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Variation Characteristics of Photosynthetically Active Radition (PAR) Over Ilorin in the Tropics

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Abstract - The annual variation of photosynthetically active radiation (PAR) measured over five (5) years period (2005- 2010) at Ilorin (8^0 32'N, 4^0 34'E) was studied. The average daily and weekly PAR were obtained and plotted. The behavior of average daily PAR is similar to that obtained for the weekly average. There is a daily and weekly fluctuation in PAR throughout the year. The highest value of PAR is 33.96MJ/m^2/day which occurred during the Harmattan period and minimum during the rain period with a value of 22.816MJ/m^2/day. The average PAR for the Harmattan and Rain period is found to be 37.585 and 29.125MJ/m^2/day respectively, while the average annual PAR is 30.050MJ/m^2/day. When PAR is plotted against days of the year, the plot is described by a logarithm fit as y= -1.39ln(x) + 39.91 with a weak correlation R^2 = 0.387. Also, when PAR is plotted against weeks of the year, the plot is best described by a logarithm fit as y= -1.56ln(x) + 34.74 with correlation R^2 = 0.524.

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VARIATION CHARACTERISTICS OF PHOTOSYNTHETICALLY ACTIVE RADITION PAR OVER ILORIN IN THE TROPICS

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I. Introduction

The quantitative and qualitative study of the solar radiation that reaches the earth's surface is of great importance for a vast range of human activities, linked to agriculture, forests, biology, animal husbandry, architecture engineering, industry and many others. Use of solar radiation in the establishment of the agricultural potential of a region has been highlighted by many researchers related to photosynthesis, evapotranspiration, water use efficiency, growth and crop productivity, in environmental controlled experiments in crop yield models, as well as climatic changes studies. (Leonordo et al, 2004)

The important of sunlight in vegetation is shown in photosynthesis process where carbondioxide and water in the presence of sunlight are synthesized to form carbonhydrate. The quantity of radiation available affects the climate of the region. The sunlight distribution, quantity of rainfall and temperature available also affects the agriculture of the sub-region such as the tropics (Owonubi, 1998). The equation for the photosynthesis process is

$$6CO_{2(liquid\,)} + 12H_2O_{liquid} + photon \rightarrow C_6H_{12}O_{6(aqeous\,)} + \ 6O_{2(gas\,)} + 6H_2O_{(liquid\,)}$$

The photon in the above equation is referred to as photosynthetically active radiation (PAR). PAR is often regarded as the spectral range of global radiation at wavebands spanning from approximately 0.4μm (400nm) through 0.7μm (700nm) which can be absorbed by photosynthesis system of plants (McCree, 1972; Alados & Alados-Arboledes, 1999; Jacovides et al, 2004). This portion of solar radiation spectrum is extremely important, because it is the solar energy source for vegetative photosynthesis to provide us with products such as food and fibre sources, biofuel carriers and additional material sources that support industrial process (Mariscal et al, 2000; Walker,2005; Myers,20005). It also plays very important roles in plant growth, and it is the principal factor in the rate of solar energy conversion into biological mediated energy. Therefore, it is a requirement parameter that must be studied to predict the production of plant products and biomass (Goudriaan & Vaa Laar, 1994; Asner & Wessman, 1999; and Mariscal et al, 2000).

Previous studies have shown that various aspect of PAR exhibit seasonal trends. For example, PAR flux density (PFD) was found to be much lower during the cool dry seasons and highest at hot dry season. Additionally, its daily changes significantly during warm wet seasons and but less during hot dry seasons (Finch et al, 2004). It was further found that daily and seasonal patterns of PAR are dependent on local climate conditions such as sky brightness, air clearness, solar elevation (Jacovides et al, 2004) and dewpoint temperature (Alados et al, 1996). PAR was also found to vary with time scale (Udo & Aro, 1999) and geographical region of assessment (Stigler & Musabilha, 1982; Udo & Aro, 1999), which makes local evaluation important for many applications.

Based on the importance of this parameter, it is therefore intended in this work to examine the annual and weekly variation of photosynthetically active radiation measured over five (5) years period (2005-

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2010). This is to specifically determine the effect of variation on the environment.

II. Material and Methods

The main data used for this study is the photosynthetically active radiation. It is being measured on a continuous basis at Ilorin using Eppley Precision Spectral Pyranometer (PSP) (SN1765F36) and calibration constant of 8 28 10^{-6} V/Wm^{-2}. The PSP has well documented calibration history and its calibration is redone every two years. Flux data generated are in Watts per meter squared (WM-2). Sampling rate of 1-second with integration time of 1-minute is maintained in compliance with the WRR (World Radiometric Reference) requirement. Linear regression is also done between calibration constant and data, and the useful constant obtained for calibration.

The equipment was set-up on the roof of a one-storey building (about 11m above the ground level) in the University of Ilorin, Ilorin, Nigeria. The sensor rod is about $1\frac{1}{2}$ m above the storey level surface. The data generated from this equipment are stored in CR10 Data-Logger before transfer to dedicated computer memory through an RS232 interface and thereafter archived.

Because the sample points were large, about One thousand, four hundred and forty values for each day. By this, the average daily and weekly data generated was found to give new data points that were closer to each other and with more discernible trend. Hence, the daily and weekly means of the measurements, over the five years is considered to be a good representative of the annual behavior.

III. Results and Discussion

The daily/weekly average profile of the PAR over the five years is drawn in fig 1&2. The onset of Harmattan came in about the beginning of November (Day 305)(week 44) and PAR was essentially constant until the middle of January (Day 19)(week 2) of the following year.

Then, after a minor dip in PAR about the middle of January, it rose to a local peak value about the end of January (Day 22)(week 4). This is followed by an approach to another minimum about the end of February and beginning of March (Day 57-61)(week 8-9). A new maximum was attained about the middle of April (Day105)(week15). This peak dropped to a low value after the middle of May (Day 136)(week19), but the drop may be due to increasing cloud and rain activities. These may reduce radiation in this wavelength range by absorption or scattering. The vegetation commences its green lush about late April (Day 113)(week 16) and the beginning of August (Day211)(week36). This is the period when PAR has its minimum value of 22.816MJ/m^2/day (Day151) (week 22).

Thereafter, there is a gentle increase until the end of October (Day 302) (week 45) and beginning of November (Day 306) (week 44) when Harmattan sets in again. It can be seen that despite the rains that commenced about May-June and became heavy in August and September, PAR continued to rise steadily. It could imply that Harmattan dust scatter more PAR to the ground than rain. It could also be attributed to clear air, cloud disappearing and hence higher penetrating of PAR during the period.

The highest value of PAR is 33.96MJ/m^2/day which occurred in early January (Day 6) (week 1). The average PAR for Harmattan Rain is found to be 37.585 and 29.125MJ/m^2/day respectively, while the average annual PAR is 30.050MJ/m^2/day. When PAR is plotted against days of the year, the plot is described by a logarithm fit as

$y = -1.39\ln(x) + 36.91$ with a weak correlation $R^2 = 0.387$. Also, when PAR is plotted against weeks of the year, the plot is best described by a logarithm fit as $y = -1.56\ln(x) + 34.74$ with correlation $R^2 = 0.524$.

IV. Conclusion

The period when PAR has its minimum value falls within the rain period while the period with its maximum value falls within the Harmattan period. Also, the average PAR for the Harmattan period is higher than the average annual value while the average PAR for the rain period is lower than the annual average. The period of minimum value of PAR is when plant green leaves are lush while the period of maximum value of PAR is when Harmattan dust arrives, leaves becomes dry. This implies that, it is not the amount of PAR that is most important for photosynthesis process to occur but it requires a significant amount of moisture.

V. Acknowledgement

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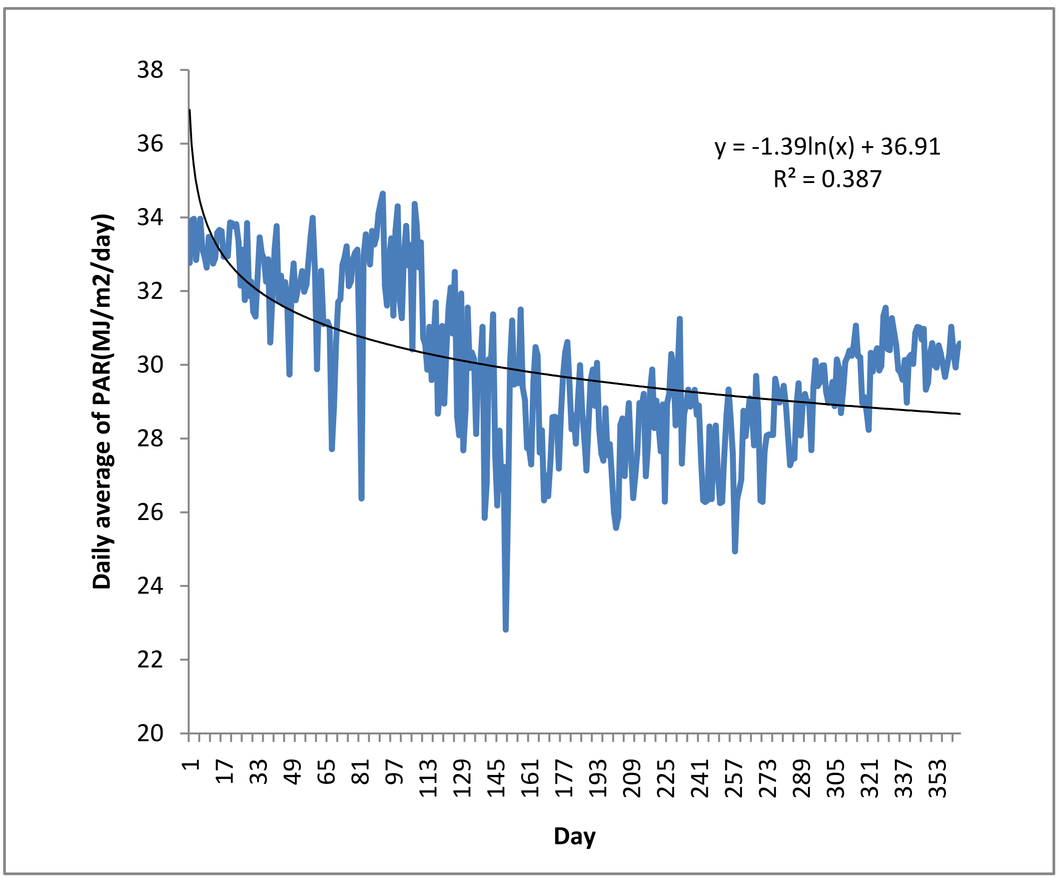

Figure 1 : Annual Daily Variation of Photosynthetically Active Radiation for the Five Years Period (2005-2010).

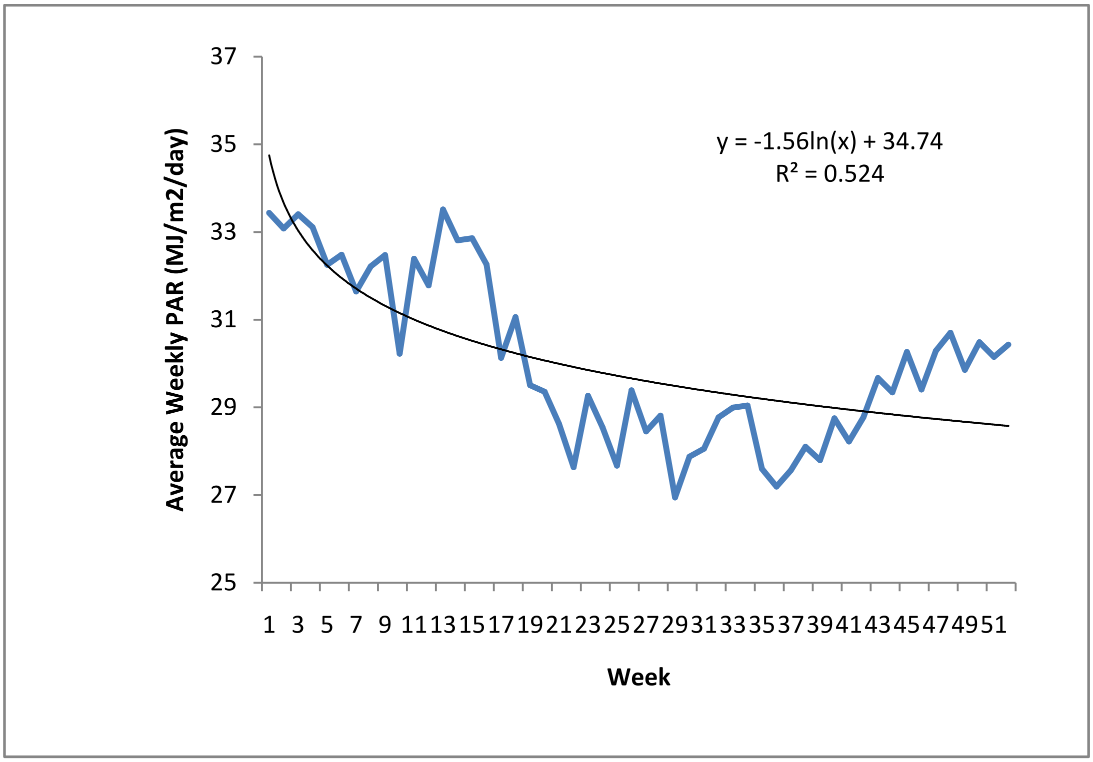

Figure 2 : Annual Weekly Variation of Photosynthetically Active Radiation for the Five Years Period (2005-2010).