Plant Archives Vol. 24, No. 2, 2024 pp. 1003-1008 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.2.141

ALBEDO AND CANOPY TEMPERATURE PATTERN OVER DIFFERENT PHENOLOGICAL PHASES OF BORO RICE IN NEW ALLUVIAL ZONE OF WEST BENGAL, INDIA

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(Date of Receiving-12-03-2024; Date of Acceptance-31-05-2024)

ABSTRACT

Analysis of field level meteorological and biometrical observations implies that year to year weather variations were significantly influencing the growth and development of plant height, number of tillers, dry matter and LAI productions over the new alluvial zone of Gangetic West Bengal. In the field of agriculture, the knowledge of albedo is very much essential for crop-growth monitoring purposes. The present research work aims to study the albedo pattern over rice field. The field experiment was conducted in Kalyani D Block farm, Nadia District, West Bengal. The albedo was measured by using pyranometer over boro (summer) rice field during the crop growing season 2017-18 and 2018-19. The canopy temperature and air temperature were measured simultaneously. This experiment noticed that the values of crop albedo was reached its highest level (8-10%) during the initial crop growing stages, thereafter, it started to decline gradually and attains its lowest level (6%) during flowering stage but again it increases to higher value (8%) at physiological maturity. The leaf area index is greater contributing factor towards the overall reflectivity of crop canopy of crop surface. The soil albedo was recorded at highest level (7-8%) during the initial crop growing stage, thereafter, it declines gradually and attained its lowest level (3-4%) during flowering stage and further it increases to 8% at physiological maturity. The relationship of Crop albedo (%) and soil albedo for different days after transplanting for two consecutive the boro rice seasons in the year 2017-18 and 2018-19 in respect to two age of seedlings and three variety, three spacing also worked out.

Key words : Albedo, Crop albedo, Soil albedo, Canopy temperature, Boro rice.

Introduction

West Bengal, Orissa, Assam, Bihar and the north-eastern states have over 45% of India's rice area, but they produce only a third of the country's rice output. Improved rice production technologies have created an increased demand for scientists, educators, and practical food production specialists. It can grow under such widely differing climatic conditions that are difficult to define most suitable climatic requirement for its growth and development. Temperature, so far radiation and rainfall influence rice yield by directly affecting the physiological processes associated with grain production. Challenges in maintaining the sustainability of rice farming have been increasing with the increased scarcity of water and competition for water resources also (Chapagain and Yamaji, 2010). Grain yield is positively corrected with the light intensity. Low rice yields in the tropics during the monsoon season are frequently attributed to low light intensity during that period. The reflection coefficient for incoming solar radiation is known as albedo which depends on the angle of incidence of radiation, physical maturity and surface characteristic, season, time of the day, etc. The knowledge of albedo is very much essential for "bio-geoengineering", which is an experiment field (Ridgwell *et al.*, 2009). Too many authors worked on albedo pattern over crops, although very little work has been carried out in India on boro rice crop. To considering this, the present work in paper aims at to find out the albedo pattern over boro rice field. With this background information, the present paper highlights the duration of major phenological states and sub-stages and quantifies the values of different crop and soil albedo indices and canopy temperature and discusses their role for the growth, development and rice yield in the two-consecutives boro seasons of 2018 and 2019.

Materials and Methods

A field experiment was conducted during the summer season 2017-18 and 2018-19 to see the crop-weather relationship at different phenological phases on *Boro* rice over new alluvial zone of West Bengal. The specific location of the experiment was in the humid sub-tropics of West Bengal at the District Seed Farm (D block farm), Kalyani, Nadia at Bidhan Chandra Krishi Vishwavidyalaya (BCKV). The experiment was laid in fairly uniform topography and well-drained soil, which had homogenous fertility and textural makeup. The details of the experiment and the methodology used for present study are discussed in the following sections.

The experiment was laid out in factorial randomized block design (FRBD) with three varieties, three spacing and two ages of seedlings with two replications.

Description of major phenological phases of rice

The major distinct phenological phases and the start and end dates and their duration of *Boro* rice will be observed during the entire growing period. The three major phenological phases along with their sub-phases is defined as a) vegetative phase: i) transplanting-tiller initiation ii) tillering - panicle initiation, b) reproductive phase: i) panicle - flower initiation ii) flowering – milk, and c) ripening phase: i) milk - dough ii) dough - physiological maturity.

Description of observed weather conditions during two experimental years

The variation of weather conditions in terms of temperature, relative humidity, rainfall, evaporation and bright sunshine for consecutive two years of field experiment namely 2017-18 and 2018-19 has been shown in Figs. 1 and 2, respectively

During the experiment period, the maximum temperature ranged from 26^{0}C to 34^{0}C and 24^{0}C to 35^{0}C (2017-18, 2018-19) and the average minimum temperature ranged from 8^{0}C to 22^{0}C and 9^{0}C to 23^{0}C (2017-18 and 2018-19).

Meteorological measurements

Replicated measurement of meteorological parameters from three selected points were taken two consecutive the boro rice seasons in the year 2017-18 and 2018-19. 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

Crop Albedo

Albedo pattern over rice canopy in Boro summer *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 both the boro rice season.

The crop albedo was strongly dependent on solar elevation. The crop albedo depends on age of the crop, extent of the ground cover, colour and reflectivity of the foliage. Crop albedo from crop canopy indirectly represents the physiological condition of the crop. How the crop albedo were improving for different crop varieties across the different days after transplanting of boro rice

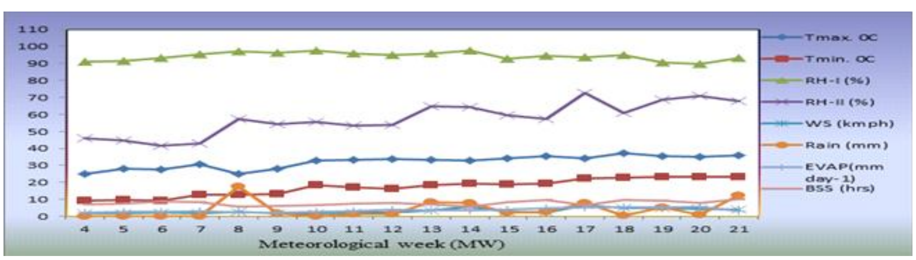


Fig. 1 : Weather condition during the boro rice-growing season 2017-18.

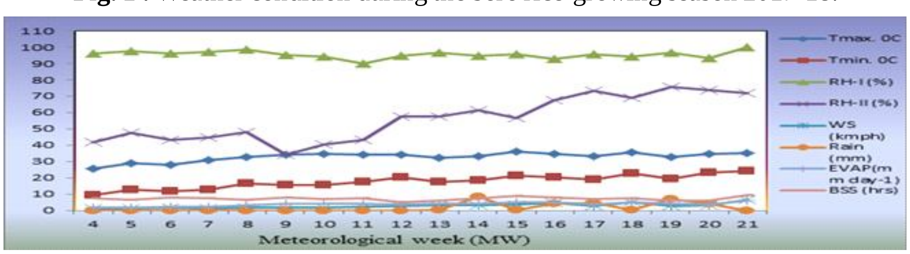
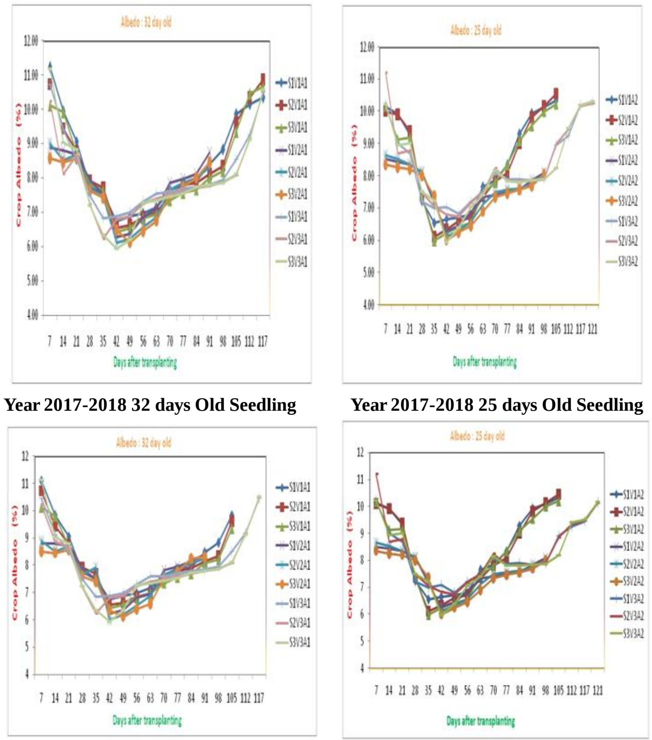


Fig. 2 : Weather condition during the boro rice-growing season 2018-19.



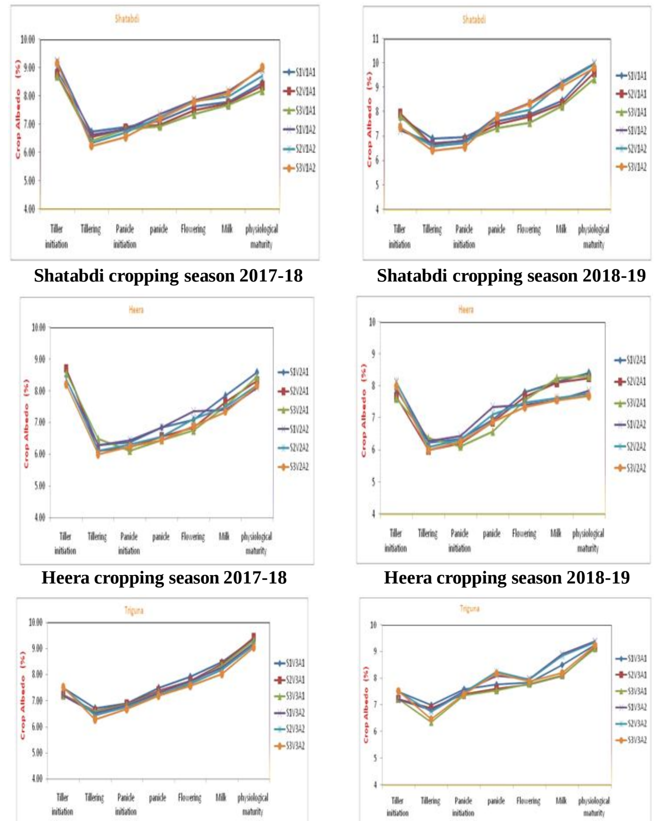
Year 2017-2018 32 days Old Seedling　Year 2017-2018 25 days Old Seedling

Year 2018-19 32 days Old Seedling　Year 2018-19 25 Days Old Seedling

Fig. 3 : Temporal variation of Crop Albedo (%) for different days after transplanting for two consecutive the boro rice seasons in the year 2017-18 and 2018-19 in respect to two age of seedlings and three variety, three spacing.

using 32 days age of seedling and 25 days age of seedling were assessed. The variation of crop albedo under different combinations due to two ages of seedling, three varieties and three spacing were compared in Fig. 3. It is interesting to note that initially taking the observation starting from 7 DAT to harvesting, the crop albedo of Triguna variety attains its highest values (10-11%) during the initially crop growth period up to 35 DAT and thereafter it decreases to its lowest value of 6% during 35-84 DAT, again it increases up to harvest with a moderate value of 8-10%. On the other hand maximum crop aldedo were noticed for both the Shatabdi and Heera varieties during 7 DAT to 35 DAT but it started to decrease and attains its lowest values during 35-77 DAT for Shatabdi and during 28-63 DAT for Heera verities.

The distribution of crop albedo at different days after transplanting was almost identical. In general, the highest crop albedo was observed in Triguna variety followed by the Shatabdi and Heera varieties irrespective to spacing and ages of seedling both the cropping seasons of 2017-18 and 2018-19. Leaf area index (LAI) is a major contributing factor towards the overall reflectivity of canopy of crop surface. In the present experiment, the low value of crop albedo during 35-84 DAT was noticed



Shatabdi cropping season 2017-18　Shatabdi cropping season 2018-19

Heera cropping season 2017-18　Heera cropping season 2018-19

Triguna cropping season 2017-18　Triguna cropping season 2018-19

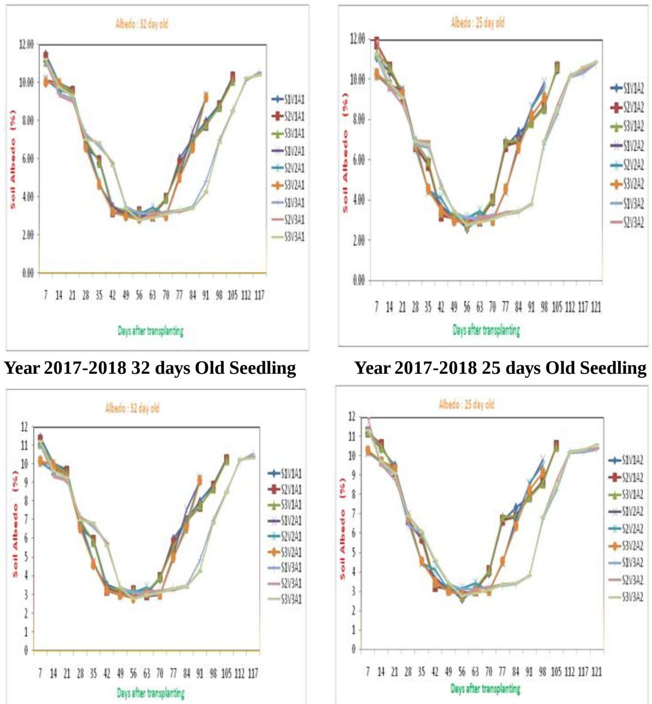
Fig. 4 : Temporal variation of crop albedo (%) for different phenological phases for two consecutive the boro rice seasons in the year 2017-18 and 2018-19 in respect to two age of seedlings and three variety, three spacing.

due to high LAI value and water stagnant in field.

The crop albedo was decreased leads to accompany with increase in green reflectance and decrease in red reflectance. Thus the green reflectance decreased and blue and red reflectance increased as leaf senescence continued and crop attains physiological maturity. Besides that during crop ripening time, moisture content of plant is comparatively low may be another reason for high reflectivity of crop.

The spectral reflectance was very low in blue and red wavebands, but consistently higher in infrared waveband. The crop albedo depends on age of the crop, extent of the ground cover, colour and reflectivity of the foliage. Crop albedo from crop canopy indirectly represents the physiological condition of the crop. How the crop albedo was improving for different crop varieties across the different phenological phases starting from tiller initiation to physiological maturity was assessed.

The variation of crop albedo under different combinations due to two ages of seedling, three varieties and three spacing are shown in Fig. 4. Irrespective of



Year 2017-2018 32 days Old Seedling

Year 2017-2018 25 days Old Seedling

Year 2018-19 32 days Old Seedling

Year 2018-19 25 days Old Seedling

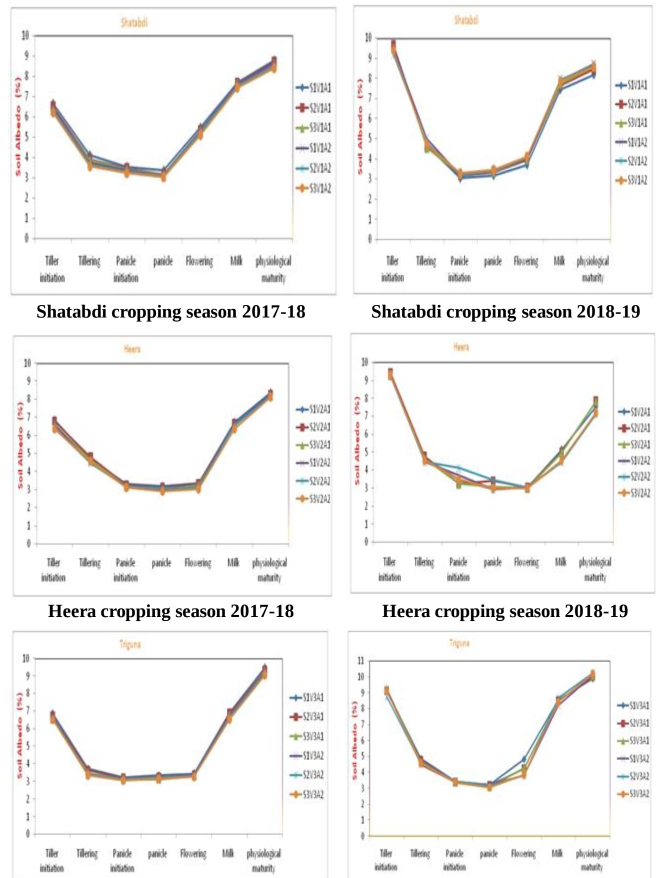
Fig. 5 : Temporal variation of soil albedo (%) for different days after transplanting for two consecutive the boro rice seasons in the year 2017-18 and 2018-19 in respect to two age of seedlings and three variety, three spacing.

both season of boro rice, the crop albedo was at the highest level (8-10%) at the initial crop growth stage followed by the decreased during tillering stage. Thereafter, it remained more of less steady (6%) up to flowering stage, followed by gradually increased till physiological maturity stage. In the present experiment, the low value of crop albedo (%) at during tillering to flowering stage due to high LAI and stagnant irrigated water in the field.

The crop albedo was decreased leading to accompanied with increase in green reflectance and decrease in red reflectance. Thus, the green reflectance decreased and blue and red reflectance increased as leaf senescence continued and crop attains physiological maturity. Besides that during crop ripening time, moisture content of plant is comparatively low may be another reason for high reflectivity of crop.

Soil Albedo

The soil albedo (%) was strongly dependent on solar elevation. The spectral reflectance was very low in blue and red wavebands, but consistently higher in infrared wave band. How the soil albedo was improving for different crop varieties across the different days after transplanting of boro rice using 32 days age of seedling and 25 days age of seedling were investigated. The



Shatabdi cropping season 2017-18

Shatabdi cropping season 2018-19

Heera cropping season 2017-18

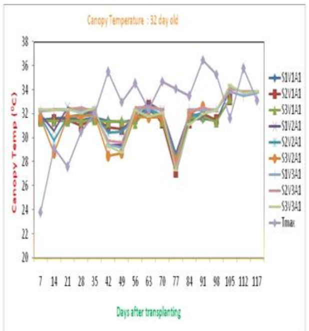
Heera cropping season 2018-19

Triguna cropping season 2017-18

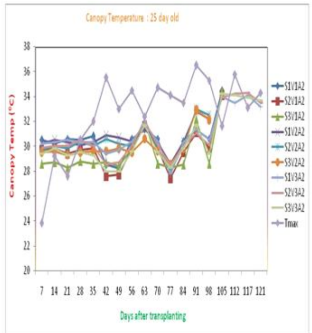
Triguna cropping season 2018-19

Fig. 6 : Temporal variation of soil albedo (%) for different phenological phases for two consecutive boro seasons of rice for the year 2017-18 and 2018-19 in respect to two age of seedlings and three variety and three spacing.

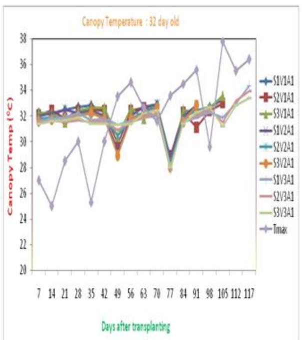
different combination due to two ages of seedling, three varieties and three spacing has been noted and presented graphically in Fig. 5. It is interesting to note that initially taking the observation starting from 7 DAT to harvesting the soil albedo of Triguna variety attains its highest values (10-12%) during 7-35 DAT, thereafter it decreases it values and reached it minimum value (4-5%) during 35-84 DAT, furthermore, it started to increase up to harvest with a moderate value of 10%. On the other hand maximum soil albedo were noticed for both the Shatabdi and Heera varieties during 7 DAT to 35 DAT but it started to decrease and attains its lowest values during 35-77 DAT for Shatabdi, and during 28-63 DAT for Heera verities. The distribution of soil albedo at different days after transplanting was looking almost identical. In general the highest soil albedo observed in Triguna variety followed by the Shatabdi and Heera in varieties in respective any spacing and age of seedlings both for the cropping season of 2017-18 and 2018-19. The temporal variation of soil albedo might be due to periodical drying and wetting of



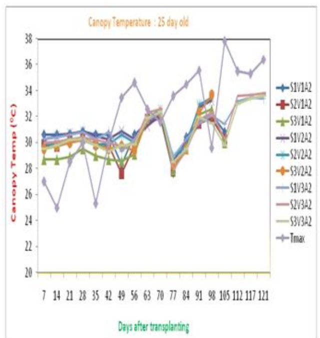
Year 2017-2018 32 days Old Seedling



Year 2017-2018 25 days Old Seedling



Year 2018-19 32 days Old Seedling



Year 2018-19 25 days Old Seedling

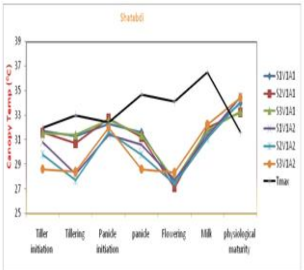
Fig. 7 : Temporal variation of Canopy temperature (°C) for different days after transplanting for two consecutive the boro rice seasons in the year 2017-18 and 2018-19 in respect to two age of seedlings and three variety, three spacing.

the soil surface during the crop growing season. The soil albedo (%) was strongly dependent on solar elevation. The spectral reflectance was very low in blue and red wavebands but consistently higher in infrared waveband. It was largely depending on angle of incidence of solar radiation, physical characteristics of the surface, season, time of the day etc a high soil albedo indicates that much of the incident solar radiation was reflected rather than absorbed. How the soil albedo was improving for different crop varieties across the different phenological phases starting from tiller initiation to physiological maturity was investigated. The variation of soil albedo at different combinations due to two ages of seedling, three varieties and three spacing were shown in Fig. 6. Irrespective of both season of boro rice, the soil albedo (%) was at the highest level 7- 8% at the initial crop growth stage followed by the decreased during tillering stage. Thereafter, it remained more of less steady (3-4%) up to flowering stage, followed by gradually increased till physiological maturity stage. The reflection of soil albedo (%) from soil surface indirectly represents the moisture condition of the soil surface. The temporal variation of soil albedo (%) might be due to periodical drying and wetting of the soil surface during the crop growing season.

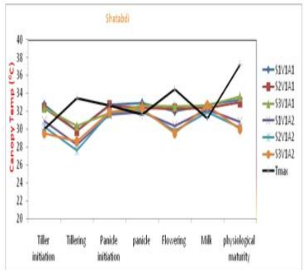
Canopy temperature

Canopy temperature (°C) was indirectly represents the physiological condition of the crop. How the canopy temperature (°C) was improving for different crop varieties across the different days after transplanting of boro rice using 32 days age of seedling and 25 days age of seedling. The variation of canopy temperature under different treatment combinations due to two ages of seedling, three varieties and three spacing are shown in Fig. 6. It is observed that during the 7-35 DAT, the canopy temperature has shown it highest values by 30-32°C, thereafter it started to show slightly decreasing trends and attains a moderate values of 27-30°C during 35-77 DAT where the crops reached to its advance growing phases. The response of canopy temperature for Shatabdi and Heera varieties were showing the similar patterns with slight variation in different phenological periods. The similar trend was shown in both the crop growing seasons. This was also observed by the other researchers (Matsui *et al.*, 2007 and Zhang, 2007) indicated that normally canopy temperature was lower than air temperature and soil water content significantly influenced the canopy temperature, lower the soil water content, higher the canopy temperature. Because of the reduction in canopy temperature by much as with the combination of hot and dry air, strong wind and sufficient water, allowing the rice production without reducing yield.

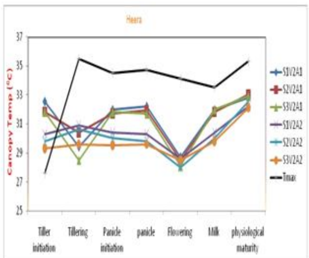
Canopy temperature (°C) was improving for different crop varieties across the different phenological phases starting from tiller initiation to physiological maturity was assessed. The different combination due to two ages of seedling, three varieties and three spacing has been noted and presented in graphically in Fig. 7. In comparison from tiller initiation to panicle initiation, the magnitude differences of canopy temperature was highest (30-32°C) irrespective to variety, spacing and age of seedlings. The canopy temperature showed a decreasing steadily trend at panicle to flowering (27-31°C) with the advancement of crop growing period. Thereafter canopy temperature were suddenly increased highest level of (27-34°C) in flowering to physiological maturity phase both for the cropping seasons of 2017-18 and 2018-19. The temporal variation of canopy temperature at different phenological stages was almost similar. The other researchers (Matsui *et al.*, 2007 and Zhang, 2007) indicated that normally canopy temperature was lower than air temperature, and soil water content significantly influenced the canopy temperature. It was stated that the lower the soil water content, higher the canopy temperature. Because of the reduction in canopy temperature by much as with the combination of hot and dry air, strong wind and sufficient



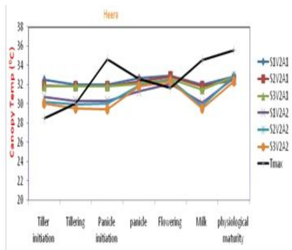
Shatabdi cropping season 2017-18



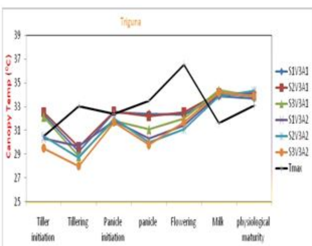
Shatabdi cropping season 2018-19



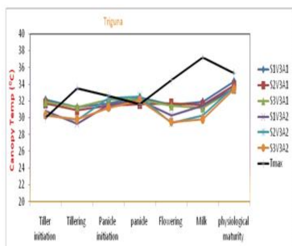
Heera cropping season 2017-18



Heera cropping season 2018-19



Triguna cropping season 2017-18



Triguna cropping season 2018-19

Fig. 8 : Temporal variation of canopy temperature (^{0}C) for different phenological phases for two consecutive the boro rice seasons in the year 2017-18 and 2018-19 in respect to two age of seedlings, three variety and three spacing.

water, allowing the rice production without reducing yield.

Acknowledgement

The help and guidance from the department of Agricultural Meteorology, BCKV are duly acknowledged.

References

Anonymous (2017a). *Agricultural statistics at glance-2017*. Directorate of Economics and Statistics, Department of Agriculture, cooperation & farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India. Available from *https:// eands.dacnet.nic.in*.

Chapagain, T. and Yamaji E. (2010). The effects of irrigation method, age of seedling and spacing on crop performance, productivity and water-wise rice production in Japan. *Paddy and Water Env*., **8(1)**, 81-90.

Krishnan, P. and Nayak S.K. (1997). Effect of seedlings age and planting time on growth and yield of photosensitive rice (*Oryza sativa*) varieties. *Ind. J. Agril. Sci.*, **67(2)**, 27-28.

Kuthe, S., Nayak M.R. and Thakare H.S. (2015). Impact of meteorological parameters on rice production in Navsari. *Gujarat Int. J. Agri. Sci.*, **7**, 492-496.

Matsui, T., Kobayashi K., Yoshimoto M. and Hasegawa T. (2007). Stability of rice pollination in the field under hot and dry conditions in the Riverina region of New South Wales, Australia. *Plant Prod. Sci*., **10(4)**, 57-63.

Pandey, K.K., Rai V.N., Sisodia B.V.S. and Singh S.K. (2015). Effect of weather variables on rice crop in eastern Uttar Pradesh, India. *Plant Archives*, **15(1)**, 575-579.

Ridgwell, A., Singarayer J.S., Hetherington A.M. and Valdes P.J. (2009). Tackling regional climate change by Leaf Albedo Bio-geoengineering. *Curr. Biol.*, **19(2)**, 146-209.

Saha, S., Mukherjee A. and Banerjee S. (2019). Effect of transplanting dates, cultivars and irrigation regimes on microclimate and yield of rice. *Int. J. Bio-res. Stress Managr.*, **10(4)**, 389-396.

Yan, C., Ding Y., Wang Q., Liu Z., Li G., Muhammad I. and Wang S. (2010). The impact of relative humidity, genotypes and fertilizer application rates on panicle, leaf temperature, fertility and seed setting of rice. *J. Agric. Sci. Cambridge*, **148(1)**, 329-339.

Zhang, W.Z., Han Y.D. and Hong-Juan D.U. (2007). Relationship between canopy temperature at flowering stage and soil water content, yield components in rice. *Rice Sci*., **14(1)**, 67-70.