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# Evaluation of Energy Balance Relationship over Rice Fields in Different Seasons at Mymensingh in Bangladesh

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***Abstract:***
*An experiment was conducted to evaluate the energy balance relationship over rice crops at the paddy field of Bangladesh Agricultural University Farmland, Mymensingh from August 2012 to July 2013. Trends of a few micrometeorological parameters were also observed. Energy balance components were measured using partly eddy covariance method. In Aman season the maximum and minimum lE was observed 9.64 $MJm^{-2}day^{-1}$ and 3.00 $MJm^{-2}day^{-1}$ at the DOY 282 and DOY 340. The average lE of the three defined growth stages of rice was found 5.63 $MJm^{-2}day^{-1}$. Average lE/Rn ratios in the three growing (Early growth, full growth, and mature crop just before harvest) periods of the Aman season were recorded 0.75, 0.92, and 0.65 respectively. Maximum H was observed 1.78 $MJm^{-2}day^{-1}$ in the mature crop before harvest and a minimum of 0.11 $MJm^{-2}day^{-1}$ in the full growth stage of rice paddy. H/Rn ratio was found from 0.1, 0.02, and 0.26 in different growth stages (Early growth, full growth, and mature crop just before harvest) of Aman rice. The maximum value of G was observed 1.31 $MJm^{-2}day^{-1}$ at the DOY 241 and the minimum was observed 0.24 $MJm^{-2}day^{-1}$at DOY 281. The average ratio of lE/Rn, G/Rn, and H/Rn was 0.77, 0.08, and 0.13 respectively. In the Boro season the maximum and minimum value of lE was recorded 9.70 $MJm^{-2}day^{-1}$ and 4.10 $MJm^{-2}day^{-1}$ at the DOY 114 and DOY 43. The average lE of the three growing stages (Early growth, full growth, and mature crop just before harvest) was found 6.60 $MJm^{-2}day^{-1}$. Average lE/Rn ratios in the three growing (Early growth, full growth, and mature crop just before harvest) periods of the Aman season were recorded 0 .74, 0.88, and 0.89. Maximum H was observed 1.49 $MJm^{-2}day^{-1}$ in the mature crop before harvest and a minimum of 0.15 $MJm^{-2}day^{-1}$ in the early growth stage of rice paddy. H/Rn ratios were found from 0.06, 0.03, and 0.09 in different growth stages (Early growth, full growth, and mature crop just before harvest) of the Aman rice. The maximum value of G was observed 1.28 $MJm^{-2}day^{-1}$at the DOY 42 and the minimum was observed 0.15 $MJm^{-2}day^{-1}$ at DOY 113. The average ratio of lE/Rn, G/Rn, and H/Rn was 0.84, 0.09, and 0.06 respectively. The latent heat flux (lE) of Boro season is larger than the Aman season which is approximately balanced to net radiation. On the other hand, the sensible heat flux of the Boro season is less than the Aman season. The ground heat fluxes (G) both two seasons were shown about similar values.*

***Key Word:*** *Energy Balance; Amon rice; Boro rice; Rn; H, lE; and G*

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## I. Introduction

The total electromagnetic radiation (spectrum) emitted by the sun is called solar radiation. So, the sun is the ultimate source of all energy that comes to the earth's surface as short and longwave radiations. The Balance of short wave and longwave radiation is the net radiation (Rn). Energy partitioning means solar energy partitioning as Rn = H + lE + G+ EPn + ERn, where Rn is net radiation, H is sensible heat flux, lE is latent heat flux, EPn is energy for photosynthesis and ERn is energy for respiration, units of all components are in Wm-2. Very little energy requires for chemical reactions for photosynthesis and respiration, so micrometeorologists neglect these two terms and use only Rn = H + lE + G. The energy partitioning depends on various environmental factors as well as the biological characteristics of vegetation in an area (Wever et al., 2002; Wilson et al., 2002). The surface energy budget affects the microclimate of the plant canopy through parameters such as temperature, humidity, evapotranspiration, and eventually plant growth.

The net radiative flux is a result of radiation balance at the surface. During the daytime, it is usually dominated by solar radiation and is almost always directed towards the surface, while at night the net radiation much weaker and directed away from the surface. As a result, the surface warms up during the day time, while it cools during the evening and night hours under a clean sky (Arya, 2001).

The direct or sensible heat flux at and above the surface arises as a result of the difference in the temperatures of the surface and the above. Actually, the temperature in the atmospheric surface layer varies continuously with height, with the magnitude of the vertical temperature gradient usually decreasing with height. The sensible heat flux is usually directed away from the surface during the daytime hours when the surface is warmer than the air above, and vice versa during the evening and night time periods. Thus, the heat flux is down the average temperature gradient (Arya, 2001).

The latent heat or water vapor flux is a result of evaporation, evapotranspiration, or condensation at the surface and is given by the product of the latent heat of evaporation or condensation and the rate of evaporation or condensation (lE). The water vapor transfer through air does not involve any real heat exchange, except where phase changes between liquid water and vapor actually take place. However, evaporation results in some cooling of the surface, which in the surface energy budget is represented by the latent heat flux from the surface to the above (Arya, 2001). During the daytime, the surface receives radiative energy, which is partitioned into sensible and latent heat fluxes to the atmosphere and the heat flux to the sub medium. Typically, H, lE and G are all positive over the land surface during the day. At night, the surface loses energy by outgoing radiation, especially during clear or partially overcast conditions. This loss is compensated by gains of heat from air and soil media and, at times, from the latent heat of condensation released during the process of dew formation. So, the partitioning of solar energy near the surface on a short-term basis is an important aspect of the different types of energy exchanges involved in the earth-atmosphere-sun system (Mahmud, 2011).

Due to seasonal variation air temperature, relative humidity, precipitation and wind speed also vary year to year. Solar radiation was higher May through July and the solar radiation in early spring and late summer tended to be rather lower. Longwave radiations over spring to autumn also exhibited similar seasonal patterns, however long wave radiations during summer and winter were larger (Mahmud, 2011). Evapotranspiration rates in autumn are low, despite the considerable precipitation. The climate warming greatly changed the partitioning of ET components over vegetative fields (Li et al., 2006).

So, we need continuous observation to find variation in energy budget components to make a reliable conclusion. In this study data from July 2012 to June 2013 were used. Considering the above views in mind, the present study were, therefore, undertaken with the following objectives: a)To measure the energy balance components (Rn = H + lE + G) over rice fields; b)To investigate few selected micrometeorological parameters that influence energy balance components over rice field from July 2012 to June 2013.

## II. Material And Methods

The experiment was conducted at the field micrometeorological Laboratory, Department of Environmental Science, Bangladesh Agricultural University, Mymensingh from July 2012 to June 2013.

**Study Location:** The flux study site, called MYM (three- letter international code name for AsiaFlux) is located in the paddy field of Bangladesh Agricultural University Farmland (Latitude 24° 43' 31.0"N, Longitude 90° 25' 27.3"E; 18 m above sea level), 6 km to the south of Mymensingh town and 115 km to the north of Dhaka, the capital city of Bangladesh (Figure 1). This extensive field (about 78.28 ha) has been used only for paddy cultivation for about 40 years, and provides sufficient upwind fetch (>300 m to the south, >500 m to the west, and about 200 m to the north and east of the mast) of uniform cover required for measuring mass and energy fluxes using tower-based eddy- covariance systems.

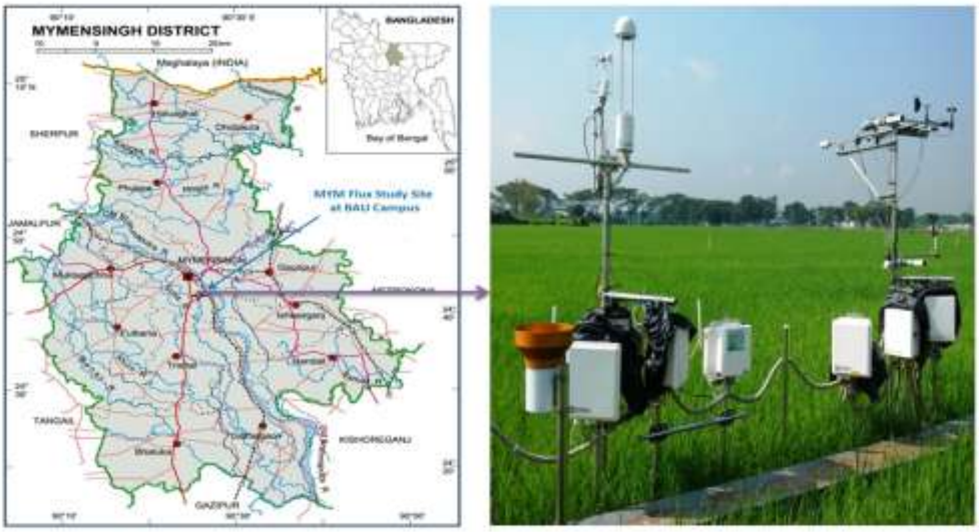


**Figure no.1:** Map of MYM Flux Study Site located at Mymensingh district

**Crop:** The general cropping patterns are irrigated *Boro* rice-Fallow-rain fed *Aman* rice. The field study has been being conducted since February 2006, but this study was focused mainly on the period from July 2012 to June 2013. The period covered two rice growing seasons: the *Aman* and *Boro* rice season in 2012 and 2013, planted rice variety in each season was BRRI dhan 49 and BINA dhan 8, respectively.

**Soil:** MYM site soils are dark-gray non-calcareous floodplain type (UNDP and FAO, 1988). Study site soil possesses silty loam texture and low contents of organic matter. Topography of the soil at MYM site was low with fairly leveled surface.

**Climate:** In the Mymensingh, both the summer and winter are relatively mild. The maximum and minimum temperatures as observed in April and January range between 33°C and 12°C. Annual mean air temperature 25.44 degree Celsius (2001-2012). Rainfall starts in May and continues up to September. Maximum, minimum and mean air temperature and annual precipitation from 2001 to 2012 at Mymensingh. The highest humidity was observed from July to September around 94% and minimum about 49% from January to April (BBS, 2008). The highest humidity was observed from July to September around 94% and minimum about 49% from January to April (BBS, 2008).

**Management practices:** The experimental crops of rice were grown under recommended cultural practices at MYM site under the active supervision of Central Farm Authority at Bangladesh Agricultural University. This experiment was conducted without any influence what so ever on the rice paddy ecosystem to measure the status of energy balance.

**Flux Measurement Systems**

**Micrometeorological measurement**

Micrometeorological parameters are very important in respect of plant physiological activity and growth where it substantially influences the energy exchange from rice paddy fields. These supporting data were sampled every 5 seconds using a CR23X data loggers supported by an AM25T multiplexer. Instruments used in micrometeorological measurement are presented in Table 1.

**Table no 1. Measurement of meteorology at MYM site**

| Observation items | Levels/depth/height | Instrument |
|---|---|---|
| Incoming and outgoing short-wave radiation | 3.0 m | Four component net radiometer (MR-40, Eko, Tokyo, Japan) |
| Incoming and outgoing long wave radiation | 3.0 m | Four Component Radiometer (MR-40, Eko) |
| Net radiation | 3.0 m | Four Component Radiometer (MR-40, Eko) |
| Incoming and outgoing PPFD | 2.95m | Quantum sensor (LI-190, LI-COR) |
| Incoming and outgoing PPFD | 2.80 m | SQ-110 (Apogee, USA) |
| Transmitted PPFD | Below canopy | Quantum sensor (LI-191, LI-COR) |
| Air temperature | 1.65, 2.95m | Platinum resistance thermometer (HMP45A, Vaisala, Finland) |
| Relative humidity | 1.65, 2.95m | Humicap (HMP45A, Vaisala, Finland) |
| Soil temperature | 0, 0.05, 0.1, 0.2, 0.4 | Type-Thermocouple |

| | | |
|---|---|---|
| | m(five points) | |
| Soil heat flux | 0.05m(three points) | Heat flux plate (MF-180M, Eko) |
| Soil water content | 0.05m (three points), 0.1, 0.2, 0.3m | TDR (TDR100, Campbell Scientific, USA) |
| Field water level | Two points | Capacitive water depth probe (model 6521, Unidata, Australia) |
| Water temperature | 0.02, 0.05m | Type-Thermocouple |
| Barometric pressure | - | Silicon capacitive pressure sensor |
| Precipitation | 1.7 m | Tipping-bucket rain gauge (TR-525M-R2, Texas Instruments, USA) |
| Surface temperature | 2.78 m | IRR-P (Campbell Scientific, USA) |
| Wind speed | 1.40, 2.10, 3.10 m | 03101 (Young, USA) |
| Wind direction | 3.10 m | 03302 (Young, USA) |
| Soil water content | 0-0.05[4)], 0-0.10, 0-0.20, 0-0.30 m | Time-domain reflectometry (TDR100, Campbell) |

**Calibration:** Every year instruments were calibrated with standard sensors especially the PAR sensors that were generally more affected due to long-term exposure at the site.

**Data Collection and Mathematical Interpolation:** Data were collected intermittently mainly on the microclimatic parameters at different days after sowing and mathematically interpolated for additional analysis.

**Microclimatic Parameters:** The following microclimatic parameters were measured in clear sunny days at 10 second intervals and the output data was then averaged for 30 min by CR23X Datalogger from July 2012 to June 2013 continuously.

**Energy Balance:** The energy balance was computed from the following equation (Ham *et al*., 1991)

$$\boldsymbol{R_n = H + lE + G} \quad \text{------------------------------ (1)}$$

Where,
$R_n$ = net radiation in W/m$^2$
$H$ = sensible heat flux in W/m$^2$
$lE$ = latent heat of vaporization in W/m$^2$
$G$ = ground heat flux in W/m$^2$

In the above-stated equation, fluxes of $R_n$ and G towards the surface were positive and towards the atmosphere were negative, while fluxes of H and towards the atmosphere were positive and vice-versa.

**Data Retrieval and Analysis:** The data received at 10 second intervals from the sensors on different micrometeorological parameters from the experimental site were primarily recorded by CR23X Data logger (Campbell Scientifics, USA). Then the output data from the Data logger as 30 min average was stored in a storage module (SM4M, Campbell Scientifics, USA). The experimental raw data at 30 min intervals were retrieved from the storage module periodically for further averaging and mathematical interpolation. After obtaining 30 min average raw data from the field, these were then averaged again for 30 min intervals by using the “Macro” program in Microsoft Excel. Data analyses were performed using MS Excel. Graphs were also prepared by the above mentioned software. As this kind of experiment only stresses on the monitoring of the climatic variables no replication possible and trends are obtained with average data streams those were collected during the intended span of this experiment. Since the initial data were recorded as 10 sec intervals which were 30 min average, so statistical errors were to minimum and hence neglected.

## III. Results and Discussions

The experiment was performed from August 2012 to July 2013 over two rice growing seasons (*Aman* season 2012 and *Boro* season 2013). During the experimental period observations were made on eighteen clear days.

**Energy balance relationship over the rice field**

**Daytime (6:00 h to 18:00 h) energy balance relationship over rice field on *Aman* season 2012**

Day time (6:00 to 18:00h) energy budget components with ratios of latent, sensible and soil heat fluxes to net radiation of different growth stages of *Aman* rice are shown in **Table 2.** In the *Aman* season we consider three growing stage: The early growth stages, full growth stage and mature crop before harvest. There was variation in *Rs* mainly due to weather conditions. *Rn* was varied mainly due to differences in surface conditions (Baten and Kon, 1997). Latent heat flux accounted for a large portion of *Rn* as it was expected from the sufficient soil water content. When soil is moist all most all the energy supplied by Rn is consumed at latent heat (Fritschen and van Bavel, 1962).

Mahmud (2011) reported that Latent heat flux density of the mature rice field before rice harvest showed highest 18.81 $MJm^{-2}$. On an average, *lE* was 4.091 $MJm^{-2}$ of the rice field. In rice field it also observed that a minimum *lE* of 1.53 $MJm^{-2}$ and maximum of 8.85 $MJm^{-2}$ in well irrigated fields. There also measured *lE/Rn* ratios from the rice field and observed *lE* was 0.40 $MJm^{-2}$ to 0.8 $MJm^{-2}$ of *Rn* when soil surface was wet and water was not limiting on *Aman* 2010 season.

On the other our observation, *l*E was found 5.43 $MJm^{-2}day^{-1}$ to 7.00 $MJm^{-2}day^{-1}$ in early growth stage, 5.55 $MJm^{-2}day^{-1}$ to 9.64 $MJm^{-2}$ $day^{-1}$ in full growth stages and 3.00 $MJm^{-2}day^{-1}$ to 4.17 $MJm^{-2}day^{-1}$ in the mature crop before harvest which nearly balanced to the net radiation. The maximum *l*E was observed 9.64 $MJm^{-2}day^{-1}$ and minimum was 3.00 $MJm^{-2}day^{-1}$ of the rice field at the DOY 282 and DOY 340. The average *l*E of the three growing stages was 5.63 $MJm^{-2}day^{-1}$.When soil is moist almost all of energy supplied by Rn is consumed as latent heat, Small quantities of energy are distributed to the soil and sensible heat flux early morning and until about 1500h (Fritschen and van Bavel, 1962). Ham *et al.* (1991) reported that in well irrigated cotton field *l*E ranges from 77 to 104%.

Ritchie (1971), also measured *l*E/Rn ratio from cotton field and reported that *l*E was 90 to 110% of Rn when soil surface was wet and water was not limiting. Average *l*E/Rn ratios in the three growing periods of *Aman* season was recorded 0 .75, 0.92 and 0.65.

H was observed 0.742 $MJm^{-2}day^{-1}$ to 1.11$MJm^{-2}day^{-1}$ in early growth stage, 0.11 $MJm^{-2}day^{-1}$ to 0.34 $MJm^{-2}day^{-1}$ in the full growth stage and 0.97 $MJm^{-2}day^{-1}$ to 1.78 $MJm^{-2}day^{-1}$ in the mature crop before harvesting. H showed negligible values, it indicating absorption of the sensible heat by the moist field from the upper air to provide energy for *l*E. *Ham et al. (1991)* reported that 8 to 21 % of Rn partitioned to H for N-S cotton rows but in our observation we found 11 to 17.8% of Rn partitioned to H in *Aman* rice field. On the other hand, H/Rn ratio was found from 0.1, 0.02 and 0.26 in different growth stages of *Aman* rice 2012.

G was found 0.78 to 1.31 $MJm^{-2}day^{-1}$ in the early growth stage, 0.24 to 0.48 $MJm^{-2}$ $day^{-1}$in full growth stages and 0.38 to 0.41 $MJm^{-2}day^{-1}$ in ripening stage before harvested of *Aman* rice. The maximum value of G was observed 1.31 $MJm^{-2}day^{-1}$ and minimum was observed 0.24 $MJm^{-2}day^{-1}$ in *Aman* season. The average ratios of *l*E/Rn, G/Rn and H/Rn were 0.77, 0.08 and 0.13 in *Aman* rice field.

**Table no 2:** Day time (6:00 h to 18:00 h) energy balance of different growth stages of *Aman* rice field. It includes different weather parameters (Air temperature, relative humidity and wind speed), incoming solar radiations (*Rs*), net radiations (*Rn*), latent heat fluxes (*lE*), sensible heat fluxes (*H*) and soil heat fluxes (*G*). Ratios of latent heat fluxes and soil heat fluxes to net radiation are also included.

| **Seasons** | **Field Status** | **DOY** | **T** | **Rh** | **Wind speed** | ***Rs*** | ***Rn*** | ***lE*** | ***H*** | ***G*** | ***lE/Rn*** | ***G/Rn*** | ***H/Rn*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **°C** | **%** | **m/s** | **$MJm^{-2}day^{-1}$** | | | | | | | |
| **Aman Season 2012** | Early growth stage | 239 | 29.18 | 84.31 | 1.88 | 15.64 | 6.96 | 5.43 | 0.74 | 0.78 | 0.78 | 0.11 | 0.1 |
| | | 240 | 29.14 | 83.28 | 2.02 | 20.37 | 8.53 | 6.30 | 1.11 | 1.11 | 0.73 | 0.13 | 0.13 |
| | | 241 | 30.04 | 79.08 | 1.68 | 20.34 | 9.28 | 7.00 | 0.96 | 1.31 | 0.75 | 0.14 | 0.1 |
| | Full growth stage | 280 | 27.79 | 88.08 | 1.31 | 12.52 | 6.21 | 5.55 | 0.17 | 0.48 | 0.89 | 0.07 | 0.02 |
| | | 281 | 28.97 | 79.91 | 0.24 | 16.31 | 6.24 | 5.88 | 0.11 | 0.24 | 0.94 | 0.03 | 0.01 |
| | | 282 | 28.47 | 84.29 | 0.64 | 19.34 | 10.32 | 9.64 | 0.34 | 0.33 | 0.93 | 0.03 | 0.03 |
| | Mature crop Before Harvesting | 338 | 21.25 | 73.92 | 0.56 | 13.67 | 6.28 | 4.17 | 1.69 | 0.40 | 0.66 | 0.06 | 0.27 |
| | | 339 | 21.05 | 72.03 | 0.74 | 13.65 | 5.91 | 3.70 | 1.78 | 0.41 | 0.62 | 0.07 | 0.3 |
| | | 340 | 19.29 | 79.88 | 0.51 | 9.66 | 4.37 | 3.00 | 0.97 | 0.38 | 0.68 | 0.08 | 0.22 |
| Average | | | **26.13** | **80.53** | **1.06** | **15.72** | **7.12** | **5.63** | **0.87** | **0.60** | **0.77556** | **0.08** | **0.13** |

**Daytime (6:00 h to 18:00 h) energy balance relationship over rice field on Boro season 2013**

Day time (6:00 to 18:00h) energy budget components with ratios of latent, sensible and soil heat fluxes to net radiation of different growth stages of *Boro* rice are shown in Table 4.3. In the *Boro* season we consider three growing stage, The early growth stage, full growth stage, mature crop before harvest. There was variation in *Rs* mainly due to weather conditions. *Rn* was varied mainly due to differences in surface conditions (Baten and Kon, 1997).

**Tables 3** shown the average temperature, humidity and wind speed in the Boro season were 24.12$^0$C, 73.85% and 0.91m/s respectively. Solar radiation is a vital micrometeorological parameter. In this season highest (24.3$MJm^{-2}day^{-1}$) solar radiation was found DOY 114 and average solar radiation 18.26 $MJm^{-2}day^{-1}$. Highest Rn was found 10.69$MJm^{-2}day^{-1}$in the DOY 114, lowest was 5.45 $MJm^{-2}day^{-1}$ in the DOY 43 and average Rn was 7.78 $MJm^{-2}day^{-1}$.

Mahmud (2011) Observed that on an average, *lE* (10.31 $MJ/m^2$) and *H* (10.87 $MJ/m^2$) was accounted similar in the *Boro* rice field due weather conditions. The *lE* (15.14 $MJ/m^2$) observed larger in full growth stage and *H*

(31.58 MJ/$m^2$) observed larger in crop maturation stage. The *lE/Rn* ratio in the *Boro* rice field observed 0.42 MJ/$m^2$.

On the other hand our experiment was observed that average *l*E (6.60 $MJm^{-2}day^{-1}$) and H (0.53 $MJm^{-2}day^{-1}$) was accounted similar in the *Boro* rice field due to weather conditions. The maximum value of *l*E was found 9.70 $MJm^{-2}day^{-1}$ in the full growth stage and H (1.49 $MJm^{-2}day^{-1}$) was observed in the crop maturation stage before harvest. The average lE/Rn and H/*Rn* ratios in the *Boro* rice filed were 0.84 and 0.06. Maximum G was found 1.28 $MJm^{-2}day^{-1}$in DOY 42 and minimum was 0.15 $MJm^{-2}day^{-1}$ and average G was found 0.67 $MJm^{-2}day^{-1}$. The average ratio of G/Rn in this time period was found 0.09.

**Table no 3:** Day time (6:00h to 18:00h) energy balances of different growth stages of *Boro* rice field. It includes different weather parameters (Air temperature, relative humidity and wind speed), incoming solar radiations (*Rs*), net radiations (*Rn*), latent heat fluxes (*lE*), sensible heat fluxes (*H*) and soil heat fluxes (*G*). Ratios of latent heat fluxes and soil heat fluxes to net radiation are also included.

| Seasons | Field Status | DOY | T | Rh | Wind speed | *Rs* | *Rn* | *lE* | *H* | *G* | *lE/Rn* | *G/Rn* | *H/Rn* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | °C | % | m/s | **$MJm^{-2}day^{-1}$** | | | | | | | |
| **Boro Season 2013** | Early growth stage | 42 | 20.83 | 65.30 | 0.95 | 15.17 | 6.31 | 4.39 | 0.63 | 1.28 | 0.69 | 0.2 | 0.1 |
| | | 43 | 21.07 | 65.97 | 0.89 | 14.61 | 5.45 | 4.10 | 0.40 | 0.99 | 0.75 | 0.18 | 0.06 |
| | | 44 | 21.77 | 65.66 | 1.47 | 14.42 | 5.55 | 4.46 | 0.15 | 0.93 | 0.8 | 0.16 | 0.02 |
| | Full growth stage | 97 | 25.44 | 71.74 | 0.56 | 20.68 | 8.60 | 7.57 | 0.35 | 0.66 | 0.89 | 0.07 | 0.04 |
| | | 98 | 27.35 | 78.78 | 1.27 | 20.22 | 8.64 | 7.64 | 0.25 | 0.72 | 0.88 | 0.08 | 0.02 |
| | | 99 | 27.71 | 82.02 | 1.19 | 18.54 | 7.91 | 6.96 | 0.34 | 0.60 | 0.89 | 0.07 | 0.04 |
| | Mature crop Before Harvesting | 112 | 25.26 | 84.44 | 0.86 | 15.17 | 7.03 | 6.42 | 0.61 | 0.24 | 0.94 | 0.03 | 0.09 |
| | | 113 | 23.14 | 77.73 | 0.50 | 21.50 | 9.80 | 8.15 | 1.49 | 0.15 | 0.83 | 0.01 | 0.15 |
| | | 114 | 24.53 | 73.02 | 0.58 | 24.03 | 10.69 | 9.70 | 0.53 | 0.44 | 0.9 | 0.04 | 0.05 |
| **Average** | | | **24.12** | **73.85** | **0.918** | **18.26** | **7.78** | **6.60** | **0.53** | **0.67** | **0.84** | **0.09** | **0.06** |

**Analysis of micrometeorological parameters that influence over rice field**

In this experiment both *Aman* season 2012 and *Boro* season 2013 were considered but here discussed about only *Aman* season.

**Solar Radiation**

Solar radiation is an important micrometeorological parameter. Solar radiation provides almost all the energy received at the surface of the earth (Rosenberg *et al.,* 1983). The diurnal variation of solar radiation over rice field in *Aman* season is shown in Figure 2. Solar radiation was higher at midday and lower in morning and late afternoon. In the early growth stage of rice (DOY 239 to DOY 241) field was shown maximum Rs was 828 W/$m^2$ in the day of year 240 at 1300h and minimum value -0.67W/$m^2$ in DOY 241 at 2000h. In the full growth stage of rice (DOY 280 to DOY 282) maximum Rs was 835.85W/$m^2$ at 1300h in DOY 282 and minimum value was almost less than -0.19 W/$m^2$ at 2200 in DOY 282. In the ripening stage of rice (DOY 338 to DOY 340) highest Rs was 696.94 W/$m^2$ at 1200h in DOY 338 and lowest value was -24.22 W/$m^2$ at 1800h in DOY 339.

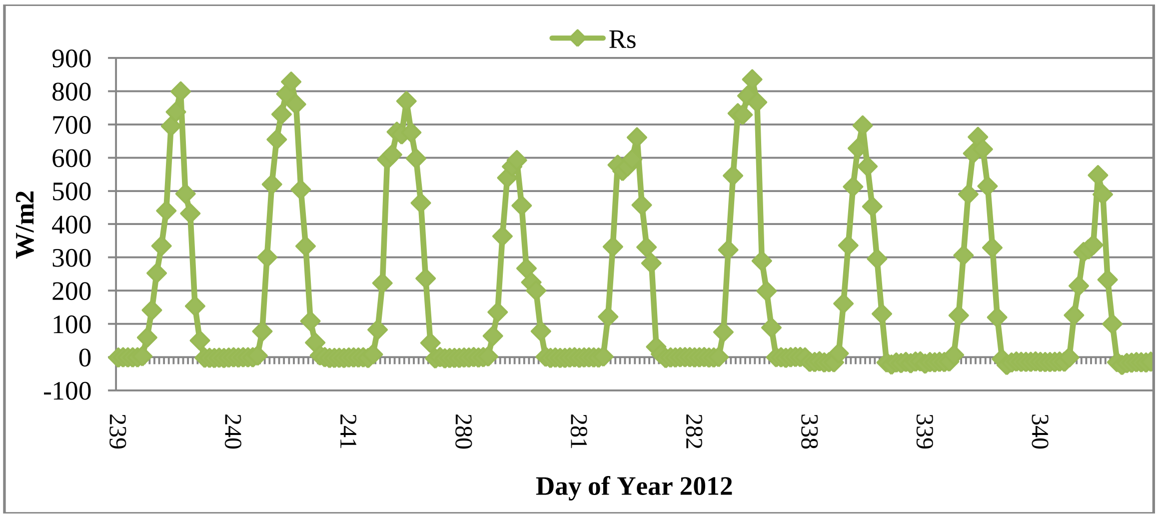


**Figure no 2.** Daily solar radiation variation in the *Aman* season (Early growth stage, full growth stage and ripening stage before harvest) 2012.

The **figure 2** shows that solar radiation is decreasing due to weather change in this *Aman* season 2012. Penetration of Rs was lower in the early morning and increased with the advancement of time of day and peak at 1300h when the sun remain mid position in the sky. Rs penetration increased rapidly at nearly 900h to till noon (Ham *et al.*, 1991).

**Air Temperature and Humidity**

Air temperature and relative humidity are very essential micrometeorological parameter. Air temperature and relative humidity were measured on DOY 239 to DOY 340 are presented in Figure 2 and Figure 3. Air temperature was lower early in the morning, with the advancement of the time of day air temperature is increasing and peaked at 1300h, after that air temperature gradually decreased. **Figure 3** shows that the maximum air temperature (32.03$^0$C) was found at 1300h in DOY 282 and minimum air temperature (12.67$^0$C) was found at 700h in DOY 340. Air temperature is decreasing due to the advancement of day (DOY 239 to DOY 340).

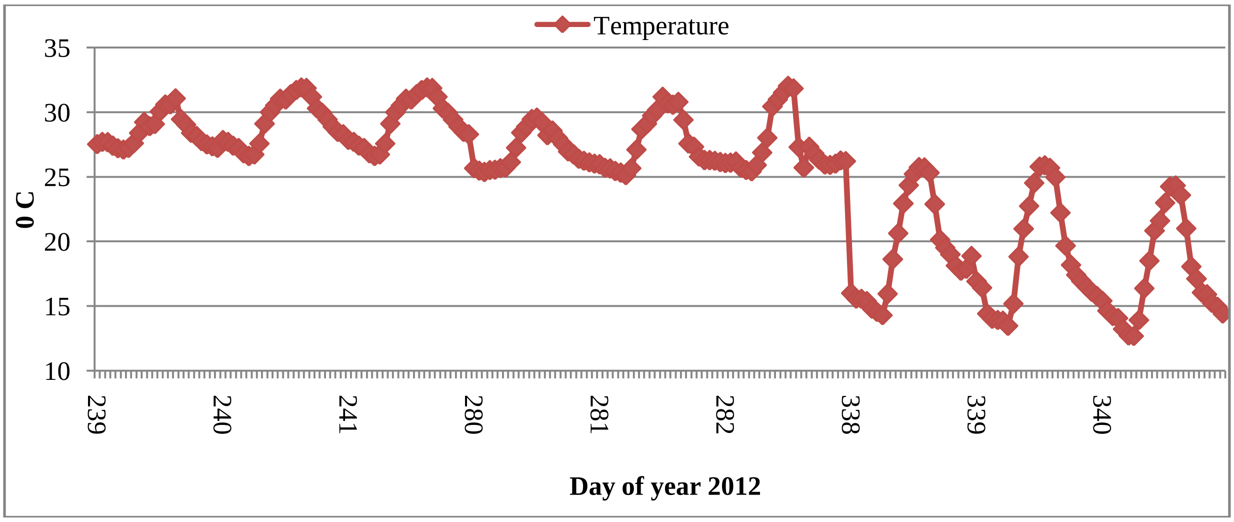


**Figure no 3:** Daily air temperature variation in the *Aman* season (Early growth stage, full growth stage and ripening stage before harvest) 2012.

Higher relative humidity was observed in the clear morning, which gradually decreased with the advancement of time of day and shown in the lowest at 1300h, after that the humidity gradually increased. The maximum humidity was found 100.98% at 800h in DOY 340 and minimum humidity was 43.62 % at 1300h in DOY 339.

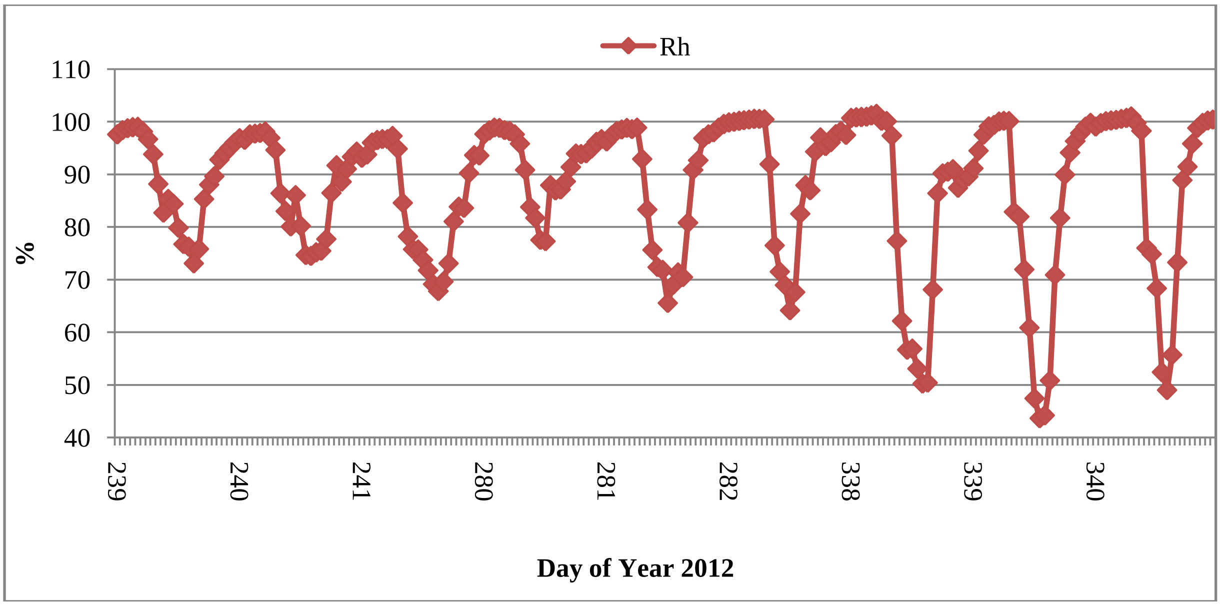


**Figure no 4.** Daily Humidity variation in *Aman* season (Early growth stage, full growth stage and ripening stage before harvest) 2012

Relationship between air temperature and relative humidity was negatively correlated. Results indicated that when Air temperature showed increasing tends at the same time relative humidity showed decreasing trends. Negative correlation also found between relative humidity and penetration on solar radiation on the other hand air temperature and solar radiation penetration were positively correlated with each other. Canopy air temperature changes slowly when solar radiation changes with cloud cover (Pennington and Heatherly, 1989).

## IV. Conclusions

An experiment was conducted to evaluate the energy balance relationship over (BRRI dhan 49 in *Aman* season and BINA dhan 8 in *Boro* Season) rice crops at the paddy field of Bangladesh Agricultural University Farmland, Mymensingh from August 2012 to July 2013. Air temperature, relative humidity, solar radiation, wind speed, precipitations and energy balance components were measured in this experiment using sophisticated modern sensors. Air temperature (Ta), Soil temperature (Ts), incoming solar radiation (Rs) showed lower value in the early morning hours, which gradually increased with the advancement of time and peaked at 13:00 hours. The relative humidity (Rh) was high in the early morning hours, which gradually decreased with the advancement of time and it was lowest at noon. Energy balance components were measured using Eddy covariance method. Net radiation (Rn) and soil heat flux (G) obtained directly from the net radiometer and ground heat flux plate. The Sensible heat flux (H) and Latent heat flux (*l*E) were calculated from Eddy covariance method.

From the result it is apparent that on Boro 2013 rice field showed slightly increase of lE than the Aman 2012 rice field. This might be due to the long sunshine hour, much water availability in the field that occurred prior to the observed period. According to Ham et al. (1991) lE partitioning tends to increase as the soil moisture is not limiting. H was still positive during the daytime. Decreased G was observed as a result of surface cooling due to the increased evaporation of soil moisture after the rain.

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