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Parameterization and validation of BRASSICA model for *Brassica juncea* in semi arid environment

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ABSTRACT

Field experiments were conducted on sandy loam soil of research farm of IARI, New Delhi during *rabi* 2001-02 and 2002-03 for evaluating and validating a dynamic simulation model 'BRASSICA' in two *Brassica juncea* cultivars *viz.* Pusa Jaikisan and Varuna grown under different thermal environments. Physiological ages of both the cultivars for different sowing times were standardized using field data generated during *rabi* 2001-02. The model was calibrated using the parameterized values for physiological age and other crop parameters generated in the first crop season. The calibrated model was then used to simulate the crop growth parameters and validated for the data generated in the second crop season. The deviation of observed and predicted days of occurrence of different phonological events varied from -5 to +3 and +3 to +8 days in case of Pusa Jaikisan and Varuna, respectively. The model also predicts the biomass production with accuracy of ±3 percent in the crop sown early as well as normal sowing time. However simulated biomass was substantially higher than the observed one in case of late sowing conditions.

Key words: *Brassica juncea*, BRASSICA model, physiological age.

Crop simulation studies play a significant role in assessing the potential of any crop. Rao (1992) developed a process oriented dynamic simulation model BRASSICA retaining some features from PNUTGRO (Boote *et al.*, 1989) and SOYGRO (Wilkerson *et al.*, 1985) model under non limiting moisture and nutrient conditions to predict potential yield under varying thermal and radiation regimes.

Various workers (Kushuwaha and Rai, 1999; Pandey and Shekh, 1999; Singh *et al.*, 2001) tested this model in different agroclimatic zones of India and they concluded that different crop specific variables and coefficients needed to be changed to suit local genotypes and environments.

Presently an attempt has been made to work out crop specific variables such as threshold physiological age, maximum specific leaf area, threshing

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percentage etc. for two *brassica* cultivars-Pusa Jaikisan and Varuna and validate the BRASSICA model for the Delhi region.

MATERIALS AND METHODS

Field experiments were conducted in two *rabi* seasons (2001-02 and 2002-03) at research farm of Indian Agricultural Research Institute, New Delhi (28°35'N, 77°10'E and 288.7 m AMSL). The climate of the station is semi arid with hot dry summers and cold winters. Over the two growing seasons, the maximum and minimum temperatures were higher during pod initiation to pod maturity period in the first crop season as compared to the second crop season. However, rainfall was much higher in the second crop season as compared to the first crop season.

Two cultivars of *Brassica juncea viz.* Pusa Jaikisan and Varuna were sown on ten different dates at the interval of 7 days starting from 1st October in randomized block design with two replications following the recommended agronomic practices. Different phenological events *viz.* emergence, first flower appearance, 50% flowering, 90% podding, end of seed filling and physiological maturity were identified by observing the plants on alternate days. Plant samples (three continuous plants from a row) were collected randomly from each plot at 7 to 10 day intervals starting from 30 days after sowing and oven dried at 80°C for more than 48 hours for constant weight. Final biomass was taken at the physiological maturity of the crop.

A dynamic simulation model BRASSICA developed by Rao, (1992) was used in the present study to simulate phenological development and biomass production of Pusa Jaikisan and Varuna. Physiological ages of the two mustard cultivars were parameterized by iteration method. The threshold physiological ages as well as other crop specific parameters of Pusa Jaikisan and Varuna were determined and parameterized from field experiments conducted during *rabi* 2001-02 for early (1st to <15th Oct), normal (15th to 30th Oct), late (1st to 20th Nov) and very late (>20th Nov) sown crops. The model was calibrated with the first season data and validated for these four sets of sowings for both the cultivars.

RESULTS AND DISCUSSION

Parameterization of BRASSICA model

The timing of major phenological events and hence the duration of intervening phases is determined in the BRASSICA model primarily by the physiological age of the crop reaching a particular threshold value related to thermal time. It is assumed that physiological age depends upon ambient air temperature with a response function having a weightage of unity between 15 to 30°C and decreased linearly to zero at 5 and 40°C. The daily increment in their physiological age was made using hourly temperatures. The threshold physiological ages for different phenological stages of two cultivars for early, normal, late and very late sown crops are presented in Table 1, where PHTHRS represents physiological

Table 1 : Parameterized physiological age of Pusa Jaikisan and Varuna for BRASSICA model

Coefficients	Physiological age (days)							
	Early sowing		Normal sowing		Late sowing		Very late sowing	
	Pusa Jaikisan	Varuna	Pusa Jaikisan	Varuna	Pusa Jaikisan	Varuna	Pusa Jaikisan	Varuna
PHTHRS (1)	6.0	6.2	6.2	6.5	5.5	5.6	5.4	5.4
PHTHRS (2)	8.3	8.5	8.5	8.7	8.1	8.1	8.1	8.1
PHTHRS (3)	25.5	26.3	25.0	27.0	22.2	24.8	21.6	22.8
PHTHRS (4)	2.7	4.0	3.0	3.8	2.8	3.2	2.9	3.3
PHTHRS (5)	26.0	26.3	21.3	22.2	18.5	18.9	16.5	16.5
PHTHRS (6)	33.0	36.0	26.8	28.5	20.9	23.3	18.5	19.8
PHTHRS (7)	48.9	49.4	40.3	42.8	35.4	36.1	30.8	31.7
PHTHRS (8)	57.8	60.5	51.3	52.7	45.1	45.7	38.0	40.8
SIZLF	140.0	115.0	155.0	125.0	140.0	100.0	130.0	90.0
SLAVAR	280.0	250.0	280.0	265.0	276.0	248.0	263.0	238.0
THRESH	54.0	54.5	54.0	55.0	53.0	54.0	55.0	55.0

threshold age for (1) emergence from sowing, (2) beginning of leaf emergence from sowing, (3) first flower appearance from sowing, (4) 50% flowering from first flower, (5) start of seed filling from first flower, (6) end of leaf elongation from first flower, (7) end of pod area increment from first flower and (8) physiological maturity from first flower. Other plant parameters like SIZLF (area of 8 to 10th leaf of main stem during flowering), SLAVAR (maximum specific leaf area of the variety) and THRESH (threshing percentage- seed to pod weight ratio) were also included in the table.

The values parameterized as above for Pusa Jaikisan and Varuna for different sowing were utilized to calibrate the model.

Validation of BRASSICA model

The calibrated model was used to simulate the crop growth parameters and validated for the data generated in the second season.

It was observed that in both the cultivars the model predicted the time of occurrence of different phenological events with reasonable accuracy (Table 2). The deviation of observed values from the simulated values varied from -5 to +3 and -3 to +8 days in Pusa Jaikisan and Varuna, respectively. In the first two stages, the simulated values were found to be very close. The higher deviation of the order of 5 to 8 days observed at 90 percent podding and end of seed filling could be due to manual error in determining these stages accurately.

It was observed that the differences between simulated and observed biomass were marginal in early

Table 2: Observed (O) and simulateds (S) days taken to reach various phenological stages of Pusa Jaikisan and Varuna

Phenological events	Early sowing		Normal sowing		Late sowing		Very late sowing	
	O	S	O	S	O	S	O	S
Pusa Jaikisan								
Emergence	6	6 (0)	6	6 (0)	7	6 (-1)	9	10 (+1)
1st flower	38	37 (-1)	43	44 (+1)	52	53 (+1)	63	65 (+2)
50% flowering	43	41 (-2)	52	49 (-3)	65	60 (-5)	69	71 (+3)
90% podding	79	77 (-2)	87	87 (0)	91	94 (+3)	92	91 (-1)
End of seed filling	126	129 (-3)	127	124 (-3)	120	117 (-3)	112	109 (-3)
Maturity	140	143 (+3)	140	139 (-1)	130	129 (-1)	121	117 (-4)
Varuna								
Emergence	6	6 (0)	7	6 (-1)	8	7 (-1)	9	10 (-1)
1st Flower	39	38 (-1)	45	47 (+2)	59	59 (0)	65	67 (-2)
50% flowering	46	43 (-3)	52	54 (+2)	71	68 (-3)	74	73 (+1)
90% podding	79	79 (0)	87	95 (+8)	97	98 (+1)	93	92 (+1)
End of seed filling	126	131 (+5)	127	130 (+3)	123	121 (-2)	113	112 (+1)
Maturity	147	147 (0)	143	143 (0)	135	132 (-3)	124	121 (+3)

Table 3: Observed and simulated final biomass of Pusa Jaikisan and Varuna during *rabi* 2002-03

Sowing	Pusa Jaikisan			Varuna		
	Observed ($g\ m^{-2}$)	Simulated ($g\ m^{-2}$)	Deviation (%)	Observed ($g\ m^{-2}$)	Simulated ($g\ m^{-2}$)	Deviation (%)
Early	1117	1142	+2.2	996	1076	+8.0
Normal	1230	1240	+0.8	1172	1206	+2.8
Late	858	928	8.2	757	880	+16.3
Very late	531	746	+40.5	458	701	+53.1

and normal sown crops in both the cultivars. However, in late sown and very late sown crops, simulated biomass was substantially higher than the observed biomass in both the cultivars. The overestimation of biomass by the model may be attributed to the damage caused by white rust disease and aphid infestation observed in late and very late sown conditions, which were not accounted for in the model. Probably incorporating a sub routine programme giving weightage for pest and diseases in the model might improve prediction especially in late and very late sown crops, which were affected by pest and diseases.

Thus it can be concluded that the model calibrated could predict accurately the time of occurrence of phenological events in both the cultivars and the biomass production with an accuracy of ±3 percent in the early as well as normal sown crops.

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