INTERDEPENDENCE RELATIONSHIPS BETWEEN PRODUCTIVITY ELEMENTS IN SOYBEANS

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Abstract: *Interdependence relationships between productivity elements in soybeans were analyzed in the present study. The Iris soybean variety was cultivated under the specific conditions of the ARDS Lovrin. Plant samples were taken randomly from 15 plots. Productivity elements were determined in plant samples. The experimental data set showed statistical reliability (Alpha = 0.05; p<0.001). Low variability in the case of PH (CV = 5.9611), PL (CV = 3.6785) and Pwdt (CV = 7.0894) parameters. Moderate variability was recorded in the case of the parameters PN (CV = 27.1951), PsW (CV = 28.3441), GW (CV = 27.3812), and respectively PW (CV = 26.1433). Correlation of different levels of intensity and statistical certainty was recorded between the productivity elements. Linear and polynomial equations of the 2nd and 3rd degree described interdependence relationships between the productivity elements considered in the study, under statistical safety conditions (p<0.001).*

Key words*: agronomic characters, biometric parameters, correlations, soybean.*

INTRODUCTION

Soybean is an important source of vegetable protein worldwide [3,6,16,17]. In order to increase the production of vegetable proteins at the level of the European Union, soybean was considered as a valuable resource, due to its yield potential and protein content [17]. The authors studied genotypes from different maturity groups and analyzed influencing factors on soybean yield. The authors obtained models that described grain production and yield per surface unit, under the study conditions.

In order to expand the soybean culture to more northern areas in Europe, the direct and interactional influence of some technological, biological and ecosystem elements on the soybean culture was studied [19]. The authors communicated the variation of some morphological parameters and productivity elements in relation to the date of sowing, the distance between rows, and the inoculation of seeds with bacterial preparations. The interest in the expansion of soybean cultivation in West African conditions led to yield evaluation experiments in relation to climatic conditions, management practices and categories of farmers [12].

Productivity elements represent a measure of the expression of soybean culture in environmental and technological conditions [11,12,18]. The TFP parameter (Total Factor Productivity) in order to evaluate productivity in relation to different categories of factors [11]. The yield and productivity of the soybean crop were analyzed in relation to different sowing densities, in order to optimize the plant density for the study conditions [5]. Symbiotic parameters, productivity elements, yield and profitability in soybeans were studied in relation to sowing methods and different levels of nitrogen [20]. Soybean yield and productivity has been studied in relation to environmental factors [8,14]. The authors obtained models in the form of regression equations, which described the yield variation in relation to climatic parameters.

In order to increase the yield and quality of soybean culture, different agrotechnical methods and bioregulatory plant growth substances were studied [3]. Soybean productivity and productivity elements were analyzed in relation to influencing factors to understand

and explain the stagnation of yields under certain conditions [10]. The authors identified factors, conditions and interactions that favored the increase in productivity in soybean crop.

The study analyzed the interdependence between soybean productivity parameters, under non-irrigated culture conditions.

MATERIALS AND METHODS

The aim of the study was to evaluate the interdependence relationships between soybean productivity parameters, under non-irrigated culture conditions. The Iris soybean variety was grown under non-irrigated conditions. The researches were carried out within ARDS Lovrin. Adequate crop technology was ensured for soil preparation, sowing, crop maintenance during the growing season. Aspect from the vegetation period of the soybean crop is presented in figure 1.

Figure 1. Soybean plants in the experimental field, Iris variety (original image by the authors)

At the physiological maturity of the plants, 99 BBCH code [13], samples were taken for determination. Fifteen plant samples were taken, randomly. Parameters considered in the study were represented by plant height (PH), pod number (PN), pod length (PL), pod width (Pwdt), pod weight (PW), grain weight (GW), pod shell weight (PSW).

The recorded values for plant productivity parameters represented the experimental database for the analysis. A general descriptive analysis of the data series was made. The experimental safety of the data and the presence of variance in the experimental data set were evaluated. The interdependence of the productivity elements was quantified through correlation analysis and regression analysis. Established statistical safety parameters were used to guarantee the analyzes and the results obtained. The calculation module in EXCEL and the PAST software [9] were used for the analysis and processing of the experimental data, and for the generation of graphic representations.

RESEARCH RESULTS

Biometric parameters in soybean plants, the Iris variety, as well as in soybean pods, were studied during vegetation and at physiological maturity. The data series were analyzed for statistical characterization, and the results are presented in table 1.

Table 1

The results of the descriptive statistical analysis for the elements of productivity in soybean, Iris variety

Statistical parameters	Soybean productivity elements						
	PH	**PN**	**PL**	**Pwdt**	**PsW**	**GW**	**PW**
N	15	15	15	15	15	15	15
Min	43.75	8.42	3.27	0.70	1.43	1.83	3.46
Max	54.97	24.09	3.67	0.92	4.20	5.38	9.45
Sum	740.94	229.22	51.83	12.69	43.69	54.54	98.26
Mean	49.40	15.28	3.46	0.85	2.91	3.64	6.55
Std. error	0.760	1.073	0.033	0.015	0.213	0.257	0.442
Variance	8.6702	17.2705	0.0162	0.0036	0.6816	0.9912	2.9329
Stand. dev	2.945	4.156	0.127	0.060	0.826	0.996	1.713
Median	49.07	14.00	3.42	0.86	2.82	3.77	6.93
25 prcntil	46.82	12.43	3.33	0.82	2.24	2.95	5.28
75 prcntil	51.46	18.00	3.56	0.89	3.55	4.46	7.97
Skewness	0.0343	0.5555	0.4149	-1.2105	0.0780	-0.2954	-0.3434
Kurtosis	-0.1301	-0.1131	-0.8580	1.0893	-0.8620	-0.4605	-0.6572
Geom. mean	49.3139	14.7659	3.4532	0.8439	2.7974	3.4925	6.3168
Coeff. var	5.9611	27.1951	3.6785	7.0894	28.3441	27.3812	26.1433

The Anova test confirmed the reliability of the data, and the presence of variance in the experimental data set, table 2.

Table 2

Anova Test results

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	19065362	8	2383170	41.58205	7.93E-32	3.537664
Within Groups	7221372	126	57312.48			
Total	26286734	134				

Biometric parameters represent elements that contribute majorly to the formation of yield. Although they have genetic determination, they register variations in relation to environmental and technological conditions. In the study conditions, low variability was recorded in the case of the parameters PH (CV = 5.9611), PL (CV = 3.6785) and Pwdt (CV = 7.0894). Moderate variability was recorded in the case of the parameters PN (CV = 27.1951), PsW (CV = 28.3441), GW (CV = 27.3812), and respectively PW (CV = 26.1433).

The low values of the variability of the dimensional parameters (PH, PL, and Pwdt) showed that the plants had relatively good conditions for vegetative growth. The moderate values of the variability of the parameters that represented the number of pods, and their weight, respectively of the grains, showed that the productivity of the plants was influenced during the vegetation period.

The correlation analysis led to the correlation diagram shown in figure 2. Very strong correlation was recorded between PsW and PN (r = 0.975***), between PW and PsW (r = 0.929***), and respectively between PW and GW (r = 0.951***). Strong correlation was recorded between PW and PN (r = 0.842***). Moderate correlation was recorded between GW and PsW (r = 0.769***). Weak correlation was recorded between

PN and PH (r = 0.603*), between GW and PN (r = 0.641*), and respectively between PsW and PH (r = 0.575*).

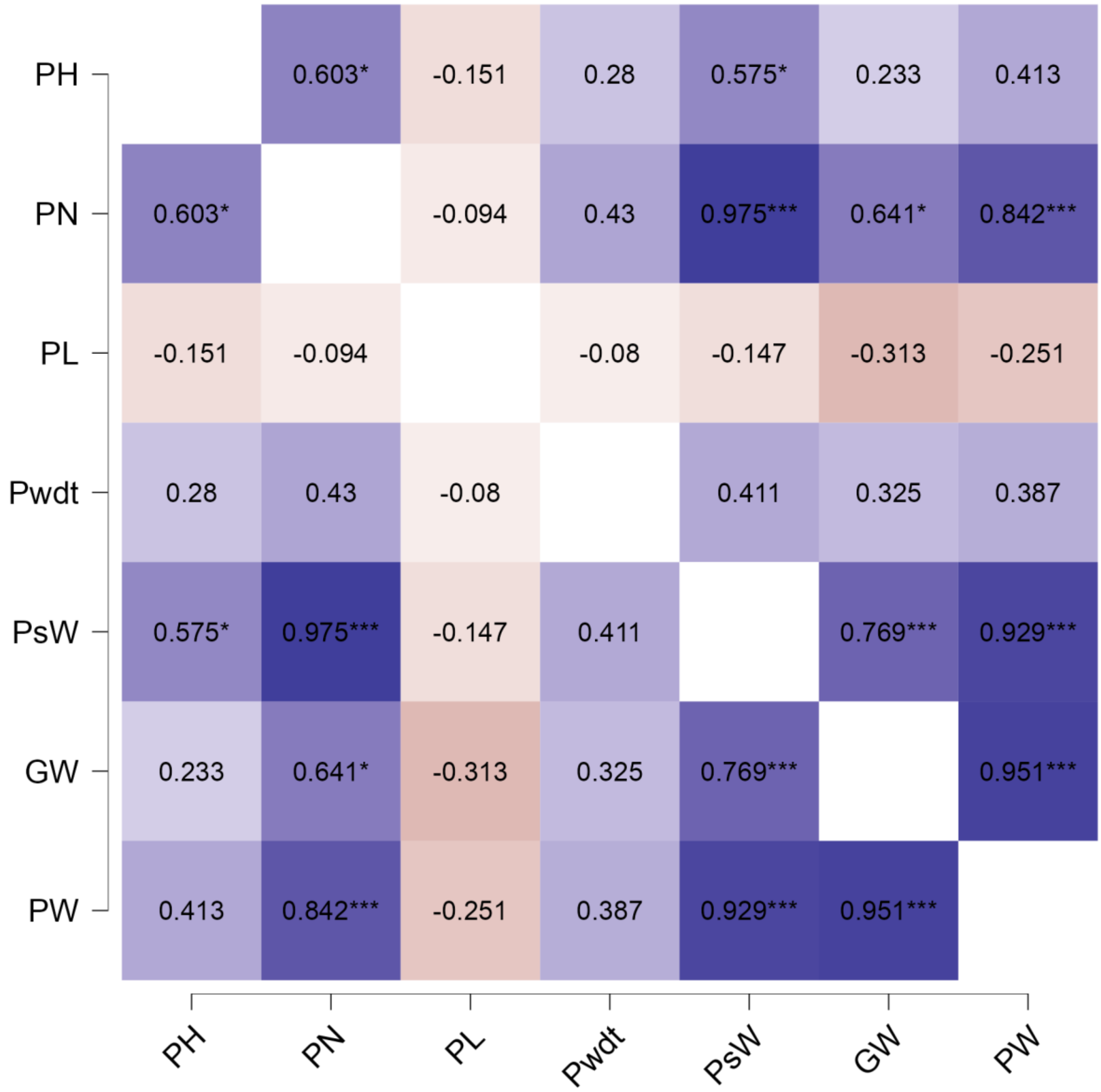

Figure 2. Correlations between elements of productivity in soybean, Iris variety

The variation of the PW parameter in relation to PN was described by equation (1), under conditions of $R^2 = 0.816$, $p<0.001$. The graphic representation of the variation of PW in relation to PN and the expression of equation (1) is given in figure 3.

$$PW = -0.02954 \cdot PN^2 + 1.309 \cdot PN - 6.078 \qquad (1)$$

The variation of GW in relation to PW was described by equation (2) under conditions of $R^2 = 0.905$, $p<0.001$. The graphic representation of the variation of PW in relation to PN and the expression of equation (1) is given in figure 4.

$$GW = 0.5529 \cdot PW + 0.01393 \qquad (2)$$

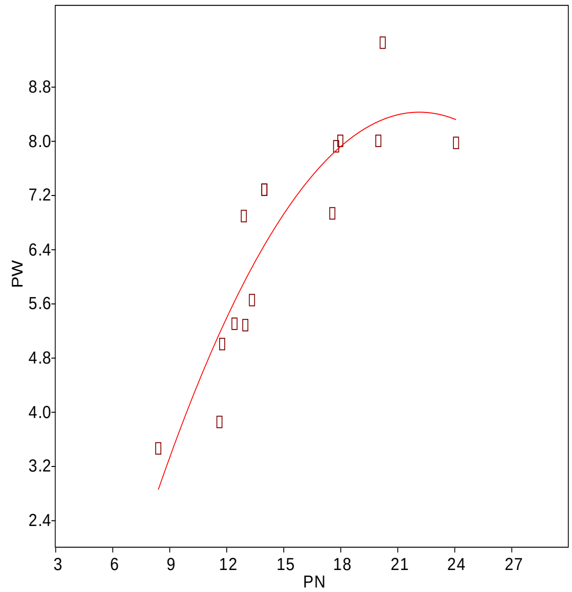

Figure 3. Graphic distribution of PW parameter in relation to PN parameter in soibean plants, Iris variety

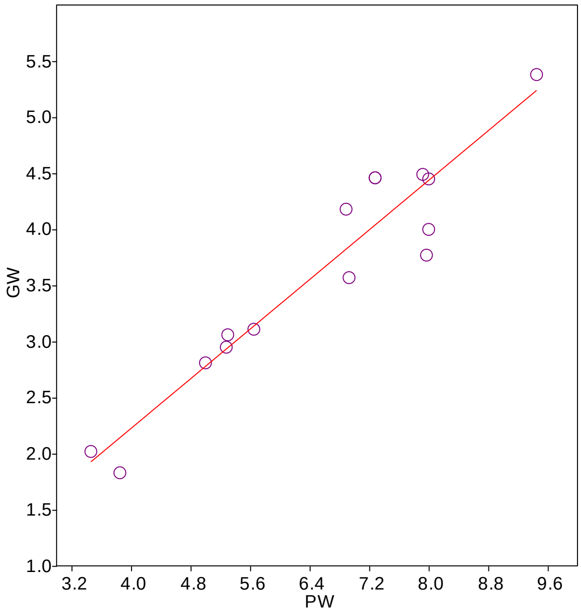

Figure 4. Graphic distribution of GW parameter in relation to PW parameter in soibean plants, Iris variety

The variation of PsW in relation to PN was described by equation (3), under conditions of $R^2 = 0.973$, $p<0.001$. The variation of PsW in relation to PW was described by equation (4), under conditions of $R^2 = 0.867$, $p<0.001$.

$$PsW = -0.006503 \cdot PN^2 + 0.4055 \cdot PN - 1.661 \quad (3)$$

$$PsW = -0.007968 \cdot PW^3 + 0.1671 \cdot PW^2 - 0.6631 \cdot PW + 2.286 \quad (4)$$

From the analysis of the variation of the PsW parameter in relation to PN and PW, a more pronounced interdependence was found in relation to PN (r = 0.975***) compared to PW (r = 0.951***). The phenomenon was described similarly by equations (3) and (4), based on the values of the regression coefficient (R^2 = 0.973 in the case of equation (3), respectively R^2 = 0.867 in the case of equation (4)).

The variation of morphological, biometric characters and productivity elements, biomass production in crop plants is of interest and was analyzed in relation to different factors. Agapie et al. [1,2] reported results on foliar parameters for several soybean varieties. Constantinescu et al. [7] reported the variation of some morphological parameters in grass cereals in relation to different genotypes. The variation of some physiological parameters in relation to treatments with magnetic nanoparticles was reported in sunflower [15].

Soybean productivity elements have been studied in relation to different sowing densities [5], in relation to different agricultural practices [11], treatments with biostimulating substances [3], with yield and production quality [4].

The present study contributes to the evaluation and understanding of the interdependence between the elements of soybean productivity under non-irrigated crop conditions.

CONCLUSIONS

The productivity elements analyzed in the Iris soybean variety recorded differentiated variability, as a specific response to the crop conditions in a non-irrigated system. PH, PL, Pwdt parameters showed low variability. Moderate variability was recorded in the case of PN, PsW, GW, and PW parameters. It can be appreciated that these parameters showed a stronger dependence on environmental conditions.

Correlation of different levels of intensity was recorded between the analyzed productivity elements, under statistical safety conditions. The regression analysis led to models in the form of linear and polynomial equations that described the interdependence between the studied productivity elements.

ACKNOWLEDGEMENTS

The present data were generated following the implementation of the ADER 1.4.1 project.

REFERENCES

[1]. AGAPIE A.L., HORABLAGA M.N., GORINOIU G., SALA F., 2022, Foliar surface calculation model in soybean, AIP Conference Proceedings, 2293(1), 350002.

[2]. AGAPIE, A.L., HORABLAGA, M.N., GORINOIU, G., SALA, F., 2022, Fractal analysis for soybean leaves characterization, AIP Conference Proceedings, 2293(1), 350003.

[3]. AMOANIMAA-DEDE H., SU C., YEBOAH A., ZHOU H., ZHENG D., ZHU H., 2022, Growth regulators promote soybean productivity: a review, PeerJ., 10, e12556.

[4]. BHEEMANAHALLI R., POUDEL S., ALSAJRI F.A., REDDY K.R., 2022, Phenotyping of Southern United States soybean cultivars for potential seed weight and seed quality compositions, Agronomy, 12, 839.

[5]. CAMICIA R.G.M., MAGGI M.F., SOUZA E.G., BAZZI C.L., KONOPATZKI E.A., MICHELON G.K., PINHEIRO J.B.S., 2018, Productivity of soybean in management zones with application of different sowing densities, Ciência Rural, Santa Maria, 48(12), e20180532.

[6]. COLEMAN K., WHITMORE A.P., HASSALL K.L., SHIELD I., SEMENOV M.A., DOBERMANN A., BOURHIS Y., ESKANDARY A., MILNE A.E., 2021, The potential for soybean to diversify the production of plant-based protein in the UK, Science of the Total Environment, 767, 144903.

[7]. CONSTANTINESCU C., HERBEI M., RUJESCU C., SALA F., 2018, Model prediction of chlorophyll and fresh biomass in cereal grasses based on aerial images, AIP Conference Proceedings, 1978(1), 390003.

[8]. FAÉ G.S., KEMANIAN A.R., ROTH G.W., WHITE C., WATSON J.E., 2020, Soybean yield in relation to environmental and soil properties, European Journal of Agronomy, 118, 126070.

[9]. HAMMER Ø., HARPER D.A.T., RYAN P.D., 2001, PAST: Paleontological Statistics software package for education and data analysis, Palaeontologia Electronica, 4(1), 1-9.

[10]. KOBAYASHI S., KUNIMITSU Y., 2024, Assessment of soybean productivity and its changing factors in Japan based on the production cost statistics, Heliyon, 10(20), e38396.

[11]. KRISTANTI N.E., RAHMAWATI F., MAKSUM M., 2016, Analysis of productivity of soybean [*Glycine Max* (L.) Merr.] for production for farmers in Indonesia, KnE Life Sciences, 2016, pp. 237-246.

[12]. MACCARTHY D.S., TRAORE P.S., FREDUAH B.S., ADIKU S.G.K., DODOR D.E., KUMAHOR S.K., 2022, Productivity of soybean under projected climate change in a semi-arid region of West Africa: Sensitivity of current production system, Agronomy, 12, 2614.

[13]. MEIER U., 2001, Growth stages of mono-and dicotyledonous plants e BBCH monograph, Federal Biological Research Centre for Agriculture and Forestry, pp. 158

[14]. NEGI A., RANJAN R., KUMAR A., 2020, Effect of weather parameters on productivity of soybean crop, Journal of Pharmacognosy and Phytochemistry, 9(6S), pp. 227-230.

[15]. PÎRVULESCU A., SALA F., BOLDEA M., 2015, Variation of chlorophyll content in sunflower under the influence of magnetic nanofluids, AIP Conference Proceedings1648, 670009-1 - 670009-4.

[16]. QIN P., WANG T., LUO Y., 2022, A review on plant-based proteins from soybean: Health benefits and soy product development. Journal of Agriculture and Food Research, 7, 100265.

[17]. SIMON-MIQUEL G., RECKLING M., PLAZA-BONILLA D., 2024. Maximising soybean productivity with late maturity groups in Mediterranean irrigated systems, Field Crops Research, 307, 109274.

[18]. TKACHUK O., PANTSYREVA H., KUPCHUK I., VOLYNETS Y., 2024, Soybean productivity of the Ukraine under ecologization of cultivation technology, Journal of Ecological Engineering, 25(5), pp. 279-293.

[19]. TOLEIKIENE M., SLAPETYS J., SARUNAITE L., LAZAUSKAS S., DEVEIKYTE I., KADZIULIENE Z., 2021, Soybean development and productivity in response to organic management above the northern boundary of soybean distribution in Europe, Agronomy, 11(2), pp. 214.

[20]. VIRK H.K., SINGH G., MANES G.S., 2018, Growth, symbiosis, productivity, and profitability of soybean at varying planting methods and nitrogen levels, Journal of Plant Nutrition, 41(9), pp. 1184-1196.