BIOLOGIA PLANTARUM 37 (1): 139-142, 1995

BRIEF COMMUNICATION

Plastochron index in relation to water stress in cowpea

B.M. JAMADAGNI, R.B. PATIL AND S.P. BIRARI

Department of Botany, Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, PIN-415 712, India

Abstract

Plastochron index (PI) in two genotypes of cowpea (*Vigna unguiculata* L. Walp) showed a remarkable sensitivity to water stress. A linear expression PI = 4.6179 + 0.7451 S ($r^2 = 0.93$) summarised the degree of sensitivity and predictability of PI to different stress levels (S). PI could be regarded as a stress sensitive trait in cowpea.

Key words: stress sensitivity, *Vigna unguiculata*

PI is considered as a sensitive developmental scale and has been extensively used for various physiological studies (Lamoreaux *et al.* 1978). It's use for field projects has received less attention. The estimation of PI is based upon relative size of succeedingly emerged leaves on main shoot. In fact, initiation and elongation of leaves is known to be very sensitive to water stress (Hsiao *et al.* 1985). However, information on PI in relation to water stress is very meager (Silk 1980, Vendeland *et al.* 1982). The current investigation is aimed to understanding the behaviour of PI under different degrees of water stress and to seek the scope for its use in the area of stress physiology of field crops.

The investigation was undertaken during post monsoon season of 1988-89 at Research Farm, Department of Botany, Konkan Krishi Vidyapeeth, Dapoli (Maharashtra). The soil of the experimental site was lateritic having moisture at field capacity between 27.50 and 30.10 %, and that at permanent wilting point in the range of 16.16 to 18.10 % with an infiltration rate of 4.4 cm h^{-1} (Dongale *et al.* 1987). Two cowpea cultivars VCM-8 and C-152 were used. The high infiltration rate caused a reduction in soil moisture to the permanent wilting point within a period of about 20 d from irrigation. Therefore, the irrigation intervals of 7, 14, 21, 28 and 35 d could create water stress for increasing periods and strengths which on the basis of the response of crop growth were denoted as zero, mild, moderate, strong and severe, respectively (Hsiao 1973). Ten treatment combinations (two cultivars and five stress

Received 3 November 1993, *accepted* 4 May 1994.

levels) were replicated thrice in a randomised block design. Linear measurements of succeedingly emerged leaves were recorded regularly on three randomly selected plants of each genotype in each stress treatment. PI was estimated by the formula:

$$PI = n + (\log L_n - \log R)/(\log L_n - \log L_{n+1})$$

where n is the serial number of the youngest leaf the length of which exceeds reference value R (10 mm) and L_n and L_{n+1} are the lengths of leaves n and n+1 (Erickson and Michelini 1957).

Both the genotypes developed more or less uniformly under all the stress treatments and reached the PI value of 3.05 to 3.50 during initial 13 to 17 d (Table 1). Under stress free condition, attainment of fourth PI occurred within 14 and 15 d in both the genotypes. In C-152, it was delayed by 2 to 3 d under mild, moderate and strong stress condition and by 4 d under severe stress. In VCM-8 it was delayed by 3 to 4 d under mild and moderate stress and by 5 d under strong and severe stress. Attainment of fifth PI appeared to be a crucial point in respect of the sensitivity to water stress. The duration for fifth PI was 20 to 21 d in zero stress, 23 d in mild stress and 24 d under moderate stress in both the genotypes. Under strong stress, it took 34 d for C-152 and 37 d for VCM-8. In severe stress, it occurred within 38 to 39 d in both the genotypes. Importantly C-152 could not produce any more leaves beyond fifth PI under severe stress, whereas VCM-8 stopped producing leaves at fifth PI in strong as well as severe stress condition. The cessation of growth at fifth PI may be regarded as an indication of strong and severe stress which occurs within period of 37 to 39 d after sowing in both the genotypes. Within this period mild and moderate stressed plants reached more than 8 plastochron units, whereas control plants approached 13 PI in both the genotypes.

The changes in PI against chronological age within each of the stress treatments were linear and very much predictable (Table 2). Highest and almost identical rates of plastochron development were noticed in both the genotypes under stress free condition (0.2772 to 0.2788 PI d^{-1}). VCM-8 showed parallel rates of plastochron development under mild and moderate stress (0.190 and 0.189 PI d^{-1}). C-152 showed relatively better rate of plastochron development (0.21 PI d^{-1}) under moderate stress than in mild stress. Noticeably low but closer rates of development were seen in strong and severe stresses (0.1129 and 0.1181 PI d^{-1} respectively) in VCM-8. Under strong stress the rate of development was higher in C-152 (0.129 PI d^{-1}) than in VCM-8. In severe stress C-152 showed very diminutive rates of development (0.096 PI d^{-1}).

The rates of PI development against the quantity of water received also showed a great predictability in both the genotypes. Importantly, the values of regression of PI against the amount of water received were very close to each other in both the genotypes. The linear expression PI = 4.618 + 0.745 S (r^2 = 0.93) summarised the dependence of PI per amount of water (S) received by the plants.

Several efforts have been made to identify a single character which could serve as a basis of selection for drought resistance (Sinha 1986). Accumulation of proline, betaine, abscisic acid, osmo-regulatory mechanisms *etc.* were claimed to be the traits having utility in screening for drought resistance (Nash *et al.* 1982, Quarrie 1981).

Table 1. Plastochron index (PI) and corresponding chronological age in days during the course of crop growth under different irrigation intervals in two varieties of cowpea.

	Irrigation intervals [d] 7		14		21		28		35	
	PI	Age [d]	PI	Age [d]	PI	Age [d]	PI	Age [d]	PI	Age [d]
Genotype C-152	2.00	4	2.00	5	2.00	5	2.00	4	2.00	4
	2.24	8	2.12	8	2.20	9	2.04	8	2.05	9
	3.31	13	3.50	14	3.26	14	3.47	14	3.05	17
	4.38	15	4.00	17	4.29	17	4.06	18	4.36	19
	5.30	20	5.69	23	5.78	24	5.08	34	5.00	38
	6.1	24	6.38	28	6.50	26	6.89	39	-	-
	7.47	29	7.28	33	7.62	29	-	-	-	-
	8.69	30	8.32	36	8.00	38	-	-	-	-
	9.46	32	9.20	47	-	-	-	-	-	-
	10.20	33	10.00	51	-	-	-	-	-	-
	11.50	34	-	-	-	-	-	-	-	-
	12.50	45	-	-	-	-	-	-	-	-
	13.06	49	-	-	-	-	-	-	-	-
Genotype VCM-8	2.00	4	2.00	4	2.00	4	2.00	4	2.00	4
	2.17	8	2.04	8	2.49	7	2.13	4	2.00	8
	3.13	12	3.39	12	3.05	14	3.06	16	3.38	16
	4.29	14	4.47	18	4.19	17	4.45	19	4.43	19
	5.60	21	5,65	23	5.63	24	5.74	37	5.66	39
	6.42	24	6.39	26	6.40	28	-	-	-	-
	7.78	26	7.30	34	7.41	34	-	-	-	-
	8.09	29	8.62	38	8.20	38	-	-	-	-
	9.18	32	9.70	43	9.00	40	-	-	-	-
	10.16	33	10.00	50	-	-	-	-	-	-
	11.72	35	-	-	-	-	-	-	-	-
	12.07	44	-	-	-	-	-	-	-	-
	13.09	48	-	-	-	-	-	-	-	-

Table 2. Regression equations and regression coefficients for predicting PI on the basis of chronological age under different stress conditions.

Genotype C-152			Genotype VCM-8		
Irrigation intervals [d]	Regression equation	r^2	Irrigation intervals [d]	Regression equation	r^2
7	PI = 0.2351 + 0.2772 d	0.96	7	PI = 0.2837 + 0.2788 d	0.97
14	PI = 0.9958 + 0.1824 d	0.98	14	PI = 1.0743 + 0.1906 d	0.98
21	PI = 0.6993 + 0.2102 d	0.96	21	PI = 1.0049 + 0.1890 d	0.99
28	PI = 1.4086 + 0.1289 d	0.94	28	PI = 1.5326 + 0.1129 d	0.92
35	PI = 1.6280 + 0.0955 d	0.84	35	PI = 1.5266 + 0.1181 d	0.93

However, many references indicate that they are of little use for such purpose (Aspinall and Paleg 1981; Sinha 1986). The PI in current investigation has shown a great degree of sensitivity and predictability under different stress levels. Further, it can be estimated from simple linear measurements of successively emerging leaves under field conditions. Moreover, the differences in estimates of the index can be detected even from the seedling stage. Hence, it can be inferred that the PI may serve as a single sensitive trait for screening the genotypes under water stress condition. The plants having ability to maintain high PI could be considered as drought tolerant types. Such a screening would be however, limited to leguminous and dicot crops as in monocot crops Erickson and Michelini's (1957) concept of PI is not applicable.

References

Aspinall, D., Paleg., L.G.: Proline accumulation: physiological aspects. - In: Paleg, L.G., Aspinall, D. (ed.): Physiology and Biochemistry of Drought Resistance in Plants. Pp. 206-239. Academic Press, Sydney - New York - London - Toronto - San Francisco 1981.

Dongale, J.H., Patil, B.P., Khanvilkar, S.A., Chavan, A.S.: Physical properties of lateritic soils in relation to their irrigability classification. - J. Maharashtra agr. Univ. **12** (1): 6-8, 1987.

Erickson, R.O., Michelini, F.J.: The plastochron index. - Amer. J. Bot. **44**: 297-305, 1957.

Hsiao, T.C.: Plant responses to water stress. - Annu. Rev. Plant Physiol. **214**: 519-570, 1973.

Hsiao, T.C., Silk, W.K., Jing, J.: Leaf growth and water deficits: Biophysical effects. - In: Baker, N.R., Davies, W.J., Ong, C.K. (ed.): Control of Leaf Growth. Pp. 239-266. Cambridge University Press, Cambridge -London - New York - New Rochelle - Melbourne - Sydney 1985.

Lamoreaux, R.J., Chaney, S.R., Brown, K.M.: The plastochron index: A review after two decades of use. - Amer. J. Bot. **65**: 586-94, 1978.

Nash, D., Paleg, L.G., Whiskic, J.T.: Effect of proline, betaine and some other solutes on heat stability of mitochondrial enzymes. - Aust. J. Plant Physiol. **9**: 47-57, 1982.

Quarrie, S.A.: Genetic variability and heritability of drought induced abscisic acid accumulation in spring wheat. - Plant Cell Environ. **4**: 147-151, 1981.

Silk, W.K.: Plastochron indices in cantaloups grown on an irrigation line source. - Bot. Gaz. **141**: 73-78, 1980.

Sinha, S.K.: Drought resistance in crop plants: A physiological and biochemical analysis. - In: Chopra, V.L., Paroda, R.S. (ed.): Approaches for Incorporating Drought Resistance in Crop Plants. Pp. 56-86. Oxford and IBH Publishing Co, New Delhi 1986.

Vendeland, J.S., Sinclair, T.R., Speath, C.S., Cortes, P.M.: Assumptions of plastochron index: Evaluation of soybean under field drought conditions. - Ann. Bot. **50**: 673-680, 1982.