Indian J. Genet., **49**(1): 67–72 (1989)

INTRASPECIFIC VARIATIONS IN CHIASMA FREQUENCIES AND TERMINALIZATION IN *TRITICUM CARTHLICUM*

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(Received: April 13, 1987; accepted: May 28, 1988)

ABSTRACT

Comparative analysis of chiasma frequencies and terminalization in seven varieties of *T. carthlicum* and one variety of *T. persicum* have been attempted at late diplotene/diakinesis and metaphase I. Variety EC 119466 showed highest chiasma frequency at both the phases. Relative ranking for mean bivalent length is more or less similar except for var. EC 119463, *T. persicum*, EC 119467 and V-1063, suggesting differential rate of condensation. Observations on chiasma frequencies and terminalization indicate isolation of *persicum* from other varieties of *carthlicum*, though it is not abrupt as *carthlicum* var. *fulginosum* also showed heterogeneity with other *carthlicum* varieties.

Key words: *Triticum carthlicum*, *T. persicum*, chiasma frequency, terminalization, intraspecific variation.

Triticum persicum Nevsk. has been merged under *T. carthlicum* by Jakubziner [1]. Mac Key [2] also grouped it under ssp. *carthlicum* of *T. turgidum* based on morphology and genetic behaviour. However, Deodikar et al. [3], based on their observations on hybrids of these species with *T. durum*, suggested that this merger is not proper. Hence, we have attempted to verify the above suggestion to treat *carthlicum* and *persicum* as separate taxa on the basis of variations in chiasma frequencies and terminalization in these two species.

MATERIALS AND METHODS

Chiasma frequencies of seven varieties of *T. carthlicum* and one variety of *T. persicum* were studied in temporary squash preparations. Data on total number of chiasmata and total bivalent length were recorded from camera lucida drawings made at table level using fluotar oil-immersion objective. Coefficient of correlation between total number of chiasmata and toal bivalent length per pollen mother cell (p.m.c.) were calculated by adopting the formula of Panse and Sukhatme [4]. Relative heterogeneity between two varieties was estimated by the Brandt and Snedecor's formula for heterogeneity (cf. Bailey [5]).

RESULTS

CHIASMA FREQUENCIES AT LATE DIPLOTENE/DIAKINESIS

Data collected on total number of chiasmata, number of bivalents with 1-5 chiasmata, total bivalent length, and correlation coefficient at late diplotene/early diakinesis are presented in Table 1. Mean chiasma frequency ranges from 32.8 to 41.2 per p.m.c., maximum being in EC 119466, followed by V-1063. The lowest frequency was obtained in *T. persicum* and EC 119463. Bivalents with single chiasmata are absent in *carthlicum* varieties but present in *T. persicum*. The proportion of bivalents with 4–5 chiasmata is highest in V-1063 and EC 119466. Similarly, total bivalent length per p.m.c is highest in EC 119466 (169.2 μm), and lowest in V-1582 (102.0 μm). In *T. persicum*, this value is 136.0 μm. Mean bivalent length per unit chiasma is maximum in EC 119463 and minimum in V-1582.

Table 1. Chiasma frequency at diplotene in the varieties of *T. carthlicum*

Variety	Total p.m.c. analysed	Mean number of bivalents with chiasmata					Chiasmata per p.m.c.		Number of chiasmata per bivalent		Mean bivalent length per p.m.c. (μm)	Mean bivalent length per unit chiasma (μm)	Mean no. of chiasmata per 100μm of bivalent length	Coefficient of correlation
		1	2	3	4	5	mean	rank	range	mean				
T. carthlicum var. EC 119463	20	—	9.5	4.30	0.25	—	32.8	7	2-4	2.34	144.7	4.41	22.7	0.49*
T. persicum	10	0.3	9.2	4.40	0.10	—	32.3	8	1-4	2.31	136.0	4.21	23.7	0.68*
T. carthlicum var. *fulginosum*	10	—	4.7	8.30	1.00	—	38.3	3	2-4	2.74	160.3	4.18	23.9	0.31
Var. EC 119466	6	—	4.0	7.33	2.17	0.5	41.2	1	2-4	2.94	169.2	4.11	24.3	0.91*
Var. V-1063	10	—	4.3	6.80	2.90	—	40.6	2	2-4	2.90	139.5	3.44	29.1	0.85**
Var. Stamneum	15	—	5.12	7.80	1.07	—	37.9	4	2-4	2.71	128.8	3.40	29.4	0.66**
Var. EC 119467	11	—	7.0	6.73	0.21	—	35.3	5	2-4	2.52	111.9	3.15	31.5	0.88**
Var. V-1582	12	—	9.5	4.17	0.33	—	32.8	6	2-4	2.35	102.0	3.11	32.2	0.66*

*, **Significant at 0.05 and 0.01 levels, respectively.

The coefficient of correlation between total bivalent length and total number of chiasmata per p.m.c. is highly significant at both levels in var. Stamneum, V-1063 and EC 119467. Other varieties showed significance at 0.05 level except for var. *fulginosum*.

CHIASMA FREQUENCY AT METAPHASE-I

Similar data recorded at metaphase-I indicate that the relative ranking of chiasma frequency remains more or less similar at both the phases except for var. V-1063 (Table 2). The lower values of *T. persicum* at metaphase I suggest localized or stationary chiasmata.

Table 2. Chiasma frequency at metaphase I in the varieties of *T. carthlicum*

Variety	Total p.m.c. analysed	Mean number of bivalents with chiasmata					Chiasmata per p.m.c.		Number of chiasmata per bivalent		Mean bivalent length per p.m.c. (μm)	Mean bivalent length per unit chiasma (μm)	Mean no. of chiasmata per 100μm of bivalent length	Coefficient of correlation
		0	1	2	3	4	mean	rank	range	mean				
T. persicum	10	—	2.60	9.50	1.90	—	27.3	8	1-3	1.95	44.8	1.64	60.9	0.53
T. carthlicum var. EC 119466	11	—	0.45	8.45	4.73	0.36	33.0	1	1-4	2.36	52.0	1.58	63.4	0.60*
Var. *fulginosum*	26	0.04	1.42	7.69	4.62	0.23	31.6	3	0-4	2.26	45.5	1.44	69.4	0.67**
Var. EC 119467	13	0.08	0.78	7.77	5.07	0.31	32.8	2	0-4	2.34	46.1	1.41	71.1	0.17
Var. EC 119463	10	0.10	1.80	9.10	2.90	0.10	29.1	6	0-4	2.08	38.8	1.33	75.0	0.74*
Var. Stamneum	9	—	0.89	9.55	3.56	—	30.7	5	1-3	2.19	38.8	1.27	79.0	0.62
Var. V-1582	10	—	0.80	9.50	3.70	—	30.9	4	1-3	2.21	36.7	1.19	84.2	0.75*
Var. V-1063	11	0.09	2.82	8.73	2.36	—	27.4	7	0-3	1.95	31.6	1.15	86.6	0.81**

*, **Significant at 0.05 and 0.01 levels, respectively.

The proportion of bivalents with zero chiasma is maximum in EC 119463, followed by V-1063 and EC 119467, and minimum in var. *fulginosum*.. On the contrary, the highest number of bivalents with four chiasmata was observed in EC 119466 at metaphase-I. Lower values were obtained in EC 119463.

Significant correlation coefficient between total bivalent length and total number of chiasmata per p.m.c. at 0.01 and 0.05 levels was noted in var. *fulginosum* and V-1063, whereas the other varieties showed significance at 0.05 level, except for *T. persicum*, and the varieties Stamneum and EC 119467. There is constancy in significance at diplotene and metaphase-I at both levels in V-1063, whereas significance at 0.05 level was observed in EC 119463, EC 119466 and V-1582. Significance in correlation coefficients between chiasma frequency and bivalent length indicates random distribution of chiasmata. Nonsignificant values suggest restricted localization of chiasmata due to linear differentiation.

CHIASMA MOVEMENT AND TERMINALIZATION

Observations on the number of interstitial and terminal chiasmata and terminalization are presented in Table 3.

The proportion of interstitial chiasmata at diplotene is highest in EC 119466 and V-1063, and lowest in *T. persicum*. During metaphase-I, the maximum number of interstitial chiasmata were found in EC 119467 and minimum in V-1063. Thus, *T. persicum* showed minimum interstitial chiasmata during both stages, either suggesting random distribution of chiasmata as well as free terminalization, or there is no linear differentiation leading to localization of chiasmata.

Table 3. Relative coefficient of terminalization in *T. carthlicum* species varieties

Type	Mean chiasma frequency at diplotene				Mean chiasma frequency at metaphase I				Coefficient of terminalization*
	interstitial (a)	terminal (b)	total (c)	ratio a:b	interstitial (a)	terminal (b)	total (c)	ratio a:b	
T. carthlicum var. V-1582	4.83	28.0	32.8	0.15	3.70	27.2	30.9	0.14	0.94
var. EC 119467	7.27	28.0	35.3	0.26	5.69	27.1	32.8	0.21	0.92
var. EC 119463	4.80	28.0	32.8	0.17	3.10	26.0	29.1	0.12	0.89
T. persicum	4.60	27.7	32.3	0.16	1.90	25.4	27.3	0.80	0.85
T. carthlicum var. *fulginosum*	10.30	28.0	38.3	0.36	5.08	26.5	31.6	0.19	0.83
var. Stamneum	9.93	28.0	37.9	0.35	3.56	27.1	30.7	0.13	0.81
var. EC 119466	13.17	28.0	41.2	0.47	5.45	27.5	33.0	0.20	0.80
var. V-1063	12.60	28.0	40.6	0.45	2.36	25.0	27.4	0.09	0.67

*Coefficient of terminalization estimated as ratio of total chiasma frequency *at MI : diplotene*.

HETEROGENEITY AMONG VARIETIES OF *T. CARTHLICUM*

The relative heterogeneity worked out from diplotene and metaphase-I is presented in Table 4.

Table 4. Relative heterogeneity among *T. carthlicum* varieties

		T. persicum	V-1582	EC 119467	EC 119466	EC 119463	V-1063	Stamneum
T. carthlicum	var. V-1582	−(+)						
	EC 119467	−(−)	+(−)					
	EC 119466	−(−)	+(−)	+(−)				
	EC 119463	+(+)	+(+)	−(−)	−(−)			
	V-1063	+(−)	−(−)	−(−)	−(+)	+(−)		
	Stamneum	−(−)	+(−)	+(−)	+(−)	+(−)	−(−)	
	fulginosum	−(−)	−(−)	+(−)	−(−)	−(−)	−(−)	−(+)

−, + Significant heterogeneity and homogeneity at 0.05 level, respectively (metaphase i).
The signs in parentheses indicate heterogeneity at 0.05 level (diplotene).

T. persicum and *T. carthlicum* var. *fulginosum* displayed maximum heterogeneity among all other varieties both at diplotene and metaphase-I stages. These observations corroborate the number of chiasmata per 100 μm of bivalent length at both stages. This indicates nonrandom crossing over or localization of chiasmata in these two types.

DISCUSSION

Each species/variety is characterized by constancy in karyotypes and chiasma frequencies. Variations in karyotypes and chiasma frequencies were reported earlier [6–8].

Seven varieties of *T. carthlicum* and one variety of *T. persicum* invariably showed 14 bivalents.

The total number of chiasmata per p.m.c. is maximum in EC 119466 at both stages. There is also very high degree of association between bivalent length and chiasma frequency per p.m.c. in this variety. This implies random distribution of chiasmata and continuous uninterrupted linear homology. Lack of such correspondence due to stationary or nonshifting of chiasmata suggests interrupted linear homology.

The variations observed in total bivalent length per p.m.c. may be due to: 1) tendencies for differential linear condensation of bivalents in individual species at the corresponding diplotene and metaphase-I stages, and 2) observational error due to the choice of noncomparable diplotene and metaphase-I cells with the same degree of spiralization and linear condensation. Though attempts have been made to select p.m.c. with comparable phases, it is difficult to exclude the source of errors.

The relative ranking of species for mean bivalent length per unit chiasma is more or less similar in vars. *fulginosum*, Stamneum, EC 119466 and V-1582 at both stages, whereas in EC 119463, *T. persicum*, EC 119467 and V-1063, the sequence differs conspicuously. This suggests the possibility of differential rate of condensation at these stages in the latter varieties.

Thus, our observations on chiasma frequencies and terminalization support the isolation of *persicum* from other varieties of *carthlicum*. Mean number of chiasmata per p.m.c., number of chiasmata per bivalent, and number of chiasmata per 100 μm bivalent length also support the separation of *persicum* from *carthlicum*. However, this separation does not appear to be abrupt as *carthlicum* var. *fulginosum* and *persicum* showed heterogeneity with other *carthlicum* varieties.

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