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Growth response of paddy (*Oryza sativa*) to radiation interception and agroclimatic indices under different planting methods

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ABSTRACT

Field experiments were conducted at PAU, Ludhiana, to study growth and radiation interception in paddy. Rice cultivars PR-115 and PR-118 were transplanted under three dates of sowing during two consecutive *Kharif* seasons of 2004 and 2005. The leaf area index (LAI) depicted a positive correlation with the photosynthetically active radiation (PAR) interception and growing degree days (GDD). Significant linear positive relationship was also observed between dry matter accumulation with PAR interception and growing degree days (GDD).Heat use efficiency was more under furrow planting as compared to conventional planting.Agroclimatic indices like GDD can be use as a tool in predicting drymatter accumulation and leaf area index of rice crop.

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Key words : Leaf area index, Dry matter, PAR interception, Growing degree days

INTRODUCTION

Rice is grown in all continents of the world due to its wide adaptability to diverse agroclimatic conditions. In India, the rice-wheat production system covers nearly 12 million ha area in the Indo-Gangetic plains in states of Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal. This system contributes about 25 per cent to the total food grain production of the country. The rice crop in India accounts for about 24 per cent of the total cropped area under food grains. In Punjab, rice cultivation has increased considerably with the availability of high yielding varieties, irrigation facilities and support price. It dominates the agricultural scene of the state in *Kharif* season having an area of 26.47 lakh ha with the highest state level average yield of 5914 kg/ha in terms of paddy in comparison to 3943 kg/ha average yield of rice (Anonymous, 2006).

On an average more than 4000 liters of water is used to produce one kilogram of rice (Anonymous, 1992). In Punjab, rice-wheat system owing to its high water demand has caused a severe problem of ground water table, which is declining at an alarming rate of 23 cm per year and has depleted about more than four meters since 1982 (Anonymous, 2002).Transplanting in puddled field is the common method of rice crop establishment, which results in formation of a hard pan and damages the soil structure. The traditional practice of continuous ponding of water results in considerable deep percolation losses and over irrigation than the crop requirements. As a result nearly 80 per cent area of the Punjab state is experiencing a fall in water table. So other practices for rice growing need to be explored to solve this problem in future. There is need to study alternative rice growing methods such as transplanting in furrows without puddling the soil which require less water. In this method the seedlings are transplanted in between the furrows and the water is applied only in furrows, which leads to 30-35% saving of water. There is also a need to study the changes in crop micro climate environment under various planting methods and their effect on yield. Keeping this in view, field studies were conducted to study the effect of two planting methods on radiation interception, crop growth and yield of rice crop.

MATERIALS AND METHODS

Field experiments on paddy were conducted during *Kharif* seasons of 2004 and 2005 with paddy at Punjab Agricultural University, Ludhiana. It is situated at 30°54'N latitude and 75°48'E longitude and is 247 m above mean sea level. The area experiences an average annual rainfall of 705 mm of which about 80 per cent is received during June to September. Two varieties of paddy, PR-118 and PR-115 were transplanted under conventional method (with puddling) and in between furrows (without puddling) on three different dates *viz.*, 25 May, 10 June and 25 June in both the crop seasons. Seedlings were

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transplanted at a spacing of 20 cm x 15 cm in conventional method and 30 cm x 10 cm in furrow planting method. Thus, plant population was 33 hills per square meter in both the methods. The experiment was laid out in the factorial split plot design keeping date of sowing as main treatment, method of transplanting as sub treatment and varieties as sub-sub treatment. Each treatment was replicated four times. Fertilizers (N and P) were applied as per the recommendations by Punjab Agricultural University, Ludhiana. Two sprays of weedicides namely Butachlor @ 3 l/ha and metsulfuron @ 75g/ha were used to control the grassy and broad leaf weeds. One spray of monocrotophos @ 1.4l ml/ha was given to control the rice stem borer and leaf folder. The photosynthetically active radiation interception was measured with quantum sensor at different growth stages of rice crop.

Per cent interception of PAR by the crop was calculated as under:

$$\text{\% PAR interception} = \frac{\text{PAR (I) - PAR (T) - PAR (R)}}{\text{PAR (I)}} \text{x100}$$

where

PAR (I) – PAR incoming above the canopy

PAR (T) – PAR transmitted to the ground

PAR (R) - PAR reflected from the canopy

Agro climatic 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:

$$\text{GDD} = \frac{(T_{max} + T_{min})}{2} - T_t$$

where

T_{max} - maximum temperature (^{0}C) during a day.

T_{min} - minimum temperature (^{0}C) during a day.

T_t - base temperature of 10.0^0 C

LAI and dry matter accumulation were calculated with PAR interception and agroclimatic indices to find out the best fit relationship.

Heat use efficiency (HUE) for dry matter accumulation and seed yield was calculated as:

$$\text{HUE} = \frac{\text{Dry matter / seed yield}}{\text{Accumulated GDD}}$$

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussion have been presented under the following sub heads:

Relationship between dry matter accumulation and PAR interception:

Relationship between PAR interception and dry matter accumulation for pooled data of both the years shown in Fig. 1, 2, 3 and 4. It is clear that dry matter increased with an increase in PAR interception. A significant relationship between dry matter and PAR interception with R^2 =0.78 and 0.79 was observed under conventional planting and 0.84 and 0.83 under furrow planting method during 2004 and 2005, respectively and when the data were pooled R^2 value was 0.75 and 0.77 under conventional and furrow planting as shown in Fig. 5 and 6, respectively. These regression equations are as:

During 2004

$Y= -0.0013X^2+ 0.9741 X +51.454$ (R^2=0.78) (under conventional planting)

$Y= -0.0096X^2+ 0.9303 X +53.052$ (R^2=0.84) (under Furrow planting)

During 2005

$Y= -0.0167X^2+ 1.1308 X +52.32$ (R^2=0.79) (under conventional planting)

$Y= -0.0121X^2+ 0.9138 X +57.55$ (R^2=0.83) (under Furrow planting)

Pooled

$Y= -0.0158X^2+ 1.0923 X +51.591$($R^2$=0.75) (under conventional planting)

$Y= -0.0101X^2+ 0.8838 X +55.692$ (R^2=0.77) (under Furrow planting)

where Y - PAR interception in per cent X - Total dry matter (g/plant)

The per cent were more in conventional planting as compared to furrow planting because LAI was more in conventional planting as compared to furrow planting. This may be due to the reason that in furrow planting row spacing was more as compared to conventional planting. 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 equations between leaf area index (X) and PAR interception (Y) were obtained:

During 2004

$Y= -1.1048X^2+ 9.7477X +48.425$ (R^2=0.88) (under conventional planting)

$Y= -1.1351X^2+ 9.914X +54.175$ (R^2=0.82) (under Furrow planting)

During 2005

$Y= -1.3267X^2+ 10.257 X +52.1$ (R^2=0.73) (under

Table 1 : Correlation (r) of GDD with LAI and biomass

Phenological stage	2004	2005	2004	2005
	LAI		Biomass	
Tillering	0.81	0.55	0.88	0.51
Booting	0.85	0.6	0.93	0.55
Heading	0.88	0.75	0.97	0.75
Flowering	0.92	0.55	0.91	0.88
Soft dough	-0.47	0.08	0.94	0.86
Hard dough	-0.24	-0.22	0.84	0.95

Table 2 : Heat use efficiency (HUE) of rice crop under different planting methods in three dates of sowing

	Total dry matter (kg/ha)		Dry matter HUE (kg/ha^{o}C/day)		Seed yield (kg/ha)		Seed yield HUE (kg/ha^{0}C/day)	
	PR-118	PR-115	PR-118	PR-115	PR-118	PR-115	PR-118	PR-115
2004								
D1M1	21115	19525	7.00	7.00	5767.5	5227.5	1.91	1.87
D1M2	25435	22892	8.34	8.04	6570	6510	2.15	2.29
D2M1	18562.5	18415	6.15	6.75	6767.5	5655	2.24	2.07
D2M2	23330	22280	7.65	8.00	7327.5	7112.5	2.40	2.55
D3M1	18892.5	16665	6.77	5.93	5370	5305	1.92	1.89
D3M2	19612.5	18255	7.60	6.84	5632.5	5457.5	2.18	2.04
2005								
D1M1	16875	19880	5.80	7.71	5330	4432.5	1.83	1.72
D1M2	15772.5	18030	5.35	6.86	6495	5337.5	2.20	2.03
D2M1	6000	5850	2.09	2.30	5425	4997.5	1.89	1.97
D2M2	6510	6300	2.08	2.44	6750	6332.5	2.15	2.45
D3M1	5657.5	5330	2.14	2.09	6207.5	6025	2.34	2.37
D3M2	8080	6767.5	2.99	2.62	6415	7560	2.38	2.93

where D1, D2 and D3 are different dates of sowing
M1-Conventional planting method, M2-Furrow palnting method

conventional planting)

$Y= -0.6492X^2+ 5.9817 X +62.133$ (R^2=0.64) (under Furrow planting)

Pooled

$Y= -0.0158X^2+ 1.0923 X +51.591$ (R^2=0.75) (under conventional planting)

$Y= -0.0101X^2+ 0.8838 X +55.692$ (R^2=0.78) (under Furrow planting)

Relationship between LAI or dry matter accumulation and agro climatic indices:

The % coefficients were worked out between GDD with LAI and biomass as shown in Table 1.A significant positive correlation was found between GDD and LAI up to flowering stage after that LAI of crop declined because of that correlation of GDD and LAI at soft dough and hard dough stage were negative. Whereas correlation of GDD and dry matter % and day length for mustard was reported by Hundal *et al.* (2003).

Total dry matter, seed yield and heat use efficiency:

Crop transplanted on 10 June (D_2) gave higher dry matter as compared to early transplanted (25 May) crop and late transplanted (25 June) crop and further resulted in higher seed yield. Similar results were also reported by Singh (2003), Singh *et al.* (2002). Relatively higher heat use efficiency was recorded when the crop was transplated on 10 June as presented in Table 2. Heat use efficiency was more under furrow planting as compared to conventional planting of rice crop. The values for dry matter heat use efficiency ranged from 5.93 to 8.34 and 2.08 to 7.71 in first and second crop seasons, respectively.

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