Jurnal Lahan Suboptimal : Journal of Suboptimal Lands
ISSN: 2252-6188 (Print), ISSN: 2302-3015 (Online, www.jlsuboptimal.unsri.ac.id)
Vol. 12, No.1: 80-87 April 2023
DOI: 10.36706/JLSO.12.1.2023.629

Correlation and Path Analysis Maize Hybrid Yield

Analisis Korelasi dan Analisis Sidik Litas Hasil Biji Jagung Hibrida

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(Received: 25 November 2022, Accepted: 27 March 2023)

Citation: Priyanto SB, Prayitno OD, Efendi R. 2023. Correlation and path analysis maize hybrid yield. *Jurnal Lahan Suboptimal: Journal of Suboptimal Lands.* 12 (1): 80-87. DOI: 10.36706/JLSO.12.1.2023.629.

ABSTRAK

Hasil biji merupakan karakter kuantitatif yang kompleks. Hal ini karena banyak karakter lain yang berhubungan dengan hasil biji. Penelitian ini bertujuan untuk mengetahui korelasi antar karakter agronomis pada tanaman jagung dan karakter yang berpengaruh terhadap hasil jagung hibrida. Percobaan ini dilaksanakan di IP2TP Bajeng Balai Penelitian Tanaman Serealia Bajeng, Gowa, Sulawesi Selatan pada bulan Maret sampai Juni 2022. Perlakuan terdiri dari sepuluh genotipe jagung hibrida. Perlakuan disusun dalam rancangan acak kelompok (RAK) dengan tiga ulangan. Variabel yang diamati adalah komponen agronomis dan komponen hasil. Guna mengetahui hubungan antar karakter dilakukan dengan korelasi pearson, karakter yang berpengaruh terhadap hasil biji ditentukan dengan analisis sidik lintas. Hasil penelitian menunjukkan karakter panjang daun, lebar daun, jumlah tanaman panen, jumlah tongkol panen, bobot kupasan basah, rendemen hasil, panjang tongkol, diameter tongkol, jumlah biji per baris dan bobot 1000 biji memiliki korelasi yang nyata terhadap hasil biji. karakter yang berpengaruh terhadap hasil jagung adalah bobot kupasan basah, rendemen hasil dan kadar air panen.

Kata kunci: analisis sidik lintas, jagung hibrida, korelasi

ABSTRACT

The yield was a complex quantitative character. It was due to many other characters being related to yield. This study aimed to determine the correlation between agronomic characters in maize and the characters that affect the yield of hybrid maize. This experiment was conducted at the Bajeng IP2TP, Indonesian Cereal Research Institute, Gowa, South Sulawesi from March to June 2022. The treatments consisted of ten hybrid maize genotypes. The treatments were arranged in a Randomized Complete Block Design (RCBD) with three replications. The variables observed were the agronomic component and yield component. Pearson's correlation was used to determine the relationship between characters, and the characters that affected the grain yield were determined by path analysis. The results showed the characters leaf length, leaf width, harvested plant number, harvested ear number, harvested ear weight, shelling percentage, ear length, ear diameter, kernel number per row and 1000 grains weight have a significant correlation to yield.

Characters that affected to maize yields were harvested ear weight, shelling percentage and grain moisture.

Keywords: correlation, maize hybrid, path analysis

INTRODUCTION

Maize utilization diversification implicates raised maize demand. Fatmawati and Zulham (2019) stated that in addition to being a staple food, maize was also used in animal feed, food industries, and pharmaceutical industries. The maize demand in 2018 was 15.063.668 tons, and in 2011 it was 15.932.111 tons and was predicted would rise yearly (Kementerian Pertanian, 2020). Therefore, maize production must be increased to meet the maize demand.

Yield was an economic trait and the ultimate goal of maize cultivation. Yield was a trait that was related to other traits. Yield Selection could occur directly or indirectly through traits associated with yield. Kmail et al. (2017) mentioned that yield was a combination of interrelated components that influence each other. Furthermore, Hapsari (2016) and Timisela et al. (2020) encountered that yield was correlated to yield component and other traits. Information on the correlation of agronomic traits with yield could simplify and shorten the selection process (Prabowo et al., 2014). Traits relationship expressed as correlation coefficients help determine the level and direction of selection (Bechere et al., 2014; Maftuchah et al., 2015). The coefficient correlation only represents the closeness between two traits without the influence of one trait on another. Therefore, the correlation analysis needs to be followed up with an analysis that could explain the closeness of the relationship by spelling out direct and indirect effects. This analysis was called a path analysis. With this method, each trait correlating to yield was broken down into direct and indirect effects (Krisnawati & Adie, 2016). In addition, Path analysis could describe the degree of relative relevance of a variable to other variables (Mustakim et al., 2019).

Correlation and path analysis studies have been extensively carried out in food and horticultural crops. In rice, traits of productive tillers number and total grain number have a direct and positive effect on yield (Kartina et al., 2016). Waluyo et al. (2022) showed that traits of leaf length have a very high positive direct effect on the yield of wet bulbs per hectare in onions. The foliage attitude and leaf spines traits could be selected as criteria to improve flesh thickness trait, and peduncle length could be selected to improve pineapple fruit weight (Nasution, 2018). Efendi et al. (2016) said that character that have direct effect to yield in drought condition were plant height, leaf area, ear length, ear diameter, and shelling percentage. In the low nitrogen condition character leaf number, harvested ear weight, ear diameter and ear length has positive direct effect to yield (Amas et al., 2021). This study aimed to determine the correlations between maize agronomic traits and the traits that affected hybrid maize yield. The information obtained may help in designing selection programs for hybrid maize improvement in Indonesia and evaluating the hybrid maize breeding program progress in Indonesia.

MATERIALS AND METHODS

This research was conducted at Bajeng experimental farm Indonesian Cereal Research Institute from March to June 2022. Ten hybrid hybrids maize: PNG 1, PNG 2, PNG 3, PNG 4, PNG 5, PNG 6, PNG 7, Pertiwi 6, NK 6172, and PAC 789 were arranged in a randomized block design (RBD) with three replications. The experimental plot's dimension was 2.8 m x 5 m, with a spacing of 70 cm x 20 cm, so there were 25 plants per row. The first fertilization was carried out seven days after planting (dap) at 135 kg N + 45 kg P2O5 + 45 kg K2O/ha. Second fertilization at 35 daps with a rate of 90 kg N/ha. Plant maintenance, weeding and hilling were done optimally. Harvesting was done in the middle two rows of the experimental plot.

The traits observed were plant height, ear height, stalk diameter, leaf angle, leaf length, leaf width, days to anthesis, days to silk, days to maturity, harvested plant number, harvested ear number, harvested ear weight, shelling percentage, grain moisture, ear length, ear diameter, kernel row number per ear, kernel number per row, 1000 grains weight and yield which was corrected to 15% moisture. Analysis of variance based on the mathematical model: $Yi= \mu+r\ (i)+\ \alpha j+\ \beta j\ +\varepsilon ij$, where: Yi = observed value, μ= general mean, R (i) = the effect of i-th replication, αj= the effect of j-th genotype, εij = Experimental error. Pearson's correlation among traits were done with the formula:

$$r_{xy} = \frac{Cov_{xy}}{\sqrt{Var_x.Var_y}}$$

where:

r_{xy} = The correlation between x and y
Cov_{xy} = The covariance between x and y
Var_x = The variance of x
Var_y = The variance of y

Furthermore, a path analysis was performed to determine the trait's direct and indirect effects to yield. Path analysis was only performed on traits that affect the yield. Traits affecting the yield were identified by regression analysis using a stepwise regression method. path analysis based on Singh and Chaudhary (1979), the formula was as follows:

$$\underset{R_x}{\begin{bmatrix} r_{11} & r_{21} & \cdots & r_{1p} \\ r_{12} & r_{22} & \cdots & r_{2p} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ r_{1p} & r_{2p} & \cdots & r_{pp} \end{bmatrix}} \underset{C_i}{\begin{bmatrix} C_1 \\ C_2 \\ \cdots \\ \cdots \\ C_p \end{bmatrix}} = \underset{R_y}{\begin{bmatrix} r_{1y} \\ r_{2y} \\ \cdots \\ \cdots \\ r_{py} \end{bmatrix}}$$

Ci values (direct effect) were calculated with the formula: $C_i = R_x^{-1}.\ Ry$

The effects that a model cannot explain were used as residual effect, calculated by the formula:

$$C_s = \sqrt{C_s^2}\ ;\ C_s^2 = C_i' R_x$$

R_x = The Correlation matrix between the independent variable,
R_x-^{1} = The inverse of matrix Rx.
C_i = The path coefficient vector that showed the direct effect of an independent variable on a dependent variable
R_y = The correlation vector between Xi (i=1, 2…, p) independent variable to Y dependent variable
C_s = Residual effect
C_i' The Transpose of matrix C_i

Data analysis was performed using Statistical Tool for Agricultural Research (STAR) Version: 2.0.1 and Microsoft Excel.

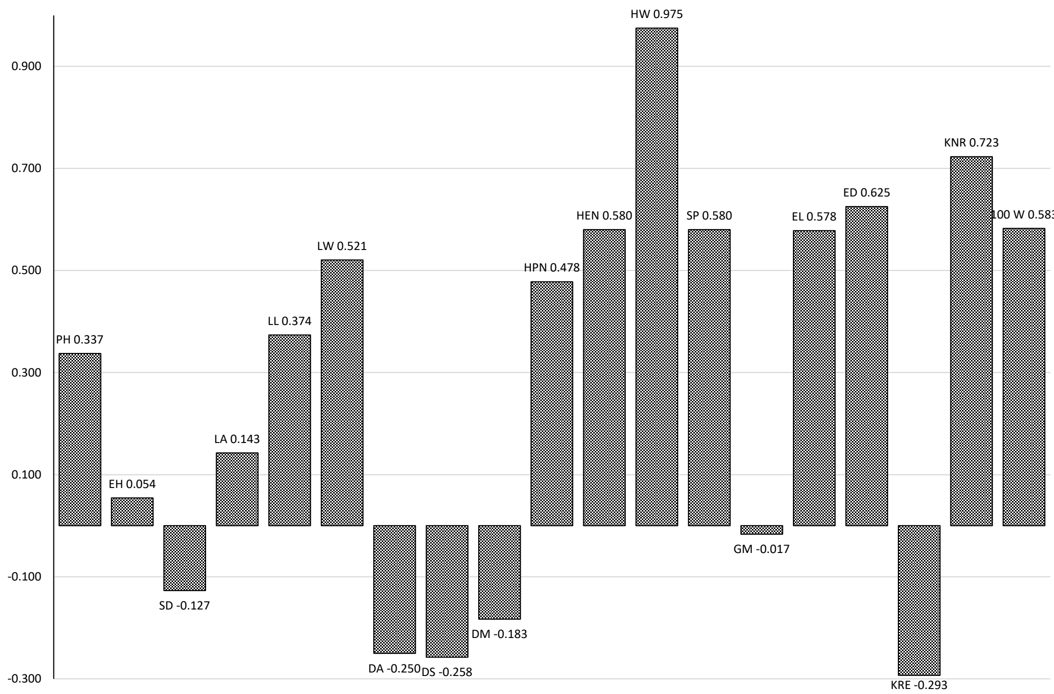
RESULTS

Analysis of variance reveals that almost all traits show a significant difference. Only two traits were not significant, i.e., leaf length and harvested ear number. The coefficient variation value was varying, which was between 1.1% (days to maturity) to 12.4% (yield). The genetic materials in this study have diverse genetic backgrounds. It could be seen in Table 1.

Agronomic traits and seed yield show various coefficient correlation values. The correlation coefficient values between agronomic traits and yield were shown in Figure 1. Six traits had negative correlation coefficients to yield, and thirteen traits had positive correlations. Traits negatively correlated to yield were stalk diameter (r = -0.127), days to anthesis (r = -0.250), days to silk (r = -0.258), days to maturity (r = -0.183), grain moisture (r = -0.017) and kernel row number per ear (r = -0.293). None traits show a significant correlation for traits with a negative correlation to yield.

Positive correlations to yield were shown by plant height (r = 0.337), plant height (r = 0.054), leaf angle (r = 0.143), leaf length (r = 0.374), leaf width (r = 0.521), harvested plant number (r= 0.478), harvested ear number (r = 0.580), harvested ear weight (r = 0.975), shelling percentage (r = 0.580), ear length (r = 0.578), ear diameter (r = 0.625), kernel number per row (r = 0.723) and 1000 grains weight (r = 0.583). Almost all traits with a positive correlation to yield show a significant correlation, except plant height, ear height, stalk diameter and leaf angle (Figure 1).

Regression analysis by stepwise regression showed that not all traits affect yield. Traits affected to yield were plant height, ear height, leaf width, days to anthesis, days to maturity, harvested plant number, harvested ear weight, shelling percentage, moisture grain, ear diameter, kernel row number per ear, and kernel number per row. Based on path analysis, traits that have a direct effect on yield were harvested ear weight, shelling percentage, and moisture grain. The trait’s direct influence was 0.882, 0.188, and -0.113, respectively. The other traits had a low direct effect but showed an indirect effect to yield through harvested ear weight. Those trait’s indirect effects were plant height (0.363), ear height (0.134), leaf width (0.477, days to anthesis (-0.169), days to maturity (-0.102), harvested plant number (0.500), shelling percentage (0.373), grain moisture (0.118), ear diameter (0.506), kernel row number per ear (-0.295) and kernel number per row (0.580). The residual traits effect was 0.023 (Table 2).



PH=plant height, EH=ear height, SD=stalk diameter, LA=leaf angle, LL=leaf length, LW=leaf width, DA=days to anthesis, DS=days to silk, DM=days to maturity, HPN=harvested plant number, HEN=harvested ear number, HEW=harvested ear weight, SP=shelling percentage, GM=grain moisture, EL=ear length, ED=ear diameter, KRE=kernel row number per ear, KNR=kernel number per row, 1000 W=1000 grains weight

Figure1. Correlation coefficient agronomic traits and yield

Table 1. Analysis of various agronomic characters and maize grain yield

Traits	Mean Square			CV (%)
	Replication	Hybrid	Error	
Plant height	60.901	761.815 **	101.851	4.5
Ear height	7.869	563.196 **	35.301	5.0
Stalk diameter	2.564	10.382 *	3.919	8.9
Leaf angle	1.549	1.137	0.716	4.1
Leaf length	18.832	55.823 **	5.916	2.8
Leaf width	0.157	1.391 **	0.082	3.0
Days to anthesis	0.233	1.559 *	0.493	1.3
Days to silk	0.633	1.633 **	0.411	1.2
Days to maturity	1.433	3.467 *	1.322	1.1
Harvested plant number	17.033	136.996 **	11.107	8.3
Harvested ear number	23.700	16.552	15.552	9.9
Harvested ear weight	0.698	4.750 **	0.760	11.3
Shelling percentage	5.225	18.519 **	2.333	1.9
Grain moisture	5.406	5.333 *	1.694	4.2
Ear length	0.234	3.199 **	0.620	4.6
Ear diameter	0.533	6.509 **	1.318	2.5
Kernel row number per ear	0.596	1.065 **	0.196	3.1
Kernel number per row	1.742	12.436 **	1.203	3.2
1000 grains weight	151.787	2430.470 **	585.690	7.1
Yield.	0.520	4.846 **	0.798	12.4

Note: CV= Coefficient variaton *= significant at 5% level of probability and **= significant at 1% level of probability

Table 2. Direct and indirect effect agronomic traits to yield

Traits	Influence direct	Indirect influence										
		PH	EH	LW	DA	DM	HPN	HEW	SP	GM	ED	KRE	KNR
PH	-0.060		-0.049	-0.012	-0.018	-0.008	-0.030	-0.025	0.003	-0.011	-0.003	0.024	-0.013
EH	0.063	0.052		0.002	0.027	0.010	0.030	0.010	-0.020	0.011	-0.022	-0.018	-0.005
LW	-0.043	-0.008	-0.001		0.017	-0.009	-0.004	-0.024	-0.009	-0.005	-0.025	0.011	-0.022
DA	-0.035	-0.010	-0.015	0.014		-0.016	-0.015	0.007	0.011	-0.005	0.015	0.000	0.007
DM	0.039	0.005	0.006	0.008	0.017		0.007	-0.004	-0.019	-0.001	-0.008	-0.003	-0.010
HPN	0.021	0.010	0.010	0.002	0.009	0.004		0.012	-0.001	0.005	0.000	-0.007	0.002
HEW	0.882	0.363	0.134	0.477	-0.169	-0.102	0.500		0.373	0.118	0.506	-0.295	0.580
SP	0.188	-0.011	-0.060	0.039	-0.056	-0.089	-0.011	0.079		-0.018	0.105	0.010	0.118
GM	-0.113	-0.021	-0.019	-0.014	-0.015	0.002	-0.028	-0.015	0.011		-0.006	0.002	0.004
ED	0.051	0.003	-0.018	0.029	-0.022	-0.010	0.000	0.029	0.028	0.003		0.008	0.032
KRE	-0.021	0.009	0.006	0.005	0.000	0.002	0.007	0.007	-0.001	0.000	-0.003		0.004
KNR	0.026	0.006	-0.002	0.013	-0.005	-0.006	0.002	0.017	0.016	-0.001	0.016	-0.005	
Residual Effect = 0.023													

Note: PH= plant height, EH= ear height, LW= leaf width, DA= days to anthesis, DM= days to maturity, HPN= harvested plant number, HEW= harvested ear weight, SP= shelling percentage, GM= grain moisture, ED= ear diameter, KRE= kernel row number per ear and KNR= kernel number per row

DISCUSSION

The genetic materials in this study have diverse genetic backgrounds. It can be seen in Table 1 indicates that almost all the observed traits show significant differences. Prayudha et al. (2019) express that genetic variability is plant breeding's primary asset. Genetic variability in the basic population will determine the success of plant breeding program (Silva et al., 2016; Tiwari, 2015). A wide genetic variability allows plant breeders to combine superior traits according to their preferences. If genetic variability is narrow, it is necessary to induce genetic variability to increase the variability. The relationship pattern between agronomic traits and yield is expressed as a correlation coefficient. Correlation coefficient values range from -1 to +1. A positive correlation value means that a change in agronomic trait will be followed by a yield change consistently. A negative correlation value means that if there is a change in agronomic trait, it will be opposite yield changes (Hazra & Gogtay, 2016). In this study, traits negatively correlated to yield did not show a significant correlation. It means that there is no relationship between yield and that agronomic trait.

Traits that show a positive and significant correlation to yield are leaf length, leaf width, harvested plant number, harvested ear number, harvested ear weight, shelling percentage, ear length, ear diameter, kernel number per row, and 1000 grains weight. Correlation coefficient traits with significant correlations ranged from 0.374 (leaf length) to 0.975 (harvested ear weight). In the grouping by Sugiyono (2017), a very strong correlation is found in harvested ear weight. Trait ear diameter and kernel number per row show a strong correlation to yield. Medium correlations to yield are shown by leaf width, harvested plant number, harvested ear number, shelling percentage, ear length, and 1000 grains weight. Meanwhile, a weak correlation is found at leaf length. Priyanto and Efendi (2022) reported a strong correlation between the harvested ear and maize yield in low N conditions.

Correlation between agronomic traits does not independently but can be concurrent or contradictory, so an increase in an agronomic trait can cause a decrease in other traits (Mulyani & Waluyo, 2020). The correlation value only illustrates a close relationship between two traits. However, it cannot explain the magnitude of the change due to these traits because the correlation coefficient does not describe a causal relationship. It is necessary to find out which traits directly affect yield by conducting a *path analysis*. This method specifies a causal relationship between correlated traits by breaking down the correlation coefficient between each trait that correlates to yield into two factors: direct effect and indirect effect (Permata et al., 2012). Traits directly affecting yield are harvested ear weight, shelling percentage, and grain moisture. Harvested ear weight has the highest direct effect on yield (0.882). The correlation coefficient between harvested ear weight and yield is very strong (0.975). Maize yield selection yield through harvested ear weight is effective to do. Singh and Chaudhary (1979) stated that a character is effectively used to select other characters when the target character's direct effect and the correlation coefficient are almost identical. Harvested ear weight is also the trait that has a direct influence and the highest correlation coefficient on maize under optimal land (Priyanto et al., 2016), drought (Efendi et al., 2016) and low nitrogen (Amas et al., 2021).

Shelling percentage and grain moisture content show something interesting. Those traits h besides having a direct effect on yield, also have an indirect effect through ear-harvested weight. The shelling percentage’s direct effect on yield was 0.188, and the indirect effect was 0.373. for trait grain moisture, the direct and indirect effects are -0.113 and 0.118, respectively. According to (Lusiana et al., 2021), the pathway model of shelling percentage and grain moisture content was a combination of multiple regression and mediation models. The residual effect is effects that direct and indirect effects of agronomic traits on yield cannot confirm. Residual effects are the character effects that are not included in the equation model. The low residual effect indicates that the path analysis has included the most critical component traits contributing to yield (Seesang et al., 2013). The residual effect of this study is 0.023. it means that factors cannot confirm by the direct and indirect effects is so little.

CONCLUSSION

The traits leaf length, leaf width, harvested plant number, harvested ear number, harvested ear weight, shelling percentage, ear length, ear diameter, kernel number per row and 1000 grains weight have a significant correlation to yield. Traits that affected to maize yields were harvested ear weight, shelling percentage and grain moisture.

ACKNOWLEDGEMENTS

Thank to PT Cipta Makmur Pertiwi for the genetic material and the funding Head of the Indonesia Cereal Research Institute (ICERI) for the Permit. We also thank IP2TP Bajeng staff for helping us experiment well.

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