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Short communication

Thermal indices in rapeseed grown in the North Bank Plain Zone of Assam

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The phenothermal index (PTI) was identified to be an important index indicating the thermal unit accumulation per growth day, which decided the rate of growth and development of the crop while, another thermal time based unit, heat use efficiency (HUE) reflects the leaf growth, biomass production and seed yield of the crop in terms of thermal time (Neog and Chakravarty, 2005a). The HUE can be used to assess seed yield in relative terms. In present investigation an attempt has been made to find the effect of PTU and HTU on growth and development of two varieties of rapeseed *Brassica campestries* crop in the North Bank Plain Zone of Assam.

An experiment was conducted in three *rabi* seasons (2009-10, 2010-11 and 2011-12) on the sandy loam soils of research farm area of B.N. College of Agriculture, Assam Agricultural University, Biswanath Chariali, Assam (26^{0}422 N, 93^{0}152 E and 104 m AMSL). Two cultivars of rapeseed *viz.*, TS-36 and M-27 were sown on six different dates at the interval of seven days starting from 15th October to 19th November to enable the crop to get exposed to different thermal conditions during its various phenological stages. The crop was grown under *rainfed* conditions during both seasons. Recommended agronomic practices were followed for growing the cultivars. The experiment was laid out in randomized block design with three replications. Based on visual observations, different phenological events *viz*. emergence start, 1st flower appearance, 50 percent flowering and physiological maturity were identified following Neog *et. al.*, 2005. Daily data on meteorological parameters were collected from agrometeorological observatory, B.N. College of Agriculture (AAU) located near the experimental field. The thermal time or GDD requirement for attaining different phenological events was computed with 5^{0}C as base temperature following Neog and Chakravarty, 2005b. In present study, Phenothermal index (PTI) expressed as degree days per growth days for vegetative stage (sowing to 1st flower appearance) and reproductive stages (1st flower appearance to maturity) of the crop were calculated following Neog and Chakravarty (2005b) as follows

$$PTI = \frac{\text{Accumulated GDD for attain the physiological stage (}^{o}\text{C day)}}{\text{Number of days taken}}$$

Efficiency of thermal energy conversion for seed yield depends upon the genetic make up of the plant, flowering time and physical maturity of the genotype (Dhankhar and Singh, 2013). Thermal use efficiency (TUE) defined as the biomass accumulated during the given period per degree-day (Kar and Chakravarty, 1999, Neog and Chakravarty, 2005b) was also computed to compare the relative performance of mustard under various treatments using the formula (Sastry *et. al*., 1985, Saha and Ghosh 2012, Dhankhar and Singh, 2013):

$$TUE = \frac{\text{Seed or total dry matter yield (kg/ha)}}{\text{Growing degree-days (}^{o}\text{C days)}}$$

Biomass at maturity was also taken. Seed yield and total dry matter of toria were correlated with thermal units by regression analysis.

It was observed that the cultivar M-27 matured between 95 to 108 days and variety TS-36 matured between 96 to 110 days in different sowings in all the three seasons. The thermal time expressed in terms of growing degree days (GDD) required for attaining maturity in M-27 ranged from 1353.3 to 1430.0^{0}C day, in different sowing dates. In case of TS-36, the degree day accumulation at maturity were found to be relatively higher and varied from 1387.7 to 1457.5^{0}C day ^{0}D (Table 2). These differences could probably due to relatively longer growth duration in TS-36.

Thermal use efficiency

Thermal use efficiency (TUE) in TS-36 varied from 0.57 to 1.23 kg ha^{-1} ^{o}C day^{-1}, whereas, in M-27 it varied from 0.48 to 1.13 kg ha^{-1} ^{o}C day^{-1} in different sowing dates in three crop seasons (Table 3). Therefore these indices can be used to assess seed yield in relative terms. From the Table 3 it is

Table 1: Thermal time requirement (days °C) to attain 50% flowering of rapeseed

Variety	DOS	2009-10	2010-11	2011-12	Mean
TS-36	15th Oct	593.0	587.4	567.7	582.7
	22nd Oct	574.9	560.9	563.3	566.4
	29th Oct	559.3	548.9	571.5	559.9
	5th Nov	560.2	568.5	572.8	567.2
	12th Nov	535.5	557.8	544.4	545.9
	19th Nov	542.2	551.0	523.0	538.7
M-27	15th Oct	576.0	552.4	552.9	560.4
	22nd Oct	575.0	560.9	563.3	566.4
	29th Oct	530.3	564.6	570.2	555.0
	5th Nov	521.5	554.8	560.0	545.4
	12th Nov	522.5	557.8	534.2	538.2
	19th Nov	520.3	551.0	509.9	527.1
Over all Mean	550.9	559.7	552.8	554.4	
SD	25.34	10.55	20.65	15.74	
CV	0.05	0.02	0.04	0.03	
SE	1.08	0.45	0.88	0.67	

Table 2: Thermal time requirement (days °C) to attain physical maturity of rapeseed

Variety	DOS	2009-10	2010-11	2011-12	Mean
TS-36	15th Oct	1457.5	1429.3	1423.4	1436.7
	22nd Oct	1414.6	1453.9	1387.7	1418.7
	29th Oct	1412.1	1425.8	1397.1	1411.7
	5th Nov	1406.5	1425.6	1408.3	1413.5
	12th Nov	1407.2	1421.2	1416.5	1415.0
	19th Nov	1412.0	1415.3	1425.1	1417.5
M-27	15th Oct	1434.7	1429.3	1401.3	1421.8
	22nd Oct	1427.8	1430.0	1373.5	1410.4
	29th Oct	1399.1	1383.7	1369.8	1384.2
	5th Nov	1363.9	1355.3	1375.0	1364.7
	12th Nov	1361.3	1360.6	1384.6	1368.8
	19th Nov	1353.3	1362.7	1380.0	1365.3
Over all Mean	1404.2	1407.7	1395.2	1402.4	
SD	31.12	33.05	19.72	24.73	
CV	0.02	0.03	0.01	0.02	
SE	0.81	0.88	0.53	0.66	

Table 3: Thermal use efficiency (kg ha^{-1} ^{o}C day^{-1}) in TS-36 and M-27 in different crop seasons

Variety	DOS	2009-10	2010-11	2011-12	Mean
TS-36	15th Oct	0.87	0.86	0.73	0.8
	22nd Oct	1.02	0.92	0.98	1.0
	29th Oct	1.10	1.23	1.14	1.2
	5th Nov	0.99	0.83	1.05	1.0
	12th Nov	0.81	0.69	0.83	0.8
	19th Nov	0.65	0.57	0.61	0.6
M-27	15th Oct	0.83	0.68	0.68	0.7
	22nd Oct	0.96	0.90	0.94	0.9
	29th Oct	1.03	1.13	1.11	1.1
	5th Nov	0.94	0.81	1.04	0.9
	12th Nov	0.77	0.66	0.75	0.7
	19th Nov	0.60	0.48	0.60	0.6
Over all Mean	0.88	0.81	0.87	0.86	
SD		0.16	0.22	0.20	0.18
CV		0.18	0.27	0.22	0.21
SE		0.17	0.24	0.21	0.20

Table. 4: Phenothermal index (Degree day/growth day) of vegetative and reproductive stage in TS- 36 and M-27

Phenological events	Year	Sowing dates						
		D1	D2	D3	D4	D5	D6	Mean
				TS -36				
Vegetative stage	2009-10	19.43	18.54	17.59	16.34	15.46	14.42	16.96
(sowing to first flower	2010-11	20.02	18.79	17.62	16.70	15.33	13.79	17.04
appearance)	2011-12	15.08	14.44	14.56	14.77	14.49	13.58	14.49
Reproductive stage	2009-10	13.41	13.03	12.79	12.70	12.49	13.24	12.94
(First flower appearance	2010-11	13.08	12.22	12.02	11.89	12.02	12.45	12.28
to maturity	2011-12	12.26	12.02	11.97	12.00	12.22	12.70	12.19
				M-27				
Vegetative stage	2009-10	19.49	18.48	17.42	16.36	15.33	14.42	16.92
(sowing to first flower	2010-11	20.13	18.84	17.42	16.34	15.31	13.79	16.97
appearance)	2011-12	15.05	14.44	14.56	14.68	14.57	13.58	14.48
Reproductive stage	2009-10	13.53	12.98	12.72	12.63	12.56	12.79	12.87
(First flower appearance	2010-11	13.14	12.29	11.86	11.69	11.81	12.24	12.17
to maturity	2011-12	12.34	11.99	11.89	11.95	12.11	12.61	12.15

evident that the TUE was more in the plants sown in early dates indicating the maximum TUE to produce a unit of biomass. This sort of relative assessment could be used to decide the optimum dates of sowing based on thermal time in any given locality depending upon the thermal time. The similar results were obtained by Saha and Ghosh (2012) and Khan *et. al*., (2010).

Phenothermal index

In all the three crop season, Phenothermal index (PTI) varied from 13.58 to 20.13^{0}D/growth day during the vegetative growth period of both the cultivars and in all the sowing dates while, in the reproductive growth stage, it was comparatively lower and ranged from 11.69 to 13.53^{0}D/ growth day in both the cultivars and crop seasons (Table 4). In the vegetative crop growth stage, the PTI was maximum in the crop sown on 15th October and gradually decreased as sowing was delayed. The similar results were also reported by Neog and Chakravarty (2005b). The prevailing high day and night temperatures during early growth stages of plants sown on early dates resulted in higher PTI.

Above ground biomass production

The above ground biomass *i.e.*, totals dry matter production at the maturity in TS-36 varied from 24.59 to 81.59 q ha^{-1}, where as in M-27, it varied from 15.92 to 74.45 q/ha in various sowing dates in the entire three crops seasons. The biomass production was higher in TS-36 as compared to M-27 being highest in the crop sown on 29th October which may due to higher leaf area index and lowest in the crop sown on 19th November. The biomass decreased gradually as the sowing was delayed in both the cultivars and seasons. Relatively shorter vegetative period in case of late sown crops might have caused significant reduction of biomass production in both the cultivars and seasons. The similar results were obtained by Roy and Chakravarty (2007) and Khushu *et. al*., (2008). The biomass was relatively higher in plants sown during second season in TS-36 as compared to the other seasons. In the second season, more rainfall caused early maturity in both the cultivars.

The seed weight (q ha^{-1}) was maximum in the first season as compared to second and third season irrespective of the cultivars and date of sowings. The seed yield was maximum in TS-36 as compared to M-27 due to higher TUE and PTI. Lower TUE and PTI in the crops sown in late conditions was reflected in lower biomass production and lower seed yield in those sowings.

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