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THE RELATIONSHIPS BETWEEN MORPHOLOGICAL TRAITS IN MAIZE (*ZEA MAYS* L.) BY LINEAR AND RANK CORRELATION COEFFICIENTS

Summary

The objective of this study was to assess the relationships between ear length, ear diameter, plant height and ear setting height in maize linear Pearson correlation coefficients and Spearman's rank correlation coefficients. The plant height and ear setting height were positively linear and rank correlated in all four years of study. The correlation coefficients, both - linear and rank, between all four traits observed in 2018 were statistically significant. Ear diameter and plant height were linear and rank correlated in 2018, however in 2015 only Pearson correlation coefficient was statistically significant between these two traits.
Keywords: *maize, linear correlation, rank correlation, ear length, ear diameter, plant height, ear setting height*

WSPÓŁZALEŻNOŚĆ POMIĘDZY CECHAMI MORFOLOGICZNYMI KUKURYDZY (*ZEA MAYS* L.) PRZY ZASTOSOWANIU KORELACJI LINIOWEJ I RANGOWEJ

Streszczenie

Celem badań było zastosowanie współczynników korelacji liniowej Pearsona i rangowej Spearmana do oceny współzależności pomiędzy długością kolby, średnicą kolby, wysokością roślin i wysokością osadzenia kolb produkcyjnych kukurydzy. Wysokość roślin i wysokość osadzenia kolb produkcyjnych były dodatnio liniowo i rangowo skorelowane we wszystkich czterech latach badań. Oba współczynniki korelacji – liniowe i rangowe, pomiędzy wszystkimi czterema cechami obserwowanymi w 2018 r., były istotne statystycznie. Średnica kolby i wysokość roślin były liniowo i rangowo skorelowane w 2018 r., natomiast w 2015 roku tylko współczynnik korelacji Pearsona był statystycznie istotny pomiędzy tymi dwiema cechami.
Słowa kluczowe: *kukurydza, korelacja liniowa, korelacja rangowa, długość kolby, średnica kolby, wysokość roślin, wysokość osadzenia kolb produkcyjnych*

1. Introduction

Phosphorus is an important nutrient necessary for the proper growth and development of plants [3, 12]. Its appropriate content in soil contributes to the rapid expansion of the plant root system [2, 9], improves nitrogen utilization, increases plant tolerance to biotic and abiotic stress, and induces lodging resistance. Environmental and agrotechnical factors can have a significant impact on the relationship between the amounts of organic and mineral forms. Organic phosphorus in most arable soils accounts for 25% to 50% of the total phosphorus [6, 14]. The availability of phosphorus for plants depends on many factors [4, 13]. The most important of these are soil pH and air-water proportions [2], followed by fertilizers, crop type, plant species and humus content [11]. The hypothesis of the experiment assumed that the depth of NP fertilizer application affected the growth and development of maize expressed by its morphological features. The adopted assumptions were verified on the basis of a 4-year field experiment using four depths of NP fertilizer application, two nitrogen fertilizers and two nitrogen dose application dates. The aim of the study was to apply Pearson's linear and Spearman's rank correlation coefficients to assess the relationships between ear length, ear diameter, plant height and ear setting height in maize.

2. Material and Methods

2.1. Experimental field

Field trial was carried out at the Department of Agronomy of Poznań University of Life Sciences, on the fields of the Gorzyń Experimental and Educational Unit, in the years 2015-2018. It was conducted for four years in the same random block design (split-split-plot) with three factors and four field replicates. The following variables were tested: A – 1st order factor – NP fertilizer sowing depth [A1 – 0 cm (broadcast), A2 – 5 cm (in rows), A3 – 10 cm (in rows), A4 – 15 cm (in rows)]; B – 2nd order factor – type of supplementary nitrogen fertilizer [B1 – ammonium nitrate, B2 – urea]; C – 3rd order factor-date of supplementary nitrogen fertilization [C1 – before sowing, C2 – top dressing in the BBCH 15/16 stage]. The same level of mineral fertilization (100 kg N/ha, 30.8 kg P/ha and 107.9 kg K/ha) was applied in all experimental objects. Fertilization was balanced against phosphorus, which was applied at the whole required dose in the form of ammonium phosphate (18% N, 46% P_2O_5), according to the experimental design under the 1st order factor. N and K fertilization was performed before maize sowing using urea (46% N) and potassium salt (60%). The fertilizer coulters (on objects with initial fertilization) were set 5 cm aside from the seeds. Application depth of NP fertilizer was according to the 1st order factor

levels. Gross plot size: 24.5 m^2 (length – 8.75 m, width – 2.8 m). The net plot area for harvesting was 12.25 m^2.

2.2. Plant material

In this paper we analyzed four morphological traits: ear length (cm), ear diameter (cm), plant height (cm) and ear setting height (cm).

2.3. Statistical analysis

The linear Pearson correlation coefficients [5] as well as rank Spearman correlation coefficients [8, 10] were used for the analyses of relationships between four morphological traits (ear length, ear diameter, plant height and ear setting height) in maize. The analyses were conducted for each year separately.

3. Results and Discussion

The positive linear and rank correlations between plant height and ear setting height we observed in all four years of study (Figs. 1-4).

Source: own study / Źródło: opracowanie własne

Fig. 1. The coefficients of linear Pearson (above diagonal) and Spearman's rank (below diagonal) correlations for the observed traits in 2015 (statistically significant correlation coefficients are marked colour)
Rys. 1. Współczynniki korelacji liniowej Pearsona (powyżej przekątnej) i rangowej Spearmana (poniżej przekątnej) dla obserwowanych cech w 2015 r. (kolorem oznaczono wartości istotne statystycznie)

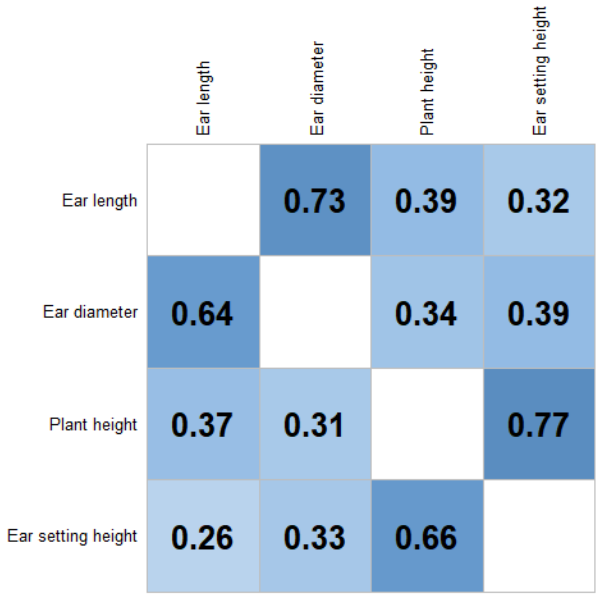
The linear correlation coefficients were larger than the rank correlation coefficients. In 2016 and 2018 correlation coefficients between plant height and ear setting height were larger than coefficients obtained in 2015 and 2017. The correlation coefficients, both – linear and rank, between all four traits observed in 2018 were statistically significant (Fig. 4). In 2017 only plant height and ear setting height were correlated (Fig. 3). Ear length and ear diameter as well as ear length and plant height were linear and rank correlated in three from four year of study – 2015 (Fig. 1), 2016 (Fig. 2) and 2018 (Fig. 4). Ear length and ear setting height were linear and rank correlated in 2016 (Fig. 2) and 2018 (Fig. 4). Ear diameter and plant height were linear and rank correlated in 2018 (Fig. 4), however in 2015 only Pearson correlation coefficient was statistically significant between these two traits (Fig. 1). All statistically significant correlation coefficients were positive.

Source: own study / Źródło: opracowanie własne

Fig. 2. The coefficients of linear Pearson (above diagonal) and Spearman's rank (below diagonal) correlations for the observed traits in 2016 (statistically significant correlation coefficients are marked colour)
Rys. 2. Współczynniki korelacji liniowej Pearsona (powyżej przekątnej) i rangowej Spearmana (poniżej przekątnej) dla obserwowanych cech w 2016 (kolorem oznaczono wartości istotne statystycznie)

Source: own study / Źródło: opracowanie własne

Fig. 3. The coefficients of linear Pearson (above diagonal) and Spearman's rank (below diagonal) correlations for the observed traits in 2017 (statistically significant correlation coefficients are marked colour)
Rys. 3. Współczynniki korelacji liniowej Pearsona (powyżej przekątnej) i rangowej Spearmana (poniżej przekątnej) dla obserwowanych cech w 2017 r. (kolorem oznaczono wartości istotne statystycznie)



Source: own study / Źródło: opracowanie własne

Fig. 4. The coefficients of linear Pearson (above diagonal) and Spearman's rank (below diagonal) correlations for the observed traits in 2018 (statistically significant correlation coefficients are marked colour)
Rys. 4. Współczynniki korelacji liniowej Pearsona (powyżej przekątnej) i rangowej Spearmana (poniżej przekątnej) dla obserwowanych cech w 2018 r. (kolorem oznaczono wartości istotne statystycznie)

The robustness of Spearman's versus Pearson's test has received relatively less empirical scrutiny [5, 8, 10]. Perhaps because Spearman's rank-order correlation is widely viewed as a nonparametric technique [10] and Pearson's coefficient is not [5]. On the other hand, the Spearman's and Pearson's formulas, when applied to ranked data in the absence of ties [8], give identical point estimates (correlation values). Although this is true, research by Borkowf [1] has shown that bivariate distributions with similar values of Pearson's or Spearman's correlation can, depending on the particular bivariate distribution, yield markedly different values for the asymptotic variance of Spearman's coefficient. Moreover, some authors have argued that commonly espoused reasons for using Spearman's coefficient, such as when paired data are not interval-scaled or when bivariate data are monotonic but nonlinear, are not really warranted [7].

4. Conclusions

1. The plant height and ear setting height were positively linear and rank correlated in all four years of study.
2. The correlation coefficients, both – linear and rank, between all four traits observed in 2018 were statistically significant.
3. Ear diameter and plant height were linear and rank correlated in 2018, however in 2015 only Pearson correlation coefficient was statistically significant between these two traits.

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