Albedo Pattern Over Rice Field in Lower Gangetic Plains of West Bengal During Kharif and Boro Seasons

KEYWORDS: Albedo, rice, air temperature, canopy temperature

Saon Banerjee	Partha Dutta
AICRP on Agrometeorology, Directorate of Research, BCKV, Kalyani, West Bengal. PIN: 741235.	Former Senior Research Fellow, Energy Water Balance Project, Directorate of Research, BCKV, Kalyani, West Bengal. PIN: 741235.

ABSTRACT *In the field of agriculture, the knowledge of albedo is very much essential for crop-growth monitoring purposes including bio-geoengineering. As limited work has been conducted on albedo pattern over crop surfaces, the present research work aims to study the albedo pattern over paddy field. The field experimentation was conducted in Nadia District, West Bengal. The albedo was measured using pyranometer over rice field throughout the gowing seasons of Kharif (wet–season) and Boro (summer) seasons. Air temperature and crop canopy temperature were measured simultaneously. It is found from the study that albedo ranges in between 11-23% during Kharif season. Higher albedo value has been observed over Boro rice field compared to Kharif rice field. The albedo value of bare soil is 17%, whereas the albedo is more than 20% over mature rice field, contributing cooling effect. The relationship among CT, AT and Albedo is also worked out.*

Introduction:
Climate change and food security are two of the biggest challenges in front of human being of the present Century (WIREs Clim Change, 2015). Agricultural land is the physical interface between earth and atmosphere. Lots of scientific progresses have done on how the cropland interacts with climate and how crops could help mitigate climate change in the future (Fowles, 2007, Banerjee et al., 2014). Agricultural land currently covers 37% of the world's land surface and the crop cover plays vital role in managing surface net solar radiation by altering the albedo (Singarayer and Davies-Barnard, 2012; Shepherd, 2012). The reflection coefficient for incoming solar radiation is known as albedo which depends on the angle of incidence of radiation, physical characteristics of the surface, season, time of the day, etc. The knowledge of albedo is very much essential for "bio-geoengineering", which is an emerging field (Ridgwell et al., 2009). Several authors worked on albedo pattern over crops, although very little work has been conducted in India over rice crop. Considering this, the present paper aims at to study the albedo pattern over paddy field.

Materials and methods:
Study area: The field experiment was conducted in the village Gontra, Ghetugachi PO, Nadia, West Bengal ($23^0$1' N latitude, $88^0$35' E longitude and 9m altitude), India. A continuous patch of rice-field (approximately 3km x 3km) has been chosen for the study. In the field almost neutral atmospheric stability exists, which is helpful for measuring meteorological observations due to less fluctuation. In the field, paddy was grown both in *Kharif* (wet–season) and *Boro* (summer) season each year. The climate of the zone is sub-tropical with an average annual rainfall of 1467.5 mm ranging from 1195.5 to 1691.9 mm. The maximum rainfall, more than 80% is received from South-West monsoon during the rainy months of June to September. Temperature range of the region is 15.6 to 35^{0}C. The sunshine hours of the area is of 8.5 to 10.5 hours except monsoon season. During cloudy days BSS comes down to 4.5 to 5.5 hours per day. The soil of the experimental field was alluvial in nature (Entisol) and silty clay in texture and well drained.

Meteorological measurements: Replicated measurement of meteorological parameters from three selected points were taken during *Kharif* (July to November) and *Boro* (January to May) seasons of 2007 and 2008. The average values of the meteorological parameters (namely, albedo, air temperature and canopy temperature) are used in the study. Albedo is the ratio of reflected radiation from the surface to incident radiation upon it. Hence, the incoming global solar radiation is measured with the help of pyranometer (Make National Instrument and Calibrated by IMD, Pune) and the reflected part of the same is measured by inverted pyranometer. Canopy temperature is measured with the help of Infrared Thermometer, while air temperature has been measured with the help of dry bulb thermometer at crop surface.

Results and discussion:
Albedo pattern over rice canopy in *Kharif* season: With the increase of crop height, the canopy architecture changes profoundly leading to changes in percentage of ground cover, which affect the albedo pattern. Hence, albedo values were measured throughout the growing season and at 12 hours when solar elevation angle is maximum. It is found from the study that albedo ranges in between 11-23% during *Kharif* season (Table 1). At transplanting stage albedo ranges between 11-12% for all the replicated measurement. As the crop attains to maximum tillering, PI and first anthesis stages, the LAI also increases. So, ground coverage by crop increases and chlorophyll content in the leaves also increases. This may be the reason for enhanced albedo during the said stages (around 20%) compared to transplanting stage. As the crop moves from 100% anthesis to maturity, LAI decreases gradually and colour of the leaves changes from green to light yellow due to decrease in chlorophyll content in the leaves. So absorption in the visible range becomes less and reflection is more and albedo further increases. At maturity, the average albedo value is 23.4%. Thus, lowest value of 11% albedo was observed during the transplanting stage, then it increases gradually upto 23.4% .

Albedo pattern over rice canopy in *Boro* season: During Rabi season at seedling stage albedo ranges between

Volume : 5 | Issue : 9 | September 2015 | ISSN - 2249-555X

13-14% for all the replicated measurement. As the crops mature to maximum tillering stage, PI and first anthesis stages, albedo ranges in between 22-24%. As described in the previous section, the crop grows from 100% anthesis to maturity, LAI decreases sharply and albedo percentage increases. At maturity, the magnitude of albedo is 25.5%. The chlorophyll content in the leaf blade gradually decreases as the crops tend to maturity. Hence reflectivity will be more at maturity stage resulting higher albedo. The lowest value of albedo (about 13%) has been obtained during transplanting stage which may be due to absorption of incoming solar radiation not only by plant itself but also by water (as the crop is grown under stagnant water). Overall, the higher value of albedo has been observed over *Boro* rice field than *Kharif* rice field. It may be due to the fact that incoming component of solar radiation is poor due to overcast sky in *Kharif* season than that of *Rabi* season. Different workers found the albedo of a fully grown rice canopy was about 22% which matches well with the findings from the present study (Markvart and Castalzer, 2003). The albedo value of bare soil is 17%, whereas the albedo is more than 20% over mature rice field. Thus, higher albedo from the crop field can be helpful for contributing cooling effect.

Relationship among Canopy Temperature (CT), Air Temperature (AT) and albedo: In the present study it is observed that significant relationship exists between CT, AT and Albedo. The relationships among these parameters graphically represented in figure 1 and 2 for Kharif and Boro season respectively. Canopy temperature in the rice field is generally lower than that of atmospheric temperature (at Stevenson Screen height), may be due to steady movement of water through soil-plant-atmospheric continuum resulting transpirational cooling of leaves. Temperature gradually increases as it away from the crop surface resulting temperature gradient and causing turbulent mixing of air. Although CT is influenced by moisture availability in the field, lower magnitude of albedo contributes to higher CT. It may be due to the maximum utilization of radiant energy for photosynthetic activity, which causes less albedo but the canopy temperature increases due to radiation absorption. When albedo is higher, CT is less. But at maturity stage albedo is higher yet CT is more. It may be due to the fact that restricted water supply at maturity stages lowers the transpirational cooling of the leaves leading to higher CT. During maturity stage atmospheric temperature and canopy temperature are closer to each other. Similar observation was found both during the *Kharif* and *Rabi* seasons. Overall canopy and air temperature remain lower in *Rabi* season than that of *Kharif* season. Recorded air temperature is always higher than canopy temperature by several degrees, which may influence downward movement of energy flux. It also indicates that the transpiration cooling is predominant over rice field.

Thus, it can be concluded that the albedo pattern over rice varies significantly with growth of the crop and seasons. The higher albedo, compared to a bare field has an effect on radiation cooling. Close relationship exists between albedo, CT and AT.

Acknowledgement: The help and guidance from the Director of Research, BCKV and Scientists of Space Application Centre, ISRO, Ahmedabad are duly acknowledged.

Table 1: Variation of albedo at different phonological stages over rice crop

Stages/ Pheno-phases	Amount of Albedo (%)	
	Kharif season	*Rabi* season
Transplanting	11.5	13.2
Tillering	20.0	22.4
Panicle initiation	20.5	23.2
First anthesis	21.8	24.0
100% anthesis	19.6	23.6
Maturity	23.4	25.5

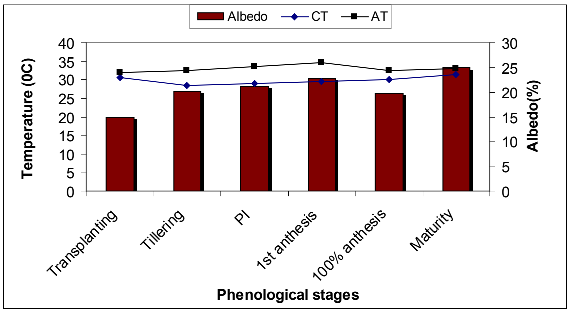

Figure 1: Relationship among Canopy temperature (CT), Air temperature (AT) and albedo during *Kharif* season

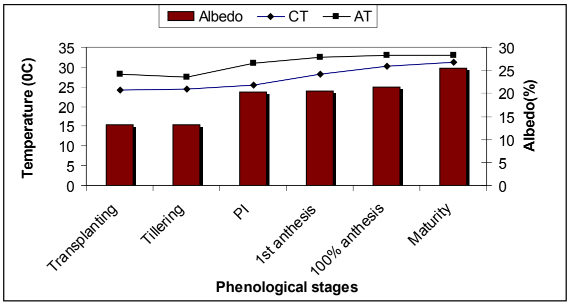

Figure 2: Relationship among Canopy temperature (CT), Air temperature (AT) and albedo during *Rabi* season

REFERENCE Banerjee, S., Das, S., Mukherjee, A., Mukherjee, A., Saikia, B. (2014). Adaption strategies to combat climate change effect on rice and mustard in Eastern India. Mitig Adapt Strateg Glob Change, doi: 10.1007/s11027-014-9595-y. | | Fowles, M. (2007). Black carbon sequestration as an alternative to bioenergy, Biomass Bioenergy, 31: 426–432. | | Markvart, T. & Castalzer, L. (2003). Practical Handbook of Photovoltaics: Fundamentals and Applications. Elsevier. ISBN 1-85617-390-9. | Ridgwell, A., Singarayer J S, Hetherington A M and Valdes P J. 2009. Tackling regional climate change by Leaf Albedo Bio-geoengineering. Current Biology, 19 (2): 146-209. | | Shepherd, J. (2012). Geoengineering: overview and update. Philos Trans R Soc A Math Phys Eng Sci, 370:4166–4175. doi: 10.1098/rsta.2012.0186. | | Singarayer, J. S. & Davies-Barnard, T. (2012). Regional climate change mitigation with crops: context and assessment. Phil. Trans. R. Soc. A 370, 4301–4316 (doi:10.1098/rsta.2012.0010) 10.1098/rsta.2012.0010 | | WIREs Clim Change. (2015). 6:255–268. doi: 10.1002/wcc.333