

Comparison Methods of Estimation Potential Evapotranspiration for Oil Palm

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Abstract
The estimation of potential evapotranspiration constitutes an important part in the evaluation of climate. Many methods exist and all of these are indirect methods using equations that relate climatic data with evapotranspiration. A comparison of the three methods to estimate crop evapotranspiration being the method of Jabatan Parit dan Saliran (1977), Doorenbos and Pruitt (1977) and Penman- Monteith (Smith, 1991). Results showed that the method of Doorenbos and Pruitt (1977) provides a fairer estimation of evapotranspiration for oil palm cultivation in Peninsular Malaysia
Keywords: Evapotranspiration, oil palm, Peninsular Malaysia

Introduction

Prediction methods for crop-water requirements are used due to the difficulty of obtaining accurate field measurements. The methods need to be applied under climatic and agronomic conditions different from those under which they were originally developed. Testing the accuracy of the methods under a new set of conditions is laborious, time consuming and costly and yet crop water requirement data are frequently needed for project planning. Calculation of crop evapotranspiration (ET_{crop}) includes the effect of climate on crop water requirement and is given by the reference crop evapotranspiration or known as potential evapotranspiration. The objective of this paper is to compare the methods of estimating potential evapotranspiration to be used for land evaluation for oil palm cultivation.

Materials and Methods

The methods of Jabatan Parit dan Saliran (1997), Doorenbos and Pruitt (1977) and Penman and Monteith (1991) were used to calculate potential evaporation. The climatic data from 2003 to 2012 of Meteorological Stations of Alor Star (Kedah), Ipoh (Perak), Subang (Selangor), Malacca (Malacca), Kluang and Senai (Johore), Kuantan (Pahang) and Kuala Kerai (Kelantan) of Peninsular Malaysia were used in this study to calculate the potential evapotranspiration data (Figure 1).

Results and Discussion

The results of potential evapotranspiration estimated by the method of Jabatan Parit dan Saliran (1977), Doorenbos and Pruitt (1977) and Penman-Monteith (Smith, 1991) are shown in Table 1.

Potential evapotranspiration for mature oil palm estimated by the method of Doorenbos and Pruitt (1977) is higher than that estimated by the method Jabatan Parit dan Saliran (1977). Considering a day/night wind ratio of 3 for coastal area the method of Doorenbos and Pruitt (1977) estimates potential evapotranspiration for mature oil palm 29% to 36% higher than the method of Jabatan Parit dan Saliran (1977). When a day/night wind ratio of 1 is considered for areas away from the coast, the method of Doorenbos and Pruitt (1977) estimates 17% to 24% higher than the method of Jabatan Parit dan Saliran (1977) except that of Alor Star where estimates of potential evapotranspiration by the method of Doorenbos and Pruitt (1977) is 31% higher than the method of Jabatan Parit dan Saliran (1977).

Considering a day/night wind ratio of 3 for coastal areas the method of Doorenbos and Pruitt (1977) estimated potential evapotranspiration 33% for Kuantan and 48% for Malacca higher than the method of Penman-Monteith (Smith, 1991). When a day/night wind ratio of 1 is considered for areas away from coast, the method of Doorenbos and Pruitt (1977) estimated potential evapotranspiration compared to the method of Penman-Monteith (Smith, 1991) in the following order: Kuala Krai (31%) > Subang (29.3%) > Ipoh (27.6%) > Ipoh (27.6%) > Kluang (24.5%) > Alor Star (21.6%).

The results showed that potential evapotranspiration for mature oil palm estimated by the method of Jabatan Parit dan Saliran (1977) is higher than that estimated by the method of Penman-Monteith (Smith, 1991) in the following order: Senai (16.5%) > Kuala Krai (10%) > Subang (9.5%) > Malacca (8.3%) > Ipoh (5%) > Kluang (3.7%) > Kuantan (3.2%). However the estimated potential evapotranspiration by the method of Penman-Monteith (Smith, 1991) is found to be 6% higher than the method of Jabatan Parit dan Saliran (1977) for Alor Star region.

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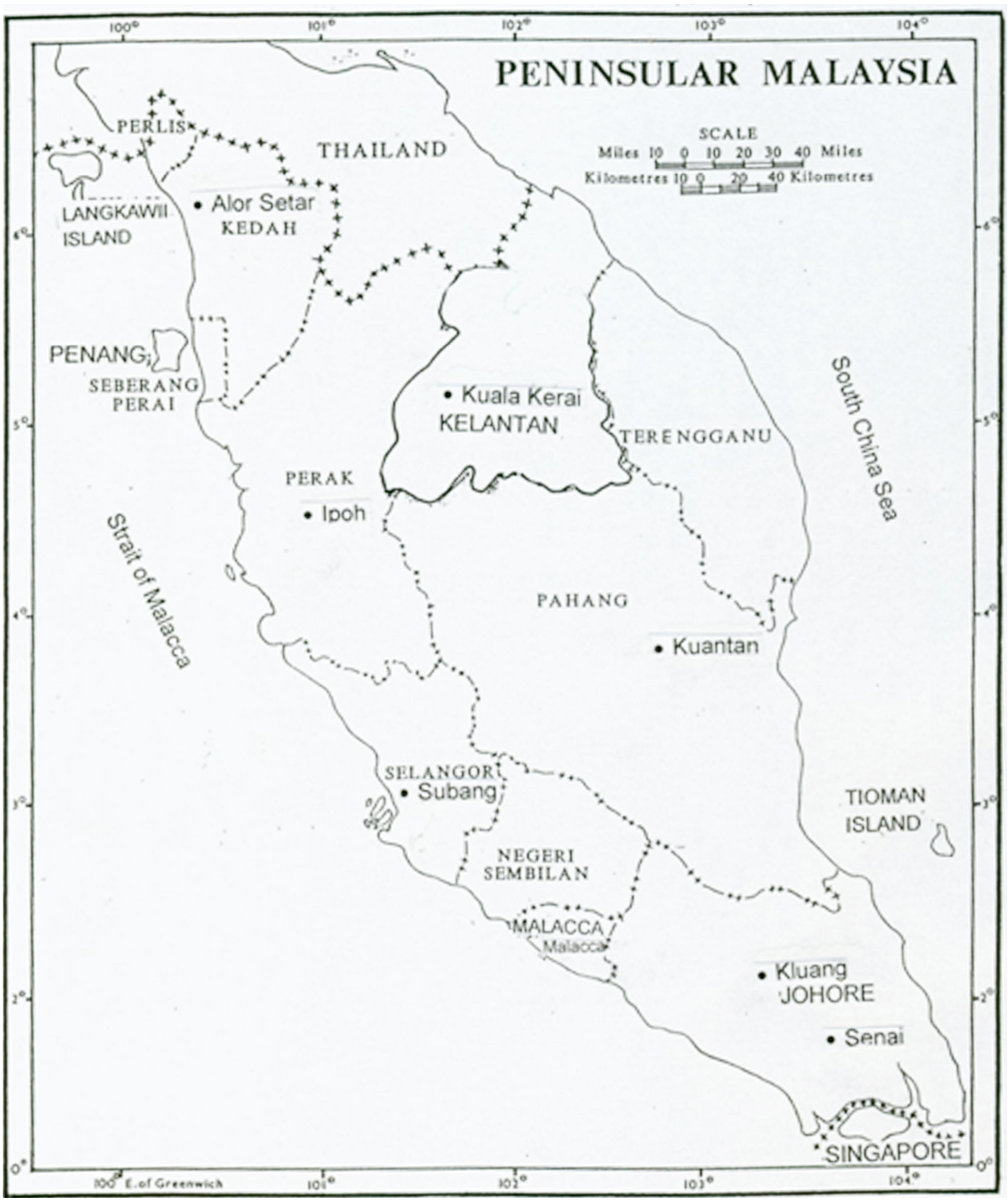

Figure 1: The location of Meteorological stations chosen for the study

The potential evapotranspiration estimated by the method of Doorenbos and Pruitt (1977) is higher than that obtained by the method of Jabatan Parit dan Saliran (1977) and the method of Penman-Monteith (Smith, 1991). The latter method is currently used to estimate potential evapotranspiration values in Peninsular Malaysia while the former method is recommended by FAO. The third method and the most recent method was reported to yield more accurate estimations of the potential evapotranspiration but require a large climatic data set (Sys et al., 1991).

The potential evapotranspiration estimated by the method of Jabatan Parit dan Saliran (1977) follows the Penman (1948) equation which predicts evaporation loses from an open water space.

Table 1: PET Values (mm month-1) Estimated by the Method of Jabatan Parit dan Saliran, Doorenbos and Pruitt and Penman-Monteith for Various Regions in Peninsular Malaysia

Stations/PET	Alor Star			Ipoh			Subang			Malacca			
Months	JPS	D	PM	JPS	D	PM	JPS	D	PM	JPS	D	D[1]	PM
J	141.7	212.6	156.0	121.8	150.3	116.6	199.0	150.0	111.3	125.2	168.0	193.7	118.1
F	139.4	197.4	151.2	117.0	123.5	122.1	120.1	164.0	114.0	121.5	170.5	196.8	123.2
M	117.8	200.8	163.1	138.6	181.0	132.1	139.0	171.4	126.5	138.0	177.6	200.3	130.5
A	149.0	184.0	152.4	104.4	167.7	126.3	133.5	160.0	118.5	136.2	163.5	176.4	123.3
M	119.6	169.6	141.0	125.5	155.0	117.8	126.6	151.0	117.0	124.1	151.6	161.8	116.0
J	138.6	150.0	131.0	127.0	148.0	113.4	123.6	144.5	110.0	120.0	143.5	147.0	107.7
J	112.8	161.8	130.8	126.2	157.0	120.0	126.2	140.4	117.0	120.1	144.8	153.0	108.0
A	166.2	157.2	128.6	124.3	149.0	117.0	123.7	134.0	113.5	119.7	141.7	153.1	106.0
S	127.5	144.3	120.6	121.5	139.2	109.2	124.2	138.0	110.0	110.1	139.5	147.6	105.3
O	119.0	136.4	120.7	116.9	138.3	104.5	122.4	136.7	112.8	124.6	149.4	158.1	116.6
N	100.0	138.3	117.3	110.7	125.0	100.0	114.3	128.1	101.0	111.0	132.0	142.5	94.5
D	124.0	150.7	134.8	111.6	134.0	105.4	108.2	130.0	99.2	113.5	151.6	168.5	101.4
Total	1555.5	2003.1	1647.5	1445.2	1705.0	1383.4	1480.8	1748.1	1352.5	1462.9	1835.5	1998.0	1350.6

JPS - Jabatan Parit dan Saliran(1977), D - Doorenbos et.al. (1977); day/night wind ratio =1,D1 - Doorenbos et.al. (1977);day/night wind ratio = 3, PM=Penman-Monteith (Smith,1991)

Table 1 (cont'd)

Stations/PET	Kuang			Senai			Kuantan				Kuala Krai		
Months	JPS	D	DPM	JPS	D	DPM	JPS	D	D[1]	PM	JPS	D	DPM
J	117.5	157.5	113.8	118.7	156.0	110.6	122.8	137.0	157.2	104.5	99.5	124.0	93.0
F	110.9	151.5	121.0	118.2	143.0	112.2	117.3	150.0	166.6	109.5	110.6	143.0	96.6
M	129.6	156.0	125.5	134.0	148.0	105.1	133.6	163.7	183.8	123.1	143.5	161.5	120.6
A	127.8	150.3	119.7	122.4	138.6	104.4	120.6	161.7	177.0	124.5	124.0	166.2	123.3
M	113.8	139.0	119.8	114.1	125.0	92.4	128.3	149.4	167.1	121.0	127.7	154.4	119.3
J	115.2	133.6	107.4	119.3	120.6	87.3	125.0	150.3	158.7	115.0	126.5	145.0	110.0
J	113.8	131.0	126.0	112.8	131.0	91.8	123.4	150.0	164.6	118.1	116.0	143.0	111.1
A	113.7	132.7	112.2	113.1	127.4	90.0	126.0	130.5	143.0	119.7	118.7	148.2	114.0
S	115.8	128.4	107.7	73.2	128.0	93.0	123.3	140.7	153.0	169.0	116.4	136.5	107.0
O	116.6	137.0	112.2	113.1	121.0	97.3	115.6	135.2	145.7	110.4	110.7	116.2	101.7
N	106.2	114.6	98.1	108.0	121.5	90.0	97.0	106.5	113.0	84.0	91.0	92.4	81.0
D	104.8	131.7	103.0	107.0	123.1	90.0	97.1	108.0	118.4	88.3	88.0	100.1	66.0
Total	1385.8	1663.3	1336.3	1353.9	1583.2	1164.1	1430.0	1683.0	1848.1	1387.1	1370.7	1630.5	1244.5

JPS - Jabatan Parit dan Saliran(1977), D - Doorenbos et.al. (1977); day/night wind ratio =1,D1 - Doorenbos et.al. (1977);day/night wind ratio =3, PM=Penman-Monteith (Smith,1991)

A slightly modified Penman equation suggested by Doorenbos and Pruitt (1977) to determine potential evapotranspiration involving a revised wind function term. This results from knowledge that under calm weather conditions, the aerodynamic term is less important than the energy term. Under windy conditions and in arid region, the aerodynamic term becomes more important. Doorenbos and Pruitt (1977) introduced an adjustment for day and night time weather condition, since they affect considerably the level of evapotranspiration.

A distinction is made between coastal and non-coastal areas since the former normally have pronounced sea breezes in the day and calm nights. The ratio of day to night wind speeds is assumed to be 3 as suggested by Doorenbos and Pruitt (1977) for coastal areas. The higher wind speed during the day in coastal area result in an increased evapotranspiration rate for oil palm. Oil palm grown on the coastal areas is expected to have about 10% higher evapotranspiration values than that grown on non-coastal areas.

Table 2: Relationship and Correlation Coefficient Values of PET between Jabatan Parit dan Saliran and Doorenbos and Pruitt, Jabatan Parit dan Saliran and Penman-Monteith and Doorenbos and Pruitt and Penman-Monteith for Various Regions in Peninsular Malaysia

Stations	JPS and D	JPS and PM	D and PM
Alor Star	PET_{JPS}= 92.46 + 0.22 PET_{D},r =0.14	PET_{JPS}= 83.20 + 0.34 PET_{PM},r =0.16	PET_{D}= 54.34 + 1.61 PET_{PM},r =0.90***
Ipoh	PET_{JPS}= 109.61 + 0.73 PET_{D},r =0.13	PET_{JPS}= 92.55 + 0.23 PET_{PM},r =0.32	PET_{D}= 35.30 + 1.07 PET_{PM},r =0.89***
Subang	PET_{JPS}= 63.59 + 0.41 PET_{D},r =0.50	PET_{JPS}= 9.82 + 1.00 PET_{PM},r =0.86***	PET_{D}= 23.28 + 1.49 PET_{PM},r =0.87***
Malacca	PET_{JPS}= 48.72 + 0.48 PET_{D},r =0.61**	PET_{JPS}= 39.25 + 0.74 PET_{PM},r =0.77**	PET_{D}= 11.11 + 1.26 PET_{PM},r =0.85***
Kluang	PET_{JPS}= 63.16 + 0.38 PET_{D},r =0.44	PET_{JPS}= 57.28 + 0.51 PET_{PM},r =0.38	PET_{D}= 33.54 + 1.97 PET_{PM},r =0.88***
Senai	PET_{JPS}= 50.26 + 0.48 PET_{D},r =0.15	PET_{JPS}= 9.52 + 0.74 PET_{PM},r =0.77**	PET_{D}= 10.18 + 1.24 PET_{PM},r =0.82***
Kuantan	PET_{JPS}= 45.57 + 0.52 PET_{D},r =0.72**	PET_{JPS}= 79.13 + 0.35 PET_{PM},r =0.42	PET_{D}= 15.17 + 1.48 PET_{PM},r =0.89***
Kuala Krai	PET_{JPS}= 31.18 + 0.61 PET_{D},r =0.80***	PET_{JPS}= 26.0 + 0.85 PET_{PM},r =0.84***	PET_{D}= 7.23 + 1.24 PET_{PM},r =0.84***

JPS- Jabatan Parit dan Saliran (Formerly known as BPT,1977), D-Doorenbos and Pruitt (1977), PM-Penman-Monteith (Smith,1991) JPS- Jabatan Parit dan Saliran (Formerly known as BPT,1977), D-Doorenbos and Pruitt (1977), PM-Penman- Monteith (Smith,1991)

The PET estimated by Doorenbos and Pruitt (1977) is highly correlated with that of the PET estimated by the method of Penman-Monteith (Smith, 1991) for all the regions in Peninsular Malaysia (Table 2).

Conclusion

The results show that the method of Doorenbos and Pruitt (1977) is recommended for determination of potential evaporation for oil palm cultivation in Peninsular Malaysia and elsewhere.

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