Intervarietal Differences in Karyotype of Tea

Madhuparna Datta and Beena Agarwal

National Agricultural and Scientific Research Foundation,
113/2, Amherst Street, Calcutta 700 009, India

Accepted April 13, 1992

Tea *Camellia sinensis* (L.) O. Kuntze is one of the most important cultivated crop plant of India. The genomic account of this plant have become very much complicated due to natural hybridization (Wight and Barua 1957, Wood and Barua 1958, Bezbaruah 1975). Though several authors (Ackerman 1971, 1973, Bezbaruah 1977, Chaudhuri and Bezbaruah 1985) worked on the genomic set up at various ploidy level of this plant, there is no report on detailed karyotype study at varietal level. The present work deals with detail karyotype analysis to find out the intervariatal relationship among 6 diploid clonal cultivars (Tocklai Vegetative [TV] variety) extensively grown in Northeast India. As the clonal varieties are mainly based on yield and quality, our another object is to see whether there is any interrelation among yield, quality and karyotype at the varietal level.

Materials and methods

Fresh shoot tips from mother bush of 6 clonal varieties—TV₁, TV₁₉, TV₂₀, TV₂₁, TV₂₂ and TS 491 were collected from Assam tea garden.

Well scattered metaphase plates were obtained by pretreating the shoot tips with para-dichlorobenzene, 0.002M Hydroxyquinolene (1:1) and aesculine for 4 1/2 hr. followed by overnight fixation in 3:1 ethanol acetic acid mixture. The best staining was obtained in 2% aceto-orcein after a prior hydrolysis in 5N HCl for 8 min. in 0–4°C.

The individual chromosome volume was calculated by the formula $\pi r^2 h$ where r is the radius and h is the length of the chromosome. The total chromosome length and volume with standard error (S. E.) were computed by adding the individual length and volume respectively. The analysis of variance (ANOVA) at the intervariatal level was also calculated. Typification of chromosomes has been done on the basis of centromere position.

Observations

The somatic chromosome number ($2n=30$) and number of nucleolar chromosomes were found constant in 6 varieties. Though a gross morphological similarity was revealed in all the varieties, the number of different chromosome types varied to a significant level (Table 1). Chromosomes were mostly of medium size (2–5 μm), but one pair of small chromosomes was noted in all varieties. All the chromosomes were divided into 6 types of which 2 types were designated as the nucleolar chromosomes:

Type A: Nucleolar chromosome with nearly subterminal and nearly median constrictions. Range of length was in between 2.41–4.07 μm .

Type B: Nucleolar, with nearly subterminal and nearly submedian constrictions. The length range was 2.22–3.52 μm .

Type C: Medium size chromosomes (1.48–5.0 μm) with nearly median primary constrictions.

Type D: Medium to short size chromosomes (1.11–3.59 μm) with nearly submedian constrictions.

Type E: Medium ($2.04\text{--}3.12\ \mu\text{m}$) with nearly subterminal chromosomes.

Type F: Medium ($1.48\text{--}2.96\ \mu\text{m}$) with submedian primary constrictions.

A clear numerical and structural alterations of centromeric chromosomes were noted in all the studied varieties (Fig. 1). Chromosomes of 'A' type were found in TV₁, TV₁₉, TV₂₀

Table 1. Detailed description of chromosome types in 6 different varieties

Variety	Chromosome No. (2n)	Range of chromosome length (μm)	No. of nucleolar chromosomes	No. of different chromosome types
TV ₁	30	1.11–3.15	2	2A 6C 20D 2E
TV ₁₉	30	1.48–4.07	2	2A 16C 10D 2F
TV ₂₀	30	1.48–4.07	2	2A 8C 18D 2F
TV ₂₁	30	1.11–2.96	2	2B 10C 14D 2E 2F
TV ₂₂	30	1.48–4.44	2	2B 16C 8D 2E 2F
TS 491	30	1.11–2.96	2	2A 16C 12D

Fig. 1. Karyogram of 6 clonal varieties of tea showing number of different types of chromosomes at a glance.

Fig. 2. A comparative account of absolute genomic length and volume in 6 varieties represented by histogram.

and TS 491 but absent in TV₂₁ and TV₂₂ where 'B' type present. 'C' and 'D' type of chromosomes were found to be present in all varieties but number of each type was different (Table 1, Fig. 1). 'E' type was found to be present in 3 varieties (TV₂₁, TV₁ and TV₂₂) and 'F' type was found in TV₂₁, TV₂₀, TV₁₉ and TV₂₂. Both 'E' and 'F' types were absent in TS 491 (Fig. 1). The overall observations revealed asymmetric karyotypes in all the studied varieties which was reflected in total F%. However, the total F% did not show any marked variation (Table 2).

Though the number was same, the absolute length and volume of total genomic

Table 2. Comparative account of total genomic length, volume and characteristics of different Tocklai vegetative (TV) clonal varieties

Variety	Total genomic ¹ length (μm) (Mean $\pm$ S.E.) of 10	Total genomic ¹ volume (μm^3) (Mean $\pm$ S.E.) of 10	Arm ratio	Total F%	Category 2*	Yield 3*	Rooting*	Drought* resistance
TV ₁	70.67 $\pm$ 0.15 a	20.82 $\pm$ 0.17 a	2.09	31.97	Standard	High	Very good	Good
TV ₁₉	88.55 $\pm$ 0.16 b	35.41 $\pm$ 0.12 b	1.74	35.88	Yield	High	Very good	Good
TV ₂₀	84.27 $\pm$ 0.20 c	32.26 $\pm$ 0.10 c	1.88	33.92	Standard	High	Good	Good
TV ₂₁	54.12 $\pm$ 0.19 d	15.17 $\pm$ 0.19 d	2.10	31.70	Quality	Average	Fair	Poor
TV ₂₂	101.38 $\pm$ 0.15 e	42.43 $\pm$ 0.11 e	1.71	36.57	Yield	High	Good	Fair
TS 491	72.91 $\pm$ 0.16 f	21.78 $\pm$ 0.18 f	1.74	36.06	Yield	High	Good	Good

¹ Data with different letters (a-f) are significantly vary at 5% level within the varieties as determined by ANOVA test.

² Standard clone: With above average yield and quality

Yield : With very high yield but average quality

Quality : With very high cup quality with average yield

³ Average yield = 300 kg/ha of made tea at maturity

* Data taken from Bezbaruah and Singh (1980).

constituents differed within the varieties (Table 2). The highest values were observed in TV₂₂ ($101.38 \pm 0.15 \mu\text{m}$; $42.43 \pm 0.11 \mu\text{m}^3$) whereas the lowest in TV₂₁ ($54.12 \pm 0.19 \mu\text{m}$; $15.17 \pm 0.19 \mu\text{m}^3$). The variation was significant in other varieties also (Table 2, Fig. 2). The characteristics of different varieties as depicted in Table 2, were taken from Bezbaruah and Singh (1980).

Discussions

The overall observations reveal a number of important findings. Though the chromosome number is same, karyotype analyses show clear differences among the varieties. Variation in nucleolar chromosome type is also observed (Table 1). The number of different chromosome types is also differed (Fig. 1, Table 1). Total F% and arm ratio proves asymmetry in all karyotypes studied (Table 2). The minute changes in chromosome types at the varietal level may be account for changes in heterochromatic part of the genome.

TV₁ being the first clonal variety (Bezbaruah and Singh 1980) shows lower genomic length and volume than the later developed varieties like TV₁₉, TV₂₀ and TV₂₂. But both length and volume are lowest in TV₂₁ (Table 2, Fig. 2). Notwithstanding the fact that chromosome length and volume are greatly dependent on differential spiralization, despiralization and histone protein content at the individual chromosome level (Mukherjee and Sharma 1986, Mukhopadhyay and Sharma 1987, Das and Mallick 1989), a clear correlation between the genomic length and volume is found to be significant in this study (Table 2). The increase in total genomic length is associated with the increase in volume. The differences within the varieties are also found significant by ANOVA test.

With a view to evaluate the cytological parameters in respect to the characteristics of Tocklai varieties (Bezbaruah and Singh 1980), it is interesting that TV₂₁ is quite indifferent in having the lowest genomic length, volume and highest arm ratio. While the other varieties are of standard or yield category, TV₂₁ is the only quality variety having average yield, fair rooting and poor drought resistance (Table 2). Though it is not possible to correlate these apparently unrelated characters in the light of present findings, but the intervarietal variation is significant as their manifestation is clearly controlled at the genic level.

Summary

Detailed karyotype analyses of 6 cultivars of tea vegetative clones are done. On the basis of centromere position, chromosomes are classified into 6 types. Number of different types varied within the varieties. Both 'E' and 'F' type are absent in TS 491. Total genomic length and volume are also considered as the parameters. Significant variation is observed at the varietal level. TV₂₁, a quality clone, is found quite indifferent in karyotype, total length and volume of the chromosomes. The other characteristic features of this variety is also different from the rest of varieties. The overall study reveals a clear varietal demarcation.

References

- Ackerman, W. L. 1971. Genetic and cytological studies with *Camellia* and related genera. Technical Bulletin No. 1427. USDA.
- 1973. Aneuploidy in *Camellia*. *J. Hered.* **64**: 197–202.
- Bezbaruah, H. P. 1975. Cytological investigation in the family Theaceae. II. Cytology of a triploid tea. *Exp. Agric.* **11**: 13–16.
- 1977. Aneuploidy in tea. *The Nucleus* **19**: 167–169.
- and Singh, I. D. 1980. Characteristics of Tocklai released planting materials. *Two and A Bud.* **27** (1): 6–8.

- Chaudhuri, T. C. and Bezbaruah, H. P. 1985. Morphology and anatomy of aneuploid and polyploid tea [*Camellia sinensis* (L.) O. Kuntze]. *J. Plantation Crops* **13** (1): 22–30.
- Das, A. B. and Mallick, R. 1989. Variation in karyotype and nuclear DNA content in different varieties of *Foeniculum vulgare* Mill. *Cytologia* **54**: 129–134.
- Mukherjee, S. and Sharma, A. K. 1986. Intervarietal relationship between chromosome size, nuclear DNA amount and protein content in *Cajanus cajan* (L.) Mill sp. *Perspectives in Cytology and Genetics* (Manna, G. K. and Sinha, U. eds.) **5**: 735–740.
- Mukhopadhyay, S. and Sharma, A. K. 1987. Karyomorphological analysis of different species and varieties of *Calathea*, *Maranta* and *Stromanthe* of Marantaceae. *Cytologia* **52**: 821–831.
- Wight, W. and Barua, P. K. 1957. What is tea? *Nature* **179**: 506–507.
- Wood, D. J. and Barua, P. K. 1958. Species hybrids of tea. *Nature (Lond)* **181**: 1674–1675.
-