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Correlation and Path Analysis in Commercial Tenera Oil Palms Collected from Southern Thailand

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ABSTRACT

Background: Tenera oil palm is widely planted as a commercial plantation crop throughout Southern Thailand. The purpose of this study was to evaluate the phenotypic correlation and the direct and indirect effects among bunch yields and vegetative characteristics in commercial tenera oil palms.

Methods: The oil yield, fresh fruit bunch, bunch number, average bunch weight, leaf area, leaf dry weight and rachis length were recorded from six commercial tenera oil palm progenies. The data were recorded between January 2019 and June 2020 at The Chaipattana Foundation's oil palm plantation in Trang Province, Thailand.

Result: Results show that fresh fruit bunch, average bunch weight and rachis length positively correlated with oil yield (r_p = 0.90**, 0.50* and 0.53, respectively), while bunch number and rachis length positively correlated with fresh fruit bunch (r_p = 0.58* and 0.47*, respectively). The path analysis shows that bunch number significantly correlated with fresh fruit bunch (0.58*) and strongly directly affected it (1.11). The fresh fruit bunch significantly correlated with oil yield, (0.90**) and had a strong direct (2.08) and indirect effect (1.20). These results indicate that bunch number and fresh fruit bunch are useful variables for oil yield improvement in further breeding programs of oil palm.

Key words: Correlation, Oil palm, Path analysis, Tenera.

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is native to the tropical rainforests of West and Central Africa and was brought to Southeast Asia in the early nineteenth century for commercial cultivation (Giacomin, 2018). Oil palm yields more compare oil than other oil crops. Palm oil is extracted from mesocarp and kernel. It is used for several purposes such as food ingredient, cosmetics and biodiesels. (Corley and Tinker, 2003). The tenera oil palm, the F_1 hybrid between Dura (maternal) type and Pisifera (paternal) type, is wildly planted for commercial purposes throughout Southern Thailand. The tenera has a thin endocarp (shell) (Sh^+Sh^-), thick mesocarp and fiber ring surrounding the endocarp (Soonsuwon *et al*. 2020). In oil palm breeding programs, plant breeders consider such things as bunch yield improvement, oil yield improvement, drought tolerance improvement, disease resistance improvement, *etc*. (Kumar *et al*. 2018). The correlation is a statistical technique used in oil palm breeding to identify the relationships among the quantitative variables of plant characteristics (Karadavut and Sozen, 2017). The correlation coefficient ranges between -1 and +1. When positive correlation ($r > 0$) indicates change in the same direction, both variables increase. When negative correlation ($r < 0$) means that two variables move in opposite directions; one variable decreases as the other increases. When $r = 0$, there is no association between the two variables (Gagné 2014; Franzese and Iuliano, 2019). The path analysis is an extension of the multiple regression; it investigates patterns of how independent variables produce direct and indirect effects on dependent variables (Lekshmanan and Vahab, 2018). The results of path analysis consist of direct effects from an independent variable on a dependent variable and indirect effects from an independent variable on a dependent variable through another independent variable. Path analysis assists in identification of characteristics that are useful as selection criteria for yield improvement (Olkin and Sampson, 2001; Osman *et al*. 2012). This study evaluated the phenotypic correlations and the direct and indirect effects among bunch yields and vegetative characteristics in commercial tenera oil palms. The results from this study might be useful for further breeding programs of oil palms in Thailand.

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MATERIALS AND METHODS

The six progenies of commercial tenera oil palms collected from Southern Thailand were planted in August 2015 at Oil Palm Collection Center, The Chaipattana Foundation, Trang

Province (7°39′45.1″N 99°36′03.3″E). They were planted at 9 x 9 x 9 m in triangular formation. For data collection, the 15 oil palm trees of each commercial tenera oil palm were randomly selected from the 4-year-old oil palm plantation. The bunch yields [fresh fruit bunch (FFB), bunch number (BN), average bunch weight (ABW) and oil yield (OY)] and vegetative characteristics [leaf area (LA), leaf dry weight (LDW) and rachis length (RL)] were collected from each selected oil palm tree. The oil yield was analyzed by the method reported by Corley (2018) and the leaf area and leaf dry weight were estimated by the method reported by Eksomtramage (2015). The study was conducted between January 2019 and June 2020. The data was statistically analyzed in phenotypic correlation coefficient (r_p) with the method reported by Al-jibouri *et al*. (1958) and Ly *et al*. (2018) as follows:

$$\text{Phenotypic correlation} = \frac{\text{Cov(ph)XY}}{\sqrt{\sigma^2\text{(ph)X} * \sigma^2\text{(ph)Y}}}$$

Where:

Cov(ph)XY = Phenotypic covariance between the variable X and Y.

σ^2(ph)Y = Phenotypic variance of the variable Y.

σ^2(ph)X = Phenotypic variance of the variable X.

The path analysis was calculated by the method reported by Krualee *et al*. (2013) and Eksomtramage (2015) as follows:

$$b'_1 = \frac{\sigma x_1}{\sigma y}$$

$$b'_2 = \frac{\sigma x_2}{\sigma y}$$

Where

b'_1, b'_2 = Path coefficient values.

r_{12}, r_{13} = Correlation coefficient values between X_1 and X_2, X_1 and X_3.

The path coefficient values can be substituted in the simultaneous equation $r_{1y} = b'_1 * r_{11} + b'_2 * r_{12} + b'_3 * r_{13} + \ldots\ldots\ldots\ldots\ldots$

RESULTS AND DISCUSSION

Phenotypic correlation among bunch yields and vegetative characteristics

The phenotypic correlations among bunch yields and vegetative characteristics in commercial tenera oil palms are illustrated in Table 1. All characteristics were positively correlated with each other characteristics, except for BN which was negatively correlated with other characteristics. OY was positively and significantly correlated with FFB, ABW and RL (r_p = 0.90**, 0.50* and 0.53*, respectively). FFB was positively and significantly correlated with BN and RL (r_p = 0.58* and 47*, respectively), while BN was negatively and significantly correlated with ABW (r_p = -0.57*). ABW was positively and significantly correlated with LA and RL (r_p = 0.63** and 0.56*, respectively). For the vegetative characteristics, LA was positively and significantly correlated with LDW and RL (r_p = 0.65** and 0.76**, respectively) and LDW was positively and significantly correlated with ABW (r_p = 0.55*). The results from this study are similar to the previous reports from Pathpo (2007); Eksomtramage and Eksomtramage (2010); Krualee *et al*. (2013); Rafll *et al*. (2013); Songrit (2014); Bueraheng (2017) who reported that OY was positively and significantly correlated with FFB and ABW. It indicates that the increase of FFB and BN will increase OY. Positive and significant correlations were also found between FFB and BN, indicating that an increase of BN will increase FFB. BN was negatively correlated with ABW, indicating that the increase of BN will result in the decrease of ABW.

Path analysis among bunch yields and vegetative characteristics

The results of path analysis among bunch yields and vegetative characteristics on fresh fruit bunch in commercial tenera oil palms are illustrated in Table 2. FFB was positively and significantly correlated with BN and RL (r_p = 0.58** and 0.47*, respectively). In addition, BN (1.11) and ABW (0.93) had strongly positive direct effects on FFB, while ABW had positive indirect effects on FFB through BN (-0.53), LA (0.59), LDW (0.37) and RL (0.52). The results are similar to results from Pathpo (2007); Eksomtramage (2015); Bueraheng (2017) who reported that BN and ABW had positive indirect effects on FFB. The results of path analysis among bunch yields and vegetative characteristics on oil yield in commercial tenera oil palms are illustrated in Table 3. OY was positively and significantly correlated with FFB, ABW and RL (r_p = 0.90**, 0.50* and 0.53*, respectively). FFB had the highest positive direct (2.08) and/or indirect effects (through BN (1.20)) on OY. In contrast, BN had negative

Table 1: Phenotypic correlation among bunch yields and vegetative characteristics in commercial tenera oil palms.

Characteristics	OY	FFB	BN	ABW	LA	LDW	RL
OY	-	0.90**	0.31	0.50*	0.36	0.16	0.53*
FFB		-	0.58*	0.33	0.29	0.00	0.47*
BN			-	-0.57*	-0.31	-0.37	-0.10
ABW				-	0.63**	0.40	0.56*
LA					-	0.65**	0.76**
LDW						-	0.55*
RL							-

*, ** Significantly different at P<0.05 and p<0.01, respectively. OY= Oil yield (kg/palm/year), FFB= Fresh fruit bunch (kg/palm/year), BN= Bunch number (no./year), ABW= Average bunch weight (kg/bunch), LA= Leaf area (m^2), LDW= Leaf dry weight (kg), RL= Rachis length (cm).

Table 2: Path analysis among bunch yields and vegetative characteristics on fresh fruit bunch in commercial tenera oil palms.

Characteristics	Correlation	Direct effect	Indirect effect				
			BN	ABW	LA	LDW	RL
BN	0.58*	1.11	-	-0.53	0.00	-0.01	0.00
ABW	0.33	0.93	-0.63	-	0.00	0.01	0.03
LA	0.29	0.00	-0.35	0.59	-	0.01	0.04
LDW	0.00	0.01	-0.41	0.37	0.00	-	0.03
RL	0.47*	0.06	-0.11	0.52	0.00	0.01	-

*, ** Significantly different at P<0.05 and p<0.01, respectively. OY = Oil yield (kg/palm/year), FFB= Fresh fruit bunch (kg/palm/year), BN= Bunch number (no./year), ABW= Average bunch weight (kg/bunch), LA= Leaf area (m^2), LDW= Leaf dry weight (kg), RL= Rachis length (cm).

Table 3: Path analysis among bunch yields and vegetative characteristics on oil yield in commercial tenera oil palms.

Characteristics	Correlation	Direct effect	Indirect effect					
			FFB	BN	ABW	LA	LDW	RL
FFB	0.90**	2.08	-	-0.82	-0.32	-0.04	0.00	0.00
BN	0.31	-1.43	1.20	-	0.54	0.05	-0.04	0.00
ABW	0.50*	-0.95	0.70	0.81	-	-0.09	0.04	0.00
LA	0.36	-0.15	0.60	0.45	-0.60	-	0.06	0.00
LDW	0.16	0.10	0.01	0.53	-0.38	-0.10	-	0.00
RL	0.53*	0.00	0.98	0.15	-0.54	-0.11	0.05	-

*, ** Significant difference at P<0.05 and p<0.01, respectively. OY= Oil yield (kg/palm/year), FFB= Fresh fruit bunch (kg/palm/year), BN= Bunch number (no./year), ABW= Average bunch weight (kg/bunch), LA= Leaf area (m^2), LDW= Leaf dry weight (kg), RL= Rachis length (cm).

direct effects (-1.43) and negative and positive indirect effects on OY through FFB (-0.82) and ABW (0.81). ABW had negative direct (-0.95) and indirect effects on OY though LA (-0.60) and RL (-0.54). According to Pathpo (2007); Eksomtramage (2015), FFB had positive indirect effects on OY.

CONCLUSION

Oil yield was positively and significantly correlated with fresh fruit bunch, average bunch weight and rachis length. Fresh fruit bunch had the highest positive direct and indirect effects on oil yield. Fresh fruit bunch was positively and significantly correlated with bunch number and rachis length. The path analysis indicates that bunch number and average bunch weight had strongly positive direct effects on fresh fruit bunch, although the average bunch weight was not significantly correlated with fresh fruit bunch. Therefore, bunch number and fresh fruit bunch are the most important variables which might be used in oil palm breeding programs. Both variables were positively and significantly correlated with oil yield and had strong direct and indirect effects on the yield.

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