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Research Article

Relationship between Intercepted PAR and Biomass of Greengram Grown in New Alluvial Zone of West Bengal

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ABSTRACT

New Alluvial Zone is recognised as the one of the high productive regions of West Bengal. The fertile lands, ample resource availability of this place trigger the production of a variety of crops. Greengram cultivation is being popularized in this zone for its climate resilience nature. Like any other crop, yield of this legume is also governed by photosynthetic efficiency. The capacity of harnessing photosynthetic radiation (PAR) regulates this physiological process. The interception and absorption of PAR are greatly influenced by weather parameters and plant morphologic characters like leaf area index (LAI). This interrelationship among LAI, interception of PAR and biomass accumulation can be utilized to design the best growing condition for this crop. This will lead to better yield of this crop. *Samrat*, being the most popular variety of greengram in this region, was selected for the field experiment during pre-*Rabi* season of 2018 in the C-Block Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal. Three dates of sowing, *viz*. 11th September (D_1), 24th September (D_2) and 8th October (D_3) were the treatments of the experiment. Crop biomass along with biophysical parameters were measured at specific growth stages namely vegetative, flowering, 1st pod formation, end of pod formation, 50% maturity and 100% maturity. It was noted that LAI had strong correlation with percent of intercepted PAR (IPAR) which in turn assisted in more biomass production. Among the three dates of sowing, crops sown in the first date of sowing were recorded with the highest LAI, IPAR percentage and final biomass. 10-12% more biomass was harvested from D_1 crops which showed almost 12-27% more cumulative IPAR acquisition than the other two dates of sowing. The pattern of the measured variables throughout the growing period was also observed. Maximum LAI and PAR interception were reported from the reproductive stages when the plants were at fully grown condition.

Key words: Greengram, Radiation, Intercepted PAR, LAI, Biomass

Introduction

Greengram is an important pulse crop grown in New Alluvial Zone of West Bengal and presently gaining popularity in view of its short life span to grow, N, fixing ability and drought tolerance capacity. Considering the climatic variability and increasing water scarcity situations in near future, promotion of such crop is very much necessary (Gregory and Ingram, 2000). Moreover, the crop can provide required nutritional values to the poor farming community (Lotte *et al.*, 2009). To enhance the greengram

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production, the genetic and agronomic development technologies have been well documented (Chauhan and Williams, 2018). However, the agrometeorological interventions, such as microclimatic modification has been less explored (Slingo *et al.,* 2005). Various physiological processes are strongly correlated to different weather variables. The crop growth and development are largely influenced by interception and absorption of photosynthetically active radiation (Meena *et al*., 2017). Canopy photosynthesis is largely dependent on capture of radiation which in turn plays a key role in both dry matter and nitrogen accumulation. On the other hand, leaf area index (LAI) is one of the factors which govern the amount of radiation interception and absorption by a canopy (Russel *et al.,* 1989). Considering the background, the present research work intends to evaluate the relationship between LAI and interception of PAR and ultimately radiation influence on biomass production of *Samrat* variety of greengram, which is the most popular greengram variety of southern West Bengal.

Materials and Methods

To fulfil the objective as stated above, the field experiment was conducted during pre-*Rabi* season of 2018 in the C-Block Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal (Lat 22°58′ N and Long 88°31′ E). Three sowing dates, at an interval of 13 days, were taken so that the crop is exposed to different weather situation. Thus the treatments were D_1 (11th September sown crop), D_2 (24th September sown crop) and D_3 (8th October sown crop), each having three replications. A spacing of 30 cm by 10 cm was maintained and 24 square meter plot was allotted for each of the replications. Standard package of practices recommended for New Alluvial Zone of West Bengal were followed for raising the crop. A Line Quantum Sensor (Model: APOGEE/MQ-301) was used to measure different components of PAR. The incident PAR (PAR_0) and transmitted PAR (reaching ground being transmitted through canopy) were recorded keeping the line quantum sensor 50 cm above crop height and 5 cm above soil surface respectively. The intercepted photosynthetically active radiation (IPAR) was computed through following formula (Nobel, 1980).

Intercepted PAR (IPAR) = (Incident PAR – Transmitted PAR) …(1)

The percentage of intercepted PAR was calculated by

% IPAR = [(IPAR ×100)/Incident PAR] … (2)

The IPAR and % IPAR were measured for all growth stages of the crop along with biophysical variables, namely LAI, biomass, etc. For biophysical parameters, samples of each treatment combination were collected by random selection method. The considered growth stages are vegetative, flowering, 1st pod formation, end of pod formation, 50% maturity and 100% maturity. Greengram, being a pulse with indeterminate type growth habit, does not achieve its particular phonological stage on one single day. Hence, proper care was taken for phenology wise biophysical characterisation. For relationship study, both the radiation and biophysical data for the particular stage were collected on same day. Those dates are mentioned in the Table 1. LAI was estimated by using the standard equation given by Watson (1947). Biomass at particular growth stage is expressed in g/m^2 unit.

Results and discussion

Relationship between LAI and intercepted PAR

The variations of LAI and IPAR for different crop growth stages for all treatments were observed, In case of first date of sowing (D_1), the LAI values were 0.46, 1.38, 1.39, 1.42, 0.72 and 0.66 for vegetative, flowering, 1st pod formation, end of pod formation, 50% maturity and 100% maturity stages respectively (Fig.1). The results regarding LAI were in agreement with the published literature for this particular crop. For the D_1 treatment, the observed intercepted PAR percentages (%IPAR) were 49.18%, 56.13%, 58.47%, 66.51%, 61.65% and 59.20% respectively for the said growth stages. From the figure it is evident that the trend of LAI and

Table 1. Date of collection data for specific growth stages

Name of the growth stages	D_1	D_2	D_3
Vegetative	3/10/2018(22 DAS)	10/10/2018(16 DAS)	29/10/2018(21 DAS)
Flowering	12/10/2018(31 DAS)	26/10/2018(32 DAS)	14/11/2018(37 DAS)
1st pod formation	26/10/2018(45 DAS)	1/11/2018(38 DAS)	30/11/2018(53 DAS)
End of pod formation	2/11/2018(52 DAS)	12/11/2018(49 DAS)	6/12/2018(59 DAS)
50% maturity	12/11/2018(62 DAS)	22/11/2018(59 DAS)	20/12/2018(73 DAS)
100% maturity	20/11/2018(70 DAS)	30/11/2018(67 DAS)	26/12/2018(79 DAS)

DAS: Days after sowing

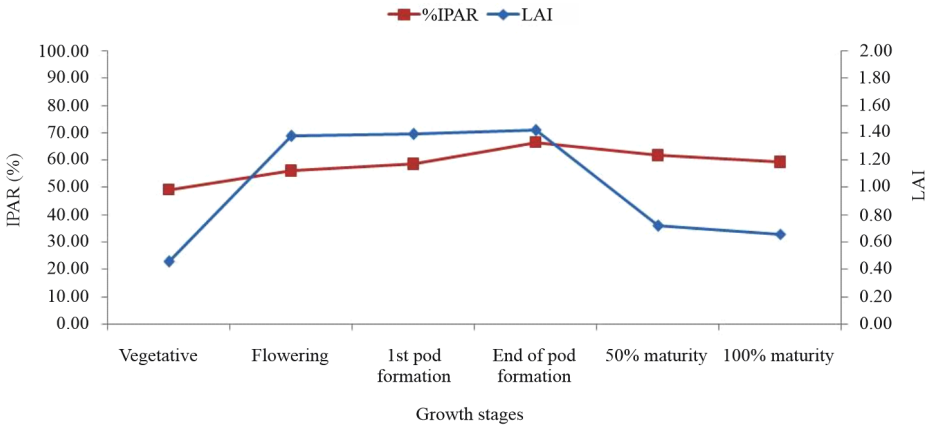

Fig. 1. Relationship of LAI and percent of intercepted PAR at various growth stages of *SAMRAT* variety for first date of sowing (D_1)

%IPAR were similar. The values increased from vegetative stage onwards and attained peak values at end of pod formation stage. Then they began to fall due to aging of leaves.

The basic pattern of LAI and percent of PAR interception for second date of sowing (D_2) matched with D_1-treatment (Fig. 2). LAI achieved the highest value of 1.53 during end of pod formation stage. Percentage of PAR interception varied from 47.41 to 67.97. In general, higher LAI and IPAR percent values were observed in D_1 compared to D_2.

The relationship between LAI and %IPAR of D_3 crop can be understood from the Fig. 3. It is very clear that LAI and % of intercepted PAR maintained the same trend as the other two treatments. For D_3 treatment, the highest LAI and %IPAR values were 1.43 and 66.35% respectively. On an average, LAI and %IPAR values remained lower than D_1 and D_2 crops throughout the entire growth period.

By keeping the whole matter in mind, it can be stated that LAI and percent of PAR interception showed a strong association. Higher LAI value contributed higher percentage of PAR interception. This statement is supported by the works of Campbell *et al*. (2001), Kiran (2002), Bergamaschi *et al*. (2004) and Bassu *et al.* (2011).

Relationship between biomass and intercepted PAR

Biomass variation along with the IPAR at different growth stages of *Samrat* variety under three dates of sowing are mentioned in Table 2. D_1 sown crop intercepted highest amount of PAR in all growth stages except flowering and 1st pod formation stages. This led to maximum above ground biomass accumulation in case of first date of sowing. Intercepted PAR value was less in case of D_3 compared to D_1 and D_2. The scheduled date of sowing for D_3 was 13 to 26 days after sowing of the other two, thus shifted towards winter

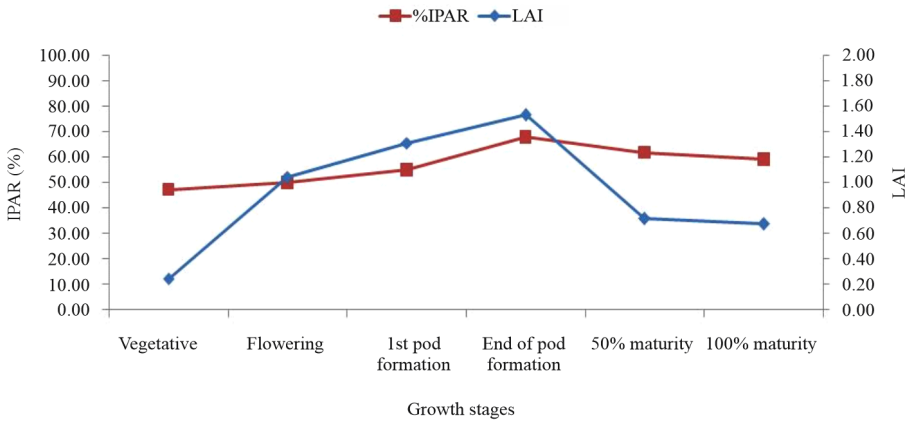

Fig. 2. Relationship of LAI and percent of intercepted PAR at various growth stages of *SAMRAT* variety for second date of sowing (D_2)

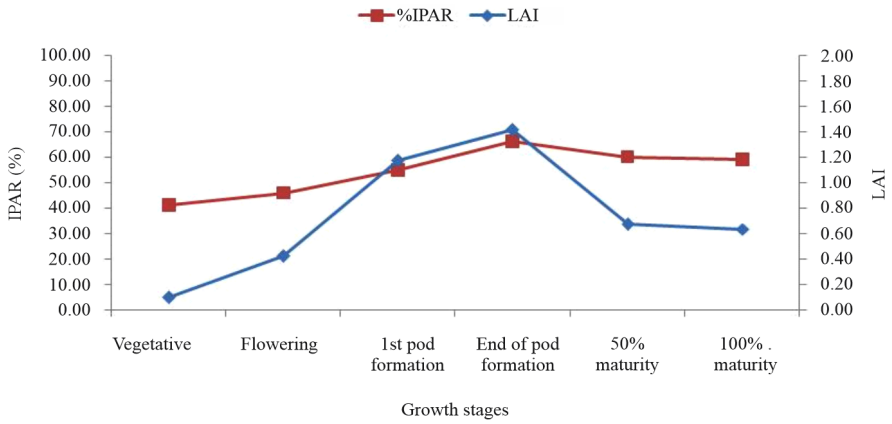

Fig. 3. Relationship of LAI and percent of intercepted PAR at various growth stages of *SAMRAT* variety for first date of sowing (D_3)

Table 2. Relationship of IPAR with biomass of *SAMRAT* variety under different dates of sowing

Growth stages	D_1		D_2		D_3	
	Cumulative IPAR (W/m²)	Biomass (g/m²)	Cumulative IPAR (W/m²)	Biomass (g/m²)	Cumulative IPAR (W/m²)	Biomass (g/m²)
Vegetative	129.25	38.28	70.22	13.53	88.53	8.91
Flowering	224.14	125.73	176.7	166.65	182.3	56.76
1st Pod Formation	352.93	266.97	320.35	205.26	265	225.39
End of Pod Formation	514.09	366.3	458.18	350.79	364.11	415.8
50% Maturity	639.14	467.28	569.89	427.68	456.26	427.68
100% Maturity	744.4	455.4	655.83	410.52	546.65	404.58

season. So, amount of intercepted PAR was reduced as a result of low incident PAR. Irrespective of the dates of sowing, increment of biomass was more (almost 165 g/m²) upto first pod formation stage. After that the rates of increase were having lower values. In the later growth stages the biomass is mainly accounted for the pod biomass. But at 100% maturity, the biomass decreased in all the sowing treatments. Leaf biomass reduced at a greater rate due to senescence. So, the above ground biomass decreased slightly at 100% maturity stage. The

above ground biomasses for D_1, D_2 and D_3 at 100% maturity were 455.40, 410.52 and 404.58 g/m^2 respectively. This denotes that amount of intercepted PAR influences biomass positively. This type of relationship has also been observed in various crops (Louarn *et al.,* 2008). In general, it was observed that the biomass accumulation continued to increase with progression of growth stages up to end of pod formation. Higher amount of PAR interception led to higher amount of biomass accumulation. The result was in agreement with Bierhuizen *et al.* (1973) and Scott *et al*. (1973). It might be the prime reason why D_1 yielded maximum above ground biomass followed by D_2 and D_3. As a whole, the sowing time and growing environment influence the biomass and yield predominantly (Roy *et al*., 2018).

Conclusions

The present experiment on greengram led to the understanding of relationship of percent of PAR interception with LAI and biomass accumulation. The following conclusions can be drawn from the above said results:

- Normal pattern of IPAR percentage gave rise to a bell shaped curve when plotted in graph. Percentage value of intercepted PAR was impacted by LAI. At earlier growth stage the % IPAR value was low. Likewise, at the end of reproductive stage, the value followed a downward trend as crops were heading towards maturity.
- Higher amount of PAR interception led to higher amount of biomass accumulation.

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