

YIELD VARIATION ANALYSIS AND SOME SEEDS PARAMETERS ON SUNFLOWER

IUHASZ CRISTIAN ANDREI¹, JURJESCU ANDREEA LIDIA¹,
TOMUȚA REBECA-IOANA¹, HORABLAGA MARINEL NICOLAE^{1,2}, FLORIN SALA^{*1,2}

¹Agricultural Research and Development Station Lovrin, Lovrin, 307250, Romania

²University of Life Sciences "King Mihai I" from Timisoara, Timișoara, 300645, Romania

*Corresponding author's e-mail: florin_sala@usvt.ro

Abstract: The yield and quality parameters of the seeds were analyzed for the experimental sunflower crops. Nine variants were considered, represented by commercial hybrids, CH1 to CH9. Sunflower crops was organized within ARDS Lovrin, agricultural year 2023 - 2024, under non-irrigated crop conditions. The yield (Y , kg ha⁻¹), the hectoliter weight (HW , kg hl⁻¹) and the weight of one thousand seeds (TKW , g 1000 seeds⁻¹) were analyzed. According to PCA, PC1 explained 57.527% of variance, and PC2 explained 33.364% of variance. The variants were associated differently, some with the HW parameter (e.g. CH8, CH9), others with the TKW parameter (e.g. CH1, CH5), or with the yield (e.g. CH2, CH3, CH6). The cluster analysis facilitated the grouping of the variants in two clusters, under conditions of $Coph.corr. = 0.875$. The yield (Y) variation in relation to HW and TKW was described by models in statistical safety conditions ($R^2 = 0.706$, $p=0.0061$).

Key words: multivariate analysis, models, seed parameters, sunflower, yield.

INTRODUCTION

The sunflower is a valuable crop plant, with multiple economic, ecological and social values [2,5,7,14,18].

To improve sunflower genotypes in terms of yield, quality and resistance to stress factors, breeding programs analyze wild relatives, and different collections of genotypes [17]. Exploitation of heterosis was considered an appropriate strategy in order to improve productivity and yield in sunflower [3].

At the same time, crop technologies are perfected, on the various technological elements [8]. Crop rotation was analyzed in relation to the yield of the sunflower crop and the sustainability of agricultural land use [8]. The sunflower sowing date, correlated with pedoclimatic conditions and the specificity of genotypes, is also of major importance for optimizing the yield [9]. In order to improve the physiological and metabolic processes and yield of sunflowers, different fertilizing substances, mineral and organic, biofertilizers, nanoparticles were studied, in relation to the type of crop system [1,13].

The sustainability of sunflower production was analyzed in relation to climate and soil conditions and the influence of climatic parameters during the growing season on yield and productivity and quality parameters was quantified [7,20,21]. Biometric plant productivity parameters and sunflower yields were studied in relation to salinity conditions, an increasingly widespread phenomenon under climate change conditions [7,16].

Different agroecological practices have been tested on sunflower for an integrated management, in relation to the agroecological principle [5]. In the context of the current economic, climatic and political situation on a global scale, it was analyzed how precision agriculture, with techniques based on remote sensing, can ensure the sustainability of the sunflower culture, with increased yields [2].

The study analyzed the yield and quality parameters of sunflower seeds under non-irrigated conditions.

MATERIALS AND METHODS

Experiments on sunflower crops were organized within ARDS Lovrin. The study analyzed the yield (Y, kg ha⁻¹) and seed quality parameters, such as the hectoliter weight (HW, kg hl⁻¹) and the weight of a thousand seeds (TKW, g 1000 seeds⁻¹).

Nine variants, given by commercial sunflower hybrids, were considered in the study. The experimental variants were marked CH1 to CH9. The crops was organized in chernozem soil conditions, non-irrigated conditions, agricultural year 2023-2024. Appropriate crop technology was applied for land preparation, sowing, maintenance works. At harvest maturity [10], mechanized harvesting was done on experimental plots. Three repetitions were ensured for each variant. In relation to the purpose of the study, the yield (Y) was recorded. From the seed production for each experimental variant, seed samples were taken from which determinations were made for the MH and TKW parameters. The average values are presented in the article.

The experimental data were analyzed to obtain the grouping of the variants with considered parameters, and the association of the variants based on similarity. The yield variation was analyzed in relation to HW and TKW parameters. The calculation module in EXCEL and dedicated software were used [6,19].

RESEARCH RESULTS

At harvest maturity, the experimental variants were harvested, on each plot. From the amount of seeds, for each variant, determinations were made for the HW (kg hl⁻¹) and TKW (g 1000 seeds⁻¹) parameters. The yield (Y) was recorded on each experimental plot. The statistical analysis of the data series led to the values presented in table 1.

Table 1

Descriptive Statistical Analysis of experimental sunflower variants

Statistical parameters	HW	TKW	Y
	(Kg Hl ⁻¹)	(g 1000 seeds ⁻¹)	(kg ha ⁻¹)
Mean	43.56	70.64	1972.70
Standard Error	1.00	2.30	79.57
Median	43.60	71.80	2051.43
Standard Deviation	4.23	9.75	337.60
Range	14.10	32.80	1017.14
Minimum	34.00	50.80	1354.29
Maximum	48.10	83.60	2371.43
Largest(1)	48.10	83.60	2371.43
Smallest(1)	34.00	50.80	1354.29
Confidence Level(95.0%)	2.10	4.85	167.89

The Anova Test (Alpha = 0.001) was used to verify the reliability of the data and the presence of variance in the data set, and the results are presented in table 2.

Table 2

Anova Test results

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	44040818.18	2	22020409	579.0293	8.72E-36	7.933915
Within Groups	1939523.43	51	38029.87			
Total	45980341.61	53				

The multivariate analysis was used to generate the PCA diagram, figure 1, in which the variants are distributed in relation to the degree of affinity to the considered parameters

(HW, TKW, Y), as biplot. PC1 explained 57.527% of variance, and PC2 explained 33.364% of variance. From the analysis of the PCA diagram, it was observed the positioning of some variants associated with the HW parameter (e.g. CH8, CH9), with the TKW parameter (e.g. CH1, CH5), or with the yield (e.g. CH2, CH3, CH6). At the same time, the independent positioning of some variants (e.g. CH4, CH7) was observed.

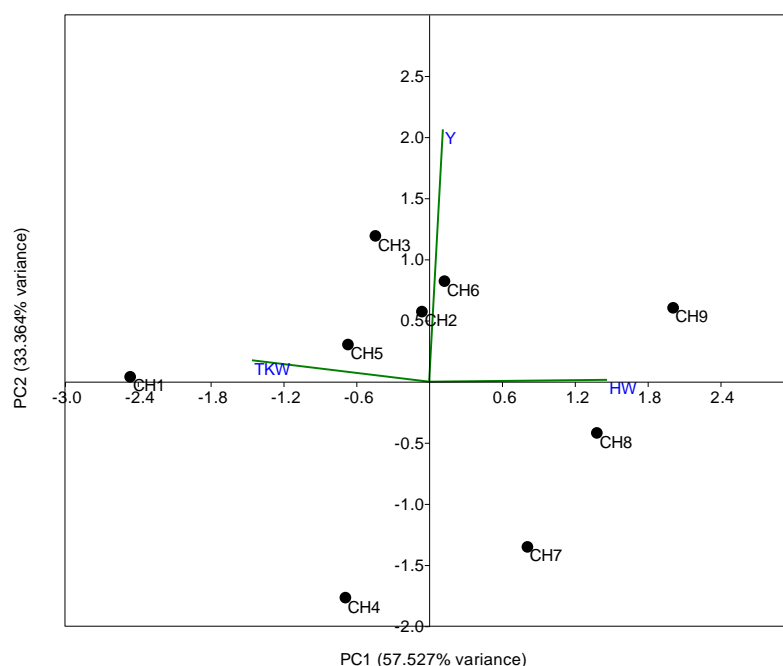


Figure 1. PCA distribution diagram of the experimental variants

The cluster analysis led to the dendrogram of grouping the variants based on similarity in relation to the three parameters considered in the study. The result was the dendrogram in figure 2, under conditions of Coph. corr. = 0.875. From the analysis of the dendrogram, the grouping of the ro variants into two distinct clusters was observed. A cluster included the variants CH4 and Ch7, which in the PCA diagram were positioned independently of the considered parameters. The other variants were grouped in the C2 cluster, in two sub-clusters, based on similarity in relation to the values of the indices considered. One sub-cluster contained three variants CH5, CH1, CH8, and the other sub-cluster contained four variants, CH6, CH9, CH2, and CH3. A high level of similarity was registered between the variants CH6 and CH9 (SDI = 29.80), according to table 3.

Regression analysis was used to obtain the yield variation (Y) in relation to HW and TKW parameters, as direct action and interaction. Equation (1) resulted, under conditions of $R^2 = 0.706$, $p = 0.0061$, $F = 5.7649$. The graphic distribution of Y values in relation to HW (x-axes) and TKW (y-axes) is presented in figure 3.

$$Y_{(HW,TKW)} = ax^2 + by^2 + cx + dy + exy + f \quad (1)$$

where: $Y_{(HW,TKW)}$ – sunflower yield (kg ha^{-1});
 x – hectoliter weight (HW, kg hl^{-1});
 y – weight of a thousand seeds (TKW, g 1000 seeds^{-1});
 a, b, c, d, e, f – coefficients of the equation (1); $a = -70.98438072$; $b = -4.27037162$;
 $c = 9873.66553593$; $d = 2923.44839620$; $e = -52.07377296$; $f = -318287.031120$

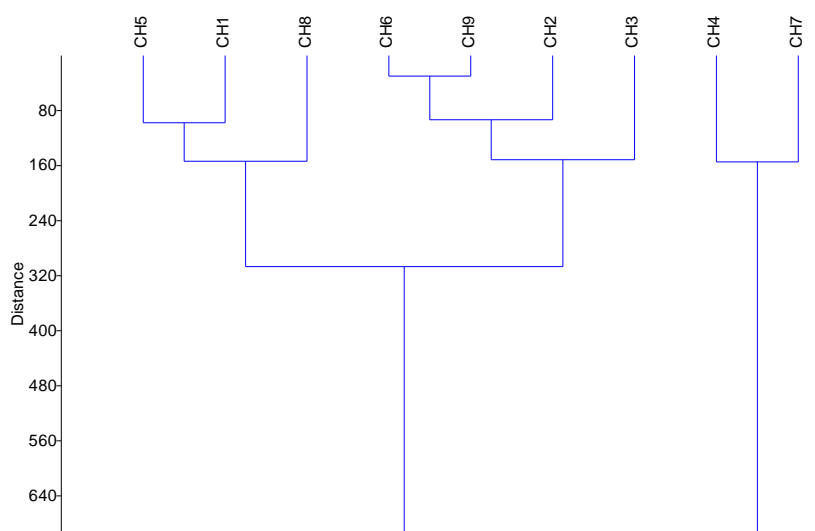
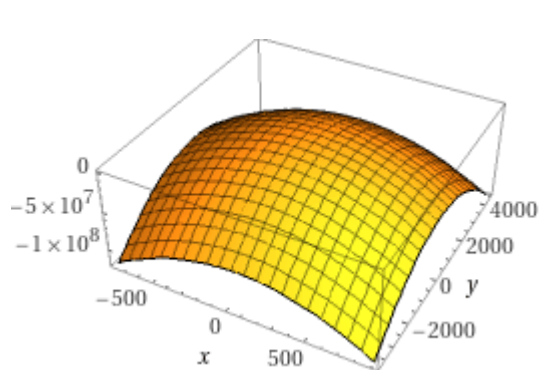


Figure 2. Dendrogram of grouping variants based on Euclidean distances

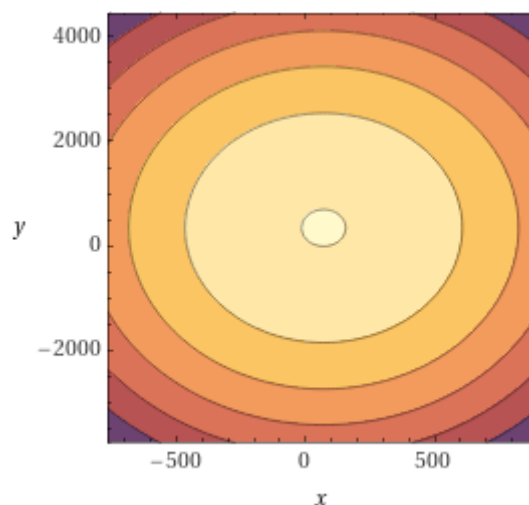
Table 3.

SDI values for the experimental variants

	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8	CH9
CH1		206.18	417.29	600.15	97.66	309.04	446.23	106.21	287.88
CH2	206.18		211.45	805.73	108.70	103.00	651.48	308.89	83.55
CH3	417.29	211.45		1017.20	320.02	108.81	862.92	520.26	134.04
CH4	600.15	805.73	1017.20		697.19	908.58	154.51	497.31	885.98
CH5	97.66	108.70	320.02	697.19		211.69	543.03	200.94	190.85
CH6	309.04	103.00	108.81	908.58	211.69		754.30	411.54	29.80
CH7	446.23	651.48	862.92	154.51	543.03	754.30		342.91	731.61
CH8	106.21	308.89	520.26	497.31	200.94	411.54	342.91		388.71
CH9	287.88	83.55	134.04	885.98	190.85	29.80	731.61	388.71	



(a)



(b)

Figure 3. Graphic distribution of the Y parameter in sunflower, in relation to HW and TKW parameters; (a) 3D format, (b) isoquants format

The yield of the sunflower crop was analyzed in relation to fertilizing or bioactive substances [1], in relation to agricultural practices and remote sensing technologies [2,4], [5]. Input optimization studies were carried out for agricultural crops, for reasons of yield sustainability [11,12,15]. The results of this study contribute to the database and information regarding sunflower culture, to the description of yield variation (Y) in relation to seed quality parameters.

CONCLUSIONS

The variation of sunflower yield (Y, kg ha⁻¹) was described in relation to seed parameters (HW, TKW) under statistical safety conditions ($R^2 = 0.706$, $p < 0.001$). Models in the form of equation, and graphic models, showed the convergent contribution of the two parameters (HW, TKW) to yield formation. This suggested that the two parameters can be optimized simultaneously, through crop techniques, as well as in breeding programs.

According to PCA, C1 explained 57.527% of variance, and PC2 explained 33.364% of variance. Cluster analysis facilitated the grouping of variants based on similarity, in relation to the considered parameters. A high level of similarity was recorded in the case of the CH6 and CH9 variants (SDI = 29.80).

ACKNOWLEDGEMENTS

The authors thank ARDS Lovrin and its partners for facilitating this study.

REFERENCES

- [1]. ADELEKE B.S., BABALOLA O.O., 2020, Oilseed crop sunflower (*Helianthus annuus*) as a source of food: Nutritional and health benefits, *Food Science & Nutrition*, 8(9), 4666-4684.
- [2]. CENTORAME L., ILARI A., GATTO A.D., PEDRETTI E.F., 2024, A systematic review on precision agriculture applied to sunflowers, the role of hyperspectral imaging, *Computers and Electronics in Agriculture*, 222, 109097.
- [3]. CHAKRABORTY N.R., LAKSHMAN S.S., DEBNATH S., RAHIMI M., 2022, Yield stability and economic heterosis analysis in newly bred sunflower hybrids throughout diverse agro-ecological zones, *BMC Plant Biology*, 22, 579.
- [4]. 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.
- [5]. DEBAEKE P., BEDOUSSAC L., BONNET C., BRET-MESTRIES E., SEASSAU C., GAVALAND A., RAFFAILLAC D., TRIBOUILLOIS H., VÉRICEL G., JUSTES E., 2017, Sunflower crop: environmental-friendly and agroecological, *OCL* 24(3): D304.
- [6]. 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.
- [7]. KHALIFANI S., DARVISHZADEH R., AZAD N., RAHMANI R.S., 2022, Prediction of sunflower grain yield under normal and salinity stress by RBF, MLP and, CNN models, *Industrial Crops and Products*, 189, 115762.
- [8]. KUSSUL N., DEININGER K., SHUMILO L., LAVRENIUK M., ALI D.A., NIVIEVSKYI O., 2022, Biophysical impact of sunflower crop rotation on agricultural fields, *Sustainability*, 14, 3965.

- [9]. **MA'ALI S., COCHRANE N., MAKGOGA W., ERASMUS J.**, 2024, The impact of planting dates and hybrid selection on sunflower seed yield and oil content, *South African Journal of Plant and Soil*, 1-10.
- [10]. **MEIER U.**, 2001, Growth stages of mono-and dicotyledonous plants e BBCH monograph, Federal Biological Research Centre for Agriculture and Forestry, 158 pp.
- [11]. **NEZHAD H.L., SHARABIANI V.R., TARIGHI J., TAHMASEBI M., TAGHINEZHAD E., SZUMNY A.**, 2024, Energy flow analysis in oilseed sunflower farms and modeling with Artificial Neural Networks as compared to Adaptive Neuro-Fuzzy Inference Systems (Case Study: Khoy County), *Energies*, 17, 2795.
- [12]. **NUNGULA E.Z., MASSAWE B.J., CHAPPA L.R., NHUNDA D.M., SELEIMAN M.F., ALI N., GITARI H.I.**, 2024, Optimizing sunflower production through the use of GIS-based soil fertility management strategy, *Cogent Food & Agriculture*, 10(1), 2390685.
- [13]. **PÎRVULESCU A., SALA F., BOLDEA M.**, 2015, Variation of chlorophyll content in sunflower under the influence of magnetic nanofluids, *AIP Conference Proceedings*, 1648, 670009-1 - 670009-4.
- [14]. **PUTTHA R., VENKATACHALAM K., HANPAKDEESAKUL S., WONGSA J., PARAMETTHANUWAT T., SREAN P., PAKEECHAI K., CHAROENPHUN N.**, 2023, Exploring the potential of sunflowers: agronomy, applications, and opportunities within bio-circular-green economy, *Horticulturae*, 9, 1079.
- [15]. **SALA F., RUJESCU C., CONSTANTINESCU C.**, 2016, Causes and solutions for the remediation of the poor allocation of P and K to wheat crops in Romania, *AgroLife Scientific Journal*, 5(1), 184-193.
- [16]. **SARKER K.K., MAINUDDIN M., BELL R.W., KAMAR SK.S.A., AKANDA M.A.R., SARKER B.C., PAUL P.L.C., GLOVER M., SHAHADAT M.K., KHAN M.S.I., RASHID Md.H., BARRETT-LENNARD E.G.**, 2024, Response of sunflower yield and water productivity to saline water irrigation in the coastal zones of the Ganges Delta, *Soil Systems*, 8, 20.
- [17]. **SEILER G.J., QI L.L., MAREK L.F.**, 2017, Utilization of sunflower crop wild relatives for cultivated sunflower improvement, *Crop Science*, 57(3), 1083-1101.
- [18]. **SREAN P., PAKEECHAI K., CHAROENPHUN N.**, 2023, Exploring the potential of sunflowers: Agronomy, applications, and opportunities within bio-circular-green economy, *Horticulturae*, 9, 1079.
- [19]. **WOLFRAM RESEARCH INC.**, 2020, *Mathematica*, Version 12.1, Champaign, IL (2020).
- [20]. **ZAPLETALOVÁ A., VICIAN T., ERNST D., ČERNÝ I., VICIANOVÁ M., BUŠO R.**, 2024, Formation of quantitative and qualitative parameters of sunflower (*Helianthus annuus* L.) after application of stimulating substances, *Journal of Central European Agriculture*, 25(3), 675-685.
- [21]. **ZYMAROIEVA A., ZHUKOV O., FEDONIUK T., PINKINA T., VLASIUK V.**, 2021, Edaphoclimatic factors determining sunflower yields spatiotemporal dynamics in northern Ukraine, *OCL*, 28, 26.