RESEARCH PAPER:

Growth parameters and radiation interception as influenced by different environments and plant geometry in rice (*Oryza sativa* L.)

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SUMMARY

A field experiment was conducted during *Kharif* season of 2009 at the Research Farm, Punjab Agricultural University, Ludhiana. Two rice cultivars, PAU 201 and PR 116 were transplanted on 15 June and 30 June under two spacings. The leaf area index was higher (2.33) under closer spacing (20 cm x 15 cm) as compared to under wider spacing (30 cm x 10 cm), the LAI of which was 2.26. Significant variations in the dry matter were also reported due to the spacing. The total dry matter was higher in wider spacing as compared to closer spacing throughout the crop growing period in both the varieties. Significant relationships were observed between leaf area index and photosynthetically active radiation. Dry matter accumulation also showed a positive relationship with photosynthetically active radiation.

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Key Words :
Rice crop, Leaf area index, Photosynthetically active radiation, Dry matter accumulation

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Rice (*Oryza sativa* L.) is the staple food for more than 60 per cent of the world population (Anonymous, 2008) and plays a vital role in the national food security. Rice occupies about 23.3 per cent of gross cropped area of the country and contributed 43 per cent of total food grain and 46 per cent of total cereal production. Rice is cultivated on 44.8 million hectares with a production of about 87.8 million tons, in India whereas, it occupies an area of 2.80 million hectares in Punjab having highest productivity (4.01 t/ha) in the country (Anonymous, 2011).

Adoption of advanced and modern technology coupled with the favourable climatic factors such as temperature, sunlight and rainfall contributed to higher rice yield. Solar radiation is the energy source that sustains organic life on earth. The biologically significant aspects of solar radiation are the intensity of radiation, spectral distribution and radiation distribution in time. The leaf area index (LAI) and dry matter production are useful indicators of crop productivity and closely related to PAR interception (Pandey *et al.,* 2004). The capture of radiation and its use in dry matter production depends on the fraction of photosynthetically active radiation (PAR) that is intercepted and the efficiency with which it is used for dry matter production (Mavi and Tupper, 2004). The ultimate capacity of a plant to produce dry matter depends on the degree of exploitation of solar radiation. Efficiency of conversion of radiation into dry matter depends upon plant traits and environmental conditions (Hundal *et al.,* 2004). In addition to the above discussed factors, plant geometry also affects the plant growth, dry matter production and yield by altering microclimate.

EXPERIMENTAL METHODOLOGY

The experiment was conducted at the Research Farm, Punjab Agricultural University, Ludhiana (30°54'N latitude and 75°48'E longitude and is 247 meter above mean sea level) during *Kharif* 2009. Two varieties of rice *viz.,* PR 116 and PAU 201 were transplanted on two different dates *viz.,* 15 June and 30 June during *Kharif* 2009 under two spacings of 20 cm x 15 cm and 30 cm x 10 cm. The experiment was replicated thrice in the Randomized Block Design. The package of practices recommended by Punjab

Agricultural University, Ludhiana were followed for cultivation of crop.

Leaf area index was measured with a Plant Canopy Analyser (LICOR model) at 15 days interval by placing the sensor once above the canopy followed by placing it at four different levels in the crop. Diurnal cycles of photosynthetically active radiation (PAR) were observed from 0900 hours to 1700 hours at different phenological stages throughout crop growth period and was measured with Line Quantum Sensor. PAR interception (%), was calculated as under:

$$\textbf{PAR interception(\%)} = \frac{\textbf{PAR(1)} - [\textbf{PAR(T)} + \textbf{PAR(R)}]}{\textbf{PAR(1)}} \textbf{x100}$$

where,

PAR (I) - PAR incoming above the canopy

PAR (T) - PAR transmitted to the ground

PAR (R) - PAR reflected from canopy

Plant samples were taken periodically throughout the crop growth season. The samples were oven dried at 70°C, till a constant weight was reached and weighed for dry matter accumulation. The results obtained were compared, standard statistical procedures and inferences were drawn. The relationships of PAR interception with leaf area index and dry matter accumulation were developed.

Experimental Findings and Discussion

The results obtained from the present investigation are presented below:

Effect of transplanting dates and plant spacing on leaf area index:

Leaf area index (LAI) is one of the most important factors which affects radiation, interception and process of photosynthesis. It determines the capacity of the plant to convert the solar energy into chemical energy and an important index to strengthen the source-sink relationship. Leaf area development and maintenance are considered to be key factors to maximize dry matter and yield. There was continuous increase in LAI up to 90 days after transplanting and thereafter a decreasing trend was observed (Table 1) in all the treatments. Rice crop transplanted on 15th June attained maximum LAI of 3.25 (PAU 201) and 3.16 (PR 116) than the crop transplanted on 30th June with a spacing of 20 cm x 15 cm. The corresponding values for the wider spacing (30 cm x 10 cm) were observed to be 3.15 and 3.12 respectively. On an average the higher LAI were observed in 15th June transplanting under both the spacings. The variability in LAI may be due to variable microclimatic parameters, varietal traits and environmental effects. These results are in agreement with the findings of Chang *et al.* (2005) and Biswas (2008).

Table 1: Leaf area index of rice crop under different dates of transplanting and spacing

Spacing	Leaf area index				
	DAT	PR 116		PAU 201	
		15 June	30 June	15 June	30 June
20 cm x 15 cm	60	1.16	1.33	1.26	1.33
	75	2.41	1.67	2.62	2.41
	90	3.16	2.78	3.25	3.05
	105	2.54	1.53	2.70	2.72
	120	2.05	1.33	1.82	2.06
Mean		2.26	1.73	2.33	2.31
30 cm x 10 cm	60	1.13	1.22	1.21	1.09
	75	1.95	1.84	2.19	1.96
	90	3.12	3.01	3.15	2.92
	105	2.85	2.65	2.76	1.70
	120	2.05	2.01	2.01	1.56
Mean		2.22	2.15	2.26	1.85

DAT – Days after transplanting

Relationship between leaf area index and PAR interception

The PAR interception and it's distribution in the canopy is primarily a function of leaf area index of a crop in space and time. The polynomial relationships between leaf area index and PAR interception were best fit for both 15th June and 30th June transplanting crop explaining their interaction. The polynomial function of PAR with LAI explained the variability of PAR interception in the canopy up to 70 per cent in 15th June transplanted followed by 61 per cent in 30th June transplanted crop (Fig. 1 and 2). These polynomial equations between leaf area index and PAR interception were obtained as under:

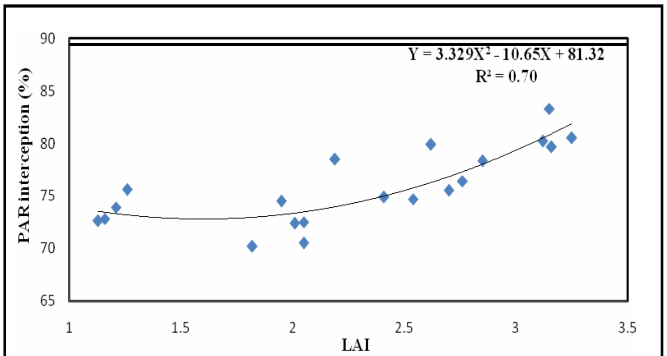

Fig. 1 : Relationship between leaf area index and PAR interception in 15 June transplanting

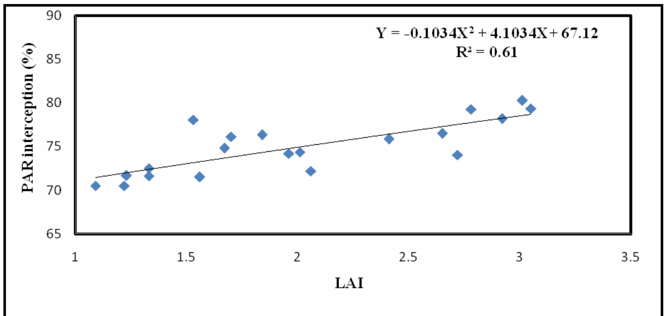

Fig. 2 : Relationship between leaf area index and PAR interception in 30 June transplanting

$Y=3.329X^2-10.65X+81.32$ $R^2=0.70$ (15 June transplanted crop)

$Y=-0.103X^2+4.10X+67.12$ $R^2=0.61$ (30June transplanted crop)

where, Y= PAR interception (%) X= Leaf area index

Effect of transplanting dates and plant spacing on total dry matter:

The total dry matter accumulation is an important growth parameter, reflecting the growth and ability of plant to convert solar energy to chemical energy. The dry matter accumulation increased progressively with advancement in age of the crop (Table 2). Dry matter accumulation was significantly influenced with change in transplanting date. The highest dry matter accumulation of 57.36 g/plant and 58.70 g/plant in narrow and wider spacing, respectively were observed in 15th June transplanted crop, This may be due to favourable weather conditions and better vegetative growth, utilization of more number of heat units and favourable temperature in 15th June as compared to 30th June transplanted crop. The lowest dry matter accumulation under delayed transplanting may be the result from reduced total field duration, owing to availability of more photo thermal time in shorter periods, which led to forced maturity. Maximum dry matter accumulation occurred in the period of 105 to 120 DAT, which was the grand phase of the crop.

Table 2 : Periodic total dry matter (g/plant) accumulated under different dates of transplanting and spacing

Spacing	DAT	Total dry matter (g/plant)			
		PR 116		PAU 201	
		15 June	30 June	15 June	30 June
20 cm x 15 cm	60	10.6	9.2	13.7	13.4
	75	25.2	19.9	29.2	21.3
	90	45.6	32.7	51.4	39.4
	105	74.5	70.6	76.9	64.3
	120	111.6	99.6	115.6	97.6
Mean		53.50	45.72	57.36	47.20
30 cm x 10 cm	60	11.8	10.7	14.1	14.6
	75	27.2	21.6	30.8	25.5
	90	46.8	35.8	53.8	41.3
	105	79.9	69.3	77.7	68.1
	120	116.2	103.6	117.1	98.9
Mean		56.38	48.20	58.70	49.68

DAT – Days after transplanting

In 15 June transplanted crop, the mean total dry matter was 57.36 g/plant and 53.50 g/plant in PAU 201 and PR 116 varieties, respectively under 20 cm x 15 cm spacing. Whereas in 30 cm x 10 cm spacing the mean total dry matter was 58.70 g/plant and 56.38 g/plant in both the varieties with same order. On an average, dry matter accumulation was higher under 30 cm x 10 cm spacing as compared to 20 cm x 15 cm spacing in both the varieties. Hari *et al.* (1997) reported dry matter accumulation as maximum in 15th June transplanting due to favourable mean maximum temperature and solar radiation.

Relationship between total dry matter and PAR interception:

Relationships between PAR interception and dry matter accumulation were established (Fig. 3 and 4) and observed that the rate of increase was slow initially and increased rapidly after booting stage. The following polynomial function of PAR interception with total dry matter accumulation was calculated as under:

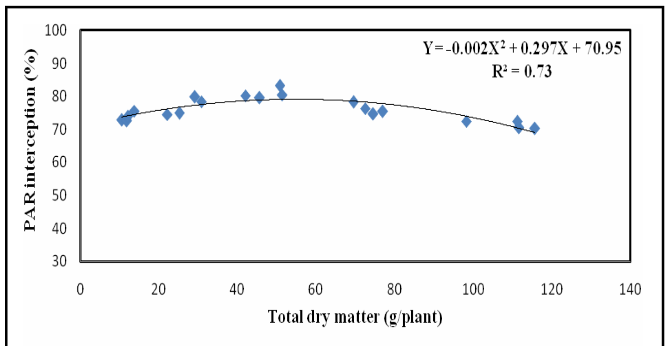

Fig. 3 : Relationship between total dry matter accumulation and PAR interception in 15 June transplanting

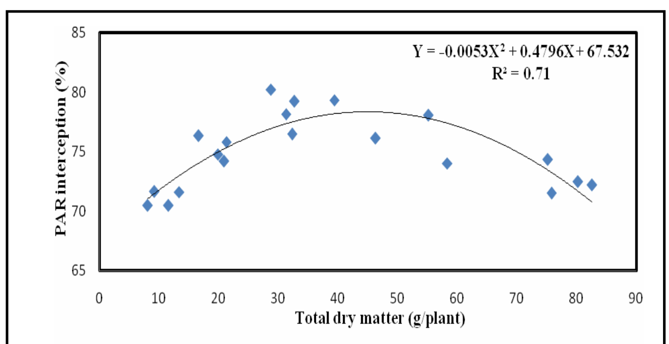

Fig. 4 : Relationship between total dry matter accumulation and PAR interception in 30 June transplanting

$Y=-0.002X^2+0.29X+70.95$ $R^2=0.73$ (15 June transplanted crop)

$Y=-0.005X^2+0.48X+67.53$ $R^2=0.71$ (30June transplanted crop)

where, Y= PAR interception (%) X= Total dry matter (g/plant)

The above calculated function that total dry matter to the extent of 73 per cent can be predicted by PAR interception if the crop is transplanted on June 15th and 71 per cent when transplanting is delayed by a fortnight. Biscoe and Gallagher (1977) also reported that the total dry matter production was found to be closely related to the amount of PAR intercepted in many crops.

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