Name	Counterpart	Title
Tania June, Yudha Kristanto	**A03**	Turbulence characteristics of the oil palm canopy and their influence on sensible and latent heat fluxes

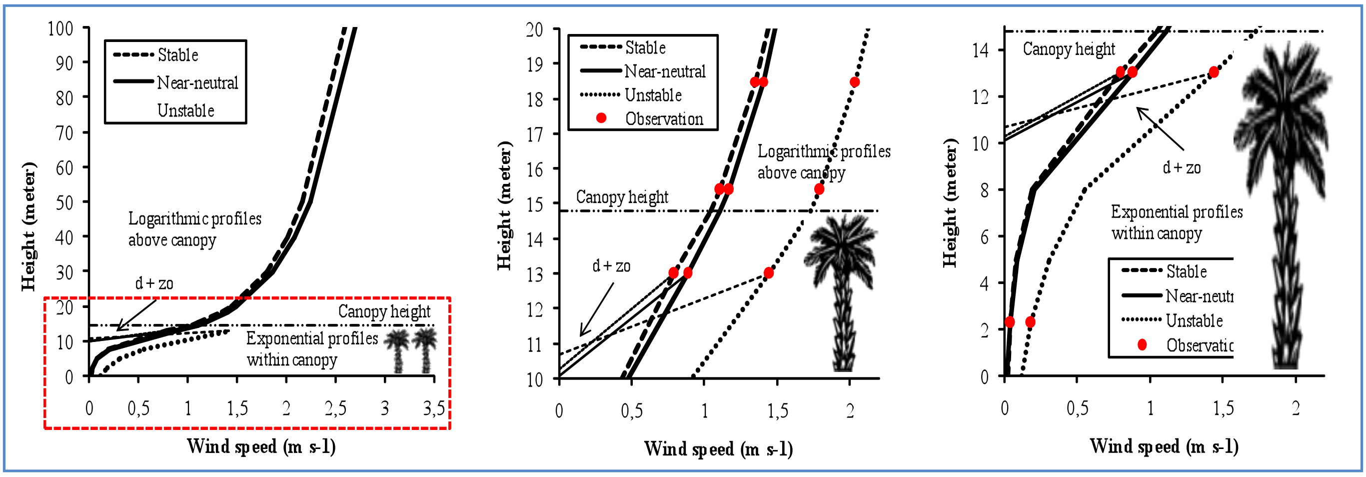
Objectives

To analyse the turbulence characteristics of the oil palm boundary layer surface and determine their implications for energy and water vapour fluxes.

Methods

Micrometeorological profile data (solar radiation, air temperature, wind speed and direction, humidity, soil temperature, and air pressure) were collected from the micrometeorological tower station in PTPN VI Jambi for the period 2014–2017. The turbulence characteristics were analysed using the profiles and gradients of the atmospheric characteristics (solar radiation, wind speed, temperature and water vapour) to produce surface roughness (roughness length, zo and zero plane displacement, d), turbulence transfer coefficient Km, and friction velocity u*, shearing stress τ and TKE (turbulence kinetic energy). Fluxes of energy, momentum and water vapour were calculated using the aerodynamic method. Influences of the atmospheric stability (neutral, unstable and inversion/stable) were taken into consideration using the Richardson Number Ri and the generalized stability factor ζ. The effect of turbulence on momentum and heat fluxes were determined and correlated with the eddy correlation measurement.

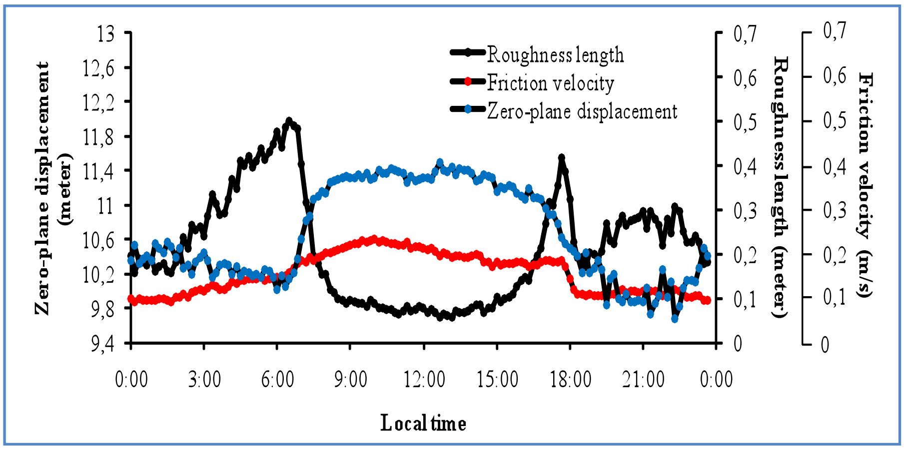
Research Summary



Turbulent motion in the air is generated by two main factors, i.e. buoyancy production and friction between moving air and rough surfaces (figure 1). Turbulence reached maximum when surface heating was greatest under unstable conditions during the day time over rough canopy surfaces and dissipated at night time. The turbulence characteristics (roughness length z_o, zero plane displacement *d*, friction velocity u*, and turbulence kinetic energy TKE) of oil palm were studied for the period 2014-2017. The data were collected from the site at PT Perkebunan Nusantara VI Batanghari, Jambi. The palms were 14.8 meters tall with LAI 2.05, and the canopy coverage was 78.6%. The structure of the oil palm canopy relates to its surface roughness and influences meteorological profiles and turbulence. Increased wind speed increased friction velocity, roughness length + zero-plane displacement, and increased turbulence (figure 2). Turbulence kinetic energy is strongly influenced by the magnitude of friction velocity. It is gen-

Figure 1. Wind profile characteristics above and below oil palm canopies under stable, neutral and unstable atmospheric stabilities (data analysed from 2015). The surface roughness was obtained through aerodynamic wind profiles and corrected using Monin-Obukhov's similarity theory. Above the canopy, wind profile follows the logarithmic pattern with equation: $u(z) = \frac{u_* \varphi(\zeta)}{k} * \{\ln(\frac{z-d}{zo}) - \Psi m(\zeta)\}$. Under the canopy the wind profile follows an exponential pattern with equation: $\bar{u}z = uh * e^{\alpha(\frac{z}{h} - 1)}$. Ψm (ζ) is the correction factor for atmospheric stability and is correlated with Richardson number Ri and α is the attenuation coefficient for wind in oil palm canopy calculated as 2.7 (function of LAI and wind profile). The zero-plane displacement (d) value of oil palm is 10.31 11.14m (≈ 0.7-0.75 canopy height, hc), roughness length (zo) 0.18-0.49 (≈ 0.01-0.02 canopy height, hc), and friction velocity (u*) 0.13-0.20ms^{-1}.

erated by wind shear and buoyancy, transported by pressure fluctuations and divergences, and dissipated into thermal energy (figure 3). All these components relate significantly to the amount of heat flux (both latent and sensible) with R^2 more than 0.75. Most of the energy available in the oil palm was used for evapotranspiration (latent heat fluxes), rather than sensible heat fluxes indicating that the palms had no lack of water during the period of measurements.



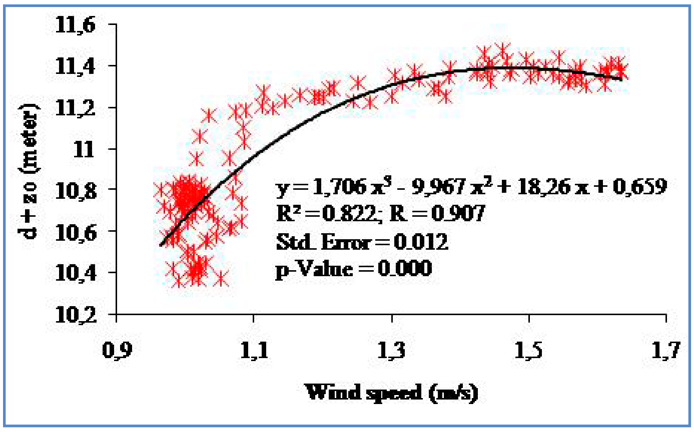
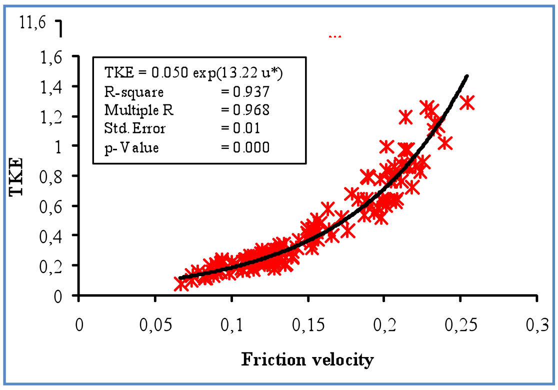
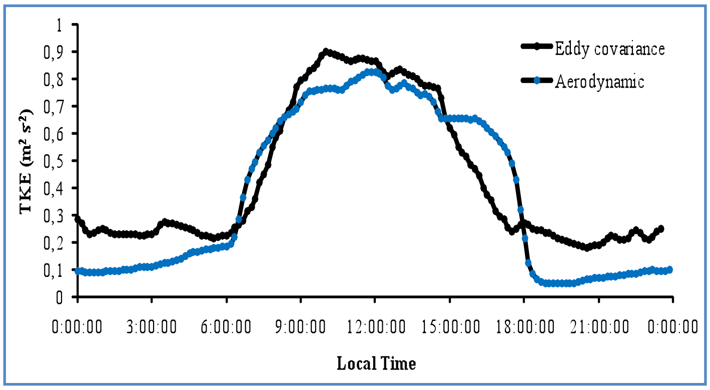


Figure 2: Diurnal pattern of turbulence characteristic parameters of oil palm (above). Data from 2014-2017 were averaged at intervals of 10-minutes. The average diurnal value of d = 10.71m, zo=0.26m and u* = 0.16ms^{-1}. The surface roughness parameter d+zo is significantly influenced by wind speed (below).





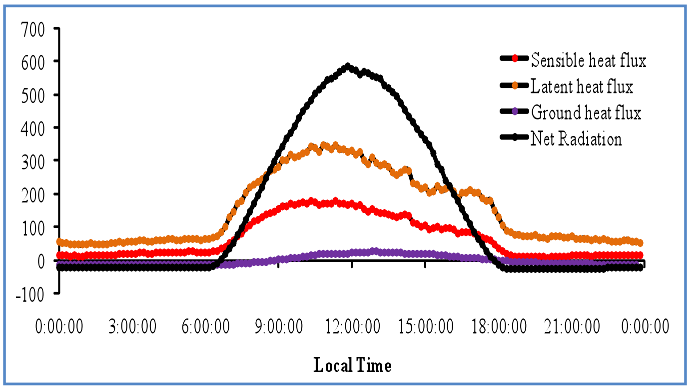


Figure 3: Diurnal pattern of Turbulence Kinetic Energy (TKE) (above) control the pattern of latent and sensible heat fluxes (below). The existence of turbulence significantly enhances the flux transfer process (with $R^2 > 0.75$).