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Radiation interception, growth dynamics and agroclimatic indices in raya (*Brassica juncea*)

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ABSTRACT

Field experiments were conducted at PAU, Ludhiana, to study growth and radiation interception in raya PBR-91 sown under three dates of sowing during two consecutive *rabi* seasons of 2004-05 and 2005-2006. The leaf area index (LAI) depicts a positive correlation with the photosynthetically active radiation (PAR) interception, GDD and HTU. Significant linear positive relationship was also observed between dry matter accumulation with PAR interception, growing degree days (GDD), heliothermal units (HTU).

Key words: Leaf area index, dry matter, PAR interception, growing degree days, heliothermal units

Indian mustard commonly grown in tropical and temperate area occupies 13 % of India's gross cropped area and forms an integral part of the cropping system. Temperature is an important weather variable, which determines productivity, particularly for *rabi* crops. All determinants of crop growth, namely radiation utilization, 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 of radiation and temperature. Efficiency of conversion of radiation into dry matter depends upon plant traits and environmental conditions.(Hundal *et al* 2004).The variations in productivity are mostly attributed to the effect of seasonal weather conditions on plant growth. Date of sowing is an important factor affecting the growing environment of crops Mustard requires a definite amount of accumulated heat energy for the completion of its life cycle. Growing degree-days (heat units) are the simple means of relating plant growth, development and maturity to air temperature. Heat unit concept has been used to predict phenology of wheat (Hundal *et al.*, (1997), Soybean (Dhingra *et al* 1995 and Shanker *et.al.*, 1996). In the present investigation, an attempt was made to determine the relationship between dry matter accumulation, leaf area index, with PAR interception and growing degree days at different growth stages under different dates of sowing.

MATERIALS AND METHODS

Field experiments were conducted at the Punjab Agricultural University, Ludhiana during *rabi* seasons of 2004-05 and 2005-06 on a loamy sand soil. The crop (Raya PBR-91) was sown on three dates viz; 5 October, 30 October and 25 November during both the seasons. The recommended dose of fertilizers (as per PAU package of practices) was applied at the rate of 100 kg N ha^{-1} in the form of urea and 30 kg P_2O_5 ha^{-1} as single super phosphate.

Green leaf area was measured at 15 days interval with a plant canopy analyser (LICOR model). The leaf area index was measured by placing the sensor above the canopy followed by placing it at four different points below the canopy diagonally across the rows. Dry matter accumulation was recorded after oven drying plant samples at 70°C for 72 hours. Diurnal cycles of photosynthetically active radiation were taken from 0900 hours to 1700 hours at different phenological stages after sufficient canopy growth. A line quantum sensor (Model LI – 190 SB) was used to measure the amount of incoming and reflected radiation 1 m above the canopy and transmitted PAR was recorded at base of canopy with the sensor base just touching the ground.

Percent interception of PAR by the crop was calculated as under:

$$\% \text{ PAR interception} = \frac{\text{PAR (I)} - \text{PAR (T)} - \text{PAR (R)}}{\text{PAR (I)}} \times 100$$

Where

PAR (I) – PAR incoming above the canopy

PAR (T) – PAR transmitted to the ground

PAR (R) - PAR reflected from the canopy

Thermal indices namely growing degree-days, helio-thermal units, photo-thermal units, and heat use efficiency were calculated for different sowing dates. Growing degree-days (GDD) were calculated as per Nuttonson, 1955 using base temperature of 5°C (Morrison et al,1990)

Helio-thermal units (HTU) was calculated as the product of GDD and corresponding actual sunshine hours for that day on daily basis.

HTU = GDD x actual sunshine hours

RESULTS AND DISCUSSION

Dry matter accumulation and PAR interception:

Relationship between PAR interception and dry matter accumulation for pooled data of both the years is shown in the equation. It is clear that dry matter increased with an increase in PAR interception . A significant relationship with R^2 =0.71 was observed between dry matter and PAR interception as shown below:

$$Y = 123.37 - 4.0763\,X + 0.0349\,X^2 \quad (R^2=0.71)$$

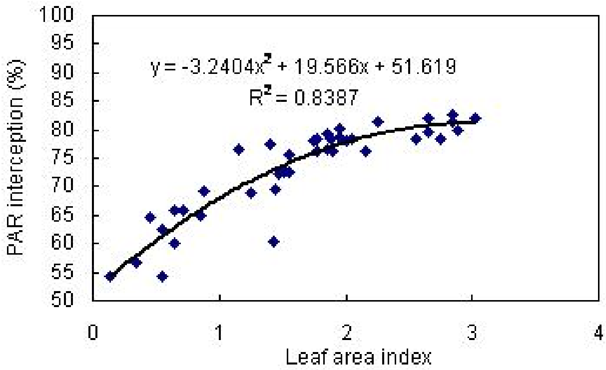

Fig. 1 : Relationship between leaf area index and PAR interception

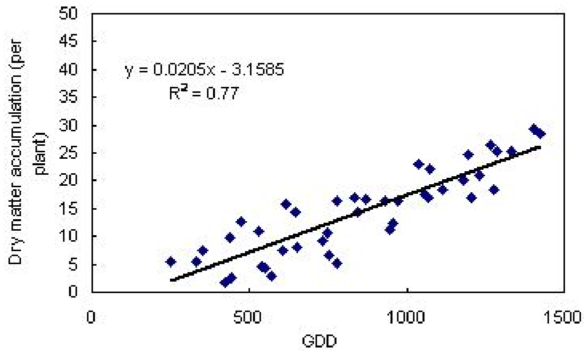

Fig. 2 : Relationship between dry matter accumulation and GDD

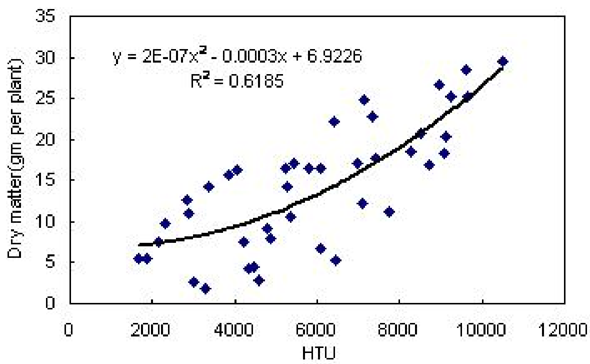

Fig. 3 : Relationship between dry matter accumulation and HTU

Table 1: Correlation coefficients between GDD and dry matter accumulation at different growth stages.

Growth stage	2004-05	2005-06
Flowering	0.21	0.25
Early siliqua development	0.66	0.31
Pod formation (Start)	0.92	0.67
Pod filling	0.88	0.81
Physiological Maturity	0.78	0.64

Where Y – Total dry matter (g plant^{-1})
X - PAR interception in percent

Hundal *et al*. (2003) also observed a direct and significant relationship between dry matter and PAR interception in mustard cultivars. Similarly Biscoe and Gallagher (1977) also reported that the total dry matter production was closely related to the amount of PAR intercepted in many crops.

LAI and PAR interception

A consistent increase in LAI was observed up to 75 to 105 DAS, thereafter it declined sharply towards maturity. LAI was higher in first date of sowing followed in decreasing order by second and third date of sowing, during both the crop seasons. The relationship between leaf area index and PAR interception is presented in Fig. 1. The intercepted PAR ranged from 70 to 90 percent. It is clear that with an increase in the LAI, PAR interception also increased during both the years to a level of optimum LAI beyond which no significant increase was observed in radiation interception. The following regression equation between leaf area index (X) and PAR interception (Y) was obtained.

$$Y = 51.619 + 19.556\,X - 3.2404\,X^2 \quad (R^2=0.84)$$

Kumar *et al* (1998) also reported that maximum solar radiation was intercepted at 90 DAS when peak LAI occurred in raya.

LAI or dry matter accumulation and thermal time indices:

Significant regression relationships were obtained between dry matter production and HTU (Fig 3).

Correlation between GDD and biomass were significant at different phenological stages as shown in Table 1.

The regression equations obtained between dry matter and thermal time indices can be a useful tool in predicting periodic dry matter accumulation and LAI development in raya using daily information on temperature and actual sunshine hours during the crop season.

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