Path Analysis of Fresh Fruit Bunch and Bunch Weight in Oil Palm

Surakitti Srikul[1/] **Somkid Damnoi**[1/] **Suteera Thawornrat**[2/] **Peerasak Srinives**[3/]
Anek Limsrivilai[4/] **Patcharin Tanya**[5/*]

Received 9 Jul. 2023/Revised 23 Jul. 2023/Accepted 24 Jul. 2023

ABSTRACT

Income of oil palm planters comes from the quantity of fresh fruit bunch (FFB) combining with the bunch weight harvested. This study focused on the direct and indirect effects of fresh fruit bunch and bunch weight using path analysis. Ninety tenera oil palm bunches were counted, weighed and individually separated. The results showed that bunch number (BNO) was a factor effect directly more than the average bunch weight (ABW), while a negative correlation was found between BNO and ABW, confirming that if the number of bunches was high, the ABW was small. Bunch weight (BW) composed of 9 characters interesting in this study: rachis weight per bunch (RCIS/B), rachillae weight per bunch (RCHAE/B), fruit weight per bunch (FW/B), fruit to bunch (FTB), mesocarp to fruit (MTF), kernel to fruit (KTF), shell to fruit (STF) and mean nut weight (MNW) were highly significant. Bunch weight (BW) was used to determine which components were effective. Fruit weight per bunch (FW/B) had the highest direct effect, followed by rachillae weight per bunch (RCHAE/B). Therefore, BNO and FW/B were selected to focus on fresh fruit bunches in the oil palm breeding programs.

Keywords: correlation; regression; yield components; tenera

[1/] Program in Agricultural Research and Development, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom 73140, Thailand
[2/] Program in Plant Breeding, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom 73140, Thailand
[3/] Academy of Science, The Royal Society of Thailand, Dusit, Bangkok 10300, Thailand
[4/] Golden Tenera Company Limited, 12/9 Na Phlapphla, Krabi Yai, Mueang, Krabi 81000, Thailand
[5/] Department of Agronomy, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom 73140, Thailand
*** Corresponding author: agrprt@ku.ac.th**

INTRODUCTION

The oil palm is an oil crop that supports food, oil products, and energy worldwide. Palm oil was extracted from the mesocarp and kernels. The goal of oil palm production to support the worldwide demand for palm oil is to improve tenera with a high oil yield. The main challenge is to increase oil production by using good varieties and field practices.

Oil palm is a crop with low genetic diversity for selection; therefore, it is improved by concentrating on yield, bunch, and fruit components. Oil palm is an oil crop that supports food, oil products, and energy worldwide. Breeding of oil palm has been performed to study some traits to correlate yield production consisting of fresh fruit bunch, bunch number, and average bunch weight, while oil yield was focused on yield and oil to bunch. It is considered to be the ratio of the part of the mesocarp, endocarp, and kernel. The resolution to determine traits correlated to yield and yield components using correlation and path analysis to select the favored palm. The correlation coefficient displayed a value between -1 and 1, with positive and negative associations between independent variations (Steel et al., 1997).

Path analysis is a useful tool for calculating the direct and indirect effects of independent traits on dependent traits (Jerrold, 1984). Balakrishna et al. (2018) studied the correlation and path coefficient in Indian oil palm and found that fresh fruit bunch (FFB) was positively correlated and path analysis with average bunch weight (ABW) and bunch number (BN). Tanya et al. (2013) found that the high positive correlation was between bunch weight and fruit weight per bunch (0.98), bunch weight and stalk weight per bunch (0.92), fruit weight per bunch and number of large size fruits (0.91), bunch weight and weight of large size fruits (0.88) and fruit weight per bunch and number of large size fruits (0.88), while the directly effecting influenced by bunch weight and bunch number. However, we had no clear information about traits correlated with yield among our tenera oil palms for breeding programs to improve for new varieties. The present study estimated phenotypic associations between yield-contributing characteristics along with path analysis to develop suitable selection criteria for oil palm improvement.

MATERIALS AND METHODS

Ninety tenera oil palm bunches were harvested at the Golden Tenera Company Limited, Krabi Province, Thailand. Traits were observed including fresh fruit bunch (FFB, kg/palm/year), bunch number (BNO, bunches), average bunch weight (ABW, kg), rachis weight per bunch (RCIS/B), rachillae weight

per bunch (RCHAE/B), fruit weight per bunch (FW/B), fruit to bunch (FTB), mesocarp to fruit (MTF), kernel to fruit (KTF), shell to fruit (STF), mean fruit weight and mean nut weight (MNW) (Rao et al., 1983).

The process of measuring the 10 traits of bunch components is shown in Figure 1. The bunches were weighed upon arrival, and the rachis was removed and weighed to obtain the RCIS/B (kg/bunch). The rachillae were then weighed to give RCHAE/B (kg/bunch). The fertile and parthenocarpic fruits with oil-bearing mesocarp were removed and weighed to obtain the FW/B (kg/bunch). FTB (%) can be calculated as the weight of the bunch. A sample of normal fertile fruits was also collected shortly after the arrival of the bunch. The fruit was weighed, the mesocarp was scraped off, the nuts were weighed, and the weight of the mesocarp was calculated as the difference. This gives the weight of the mesocarp at the time of taking the fruit sample, that is, the weight unaffected by drying of the fruit before scraping and during scraping of the mesocarp. MTF (%) was calculated from the weight of the fruit sample and nuts. The nuts were air-dried for approximately three days to facilitate cracking. The shell was removed, and the kernels were weighed to calculate the KTF (%) and STF (%).

The correlation between 13 traits was estimated by Steel et al. (1997), whereas path analyses were calculated as direct and indirect effects according to Jerrold (1984), performed using R-Stat (R Core Team, 2022).

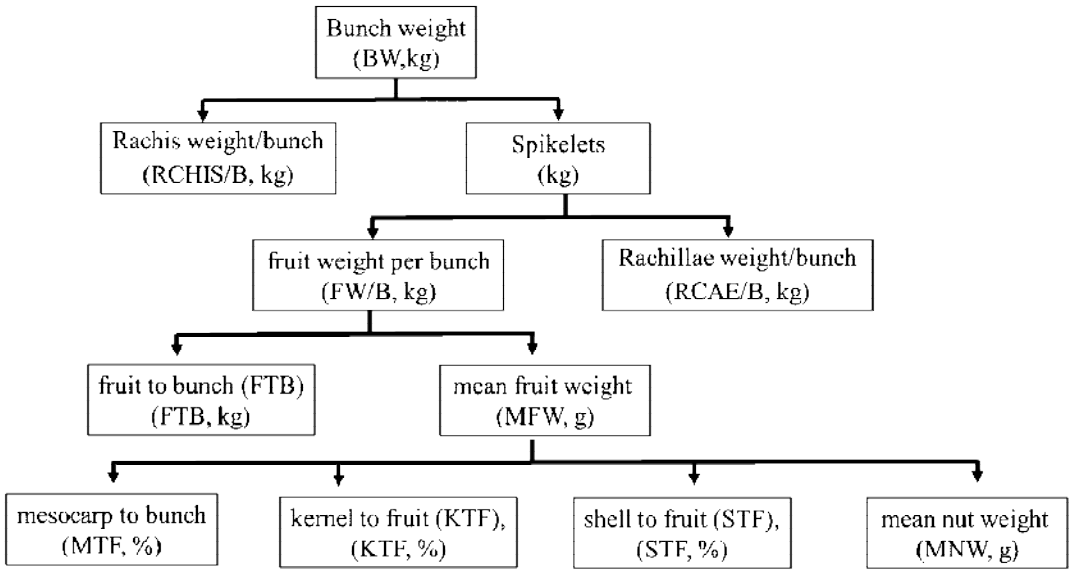

Figure 1 Diagram of measuring traits of bunch weight (BW)

RESULTS AND DISCUSSION

The correlation among the 13 traits showed that only bunch number (BNO) had the highest positive significance for fresh fruit bunch (FFB) (r = 0.59**) (Table 1). The correlation analysis revealed that bunch weight (BW) displayed a substantial correlation coefficient value (r = 0.15) with FFB, although the results did not reach statistical significance. These findings imply that BW may possess the capacity to contribute to the observed variations in FFB. The result showed that the significant direct effect from BNO was R^2 = 0.85 and ABW was R^2 = 0.15 (Figure 2). BNO was highly negatively correlated with average bunch weight (ABW) with no significant difference (r = -0.76), as described by Obisesan and Fatunla (1982) regarding the correlation between the BNO and mean ABW, which was negative (r = -0.41) same as reported from Cedillo et al. (2018) the correlation between bunch number and average bunch weight was -0.368 in dura x dura. BW was highly negatively correlated with BNO (r = -0.40**) and ABW (r = 0.59**). Considering this, when BNO is high, in contrast to ABW, is low. These results are similar to report in dura palm by Tanya et al. (2013), who reported that FFB had a high correlation with BNO; however, the difference in ABW in this study was not significantly correlated because the palm materials were tenera. The same result was reported by Okoye et al. (2009), who reported that only BNO was correlated with FFB and did not include ABW, with r = 0.653** of dura × tenera. Okwuagwu et al. (2008) reported highly significant positive relationships between FFB and BNO, whereas BNO showed strong negative correlations between BN and ABW in the 3 dura × tenera population, with correlation coefficients of –0.220**, –0.260**, and –0.368**.

The correlation coefficients between different oil palm traits are presented in Table 1. The Rachis weight per bunch (RCIS/B), rachillae weight per bunch (RCHAE/B), fruit weight per bunch (FW/B), fruit to bunch (FTB), kernel to fruit (KTF), shell to fruit (STF), and mean nut weight (MNW) were significantly positively correlated with bunch weight (BW), whereas mesocarp to fruit (MTF) was significantly negatively correlated, and mean nut weight was not significantly correlated with BW, as shown in Figure 3. The highest direct effect on BW was FW/B (r=0.777 or R^2 = 0.756), followed by RCHAE/B (R^2 = 0.165) and RCIS/B (R^2 = 0.078). Bunch weight (BW) was strongly associated with RCIS/B (r = 0.81**), RCHA/B (r = 0.72**), and FW/B (r = 0.92**), according to Corley and Tinker (2016), who explained the main traits of the oil palm bunch component. The percentages of RCIS/B: RCHA/B: FW/B were 10, 20, and 30%, respectively, composed of BW, so this

information will be considered for breeding tenera with high amounts of fruit set or big fruit.

Kernel to fruit (KTF) (r = 0.39**), shell to fruit, (STF) (r = 0.43**), and mean nut weight (MNW) (r = 0.41**) were positively correlated with BW, whereas mesocarp to fruit (MTF) (r = -0.45**) was negative. The bunch component showed that RCHAE/B was negatively correlated with fruit to bunch (FTB) (r = -0.39**), FTB was correlated with fruit weight per bunch (FW/B) (r = 0.51**), and MNW (r = 0.42**). Oil palm fruit consisted of mesocarp, endocarp (shell), and kernel, in this study confirms the ratio of them that MTF had the strong negative associated with KTF (r = -0.90**) and STF (r = -0.91**) and MNW (r = -0.75**) same as the report of Okoye et al. (2009). This information will be supported by breeders aiming to breed a new tenera with a high benefit value of crude palm oil (CPO) or palm kernel oil (PKO).

The results showed a direct effect of BNO on FFB, while BW had a strong direct effect on FW/B. FW/B had a significant positive correlation with MNW, STF, and KTF MTF, whereas there was a significant negative correlation with MTF. It seems that when we breed a new variety of oil palm, we have to consider the fruit

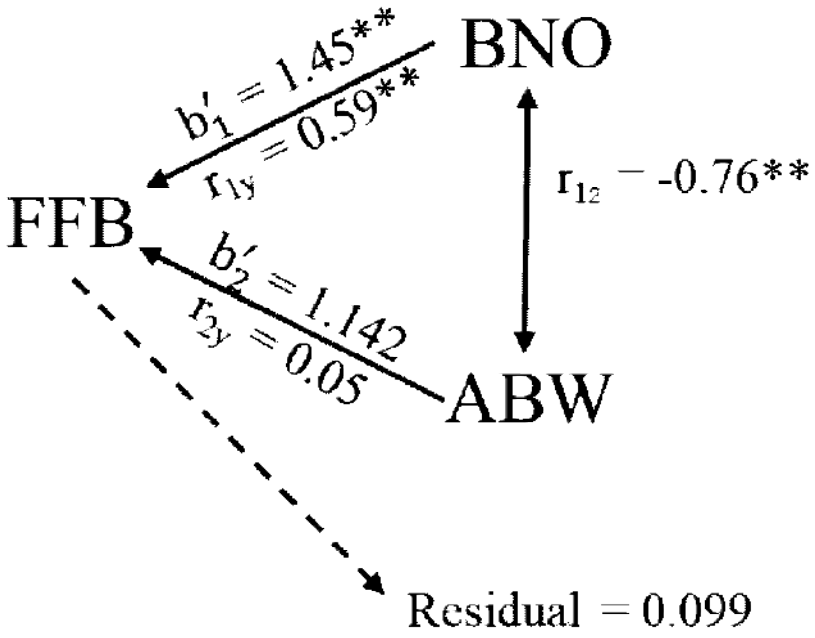

Figure 2 Path coefficient analysis of bunch number (BNO, bunches) and average bunch weight (ABW, kg) on the direct and indirect effects of fresh fruit bunch (FFB, kg/palm/year)

Table 1 Correlation coefficient among thirteen traits in tenera oil palm

	FFB	BNO	ABW	BW	RCIS/B	RCHAE/B	FW/B	FTB	MTF	KTF	STF	MFW
FFB	1											
BNO	0.59**	1										
ABW	0.05	-0.76	1									
BW	0.15	-0.40**	0.59**	1								
RCIS/B	0.32	-0.15	0.38**	0.81**	1							
RCHAE/B	0.12	-0.29	0.45**	0.72**	0.65**	1						
FW/B	0.12	-0.41**	0.57**	0.97**	0.72**	0.55**	1					
FTB	-0.12	-0.24	0.19	0.31	0.001	-0.39**	0.51**	1				
MTF	-0.05	0.52**	-0.69**	-0.45**	-0.39**	-0.36*	-0.43**	-0.1	1			
KTF	0.05	-0.52**	0.7**	0.39**	0.38**	0.31	0.37*	0.08	-0.90**	1		
STF	0.04	-0.43**	0.55**	0.43**	0.34*	0.34*	0.41**	0.1	-0.91**	0.65**	1	
MFW	-0.07	0.07	-0.17	0.001	-0.11	-0.13	0.05	0.21	0.17	-0.32	-0.003	1
MNW	0.01	-0.42**	0.49**	0.41**	0.28	0.23	0.42**	0.23	-0.75**	0.57**	0.79**	0.48**

Remark: Fresh fruit bunch (FFB), bunch number (BNO), average bunch weight (ABW), rachis weight per bunch (RCIS/B), rachillae weight per bunch (RCHAE/B), fruit weight per bunch (FW/B), fruit to bunch (FTB), mesocarp to fruit (MTF), kernel to fruit (KTF), shell to fruit (STF), mean fruit weight (MFW) and mean nut weight (MNW)

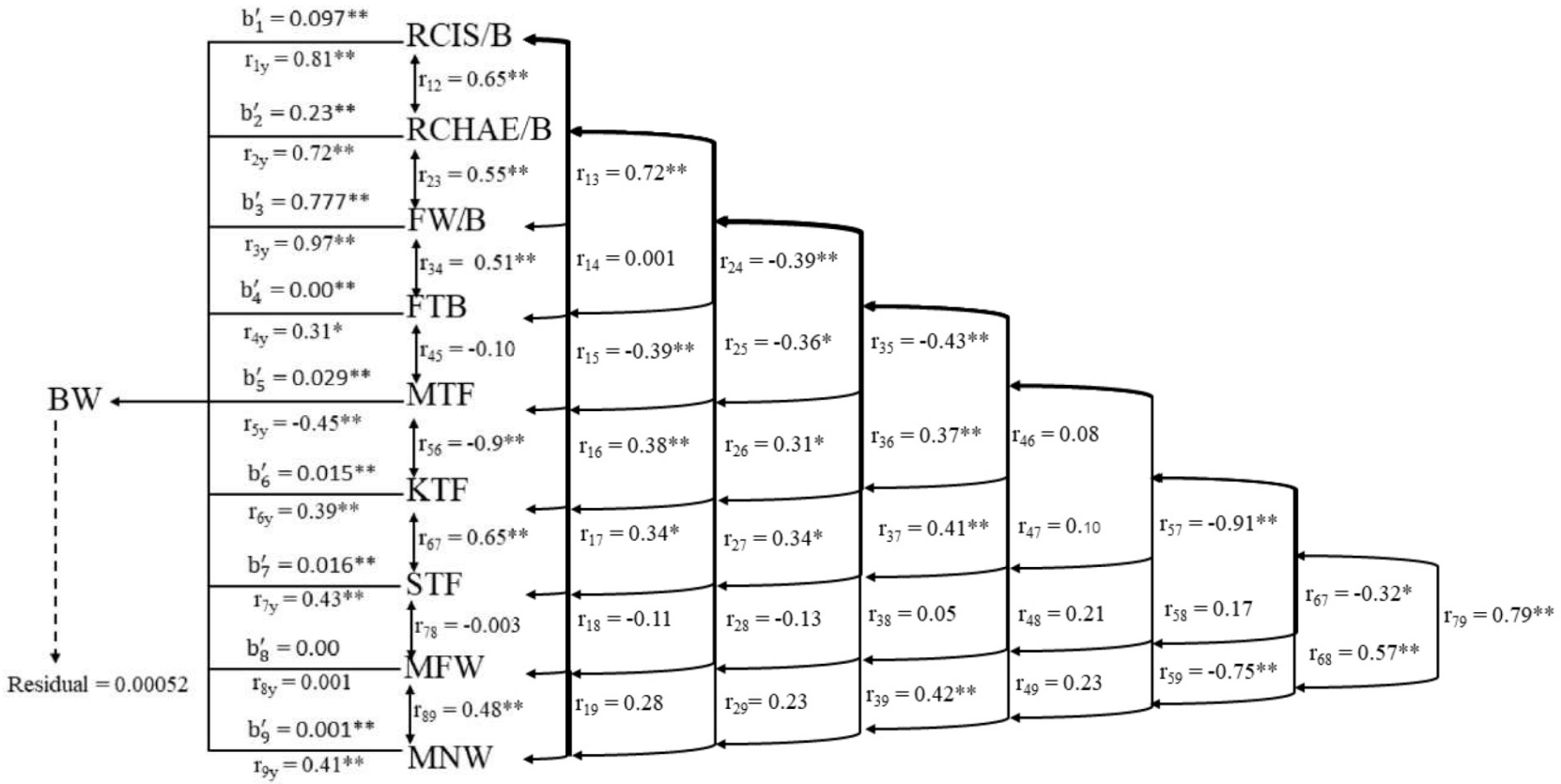

Figure 3 Path coefficient analysis of rachis weight per bunch (RCIS/B), rachillae weight per bunch (RCHAE/B), fruit weight per bunch (FW/B), fruit to bunch (FTB), mesocarp to fruit (MTF), kernel to fruit (KTF), shell to fruit (STF), mean fruit weight (MFW) and mean nut weight (MNW) on the direct and indirect effects of bunch weight (BN, kg)

component with a high level of mesocarp or kernel for the oil palm industry of CPO or PKO. This information will be used to support the oil palm industry in the future by zoning of oil palm fields with high mesocarps or kernels to support their products, which will increase the benefit value and the oil palm planter will earn more income.

CONCLUSION

In the breeding program, traits were correlated to yield production, which was used to consider for objective to project the point of traits for a new breed in tenera oil palm. In this study, we focused on BNO for FFB, in contrast to BNO and ABW. Moreover, BW should be emphasized to decrease the size of the rachis and rachillae with increasing FW/B. However, fruit components should be bred depending on the oil purpose from the mesocarp or kernel.

ACKNOWLEDGEMENT

This research was partially supported by (1) the Center of Excellence on Biotechnology of Oil Palm for Renewable Energy, Ministry of Higher Education, Science, Research and Innovation, (2) the Center of Advanced Study on Agriculture and Food of Kasetsart University, Bangkok, Thailand (project no. CASAF147) and (3) the Golden Tenera Company Limited, Krabi Province, Thailand.

REFERENCES

Balakrishna, P., R. Pinnamaneni, K.V. Pavani and R.K. Mathur. 2018. Correlation and path coefficient analysis in Indian oil palm genotypes. Journal of Pure and Applied Microbiology. 12(1): 195-206.

Cedillo, D.O., C.F. Barrera, J.O. Cedillo, J.O. Carrera, M.D.V. de Resende and C.D. Cruz. 2018. Estimates of parameters, prediction and selection of an oil palm population in Ecuador. Revista Faultad Nacional de Agronomia Medellín. 71(2): 8477-8487.

Corley, R.H.V. and P.B. Tinker. 2016. The Oil Palm. 5th ed. Willey Blackwell Publ. Co. Inc., USA. 680 p.

Jerrold, H.Z. 1984. Biostatistical Analysis. Prentice-Hall, New Jersey.

Obisesan, O. and T. Fatunla. 1982. Heritability of fresh fruit bunch yield and its components in the oil palm (*Elaeis guineensis* Jacq.). Theoretical and Applied Genetics. 64(1) : 65-8.

Okoye, M.N., C.O. Okwuagwu and M.I. Uguru. 2009. Population improvement for fresh fruit bunch yield and yield components in oil palm (*Elaeis guineensis* Jacq.). American-Eurasian. Journal of Scientific Research. 4(2): 59-63.

Okwuagwu, C.O., M.N. Okoye, E.C. Okolo, C.D. Ataga and M.I. Uguru. 2008. Genetic variability of fresh fruit bunch yield in Deli/*dura* x *tenera* breeding populations of oil palm (*Elaeis guineensis* Jacq.) in Nigeria. Journal of Tropical Agriculture. 46 (1-2): 40–45.

R Core Team. 2022. R: A language and environment for statistical computing. R Foundation for

Statistical Computing, Vienna, Austria. Available at: https://www.R-project.org/. Accessed: December 18, 2022.

Rao, V., A.C. Soh, R.H.V. Corley, C.H. Lee, N. Rajanaidu, Y.P. Tan, C.W. Chin, K.C. Lim, S.T. Tan, T.P. Lee and M. Ngui. 1983. A Critical reexamination of the method of bunch quality analysis in oil palm breeding. PORIM Occasional Paper No. 9: 1-28.

Steel, R., J.H. Torrie and D. Dickey. 1997. Principles and Procedures of Statistics: A Biometrical Approach. 3nd ed. McGraw Hill Book Com. Inc. New York. 666 p.

Tanya, P., Y. Hadkam, P. Taeprayoon and P. Srinives. 2013. Estimation of repeatability and path coefficient of bunch and fruit traits in Bang Bort Dura oil palm. Journal of Oil Palm Research. 25(1): 108-115.