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Radiation use efficiency of mustard cultivars under different sowing dates

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ABSTRACT

Field experiments were conducted at Ludhiana to determine cultivar and sowing date effects on radiation use efficiency (RUE) and crop growth rate (CGR) in mustard. Two mustard cultivars viz: Bio-902 and Pusa-Bold were sown on different dates during two consecutive *rabi* seasons of 1999-2000 and 2000-2001. CGR computed for different crop growth intervals revealed peak CGR of 33.7 and 30.4 g m^{-2} day^{-1} for Bio-902 and Pusa-bold, respectively sown in first week of November. The highest RUE of 2.44 g MJ^{-1} for dry matter accumulation and 0.62 g MJ^{-1} for seed yield were recorded when the crop was sown in third week of October. Significant linear regression relationship ($R^2 = 0.89$) was observed between total dry matter accumulation and cumulative photo synthetically active radiation (PAR).

Key words: Mustard, RUE, CGR, PAR, Brassica.

Indian mustard commonly grown in tropical and temperate areas occupy 13% of the country's gross cropped area and forms an integral part of the cropping system. Even under optimum growth conditions of no water and nutrient stress, temperature and radiation combination play a key role in influencing growth and development of mustard (Kar and Chakravarty, 1999).

Radiation use efficiency (RUE), i.e., efficiency of utilization of radiation in terms of dry matter accumulation is an important aspect, which has great practical application. Grain yield is the product of radiation interception, conversion efficiency of intercepted radiation into dry matter and partitioning. Efficiency of conversion of radiation into dry matter depends upon plant traits and environmental conditions. Attempts have been made in the past to evaluate RUE of brassica (Kar and Chakravarty, 1999), winter oilseed rape (Justes *et al*., 2000), and other crops like maize, sorghum, wheat, rice and sunflower (Kiniry *et al*, 1989).

In the present study, an attempt was made to determine crop growth rates (CGR) at different growth stages and the radiation use efficiency of mustard cultivars under varied environments effected through different dates of sowing. A regression model was developed for the prediction of dry matter accumulation from intercepted photo-synthetically active radiation (PAR).

MATERIALS AND METHODS

Field experiments were conducted at Ludhiana (30°-54' N latitude and 75°- 48' E longitude, 247m above mean sea level)

Table 1 : Crop growth rate (CGR) of two mustard cultivars sown on different sowing dates during *Rabi* 1999-2000.

Days after sowing	18/10/99		9/11/99		2/12/99	
	Bio-902	Pusa-bold	Bio-902	Pusa-bold	Bio-902	Pusa-bold
30	0.3	0.2	0.4	0.4	0.2	0.1
45	5.8	5.4	4.8	3.6	1.0	1.6
60	6.8	6.4	5.7	6.0	5.3	3.2
75	22.8	19.1	15.8	11.3	7.1	5.3
90	24.1	22.8	20.6	22.5	9.5	16.1
105	22.1	22.6	33.7	23.5	11.8	5.0
120	19.1	18.2	21.2	30.4	15.9	13.4
135	20.0	16.1	11.2	10.3	10.3	9.5
150	18.7	17.4				

Table 2 : Crop growth rate (CGR) of two mustard cultivars sown on different sowing dates during *Rabi* 2000-2001

DAS	30/9/00		20/10/00		10/11/00		30/11/00	
	Bio-902	Pusa-bold	Bio-902	Pusa-bold	Bio-902	Pusa-bold	Bio-902	Pusa-bold
30	0.7	0.5	0.7	0.4	0.5	0.6	0.2	0.2
45	1.8	2.0	3.5	2.8	1.6	1.4	0.8	0.4
60	7.1	6.6	6.5	5.7	3.6	2.4	1.5	1.3
75	8.8	7.9	9.0	7.7	8.1	7.2	6.1	5.4
90	9.4	7.0	13.1	10.9	11.0	10.3	6.5	6.8
105	10.4	11.2	20.1	17.7	13.2	12.8	4.1	3.8
120	17.8	10.5	10.8	14.1	11.2	11.2	3.9	3.7
135	15.7	16.3	14.8	17.2	11.1	10.9		
150	15.1	15.9	18.6	15.4				
165	17.1	17.0						

during two consecutive *rabi* seasons of 1999-2000 and 2000-2001. Two cultivars of mustard viz. Bio-902 and Pusa-Bold were grown under three dates of sowing during 1999-2000 and four dates of sowing during 2000-2001. The crop received 100 Kg N and 30 Kg P ha^{-1}. One-half nitrogen and all of phosphorous was applied as basal application while one-half nitrogen was applied with first post sowing irrigation. Plant samples were collected at 15 days interval for leaf area index (LAI) and total dry matter accumulation.

Crop growth rate (CGR) was computed as under:

Table 3 : Harvest characteristics and yield attributes of two mustard cultivars sown on different sowing dates during *Rabi* 1999-2000 and *Rabi* 2000-2001

Treatment	No. of Primary branches m^{-2}	No. of secondary branches m^{-2}	No. of silliqua m^{-2}	No. of seeds silliqua^{-1}	1000-seed weight (g)
Rabi 1999-200					
Date of sowing					
18/10/99	139.6	240.4	2665.5	8.4	6.5
9/11/99	128.4	107.0	1713.8	9.2	6.6
2/12/99	93.0	28.8	1199.6	9.5	5.8
CD (Dates) 5 %	22.65	81.1	561.1	0.8	NS
Cultivars					
Bio-902	119.2	115.2	1736.9	9.0	6.2
Pusa-bold	121.4	135.8	1982.4	9.0	6.3
CD (cultivar) 5%	NS	NS	NS	NS	NS
Interaction (Dates X Cultivar) at 5%	NS	NS	793.6	NS	NS
Rabi 2000-2001					
Date of sowing					
30/09/00	159.4	255.4	4839.4	10.2	6.8
20/10/00	179.1	368.9	6553.9	9.7	7.6
10/11/00	174.2	268.4	1968.6	10.4	8.6
30/11/00	154.5	232.1	1156.6	8.9	7.6
CD (Dates) 5%	NS	95.5	2138.8	NS	0.9
Cultivars					
Bio-902	173.0	284.9	4091.9	9.7	7.9
Pusa-bold	160.6	277.5	3167.3	9.9	7.5
CD (cultivar) 5%	NS	NS	NS	NS	NS
Interaction (Dates X Cultivar) at 5%	NS	NS	NS	NS	1.2

$$CGR = (gm^{-2} d^{-1}) = \frac{DW_2 - DW_1}{T_2 - T_1}$$

Where, DW_2 and DW_1 are the total above ground dry matter of the crop from unit area (g m^{-2}) observed on days T_2 and T_1, respectively, during the time interval.

The leaf area was measured by leaf area meter (Li-Cor model LI-3000A) and the leaf area index was calculated. The incident PAR was obtained by multiplying daily incident solar radiation with 0.45 (Rosenthal and Gerik, 1991). Intercepted radiation was calculated from incident radiation using Beer's Law (Monsi and

Table 4. : Photosynthetically active radiation use efficiency (RUE) of two mustard cultivars sown on different sowing dates during *Rabi* 1999-2000 and *Rabi* 2000-2001

Crop year	Cultivar	Sowing date	Accumulated intercepted PAR (MJ m^{-2})	Total dry matter (gm^{-2})	Seed yield (gm^{-2})	Dry matter RUE (gMJ^{-1})	Seed yield RUE (gMJ^{-1})
1999-2000	Bio 902	18/10/99	351	611	132.3	1.74	0.38
		9/11/99	303	475	95.9	1.57	0.32
		2/12/99	188	289	49.9	1.54	0.27
	Pusa bold	18/10/99	351	540	113.2	1.54	0.32
		9/11/99	303	429	85.4	1.42	0.28
		2/12/99	188	270	38.4	1.44	0.20
2000-2001	Bio 902	30/09/00	269	538	124.4	2.00	0.46
		20/10/00	223	544	138.4	2.44	0.62
		10/11/00	194	378	103.7	1.95	0.53
		30/11/00	127	207	57.5	1.63	0.45
	Pusa bold	30/09/00	269	524	117.4	1.95	0.44
		20/10/00	223	533	130.8	2.39	0.59
		10/11/00	194	311	86.8	1.60	0.45
		30/11/00	127	182	44.8	1.43	0.35

Saeki, 1953) as under:

$$I = I_o (1 - e^{-k*LAI})$$

Where, I = Intercepted radiation (MJ m^{-2})

I_o = Incident radiation (MJ m^{-2})

k = Extinction coefficient (0.75) (Justes *et al.*, 2000)

LAI = Leaf area index

Cumulative intercepted PAR was computed on daily time step basis by interpolating the measured leaf area index between two dates of sampling. RUE for seed and total dry matter was computed as under:

$$\text{RUE (g MJ}^{-1}) = \frac{\text{Seed Yield or Total dry matter (g m}^{-2})}{\text{Cumulative intercepted PAR (MJ m}^{-2})}$$

RESULTS AND DISCUSSION

Crop growth rate (CGR)

The data on CGR for Bio-902 and Pusa-bold mustard cultivars for two crop seasons and growth periods between emergence to 30 days after sowing and thereafter at biweekly interval are presented in Table 1 and 2. In general the maximum

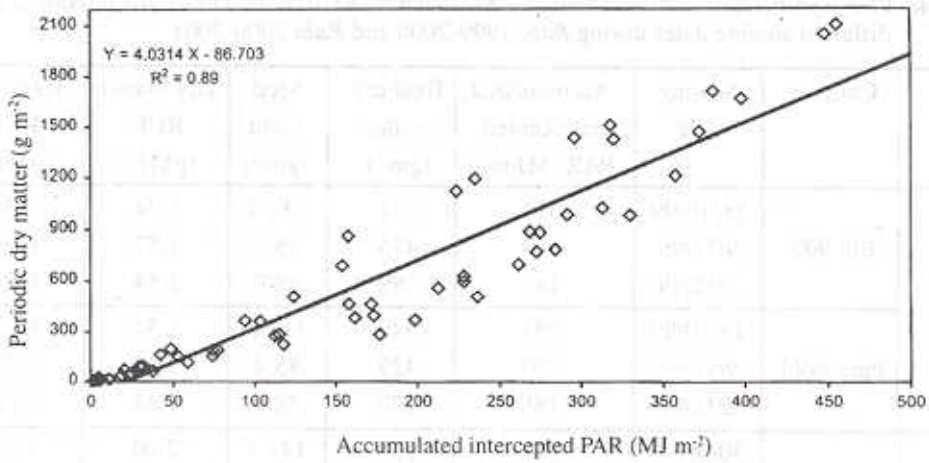

Fig. 1: Relationship between total dry matter (TDM) and accumulated intercepted photosynthetically active radiation (PAR) in mustard

CGR of 33.8 for Bio-902 and 30.4 g m^{-2} day^{-1} for Pusa-bold was observed for the crop sown on 9th November 1999. In both the crop seasons CGR decreased with delay in sowing. The crop sown in late November or early December recorded peak CGR of only 6.8 to 16.1 g m^{-2} day^{-1}. The peak CGR occurred between 90 to 120 DAS in all the treatments. In general, Bio-902 revealed higher CGR as compared to Pusa-bold attributable to profuse pod habit compared to Pusa-bold. Similar results have been reported for mustard cultivars B.O.-54 and Pusa-bold and Toria-T_9 by Kar and Chakarvarty (2000).

Yield attributes of mustard

The data on harvest characteristics and yield attributes of Bio-902 and Pusa-bold for two crop seasons of 1999-2000 and 2000-2001 are depicted in Table 3. Mustard cultivars sown in third week of October in both the crop seasons showed higher yield attributes. However early sowing of mustard in last week of September increased the vegetative growth thus increasing the total biomass production but decreased the economic yield attributes. Similar results on sowing dates of three mustard cultivars (RH 30, Luxmi and Varuna) have been reported by Khichar *et al* (2000). Though the two mustard cultivars did not differ significantly in total biomass production, statistically higher seed yield was obtained for Bio-902 by virtue of its profuse pod habits. The total biomass and seed yield revealed a significant interaction for date of sowing and cultivar.

Total dry matter (TDM) and intercepted PAR

The regression equation obtained between total dry matter (TDM) accumulation in above ground parts from 30 DAS upto physiological maturity as

dependent variable and total accumulated intercepted PAR as independent variable based on data of two crop seasons and two varieties are shown in Fig. 1. Significant linear relationship between TDM and PAR were observed in mustard crop as shown below:

$TDM = 4.0314\ PAR - 86.703 \quad (R^2 = 0.89)$

Radiation use efficiency (RUE)

Accumulated intercepted PAR, accumulated dry matter and seed yield of mustard at harvest and RUE for different treatments are given in Table 4. In general earlier sown mustard received more PAR and accumulated more dry matter as compared to later sown crop irrespective of cultivar type.

The highest RUE 2.44 g MJ^{-1} and 0.62 g MJ^{-1} was recorded for dry matter and seed yield, respectively when the crop was sown in third week of October. In most cases, however, RUE decreased with the delay in sowing. Khichar *et al* (2000) reported similar results on sowing dates of three mustard cultivars (RH 30, Luxmi and Varuna) Cv. Bio-902 due to its profuse growth habits performed better in terms of RUE for both total dry matter accumulation and seed yield than cv. Pusa-bold.

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