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Short Communication

Influence of sowing time and planting geometry on yield and radiation use efficiency of various rapeseed-mustard cultivars

JAGJEEWAN SINGH[1], SOM PAL SINGH and P K KINGRA

School of Climate Change &Agril. Meteorology
Punjab Agricultural University, Ludhiana
E-mail: singhjagjeewan@gmail.com

Rapeseed and Mustard (*Brassica spp*.) is the second most important oilseed crop in India. As a *rabi* season crop, rapeseed-mustard is highly sensitive to photoperiod and temperature (Neog and Chakravarthy, 2005). Response of growth and yield of rapeseed-mustard depends upon the temperature coinciding during each phenological stage (Gouri *et al*., 2005) which depends up on the sowing time of crop. Different sowing dates exposes the crop to different weather conditions affecting temperature and solar radiation captured by the crop canopy and crop growth. Consequently with delay in sowing crop is exposed to low temperature and lower amount of solar radiation during vegetative and high temperature during pod formation to physiological maturity which shortens the life cycle of rapeseed mustard (Pradhan *et al.,* 2014). The final grain yield of a crop is closely related to light in the form of photosynthetically active radiation which is used directly food synthesis. The photosynthesis process is controlled by the temperature and amount of radiation interception. The light efficiency is further attributed to the leaf area of the crop which is more or less controlled by temperature and water.

There is a need to assess the production efficiency of mustard through understanding the relationship between temperature, radiation and crop production. Keeping these facts in view, the present investigation was carried out to study the effect of sowing time and planting geometry on growth, radiation use efficiency, yield and yield attributes of the rapeseed mustard cultivars under Punjab conditions.

The present investigation was conducted at Research farm of Punjab Agricultural University, Ludhiana in split-split plot design with three replications during *rabi*, 2015-16. Three cultivars of rapeseed-mustard (PBR 357, PC6 and GSC 7) as subplots were grown at five sowing dates as main plots alongwith two row orientations (north-south) and (east-west) as sub sub plot. The crop was sown on 7th October, 17thOctober and 27th October, 2015. Flowering and seed filling periods were considered as thenumber of days between the beginning of flowering to the end of flowering, and between the beginning of seed filling to the end of seed filling, respectively.

Daily weather data of maximum and minimum temperature were recorded from the meteorological observatory installed near the research farm.The photosynthetically active radiation (PAR) observations were taken at different intervals with the help of a Line Quantum Sensor (Model LI-190 SB) and output of Quantum Sensor was recorded with a digital multi-voltmeterduring the crop season. The data was taken at the top, middle and bottom of the crop canopy and intercepted PAR capture was worked out for different treatments by formula:

Intercepted PAR=PAR Incident - PAR(Transmitted+Reflected)

PAR (I) = PAR incident at the top of the canopy

PAR (R) = PAR reflected by the crop canopy

PAR (T) = PAR transmitted to the ground

Radiation use efficiency for dry matter was obtained as:

$$\text{RUE} = \frac{Dry\ \ matter\ \ yield\ \ (gm^{-2})}{AIPAR\ \ (MJm^{-2}day^{-1})}$$

Where,

RUE= Radiation use efficiency (gMJ^{-1}day^{-1}),

AIPAR= Accumulated intercepted photosynthetically active radiation ($MJm^{-2}day^{-1}$)

The PAR values were converted from mmol m^{-2} s^{-1}to the MJ m^{-2} day^{-1} using the following formula:

1 MJ m^{-2} day^{-1} = 0.0007826 PAR (mmol m^{-2} s^{-1}) ′ BSS

From sowing onwards the accumulated intercepted PAR by the particular variety under different treatments were calculated by multiplying the total incident, intercepted radiation and crop days. For the next periodic interval cumulate intercepted PAR values, the values of previous periodic interval were added.

PAR interception and radiation use efficiency

The radiation interception and its effciency increased up to flowering stage and decreased thereafter due to the

Table 1: Effect of thermal environments and row orientation on PAR interception (%) and radiation use efficiency of three mustard cultivars

Treatments	PAR interception (%)			RUE (gMJ^{-1})		
	Vegetative	Flowering	Pod filling	Vegetative	Flowering	Pod filling
Date of sowing						
7th October	62.0	91.3	83.9	2.72	3.26	3.42
17th October	49.6	84.6	78.7	2.27	2.72	2.86
27th October	25.6	79.5	67.5	1.60	1.92	2.02
CD	14.6	8.7	11.3	0.28	0.34	0.35
Cultivars						
PBR 357	48.4	85.9	80.3	2.39	2.87	3.02
PC 6	42.8	84.5	75.0	2.06	2.56	2.59
GSC 7	45.9	85.1	74.8	2.14	2.47	2.69
CD	NS	8.7	4.6	0.20	0.24	0.25
Row orientation						
N-S	44.8	84.0	75.2	2.08	2.50	2.62
E-W	46.2	86.3	78.2	2.31	2.77	2.91
CD	NS	NS	NS	0.10	0.13	0.13

Table 2: Yield and yield attributes of *Brassica* cultivars in three dates of sowing and two row orientations

Treatments	Biological yield ($q\ ha^{-1}$)	Grain yield($q\ ha^{-1}$)	Harvest index(%)
Date of sowing			
7th October	90.0	20.1	22.3
17th October	85.5	17.9	20.9
27th October	79.4	14.8	18.7
CD (p=0.05)	4.46	1.55	1.07
Cultivars			
PBR 357	86.8	19.1	21.8
PC 6	83.0	15.9	19.1
GSC 7	85.0	18.2	21.3
CD (p=0.05)	2.67	1.12	0.94
Row orientation			
N-S	84.2	16.9	20.0
E-W	85.7	18.3	21.3
CD (p=0.05)	1.15	0.75	0.70

fact that most of the leaves were defoliated at pod filling stage (Table 1). The maximum PAR interception and radiation use efficiency was observed in 7th October sown mustard as compared to 17th and 27th October sown crop. Among the cultivars, the highest interception and efficiency was observed in PBR 357 followed by GSC and PC 6 with zenith at flowering stage. Between the row orientations, the difference in radiation interception was non-significant at all the stage but its efficiency was maximum in East-West sown crop rather than North-South direction. Tyagi (2017) also reported maximum heat use efficiency in early sown crop of mustard at Tikamgarh, Madhya Pradesh.

Yield and yield attributes

The biomass seed yield and harvest index of mustard

Table 3: Relationship between yield and temperature during different phenological stages

Temperature	Flowering to pod filling	Pod filling to physiological maturity
Maximum temperature	+0.72*	-0.65*
Minimum temperature	-0.60*	-0.73*

Asterisks indicates significant correlation among climatic drivers and yield (*p<0.01)

were significantly highest in crop sown on 7th October and lowest in 27th October sown crop. Among the cultivars, PBR 357 recorded highest biological yield seed yield and harvest index which were statistically at par with GSC 7 (Table 2). Between the row orientation, E-W direction recorded significantly higher yield and yield attributes than N-S direction. These results were in conformity with Roy (2003) who reported that peak biomass was obtained in E-W direction rather than N-S direction of sowing.

The harvest index is an important parameter which indicates the photosynthetic efficiency of plant towards production of economic yield. The harvest index of crop sown on 7th October was significantly higher than crop sown on 17th October followed by 27th October sown crop (Table 2). The harvest index was significantly reduced by delay in sowing as reported by Siadat and Hemayati, (2009). Among the cultivars the highest harvest index was of cultivar PBR 357 which statistically at par with GSC 7. Variety GSC 7 recorded higher harvest index than PC 6. Among the row orientation, the higher harvest index was recorded in E-W sown crop than N-S sown crop. These results are in conformity with the Jha *et al.* (2015).

Correlation between grain yield and temperature

Seed yield of mustard was significantly correlated with maximum and minimum temperature during different phenological stages of three cultivars of mustard. During flowering to pod filling stage, the grain yield showed significantly positive correlation ($r = 0.72$, $p < 0.01$) with maximum temperature and significantly negative correlation with minimum temperature ($r = 0.60, p < 0.01$). During pod filling to physiological maturity, the grain yield showed significantly negative correlation with maximum ($r = 0.65, p < 0.01$) and minimum temperature ($r = 0.73, p < 0.01$) (Table 3). Gupta *et al.* (2017) also reported negative correlation with maximum temperature during pod formation stage of mustard in Jammu.

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