J. Phytol. Res. **19**(2) :275-279, 2006

LEAF APPEARANCE AND CHLOROPHYLL CONTENT IN INDIAN MUSTARD (*BRASSICA JUNCEA* L.) UNDER DIFFERENT CROP GROWING ENVIRONMENTS

M. K. TRIPATHI, V. U. M. RAO, DIWAN SINGH and RAJ SINGH
Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar-125 004, India.

A field experiment was conducted during two consecutive crop seasons (*rabi*) of 2002-03 and 2003-04 at Agricultural Meteorology Research Farm, CCS Haryana Agricultural University, Hisar to study the leaf appearance and chlorophyll content in Indian mustard *cv.* Laxmi sown under different growing environments comprising of sowing dates and in-season growth manipulations. The earliest sown crop (October 5: S_1) took least days to emerge leaves as compared to later sown crops (October 20: S_2) and (November 5: S_3). Amongst the in-season growth manipulation treatments, the days taken to leaf emergence were erratic and non-significantly differed. A positive correlation was noted between leaf chlorophyll content and seed yield.

Keywords: *Brassica juncea;* Chlorophyll; Growing environments; Growth manipulation; Indian mustard; Leaf appearance.

Introduction

Among different climatic factors, temperature and photoperiod are the most dominant factors and they greatly influence the rate of various growth processes and, thereby the times of appearance of different plant parts, and their development. Bose[1] reported that higher temperatures under short-day conditions were responsible for development of large number of leaves on main stem. Besides morphological characters, the physico-biochemical process *viz.*, photosynthesis is influenced by the duration and intensity of light, temperature and chlorophyll content. The green plants utilize light energy produce *i.e.* photosynthates. Sowing time is the main factor which decides the environmental conditions of a crop, timing and rate of organ appearance. The concept of heat units had long been in use to study the phenological development of different crops. Patel and Mehta[2] concluded that the subsequent phenophases of *Brassica juncea* appeared after accumulating certain amount of heat units over the previous phenophases. The purpose of present study is to quantify the thermal requirement for leaf appearance and subsequently the total leaf chlorophyll content under different growing environments.

Materials and Methods

A field study on Indian mustard *cv.* Laxmi was conducted during two consecutive winter crop seasons of 2002-03 and 2003-04 at Agricultural Meteorology Research Farm, CCS Haryana Agricultural University (29° 10'N Lat.; 75°46'E Long. and altitude of 215.1 m a.s.l). The study was conducted in split plot design with four replications and comprised of three sowing dates *viz.*, October 5 (S_1), October 20 (S_2) and November 5 (S_3) in main plots and seven in-season growth manipulations *viz.*, control or no manipulation (L_1), main shoot cut-off at 15 cm on 40 DAS (L_2), main shoot cut-off at 15 cm on 50 DAS (L_3), 1st primary branch cut-off on 55 DAS (L_4), 2nd primary branch cut-off on 60 DAS (L_5), plant defoliated to 50 cm above ground on 60 DAS (L_6) and plant defoliated to 50 cm above ground on 75 DAS (L_7) in sub-plots. The crop was grown following the recommended package of practices. The appearance of leaves was recorded on main stem when each leaf emerged out and attained a size of 2 cm. The average daily temperatures above a base temperature represent the heat units and were calculated using the following expression:

$$HU = \sum \frac{T_{max} + T_{min}}{2} - T_b \,°C$$

Where, T_{max} and T_{min} represents the daily maximum and minimum temperature (°C) and T_b is the base temperature. For *Brassica* species, T_b was taken as 5 °C following Morrison *et al.*[3]. The total chlorophyll content was calculated at 50 per cent flowering, 100 per cent flowering, start of seed filling and end of seed filling growth stages. The chlorophyll content was calculated employing the Sawhney and Singh[4] method. Leaf discs were washed and blotted dry and then dipped in DMSO (dimethyl sulphoxide) overnight. The absorbance of the solution was recorded next day at 645 and 663 nm, respectively and the values were added to find out the amount of total chlorophyll.

Table 1. Effect of treatments on days taken for appearance of leaves on main stem in mustard over two crop seasons.

Treatments	First Leaf		Second Leaf		Third Leaf		Fourth Leaf		Fifth Leaf	
	02-03	**03-04**	**02-03**	**03-04**	**02-03**	**03-04**	**02-03**	**03-04**	**02-03**	**03-04**
Sowing dates										
S_1	8.38 (187)	8.6 (175)	11.2 (243)	11.7 (231)	14.5 (320)	15.2 (302)	17.7 (377)	18.0 (350)	21.9 (452)	22.0 (419)
S_2	9.25 (163)	9.6 (154)	12.8 (226)	13.4 (220)	16.2 (304)	16.6 (291)	19.3 (353)	19.7 (338)	23.9 (417)	24.1 (374)
S_3	11.21 (152)	11.3 (138)	14.7 (211)	15.0 (202)	17.9 (273)	18.2 (264)	21.0 (306)	21.4 (289)	26.8 (364)	27.0 (324)
CD (5%)	0.28	0.40	0.51	0.39	0.32	0.40	0.45	0.47	1.20	0.76
Growth manipulations										
L_1	9.3 (167)	9.7 (157)	12.7 (227)	13.3 (219)	16.1 (296)	16.7 (284)	19.1 (343)	19.6 (329)	23.8 (403)	24.4 (377)
L_2	9.6 (168)	9.9 (155)	12.7 (227)	13.3 (215)	16.3 (299)	16.7 (289)	19.1 (343)	19.7 (325)	24.4 (413)	24.2 (377)
L_3	9.4 (165)	9.6 (155)	12.7 (227)	13.3 (219)	16.3 (301)	16.7 (286)	19.6 (346)	19.7 (324)	24.2 (411)	24.3 (370)
L_4	9.7 (169)	10.0 (157)	12.8 (232)	13.2 (217)	16.3 (296)	16.6 (286)	19.7 (348)	19.8 (329)	24.6 (417)	24.1 (373)
L_5	9.7 (169)	9.9 (155)	13.2 (224)	13.6 (220)	16.1 (299)	16.6 (283)	19.6 (346)	19.9 (322)	23.9 (407)	24.7 (373)
L_6	9.5 (168)	9.7 (155)	13.2 (225)	13.5 (216)	16.2 (299)	16.8 (286)	19.2 (346)	19.7 (326)	24.7 (417)	24.4 (368)
L_7	9.8 (165)	10.0 (155)	13.0 (227)	13.3 (217)	16.1 (302)	16.7 (285)	19.1 (346)	19.5 (326)	23.8 (409)	24.4 (367)
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Values in parenthesis are corresponding heat units

Contd.—

Table 1 contd.

Treatments	Sixth Leaf		Seventh Leaf		Eighth Leaf		Ninth Leaf		Tenth Leaf	
	02-03	**03-04**	**02-03**	**03-04**	**02-03**	**03-04**	**02-03**	**03-04**	**02-03**	**03-04**
Sowing dates										
S_1	24.8	25.1	28.	29.6	32.9	33.3	36.3	36.7	41.0	41.5
	(494)	(477)	(536)	(523)	(557)	(542)	(623)	(613)	(678)	(655)
S_2	27.4	28.0	31.7	32.2	35.8	36.5	39.7	40.1	44.0	44.3
	(469))	(456)	(517)	(508)	(530)	(525)	(579)	(571)	(616)	(611)
S_3	30.5	31.0	34.8	35.3	38.5	39.0	43.6	44.1	46.9	47.4
	(407)	(378)	(451)	(415)	(496)	(492)	(539)	(523)	(568)	(541)
CD (5%)	0.65	0.35	0.53	0.52	0.48	0.74	0.40	0.45	0.81	0.59
Growth manipulations										
L_1	27.7	28.2	31.7	32.4	35.7	36.3	40.0	40.5	43.6	44.2
	(458)	(437)	(499)	(483)	(528)	(518)	(579)	(569)	(620)	(602)
L_2	27.6	27.8	31.7	32.3	35.5	36.3	—	—	—	—
	(457)	(438)	(508)	(481)	(528)	(518)				
L_3	27.4	28.0	31.7	32.2	35.7	36.5	39.7	40.2	44.3	44.7
	(456)	(436)	(505)	(482)	(527)	(520)	(581)	(569)	(620)	(605)
L_4	27.7	28.0	31.7	32.5	36.0	35.8	39.7	40.2	44.0	44.4
	(559)	(438)	(501)	(479)	(528)	(518)	(582)	(570)	(622)	(602)
L_5	27.6	28.1	31.3	32.2	35.8	36.2	39.9	40.3	42.9	44.2
	(457)	(438)	(497)	(482)	(527)	(520)	(580)	(569)	(621)	(604)
L_6	27.7	28.1	31.7	32.1	35.5	36.4	40.1	40.5	44.2	44.6
	(457)	(438)	(498)	(483)	(527)	(521)	(579)	(568)	(621)	(600)
L_7	27.5	28.2	31.9	32.6	36.0	36.5	39.9	40.2	44.1	44.4
	(455)	(434)	(500)	(483)	(528)	(519)	(582)	(568)	(620)	(603)
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Values in parenthesis are corresponding heat units

Table 2: Effect of treatments on chlorophyll content (mg g^{-1}) of leaf at different phenophases in mustard during two crop seasons.

Treatment	50% flowering		100% flowering		Start of seed filling		End of seed filling	
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04
Sowing dates								
S_1	4.02	3.80	3.90	3.74	3.32	3.15	1.42	1.24
S_2	3.98	3.77	3.73	3.64	3.12	3.03	1.39	1.23
S_3	3.04	2.91	2.84	3.70	2.58	2.46	1.14	1.10
CD (5%)	0.06	0.09	0.15	0.31	0.31	0.17	0.03	0.08
Growth manipulations								
L_1	4.31	4.04	3.71	3.61	3.23	3.05	1.32	1.23
L_2	2.61	2.56	3.08	2.99	2.59	2.56	1.30	1.18
L_3	1.83	1.77	2.95	2.77	2.14	2.15	1.27	1.14
L_4	4.26	4.04	3.70	3.62	3.22	3.03	1.32	1.19
L_5	4.24	3.97	3.70	3.61	3.32	3.11	1.30	1.20
L_6	4.27	4.01	3.61	3.42	3.28	3.05	1.32	1.22
L_7	4.26	4.02	3.69	3.48	3.29	3.10	1.32	1.19
CD (5%)	0.12	0.08	0.23	0.36	0.16	0.18	NS	NS

Table 3. Correlation coefficient (r) between total chlorophyll content at different phenological stages and seed yield.

Phenological stages	r
50% Flowering (50% F)	0.64**
100% Flowering (100% F)	0.81**
Start of seed filling (SSF)	0.80**
End of seed filling (ESF)	0.84**

** Significant at P=0.01

Results and Discussion

The bright sunshine period at sowing time declined from 10.1 to 8.4 h day^{-1} and 9.4 to 8.9 h day^{-1} at successive sowing dates, similarly the mean daily temperature also declined from 28.8 to 21.9 °C and 24.5 to 24.0 °C respectively, in first and second year of study (2002-03 and 2003-04). Due to shortening of bright sunshine period and fall in temperature under S_2 and S_3 crops, longer time was taken for emergence of leaves (Table-1) as compared to the early sown crop (S_1). These results are in conformity with those reported by Nanda *et al.*[5]. The sowing dates significantly influenced the accumulated heat unit requirement to leaf appearance. The highest heat units were accumulated in S_1 followed by S_2 and S_3, respectively. Angus *et al.*[6] also observed that the rate of development of most of crop species depends upon photoperiod as well as the temperature.

Amongst the growth manipulation treatments, the leaf emergence was erratic (Table-1) showing no specific and significant difference. When the normal crop (control) attained 9th leaf stage, the L_2 (leaf cut-off) treatment had already been administered and therefore, the leaf emergence could not be analyzed in L_2 treatment. However, other treatments at this stage were non-significant. The accumulated heat units or growing days also followed a similar pattern under different growth manipulation treatments.

The total chlorophyll content in leaves at different phenophases of crop over two crop seasons was estimated and the results pertaining are presented in Table 2. It was observed that at 50% F stage, the chlorophyll content was significantly higher in S_1 and S_2 as compared to S_3. The higher value of chlorophyll content in early sowing may be due to warmer growing environment, which supported better plant physiological characters. However under late sown conditions the temperature declined during grand growth period. The reduction in temperature during vegetative and flowering phases may have effect on chlorophyll content. It was also observed that the total chlorophyll content values declined from 50% F to ESF stage in all sowing dates. These results are in conformity with those reported by Elf and Ohlsson[7].

Amongst the growth manipulation treatments, it was observed that from 50% F stage to SSF stage, the chlorophyll content in L_2 and L_3 treatments were significantly lower than other treatments. The low chlorophyll contents in L_2 and L_3 was because of relatively younger leaves which emerged after cut-off operations where as in the remaining treatments the leaves were of quite older age and thus rich in chlorophyll. Chongo and McVetty[8] also observed that the chlorophyll content increased with age of leaves. By the time crop approached the end of seed filling phase, the effect of in-season growth manipulation on chlorophyll content has already vanished since the leaves have grown older in L_2 and L_3 treatments and had become rich in chlorophyll and hence become non-significant.

The correlation coefficients (r) were worked-out between seed yield and chlorophyll content at different growth stages. The study showed (Table-3) a significant and positive association of seed yield with chlorophyll content during the reproductive phase comprising of period from flowering to seed development phases (50% flowering, 100% flowering, start of seed filling and End of seed filling). The dependence of seed yield on chlorophyll content is obvious since for assimilation of photosynthates (by process of photosynthesis) the chlorophyll is a pre-requisite. Similar results have earlier been reported by Ilmulwar *et al.*[9] for mustard crop.

References

1. Bose T K 1973, *Indian Agriculturist* **171** 75-80.
2. Patel J G and Mehta A N 1987, *Int. J. Ecol. Environ. Sci.* **13** 105-115
3. Morrison M J, Mcvetty P B E and Scarth R 1990, *Can. J. Plant Sci.* **70** 139-149.
4. Sawhney V and Singh D P 2002, *Field Crop Res.* **77** 1-6.
5. Nanda R, Bhargava S C and Rawson H M 1995, *Field Crop Res.* **42** 125-134
6. Angus J F, Mackenzie D H, Morton R and Schafer C A 1981, *Field Crop Res.* **4** 269-283.
7. Elf S and Ohlsson I 1987, In: 7th International Rapeseed Congress, Poznan, Poland, 11-14 May, 1987
8. Chongo G and McVetty P B E 2001, *Can J. Plant Sci.* **81** 1-6.
9. Ilmulwar S R, Hatmode C N, Deotale R D, Basole V D, Mahalle S N and Pawar P S 2003, *J. Soil and Crop* **13** 158-161.