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Developement of Yield Predictive Models on the Basis of Thermal Indices for *Brassica Juncea* in Tarai Region of Uttranchal

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Abstract

A field investigation was carried put during *rabi* season of the year 2014 and 2015 at Norman E. Borlaug Crop Research Centre (CRC) of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, (Uttarakhand) in split plot design (SPD) taking three dates of sowing *i.e.* Oct 22, Nov 01and Nov 11 in main plots and five planting geometries *viz.*, 30 × 10 cm, 30 × 20 cm, 30 × 30 cm, 45 × 15 cm and 45 × 30 cm in sub- plots with three replications on the thermal requirement of Indian mustard var. RGN-73 thermal indices; GDD, PTU, HTU and PTI were calculated at different phenological stages of the Indian mustard The crop sown on 22nd October was found to accumulate more thermal units; and among the planting geometries, the wider geometries (30 × 30 cm, 45 × 15 cm and 45 × 30 cm) accumulated more thermal units.

Keywords: *Brassica Juncea*; Sowing Dates; Planting Geometries; Thermal Indices; Yield Predictive Models.

Introduction

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is a crop of tropical as well as temperate zones demanding cool and dry weather for optimum growth and development. High temperature at flowering stage reduces seed yield because of pollen sterility. Mustard is a long day plant requiring 16 h of light period in 24 h cycle,but, flower if it is provided with a cycle of 8 h of light period with 4 h of dark period (short night). It requires to flower in about 50 days under 16/8 h light/dark period.

Growing degree days (GDD), photo-thermal unit (PTU), helios thermal unit (HTU), have frequently been used as a weather based parameters for assessing crop phenology. The GDD is used to quantify effect of temperature and described the timing of different biological process (McMaster and Wilhelm 1997; Qiao-yan et al. 2012). The present investigation was carried out to quantify relationship of GDD, PTU, HTU, with phenological development of crop. The occurance of different phenological events are set within the lifecycle of a plant, but, the duration of a particular stage of growth is directly influenced by temperature within a specified range (Reath and Wittwer, 1952) for a particular species, predictable by using the sum of daily air temperatures. The primary focus for estimating phenology has been the approach of growing degree-days (Nuttonson, 1955). assuming a direct and linear relationship between growth of plants and temperature with every plant having its own threshold or base temperature below which the growth does not take place, This approach has widely applied by scientist in past to correlate the phenological development of different crops to predict maturity days.

Growing degree days (GDD), photo-thermal unit (PTU), helios thermal unit (HTU), for assessing crop phenology. therefore the study was carried out to find out the thermal requirement of mustard crop at different phenological events and *Developement of yield predictive models on the basis of thermal indices for Brassica juncea* in tarai region of Uttranchal.

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Materials and Methods

The investigation was conducted in silty clay loam soil at Norman E. Borlaug Crop Research Centre (CRC) of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar(29°N latitude and 79.3°E longitude with an elevation of 243.83 m from the mean sea leve), during the *rabi* season of the year 2014-15. This region comes under sub-humid and sub-tropical climate with four distinct seasons Having average rainfall of this area is about 1434.4 mm annually with maximum precipitation during the South-West monsoon. The daily meteorological data used for the study (*i.e.* minimum and maximum temperature, bright sunshine hours) were taken from Agrometeorological observatory at Norman E. Borlaug Crop Research Centre of the University.

The experiment was laid out in Split Plot Design taking the plots of 4.2 m × 3.6 m with three replications having three planting dates *viz.* 22nd October, 01st November and 11th November, as main plot treatment and five planting geometries *viz.* 30 × 10 cm, 30 × 20 cm, 30 × 30 cm, 45 × 15 cm and 45 × 30 cm as sub-plot treatment. Indian mustard (*Brassica juncea*) variety RGN-73 was selected for the experiment which is a medium maturing variety and takes 120-151 days to mature (Yadava and Shekhawat, 2007).

Recommended dose of fertilizers for the mustard crop *i.e.* 120 kg N, 40 kg P_2O_5 and 20 kg K_2O per ha were applied through Urea, Single Super Phosphate and Murate of Potash. Phosphorus and potassium were applied at the time of sowing while the nitrogen was applied in three split doses of 40 kg/ha each at sowing, 30 and 60 DAS for all the treatments. The number of days taken to attain various phenophases of mustard was determined visually by daily field inspection.

All the indices were worked out following Singh *et al.* (2014) as given below:

Growing Degree Days (GDD): A degree day (°C day) or heat unit is the departure from the mean daily temperature above a minimum threshold temperature.

$$GDD = \sum \frac{(Tmax + Tmin)}{2} \quad Tb$$

Where, Tmax and Tmin are daily maximum temperature and daily minimum temperature, respectively. Whereas, Tb represents minimum threshold temperature for the crop growth (base temperature). The base temperature at different phenological stages of mustard was taken as 5°C (Adak *et al.*, 2009; Roy *et al.,* 2005; and Singh *et al.*, 2014).

Photo-Thermal Unit (PTU): Photo-thermal unit (PTU) (°C days hours) was calculated on the basis of GDD and day length.

PTU = GDD × Day length

Helios Thermal Unit (HTU): Helios thermal unit (HTU) (°C days hours) was calculated on the basis of GDD and sunshine hours (BSSH).

HTU = GDD × Duration of sunshine hours

Results and Discussion

Daily weather dara is presented oin Table1-2.The crop planted on October 22 consumed more number of days to reach all the phonological stages as compared to the crop planted on November 01 and November 11. due to weather conditions being favorableand lateron the crop showed the effect of forced maturity.

Findings of Nanda *et al.* (1996); Prakash *et al.* (2000); Rabiee *et al.* (2004) and Roy *et al.* (2005) have also shown similar results. Widely spaced plants consumed more number of days to accomplish a particular phenophase than the closely spaced plants due to more competition for the resources Days to 50 % flowering, was recorded maximum for 45 × 30 cm geometry.

Growing degree days	Units accumulated up to germination	Units accumulated up to 50% flowering	Units accumulated up to maturity
Based on sowing dates	Y=0.217X-224.1(R2=0.99)	Y=0.724X-270.7(R2=0.99)	Y=0.165X-12.9(R2=0.769)
Based on planting geometry	Y=-0.027X-196.5(R2=0.45)	Y=-0.045X-804.5(R2=0.68)	Y=-0.067X-196.5(R2=0.54)
Photothermal unit			
Based on sowing dates	Y=3.068X-2691(R2=0.99)	Y=7.907X-3439(R2=0.99)	Y=0.992X+14467(R2=0.486)
Based on planting geometry	Y=-0.304X+2124(R2=0.45)	Y=-0.473X+8354(R2=0.70)	Y=-0.826X+7204(R2=0.57)
Heliothermal units			
Based on sowing dates	Y=0.536X+348.3(R2=0.54)	Y=5.360X-2400(R2=0.45)	Y=0.712X+8970(R2=0.48)
Based on planting geometry	Y=-0.254X+1461(R2=0.55)	Y=-0.154X+5360(R2=0.70)	Y=-0.667X+10911(R2=0.57)

Table 1: Average meteorological data recorded at Pantnagar during mustard growing season from 2014-15

Std week	Tmax (°C)	Tmin (°C)	Relative Humidity Max (%)	Relative Humidity Min (%)	Rainfall (mm)	Sun Shine Hrs	Wind Velocity (Km/hr.)	Evap. (mm)
43	30.9	16.6	85	55	0	1.7	5.3	2.5
44	28.5	13.1	91	46	0	1.8	4.3	2.6
45	29.2	12.8	91	46	0	2.7	8.2	2.5
46	27.9	9.5	94	34	0	2.7	7.7	2.9
47	26.3	8.6	92	38	0	2	8	2.4
48	26.2	8.7	92	41	0	2.3	7.9	2.3
49	24.3	9.9	94	49	0	2	4.9	1.8
50	20.8	8.2	91	57	5.7	5.3	4.3	2.1
51	16.8	7.4	96	78	0	3.9	4.1	1.2
52	18.5	4.9	95	57	0	3.4	5.2	1.1
1	19.1	11.5	93	77	3.1	6	2.8	1.4
2	15.7	8.4	95	75	0	3.5	3	0.8
3	15.8	8.1	95	71	0	3.4	2.5	1.2
4	18.4	8.6	95	75	1.6	4.8	3.6	1.2
5	18.4	8.1	88	62	0	6	4	1.5
6	22.4	7.4	94	54	0	3.9	7	2.1
7	23.2	9.7	88	51	0	3.9	5.7	2
8	27.1	13.4	90	55	0	3.3	5.5	2.1
9	23.3	13	92	61	9.7	6.3	4.4	2.8
10	25.2	10.2	89	45	0	5.8	8.8	2.9
11	26.9	12.7	90	51	0.2	5	6.6	2.9
12	29.3	13.7	88	45	0	4.6	9.5	3.5
13	31.3	17.7	85	46	3.7	5.1	7.7	4.3
14	29.2	15.8	90	48	2.7	5	6.4	3.7

Table 2: Average meteorological data recorded at Pantnagar during mustard growing season from 2015-16

Std week	Tmax (°C)	Tmin (°C)	Relative Humidity Max (%)	Relative Humidity Min (%)	Rainfall (mm)	Sun Shine Hrs	Wind Velocity (Km/hr.)	Evap. (mm)
43	31.2	13.9	88	48	0	8.7	3	4
44	29	13.7	90	43	5	6.2	2.9	3
45	28	12.1	91	43	2	6.6	3	2.5
46	29	11.9	91	38	0	7.8	2.8	2.7
47	27.7	11.3	92	41	0	7.2	1.6	2.3
48	26.7	12.6	91	46	0	3.7	2.7	2.1
49	24.6	10.2	96	49	0	1.8	2.3	1.6
50	21.1	10.3	94	64	0	2.1	4.3	1.3
51	20.5	4.6	96	50	0	5.3	2.5	1.5
52	21	5	95	46	0	6.1	3	1.5
1	23.6	6.9	92	39	0	6	2.7	1.5
2	22.3	7	94	49	0	4.3	3.3	1.7
3	17.4	6.6	94	64	0	2.3	4.6	1.4
4	17.9	4.1	94	53	0	3.3	3.2	1.3
5	22.2	6.8	96	48	0	4.8	5.3	1.9
6	23.3	8.3	93	46	0	5.4	3.7	2.4
7	26.4	9.4	82	32	0	6.8	5.5	3.1
8	26.4	11.8	87	44	2.5	4.6	6.3	2.9
9	28.8	12.1	88	37	0	7.4	3	3
10	30.4	13.4	86	37	0	8.4	6.1	4.2
11	29.1	13.5	83	37	0.9	7.1	7.7	4.7
12	31.3	14	80	28	0	8.8	6.6	4.7
13	33.7	16	78.4	32.3	0	7	5.1	4.8
14	35.6	20.4	64.9	31.6	0	6.9	6	6.7

Growing Degree Days

The data pertaining to accumulated heat units in different treatments are presented in Figure 2. The GDD accumulation was considerably highest in D_1 (1513.35 day °C) than other sowing dates and in G5 (1500.05 day °C). The minimum GDD was accumulated in D_3 and in G1 treatment. The GDD accumulation was highest in D_1 due to longer

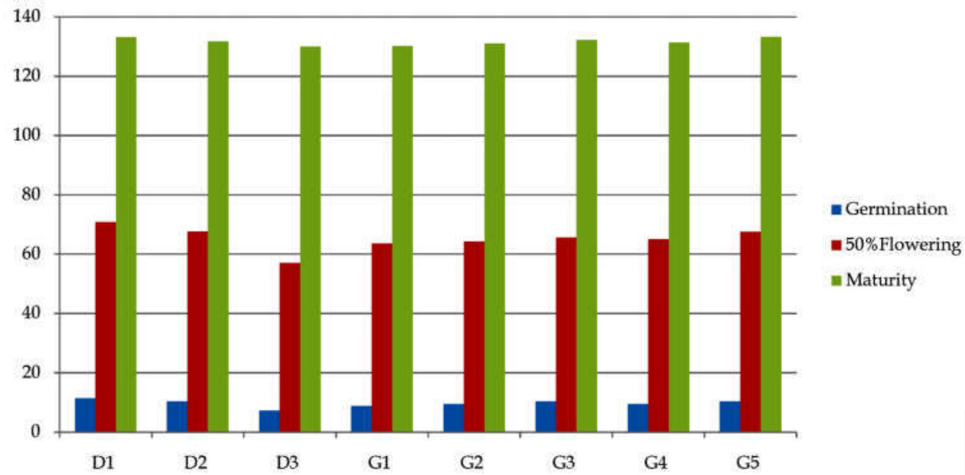

Fig. 1: Days taken to attain various phenophases of the crop during 2014-15 and 2015-16 (pooled)

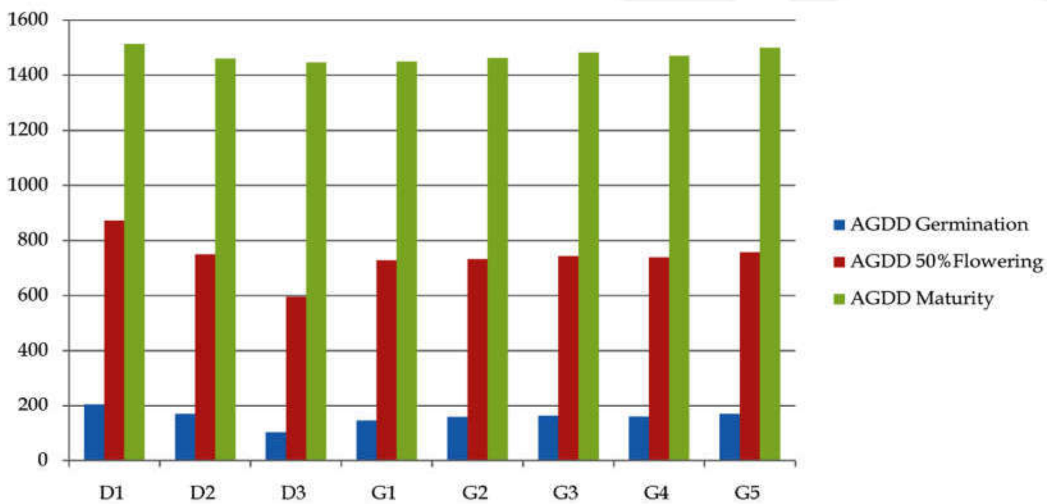

Fig. 2: Total heat units (GDD) required to attain various phenophases as influenced by dates of sowing and spacing of the crop during 2014-15 and 2015-16 (pooled)

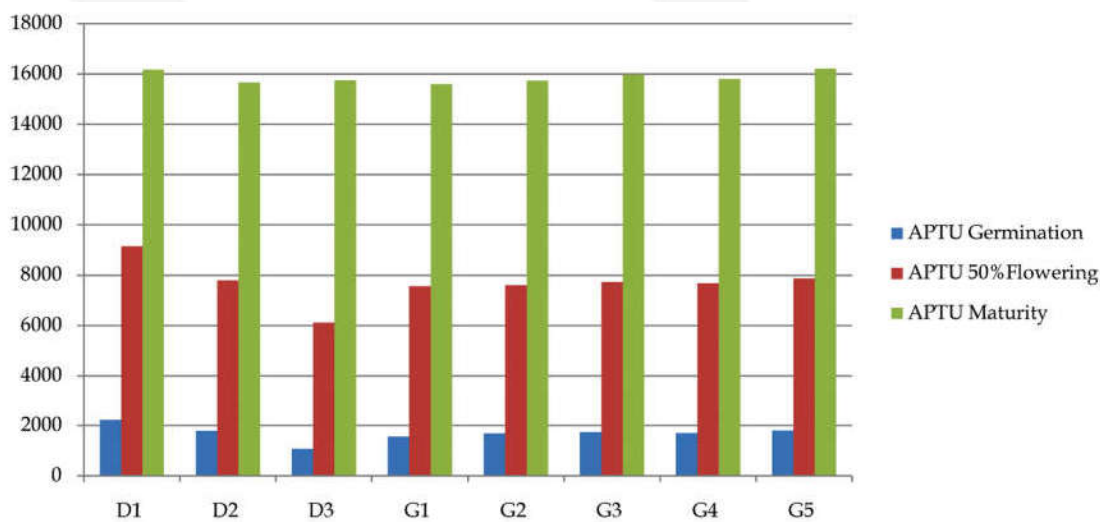

Fig. 3: Total Photothermal units required to attain various phenophases as influenced by dates of sowing and spacing of the crop during 2014-15 and 2015-16 (pooled)

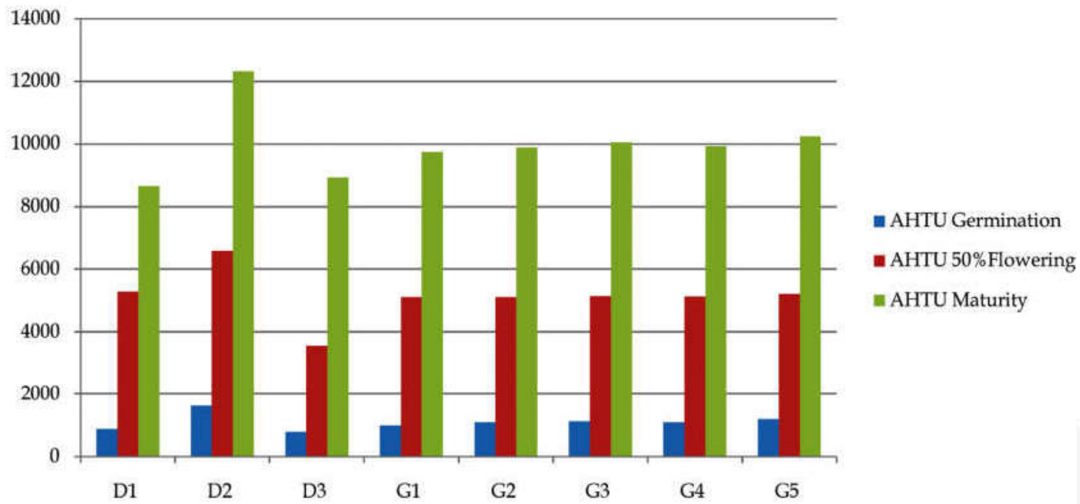

Fig. 4: Total heliothermal units required to attain various phenophases as influenced by dates of sowing and spacing of the crop during 2014-15 and 2015-16 (pooled)

duration of crop growing period and lowest in D_3 sowing due to forced maturity caused by increase in temperature. The Decrease in GDD may be due to Decrease in the maturity period of the crop. The decrease in GDD with delayed sowing has also been reported by Kumari *et al.* (2012) and Roy *et al.* (2005).

Photothermal Unit

The photothermal unit (PTU) under various sowing dates is presented in the Figure 3. The highest PTU was obtained by D_1 (16174° day hrs) followed by D_2 And D3 among the sowing dates and in G5 (16203° day hrs) among spacings.

Heliothermal Units

The accumulated heliothermal unit (HTU) under various sowing dates is presented in the Fig-4. Different sowing dates considerably influenced heliothermal unit (HTU). The D2 accumulated maximum heliothermal units (12326°day hrs) to reach maturity stage and in G5(12326°day hrs) among spacings.

Yield predictive models developed based on thermal indices on the pooled data.

Conclusion

The pooled results of 2014-15 and 2015-16 rabi season indicates that the mustard var. RGN-73 requires almost 1510-1580 °C days GDD units and 115-135 days to reach maturity. The crop sown on 22nd October was superior in terms of accumulation of most of the thermal indices over other dates. yield predictive models on the basis of thermal indices for *Brassica juncea* can predict the yield to a considerable accuracy and may be used on the field basis.

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