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PAR distribution in mustard (*Brassica juncea* L. var. Pusa bold) crop canopy

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ABSTRACT

Solar radiation particularly PAR region in solar spectrum supplies energy for photosynthesis by which plant is able to produce biomass. Experiment was carried out in IARI, agricultural research farm New Delhi in two consecutive *rabi* seasons to study the PAR distribution in mustard crop canopy. PAR interception at 50% crop height and at the bottom by the whole canopy decreased up to 12.00 hrs after which it increased and reached maximum at 16.00 hrs in both the seasons. Nitrogen fertilization influenced light interception significantly and maximum PAR interception was observed during flowering stage of the crop. An increase in the applied nitrogen resulted in an increase in Light Use Efficiency (LUE) over the control in both pre and post-anthesis periods.

Key words : PAR, LUE, Light interception, Mustard

Much of the observed seasonal and intra-seasonal variations in the agricultural output are frequently attributed to the effect of weather conditions on plant growth. Ultimate source of practically all of the energy for physical and biological processes occurring on earth is solar radiation. All the five determinants of crop growth proposed by Charles-Edward (1981), namely, light interception, utilization of intercepted light, dry matter loss due to respiration, partitioning of assimilates to economically harvestable parts and duration of crop growth are influenced by the prevailing environmental conditions such as radiation and temperature. PAR interception by crop canopies depends on leaf growth and architecture of the canopy while the light utilization efficiency, in addition, depends on the photosynthetic characteristics of the individual leaves in the canopy. Thus a study of light interception in crop canopies assumes great significance. Studies involving field grown plants under their natural conditions are very few in literature. The present study was carried out with the objective of understanding the distribution pattern of PAR in mustard crop canopy and to study its interception and use efficiency in mustard crop.

MATERIALS AND METHODS

The field experiments were carried out for two consecutive years (1988 - 89 and 1989 - 1990) in the experimental farm area of the Indian Agricultural Research Institute (IARI), New Delhi. *Brassica juncea* L. var. Pusa Bold was raised for carrying out the

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present investigation with two levels of nitrogen fertilization along with control (0, 30 and 60 kg Nha^{-1}) with four replications. The experimental layout consisted of 12 plots of size 9m x 8m laid out in Completely Randomized Design (CRD). Single super phosphate (SSP) at the rate of 60 kg P_2O_5 ha^{-1} and muriate of potash at the rate of 40 kg K_2O ha^{-1} were uniformly broadcast on the field as per the recommended practice. Crops were raised under well irrigated conditions, with one irrigation at pre sowing and two more at critical stages of growth.

Observations of plant parameters (biomass, leaf area, specific leaf area and pod surface area) and meteorological parameters (temperature, rainfall, sunshine hours, evaporation, light interception) were recorded at different phenological stages (emergence, flowering, end of pod formation, end of seed filling and maturity).

The following radiation parameters are calculated using the formulae:

(i) $IPAR = 1 - I_h/I_0$

Where I_0 is the incident PAR and Ih is the PAR at height h above the ground level.

(ii) $APAR = 1 - I_h/(I_0 - I_{ref})$

Where I_{ref} is the reflected PAR.

The measurements were taken on clear days at weekly intervals between 11.30 and 13.00 hrs IST using a radiation integrator LICOR model 191B.

RESULTS AND DISCUSSION

Diurnal variation of light interception

Diurnal variation of PAR interception was studied in mustard canopy at hourly intervals during first rabi season (1988-89). The observed crop reflection coefficient and the incident PAR intercepted at two levels of the crop canopy (viz., at 50% height and at bottom) at 84 DAS corresponding to the end of flowering stage is shown in Fig.1. The PAR interception in control at 50% height of the canopy began to decrease from about 45% observed at 9:00 hrs. and reaching a minimum of about 12% at 12:00 hrs. and thereafter it again started increasing attaining the morning values by 16:00 hrs. The interception by the whole canopy began to decrease from about 81% observed in the morning to about 52% at noon and showed a similar trend as that of the top half of the canopy. The reflection coefficient decreased from about 8% observed at 9:00 hrs. to about 6.5% at 12:00 hrs. The PAR interception at other nitrogen treatments showed similar trend as that of the control treatment; the values of maximum and minimum interception increased with the nitrogen fertilizer application.

Since the variation of the PAR flux is largely due to the variation of the direct component of the radiation it appears that the penetration of the direct component of the PAR is limited to the middle layers: PAR flux at the bottom level of the canopy is largely due to the diffuse radiation coming either from the incident radiation or from the scattering of the direct radiation within the crop canopy. In Fig.2 the fraction of the incident PAR transmitted by the canopy was plotted as a function of the solar zenith angle. The transmitted PAR at the bottom of the canopy showed little variation with the zenith angle. At 50% height, the PAR transmission increases with the zenith angle indicating a greater influence on the fraction of the direct component of PAR as compared to the direction of the incident radiation.

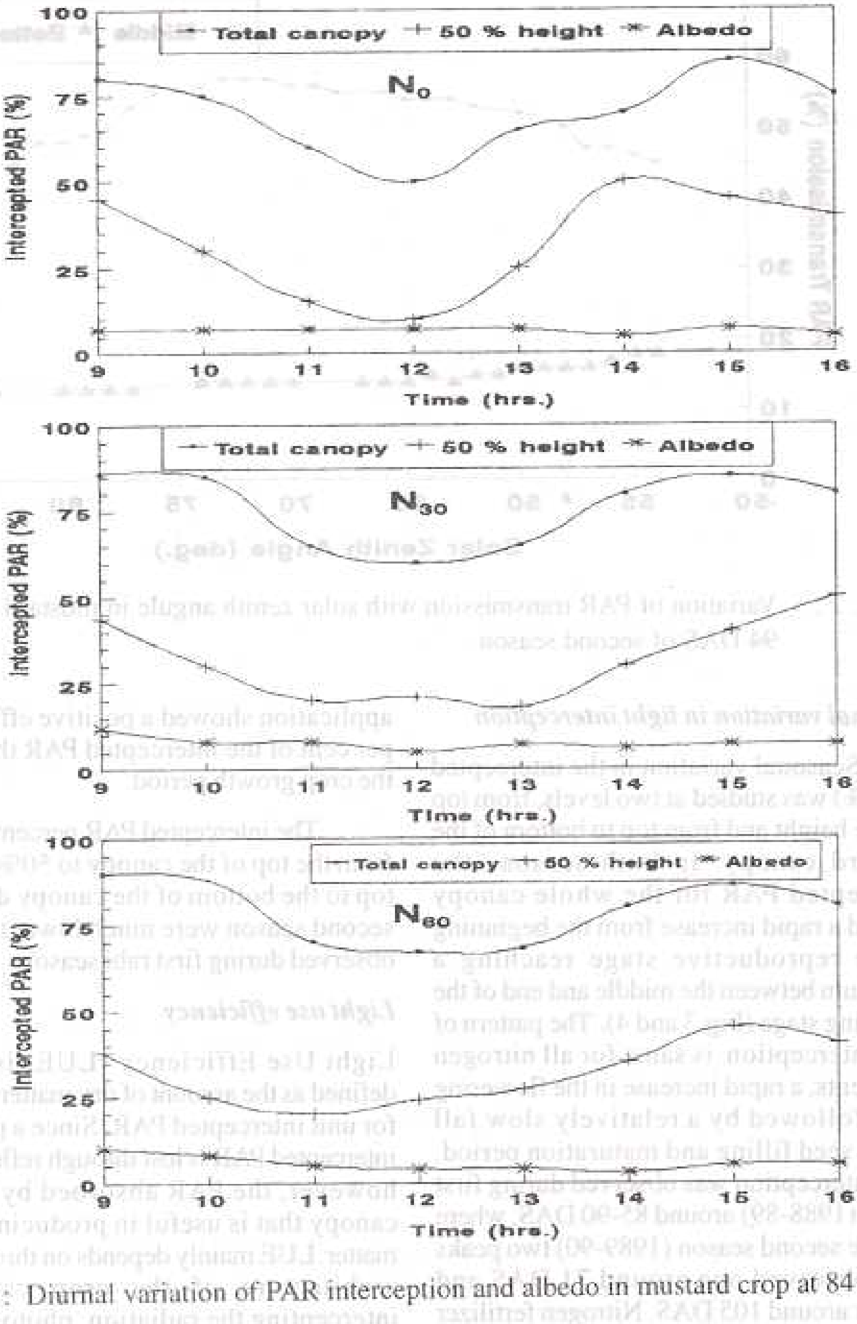

Fig. 1 : Diurnal variation of PAR interception and albedo in mustard crop at 84 DAS.

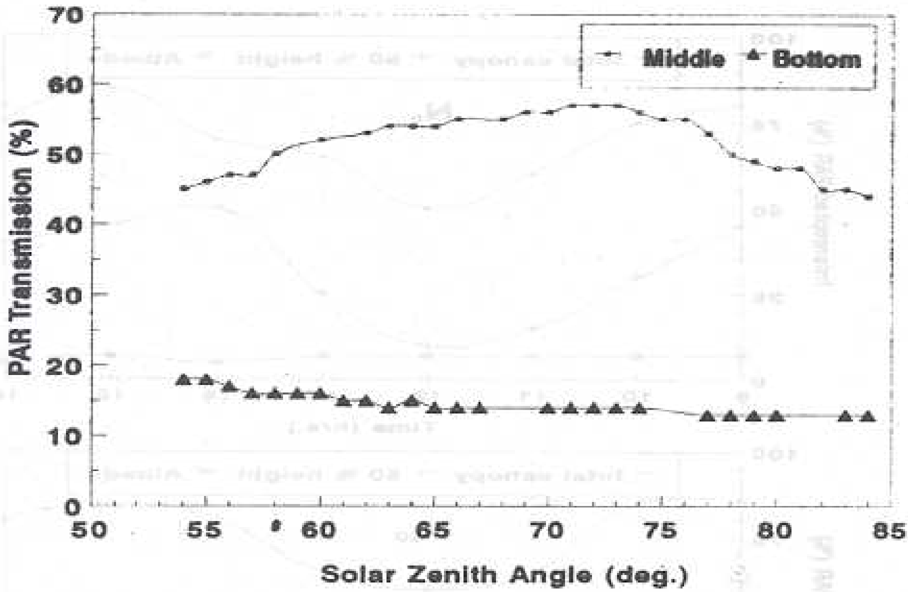

Fig. 2 : Variation of PAR transmission with solar zenith angule in mustard crop in 94 DAS of second season.

Seasonal variation in light interception

Seasonal variation in the intercepted PAR (%) was studied at two levels, from top to 50% height and from top to bottom of the mustard canopy. In both seasons the intercepted PAR for the whole canopy showed a rapid increase from the beginning of the reproductive stage reaching a maximum between the middle and end of the flowering stage (Fig.3 and 4). The pattern of PAR interception is same for all nitrogen treatments, a rapid increase in the flowering stage followed by a relatively slow fall during seed filling and maturation period. Peak interception was observed during first season (1988-89) around 85-90 DAS, where as in the second season (1989-90) two peaks were observed one around 71 DAS and another around 105 DAS. Nitrogen fertilizer application showed a positive effect on the per cent of the intercepted PAR throughout the crop growth period.

The intercepted PAR percentages both from the top of the canopy to 50% and from top to the bottom of the canopy during the second season were much lower than those observed during first rabi season.

Light use efficiency

Light Use Efficiency (LUE) is usually defined as the amount of dry matter produced for unit intercepted PAR. Since a part of the intercepted PAR is lost through reflection it is however, the PAR absorbed by the crop canopy that is useful in producing the dry matter. LUE mainly depends on three factors; architecture of the crop canopy in intercepting the radiation, photosynthetic

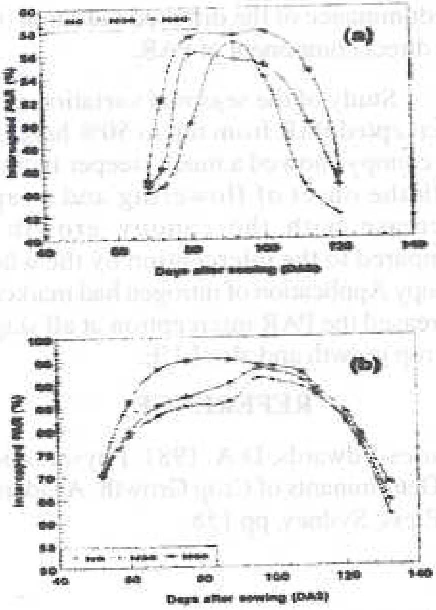

Fig. 3 : Seasonal variation of PAR interception in mustard crop during first season (1988-89) at (a) 50% height and (b) bottom of the canopy

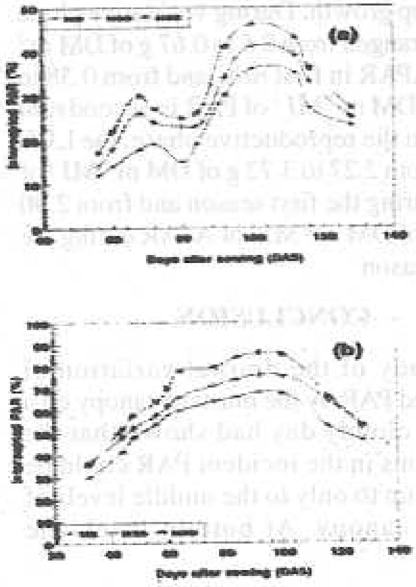

Fig. 4 : Seasonal variation of PAR interception in mustard crop during first season (1989-90) at (a) 50% height and (b) bottom of the canopy

Table 1: Light use efficiencies (DM m^{-2} MJ^{-1}) in mustard crop at two growth stages.

Growth Stage	Light Use Efficiency		
	N_0	N_{30}	N_{60}
First *rabi* season (1988-89)			
Vegetative	0.50±0.01	0.60±0.12	0.67±0.14
Reproductive	2.27±0.12	2.36±0.01	2.44±0.11
Second *rabi* season (1989-90)			
Vegetative	0.38±0.07	0.55±0.15	0.59±0.16
Reproductive	2.90±0.10	3.72±0.10	3.62±0.10

efficiency of the leaves in utilizing the intercepted radiation in producing dry matter and loss of dry matter due to respiration. In the present investigation, LUE was calculated for the vegetative and the reproductive phases.

The LUE value obtained at different stages of mustard crop growth during two *rabi* seasons are presented in Table 1. In first season the LUE values were higher in the vegetative stage than the corresponding values in the second season while the converse was true for the reproductive phase of the crop growth. During vegetative phase the LUE ranged from 0.5 to 0.67 g of DM m^{-2} MJ^{-1} of APAR in first *rabi* and from 0.38 to 0.59 g of DM m^{-2} MJ^{-1} of PAR in second *rabi* season. In the reproductive phase, the LUE ranged from 2.27 to 3.72 g of DM m^{-2} MJ^{-1} of APAR during the first season and from 2.90 to 3.72 g of DM m^{-2} MJ^{-1} of APAR during the second season

CONCLUSION

Study of the diurnal variation of intercepted PAR by the mustard canopy on a partially cloudy day had shown that the fluctuations in the incident PAR could be observed up to only to the middle levels of the crop canopy. At bottom level, the fluctuations were quite small attributable to predominance of the diffused radiation over the direct component of PAR.

Study of the seasonal variation of the intercepted PAR from top to 50% height of the canopy showed a much steeper increase with the onset of flowering and a rapid decrease with the canopy growth as compared to the interception by the whole canopy Application of nitrogen had markedly increased the PAR interception at all stages of crop growth and also LUE.

REFERENCE

Charles-Edwards, D.A. 1981. Physiological Determinants of Crop Growth, Academic Press, Sydney, pp 158.