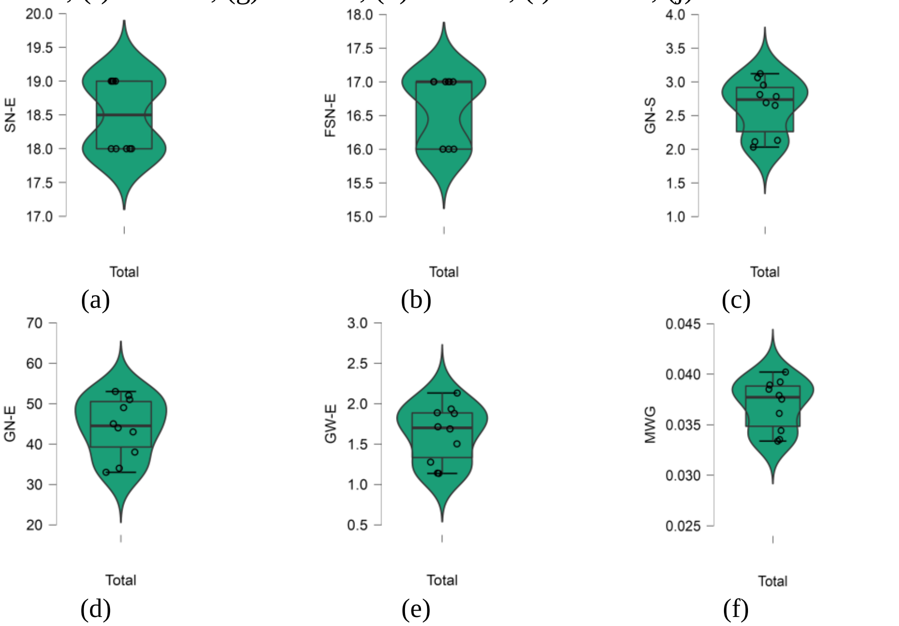



Figure 4. The distribution in boxplot format of the values of the productivity elements at ear level, Solehio wheat variety; (a) SN-E – spikelets number in ear; (b) FSN-E – fertile spikelets number in ear; (c) GN-S – grains number in spikelets; (d) GN-E – grains number in ear; (e) GW-E – grains weight in ear; MWG – mean weight of a grain

$$Chl = -5.328x^2 + 41.25x - 23.05 \quad (2)$$
$$Car = -0.7036x^2 + 6.456x - 2.328 \quad (3)$$

where: x – Leaf position

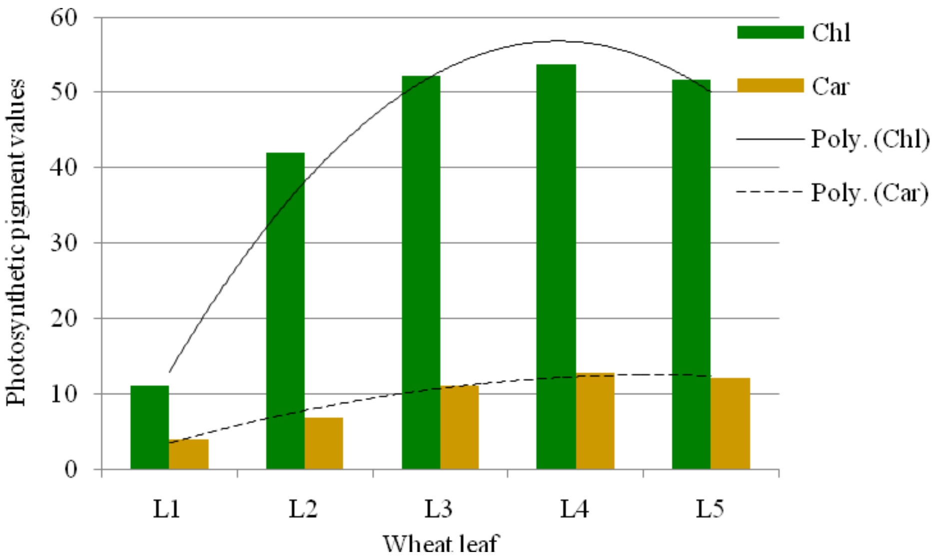



Figure 5. Distribution of photosynthetic pigments (Chl and Car) in relation to the position of the leaves on the stem, Solehio wheat variety (45 – 47 BBCH code)

The correlation analysis highlighted different levels of correlation, positive or negative, between the photosynthetic pigments at the level of the 5 studied leaves on the height of the plants, between the productivity elements at the ear, as well as between the productivity elements and the photosynthetic pigments, under statistical safety conditions (* p<0.05; ** p<0.01; *** p<0.001), figura 6.

At the level of photosynthetic pigments, very strong, positive correlations were recorded between Chl and Car (r=0.937) at the level of the L3 leaf (p<0.001). Strong correlations were identified between Chl and Car at the L2 leaf level (r=0.887), at the L4 leaf level (r=0.893) under conditions of p<0.001, respectively between Chl L2 and Chl L1 (r=0.809), between Chl L5 and Chl L1 (r=0.801), between Car L5 and Chl L1 (r=0.824) and between Chl L5 and Car L5 (r=0.859) under conditions of p<0.01.

At the level of productivity elements at the spike, very strong positive correlations were recorded between GN-E and GN-S (r=0.970), between GW-E and GN-E (r=0.965), between GE-E and GN-S (r=0.938) under conditions of p<0.001. Some moderate or weak correlations were also recorded, under statistical safety conditions (p<0.05).

Between productivity elements and photosynthetic pigments, certain correlations were also recorded, of different levels of intensity and statistical certainty.

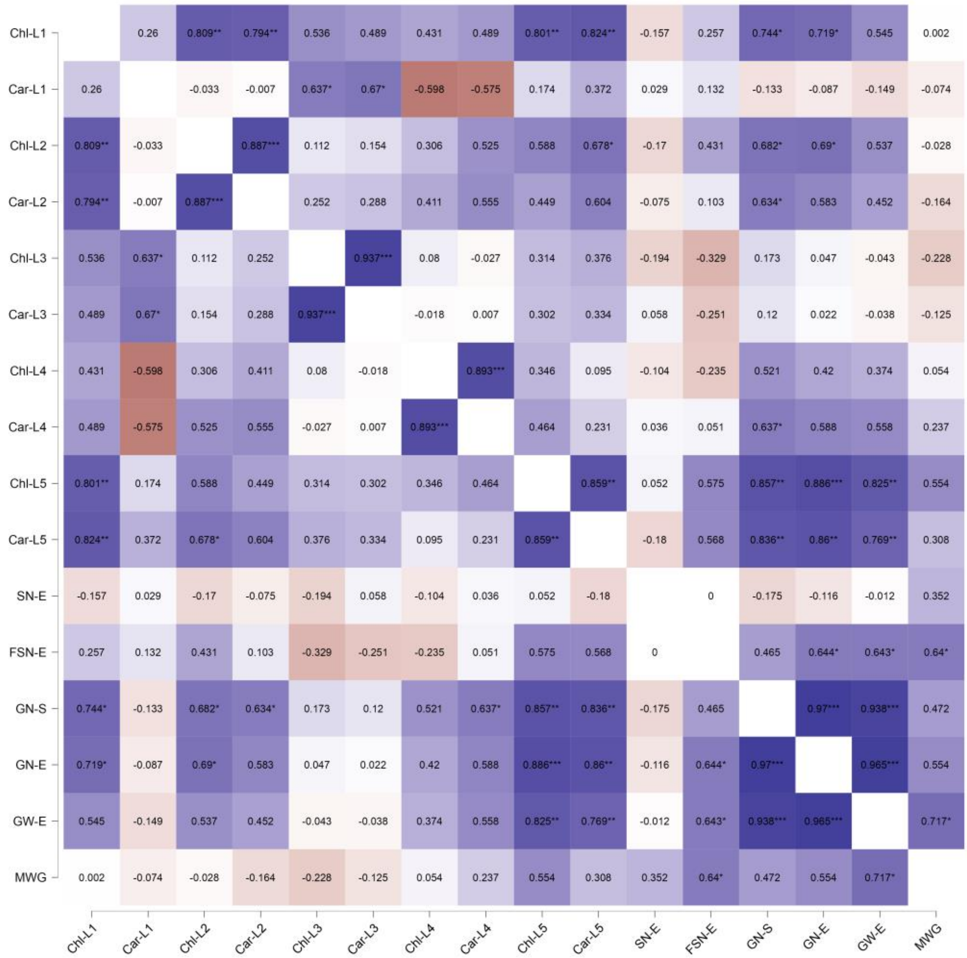



Figure 6. The level of correlations, in the form of Pearson's r heatmap, between photosynthetic pigments, leaves L1 to L5, and productivity elements in the ear, Solehio wheat variety

Strong, positive correlations were recorded between GN-E and Chl L5 ($r=0.886$, $p<0.001$), between GN-E and Car L5 ($r=0.860$, $p<0.01$), between GN-S and Chl L5 ($r=0.857$, $p<0.01$), between GN-S and Car L5 ($r=0.836$, $p<0.01$) and between GW-E and Chl L5 ($r=0.825$, $p<0.01$). Moderate, positive correlations were recorded between GW-E and Car L5 ($r=0.769$, $p<0.01$), between GN-S and Chl L1 ($r=0.744$, $p<0.05$) and between GN-E and Chl L1 ($r=0.719$, $p<0.05$). Weak correlations were recorded between GN-S and Chl L4 ($r=0.637$, $p<0.05$), between GN-S and Chl L2 ($r=0.682$, $p<0.05$), between GN-S and Car L2 ($r=0.634$, $p<0.05$) and between GN-E and Chl L2 ($r=0.690$, $p<0.05$). Also, other correlations, positive or negative, were recorded between the productivity elements at the ear and the photosynthetic pigments recorded at the level of the leaves on the stem of the wheat plants (L1 to L5).

Starting from these recorded correlation levels, regression analysis was used to evaluate and describe through equations and graphic models, the variation of productivity elements in relation to the photosynthetic pigments in the standard leaf. Thus, the variation of productivity elements in relation to the content of photosynthetic pigments in the standard leaf was described by equation (4), under statistical safety conditions. The values for the coefficients of equation (4) and the statistical safety parameters ($R^2$, p, RMSEP), in relation to each element of productivity, are presented in table 3. Based on the values of the coefficients of equation (4), 3D models were obtained and in the form of isoquants, which graphically represented the variation of productivity elements in the ear in relation to Chl and Car from the flag leaf. For example, the graphic models for the variation of FSN-E in relation to Chl and Car (L5), figure 7, the variation of GW-E in relation to Chl and Car (L5), figure 8, and the variation of MWG in relation to Chl and Car are presented (L5), figure 9.

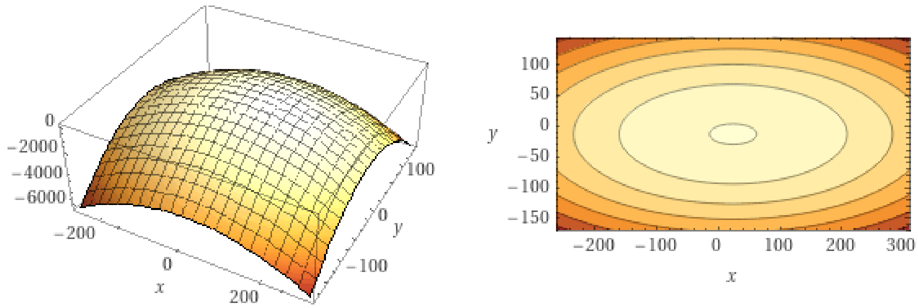
$$Y = ax^2 + by^2 + cx + dy + exy + f \quad (4)$$

where: Y – productivity element in ear (detailed in table 3);
x – Chl (x-axis); y – Car (y-axis); a, b, c, d, e, f – coefficients of the equation (4), table 3.

Table 3. The values of the coefficients of equation (4) and of the statistical safety parameters

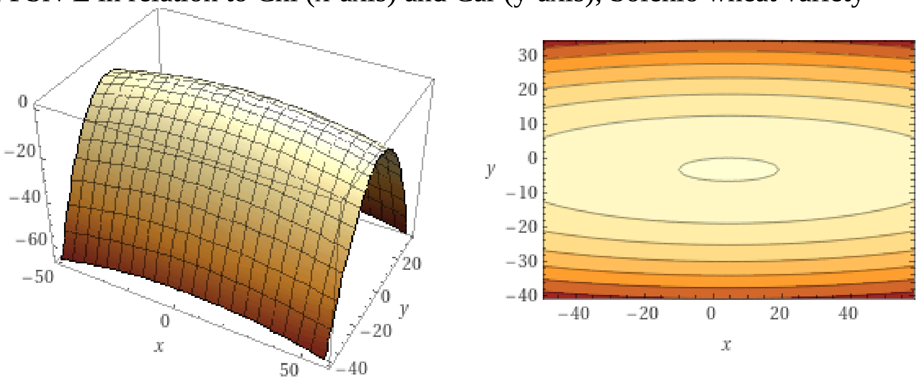
| Y productivity elements in ear | Coefficients of equation (4) | | | | | | Statistical parameters | | |
|---|---|---|---|---|---|---|---|---|---|
| | a | B | c | d | e | f | $R^2$ | p | RMSEP |
| SN-E | -0.07870 | -0.20579 | 4.05314 | -16.13653 | 0.39053 | 0 | 0.999 | 0.001 | 0.32677 |
| FSN-E | -0.03055 | -0.15877 | 1.45439 | -4.15443 | 0.15462 | | 0.999 | 0.001 | 0.36414 |
| GN-S | 0.00644 | -0.00788 | -0.34179 | 1.60984 | -0.02423 | | 0.995 | 0.001 | 0.17023 |
| GN-E | 0.00702 | -0.83028 | -2.39607 | 10.04188 | 0.24207 | | 0.997 | 0.001 | 2.46553 |
| GW-E | -0.00232 | -0.04234 | 0.02091 | -0.26682 | 0.02597 | | 0.988 | 0.001 | 0.17568 |
| MWG | -0.00005 | -0.00023 | 0.00327 | -0.01259 | 0.00032 | | 0.997 | 0.001 | 0.00178 |

Within the productivity elements at the spike level, it was found that SN-E had very low correlations with photosynthetic pigments from L1 to L5 leaves. The number of spikelets in the ear is a genetically defined character (Li *et al.*, 2021; Zhang *et al.*, 2022), and in the study conditions, a very low interdependence of the SN-E parameter with the content of photosynthetic pigments in the arranged leaves was found on the plant stem (L1 to L5), considered in the study. In some studies, it was hypothesized that the number of differentiated spikelets correlates with the N nutrition of the plant in the late stage of differentiation in the late stage of spikelet differentiation (Wada, 1969), but also in different stages of the reproductive period (Kamiji *et al.*, 2011), and the number of degenerate spikelets correlates with the evolution of the crop from then until heading.



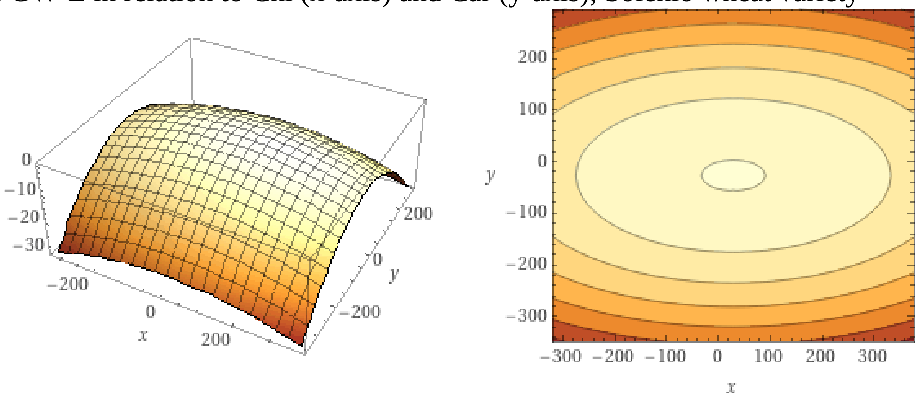

(a) (b)

Figure 7. 3D models (a) and in the form of isoquants (b) regarding the variation of FSN-E in relation to Chl (x-axis) and Car (y-axis), Solehio wheat variety




(a) (b)

Figure 8. 3D models (a) and in the form of isoquants (b) regarding the variation of GW-E in relation to Chl (x-axis) and Car (y-axis), Solehio wheat variety




(a) (b)

Figure 9. 3D models (a) and in the form of isoquants (b) regarding the variation of MWG in relation to Chl (x-axis) and Car (y-axis), Solehio wheat variety

In the case of the FSN-E parameter, it showed positive correlations with the chlorophyll content in the L2 leaf (r=0.431), negative correlations with the photosynthetic pigments in the L3 leaves (r=-0.329 in the case of Chl-L3, r=-

0.251 in the case Car-L3) and L4 leaves (r=-0.235 in the case of Chl-L4). Even if they are correlations of weak intensity, they show the interdependent relationship between the fertile spikelets and the photosynthetic pigments in the leaves on the stem position, respectively with the vegetation state of the plants in different stages of plant growth.

The number of grains in the spikelet (GN-S), the number of grains in the ear (GN-E), the weight of the grains in the ear (GW-E) are determined genetically (Christiansen et al., 2011; Nadolska-Orczyk *et al*., 2017), but also varies in relation to environmental factors or elements of technology, fertilization, irrigation, etc. (Zhou *et al*., 2018; Ma *et al*., 2022).

The productivity elements GN-S, GN-E and GW-E presented strong correlations with the photosynthetic pigments in the L5 (flag) leaf, a fact that confirms the importance of the flag leaf in defining the productivity elements in the ear and the quality of wheat production. The obtained results are in agreement with other studies, which presented the importance and contribution of photosynthetic pigments to the formation and filling of grains in the wheat ear (Sanchez-Bragado, 2016; Wang *et al*., 2016).

Significant positive correlations, between the number of grains in the spikelet and the number of grains in the ear (r=0.607), and the weight of the grains in the spikelet (r=0.573) were also reported in other comparative analysis studies of some wheat genotypes (Xhulaj Bode and Koto, 2022), in studies on the main components in the formation of wheat production (Nazarenko *et al*., 2021), or in studies on the relationship with fertilization (Rawashdeh and Sala, 2016; Ma *et al*., 2022).

## CONCLUSIONS

The content of photosynthetic pigments (Chl, Car) determined of the Solehio wheat variety, in the booting stage (45 – 47 BBCH code), recorded differentiated values, gradually increasing, from the basal leaf (L1) to the standard leaf (L5).

For the productivity elements at the ear level, correlations of different intensity levels (strong, moderate) were obtained with the photosynthetic pigments recorded in the leaves, in relation to the position of the leaf on the stem (structural units, L1 to L5), under conditions of statistical certainty ($p<0.001$, $p<0.01$).

Through the regression analysis, models were obtained in the form of an equation and graphic models (3D and in the form of isoquants) that described the variation of the productivity elements in relation to the photosynthetic pigments (Chl and Car) at the level of the standard leaf (L5), in conditions of statistical safety ($R^2$, p and RMSEP).

The obtained data show the differentiated contribution of the photosynthetic pigments in the leaves (L1 to L5, in relation to the structural units of the stem) at the determined moment (booting stage, 45-47 BBCH code), to the formation of the productivity elements in the ear.

The approach model can be adapted and extended to other straw cereals, at different stages of vegetation, for comparative studies and analysis.

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