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KNOB COMPOSITION IN NORTHEASTERN HIMALAYAN MAIZE

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ABSTRACT

Knob-heterochromatin distribution studied in Northeastern Himalayan maize has revealed that, in general, the strains possess low knob number. There are significant differences in knob number among the strains collected from different altitudes of Sikkim ranging from 1200 to 2500 m. Strains occurring at higher altitudes of Sikkim possess fewer knobs in comparison to the strains at lower altitude. The mean knob number among strains of low, medium and high altitude is 4.8, 2.9, and 2.2, respectively. The Sikkim Primitive strains have been classified into two groups, one having higher knob number (8–12), distributed in Sikkim and Tripura, and the other with lower knob number (1–4) represented by the strains from Meghalaya.

Key words: Northeastern Himalayan maize, Sikkim Primitive, knob-heterochromatin.

The maize grown in the Northeastern Himalayan (N.E.H.) region, including Upper Burma, Nepal and Bhutan, is of considerable antiquity [1–4]. Impressed by the extreme diversity of maize in this region, Anderson [5] considered maize to have an ancient Asiatic origin and trans-Pacific migration to South America. The presence of primitive forms of maize in Sikkim (S.P.) [6, 7] has reawakened the interest in N.E.H. maize among the scientists [8–10].

Although attempts have been made to describe the morphological features of N.E.H. maize [1, 11, 12], the cytological characterization is lacking. Literature reveals very little information [13–15] on the distribution of knob heterochromatin in these strains of maize. This paper aims to explain the status of N.E.H. maize on the basis of knob composition at pachytene.

MATERIALS AND METHODS

Twenty strains of maize collected from various altitudes and different ethnic groups of N.E.H. constituted the basic material for this study. The strains used in this study and their place and altitude of collection (in m), respectively, are as follows: S-18 (Nazitam, Sikkim; 1300), S-23 (S.P.) (Nazitam, Sikkim; 1300), S-29 (Nazitam, Sikkim; 1300), S-57 (Namche, Sikkim; 1320), S-35 (Namche, Sikkim; 1440), S-19 (Namche, Sikkim; 1440), S-20 (Namche, Sikkim; 1450), S-45 (Gangtok, Sikkim; 1600), S-25 (Phodong, Sikkim; 1640), S-55 (Pelang, Sikkim; 1700), S-22 (Pelang, Sikkim; 1740), S-21 (Lachung, Sikkim; 2400), S-30 (Lachung, Sikkim; 2400), S-56 (Lachung, Sikkim; 2400), S-39 (Lachung, Sikkim; 2400), M-1 (S.P.) (Garo Hills, Meghalaya; 1200), M-25 (S.P.) (Garo Hills, Meghalaya; 1200), M-15 (S.P.) (Garo Hills, Meghalaya; 1350), T-1 (S.P.) (Kamalpur, Tripura; 1050), T-2 (S.P.) (Kanchanpur, Tripura; 1050).

The PMC were fixed in 1:3 acetoalcohol and preserved in 70% alcohol. Pachytene analysis was done on PMC from 3-5 plants in each culture, using the conventional acetocarmine method. Length of chromosome, position of centromere, and number and position of knobs were ascertained in well spread configurations with the help of photomicrographs and actual line drawings. Statistical analysis for group comparison was made according to Gomez and Gomez [16].

RESULTS

To study the relationship between altitude and knob number, collections from Sikkim were divided into three groups. Maize collected from altitudes ranging from 1200 to 1400 m has the mean knob number of 4.86, while collections from 1440 to 1700 m have a mean knob number of 2.93 and collections from 1740 to 2400 m—2.2. The materials studied from different altitudes of Sikkim, in respect to number of knobs, are quite homogeneous within the groups, but significant differences were observed between the groups (Table 1).

Table 1. Comparison of data on knob numbers from low, medium and high altitudes of Sikkim

Knob number at different altitudes								
low (1200–1400 m)			medium (1440–1700 m)			high (1740–2440 m)		
strain	mean	F	strain	mean	F	strain	mean	F
S–16	4.2 ± 0.45		S–19	2.4 ± 0.89		S–21	2.4 ± 0.89	
S–29	4.8 ± 1.10	3.36	S–20	4.0 ± 0.70	3.00	S–22	2.4 ± 0.89	1.06
S–57	5.6 ± 0.71		S–25	2.8 ± 1.09		S–30	1.8 ± 0.83	
			S–35	2.4 ± 0.89		S–39	2.6 ± 0.89	
			S–45	2.4 ± 0.89		S–56	1.8 ± 0.44	
			S–55	3.6 ± 0.89				
Mean	4.9±0.99			2.9±1.04			2.2 ± 0.81	
F between groups 45.75**								

**Significant at 1% level.

Chromosomes were identified on the basis of their length and arm ratio (Table 2). Knob positions have been ascertained in S-29, S-20, S-45, S-22 and S-30 (Table 2; Fig. 1). While studying the knob positions in these strains it was noted that most of the knobs are found at subterminal positions. It is also interesting to note that in these strains 2L and 8L are the common knob forming positions (Table 2). Knob of the knobs are found at subterminal positions. It is also interesting to note that in these strains 2L and 8L are the common knob forming positions (Table 2). Knob 8L in S-29 is terminal which may be due to excessive condensation of chromosomes at pachytene as evident from the smaller size of the chromosomes in comparison with other strains (Table 2).

Table 2. Length and arm ratio of chromosomes at pachytene and knob position

Strain	Total length and arm ratios of different chromosomes																			
	I		II		III		IV		V		VI		VII		VIII		IX		X	
	L	AR	L	AR	L	AR	L	AR	L	AR	L	AR	L	AR	L	AR	L	AR	L	AR
S-29	76	1.37	75 (Lst)	1.34	73	1.92	69 (Lst)	1.76	65	1.03	62	2.88	52	1.95	49 (Lt)	2.77	35	2.50	27 (Lt)	2.86
S-20	106	2.03	70 (Lst)	2.04	69 (Lst)	2.63	62	1.95	62 (Lst)	1.07	56	1.95	53 (Lst)	7.83	52	1.89	48	3.00	34	1.83
S-45	144	1.25	114 (Lst)	1.24	90	2.10	87	1.72	83	1.08	74	3.00	69	3.06	62 (Lst)	3.13	60 (Lt)	1.86	49	2.06
S-22	87	1.72	82	4.86	72	2.95	57	1.85	52	1.20	48	2.43	46 (Sst)	2.29	46 (Lst)	1.71	39	1.60	22	3.40
S-30	118	1.41	96 (Lst)	1.04	86	1.46	80	3.21	75	1.34	70	13.00	67	2.53	65 (Lst)	5.50	63	1.52	52	3.00

L—length(μm), AR—arm ratio, Lst—subterminal knob on long arm, Sst—subterminalknob on short arm, and Lt—terminal knob on long arm.

The situation in respect of S.P. maize has been dealt with separately because of their distinctive morphological features. Based on the number of knobs, the S.P. maize represents two groups, one, with a low knob number (1–4), represented by M–1, M–15 and M–25; and the other, with relatively higher knob number (8–12), represented by S-23, T-1 and T-2 (Table 3).

Table 3. Comparison of knob number between two groups of Sikkim Primitives

Knob number in two groups					
A (high knob number)			B (low knob number)		
strain	mean	F	strain	mean	F
T–1	8.2 ± 0.83	4.86**	M–1	2.2 ± 0.44	0.47
T–2	10.0 ± 1.41		M–15	2.6 ± 0.89	
S–23	8.4 ± 0.54		M–25	2.2 ± 0.83	
Mean	8.86 ± 1.24			2.33 ± 0.72	
F Between the groups 408.69**					

** Significant at 1% level.

DISCUSSION

Knob heterochromatin is the characteristic feature of maize chromosomes, which is clearly visible as darkly stained bodies (knobs) during the pachytene stage of meiosis. Knobs are structurally stable units that occupy fixed positions on the chromosomes [17, 18]. The maize chromosomes are identifiable at pachytene by virtue of their length and arm ratio [19]. In this study, chromosome length ranged from 22 μm to 144 μm, which is quite close to the standard dimensions in maize [20]. Small variations may be attributed to differential condensation at pachytene. The arm ratios, however, do not exactly fit into the model of the cytological map [19], most probably, due to limited samples. Nevertheless, these results do not differ much, and the chromosomes can be easily identified on the basis of their total length and arm ratios. Hence, it was possible to assign the exact positions of the knobs on specific chromosomes.

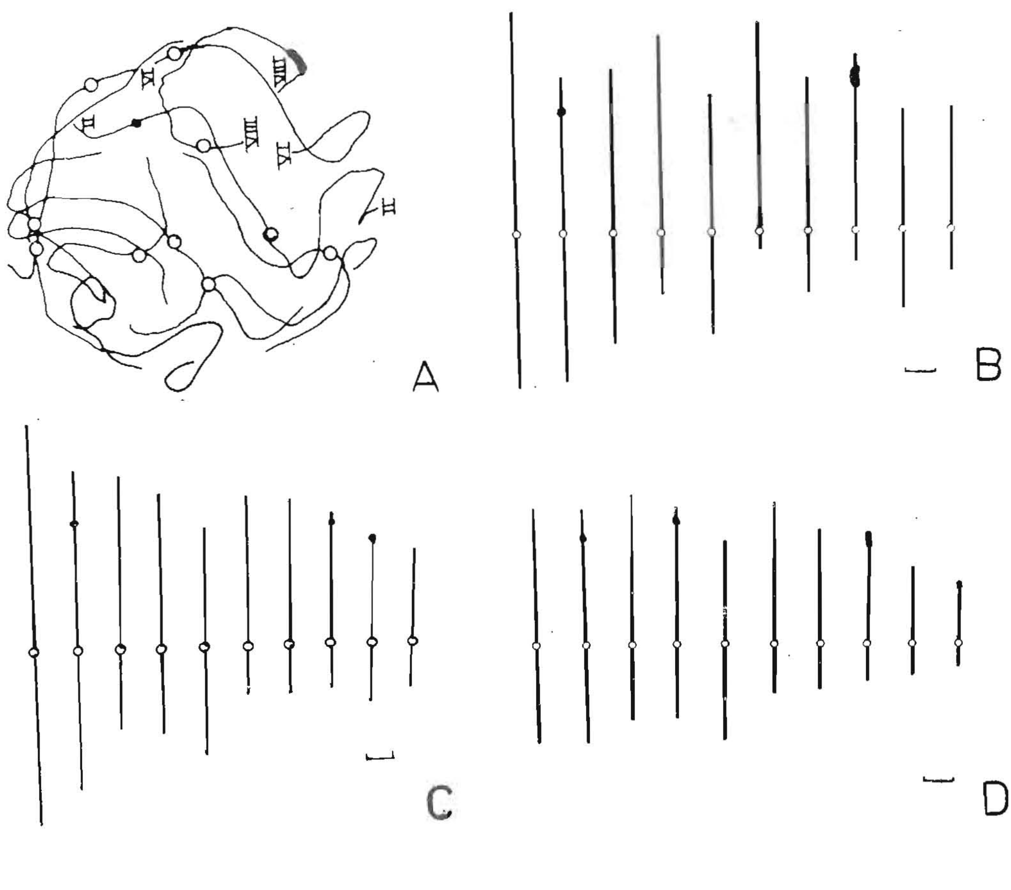

Fig. 1. A, B) Line drawings of chromosomes and idiogram of S-30; C) idiogram of S-45, and D) idiogram of S-29. Scale 10μm.

The strains studied from N.E.H., in general, possess low knob number (1–6), except for the S.P. strains from Sikkim and Tripura (8–10). Variations in shape and size of knobs are attributed to differential condensation of the chromosomes and homo– and heterozygosity for knobs. Differences in chromosome knob number have been used successfully to elucidate the origin of varieties of Latin American corn [17, 21–24]. Mangelsdorf and Cameron [25] have noticed that within each locality in Guatemala there is a wide variation in altitudes and the form of maize occurring at lower altitudes are tripsacoid in nature, and have a greater number of knobs than the forms occurring at higher altitudes. A similar situation was observed with the Sikkim maize. There are significant differences in knob number between the strains collected at different altitudes. Collections from lower altitudes have higher knob number than the maize found at higher altitudes. While comparing the knob positions of Sikkim strains, namely, S–20, S–22, S–29, S–30 and S–45, with the established American races of maize, viz., Confite Morocho, Nal–Tel, Palomero Toluqueno and Pira, it was noted that they do not show any set pattern, however, they reveal some relationship among them as the knob positions at 2L and 8L are common in them.

The situation in respect of Sikkim Primitive maize is quite different. Within S.P. maize, both low and high knob number types exist in N.E.H. The Sikkim Primitive collections from Sikkim and Tripura possess higher knob number than the S.P. strains from Meghalaya, indicating two different linkages of S.P. maize.

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