Research Article

Tertiary trisomics in $2n = 12$ *Coix* taxon

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Abstract: Tertiary trisomics have been isolated from the domesticated outcrossed population of a comparatively new taxon of *Coix* with $2n = 12$ chromosome number and also from the selfed progenies of the chromosomal variants ranging from $2n=11$ to $2n=13$. Cytological analysis of these trisomics indicated that different chromosomal associations forming a trivalent, pentavalent and univalent were frequent at diakinesis. Disomics ($2n = 12$) and their monosomics ($2n-1$; $2n = 11$) showing interchanged quadrivalents at diakinesis were observed to be the main sources of these tertiary trisomics.

Keywords: Tertiary trisomics; *Coix*; Pentavalents; Interchanged quadrivalents.

Introduction

As compared to the reports available on primary trisomics (Rick & Barton, 1954; Pantulu, 1967; Iyer, 1968; Burton & Powell, 1968), literature on tertiary trisomics is very limited. Tertiary trisomics have been reported in pearl millet (Venkateswarlu & Mani, 1978; Sai Kumar *et al.*, 1985), tomato, (Khush & Rick, 1967), barley (Burnham *et al.*, 1954) etc. Tertiary trisomics may occur spontaneously among the progeny of translocation heterozygotes. Reciprocal translocations are not uncommon in the genus *Coix*, a monoecious member of tribe Maydeae belonging to the family Poaceae (Barve & Sapre, 1985; Nirmala & Rao, 1983; Rao & Venkateswarlu, 1977; Venkateswarlu, 1958; Barve & Sangeetha, 2010). The spontaneous occurrence and behaviour of tertiary trisomics that have been detected among the domesticated population of $2n = 12$ *Coix* taxon is reported in the present paper.

Materials and Methods

Coix L. is an oriental relative of maize. The chromosome numbers of *Coix* reported so far, range mostly from $2n = 10$ to 40. The genus is characterized by the basic number $x = 5$ (Celarier, 1957; Fedorov, 1974; Goldblatt, 1984). Young male racemes of $2n=12$ *Coix* taxon plants were fixed in acetic-alcohol solution (1:3) for meiotic studies. Anthers were squashed in 1% aceto-carmin and fresh preparations were used for study of various chromosomal configurations and photomicrography (1000x magnification).

Results and Discussion

An organism having an extra interchanged chromosome in addition to the normal chromosome complement is a tertiary trisomic. During the cytological screening of an outcrossed population of $2n = 12$ *Coix* taxon, a few trisomic plants with $2n = 13$ ($2n+1$) chromosomes were isolated. Detailed cytological analysis showed that the extra chromosome of the complement was a translocated chromosome. Majority of the microsporocytes exhibited five bivalents and a trivalent configuration at diakinesis (fig. 1). In 18.38% of PMCs, a pentavalent configuration was observed (fig. 2), characteristic of tertiary trisomics, along with four bivalents, indicating that the additional univalent was an interchanged one and had arms of two different non-homologous pairs of chromosomes. Other configurations recorded at diakinesis were 6II+I (fig. 3), IV+III+3II (fig. 4) and 5II+3I (fig. 5) in decreasing frequency (Table 1). The frequencies of the different associations obviously depend upon the length of the chromosomes involved, the length of the duplicated segments and the chiasma frequency. Different configurations of trivalents like 'sauce pan', 'ring', 'y-shaped' etc. were observed based on the number and position of chiasma/ta. Pentavalents also exhibited different configurations like 'dumb bell', 'y-shaped' etc. at diakinesis.

Table 1. Diakinesis showing the various chromosomal configurations.

Total number of PMCs scored	III+5II	V+4II	6II+I	IV+III+3II	5II+3I	IV+4II+I
321	209	59	24	20	6	3
	65.11%	18.38%	7.48%	6.23%	1.87%	0.93%

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Table 2. Anaphase –I/telophase-I showing distribution of univalents.

Total number of PMCs scored	7I–6I	5I–III–5I	Sticky separation with chromatintail	6I–II–5I	8I–5I	6I–I–6I	9I–4I
202	118	31	22	18	6	5	2
	58.41%	15.35%	10.89%	8.91%	2.97%	2.48%	0.99%

Figs. 1-11. Meiosis in the tertiary trisomic plant:

Diakinesis showing (1) III + 5II, (2) V + 4II, (3) 6II + I, (4) IV + III + 3II, (5) 5II + 3I; (6) Metaphase-I showing oriented III and 5 II; (7-9) Anaphase-I showing (7) 7I – 6I (8) 8I – 5I and (9) 9I – 4I distribution to the opposite poles; (10) Normal microspore tetrads, (11) Tetrads with unequal distribution of chromatin.

The effect of tertiary trisomic condition was reflected at metaphase-I and anaphase-I. Although majority of the PMCs (48.99%) showed oriented III+5II (fig. 6), in a few PMCs, the trivalent, pentavalent or bivalents were seen unoriented at metaphase-I plate indicating the difficulty in their orientation. Unoriented or precocious univalents were also observed sometimes. The anaphase-I segregation was recorded to be mostly sticky, producing chromatin trails. The trivalents mostly showed difficulty in disjunction and showed sticky stretched segregation and ultimately segregated as II – I giving 7I – 6I distribution at the opposite poles in most of the PMCs (58.41%) (fig. 7). The pentavalent also showed difficulty in disjunction, but ultimately segregated as III – II giving 7I – 6I distribution at respective poles. Sometimes, the trivalent did not segregate and moved to one pole along with the univalents or lagged in the center or was seen precociously at one of the poles. In some cells (8.91%), a bivalent lagged was recorded. The misbehaviour or unequal segregation of trivalent or pentavalent led to distribution of univalents as 8 – 5 (fig. 8) or 9 – 4 (fig. 9) (Table 2). The microsporocytes with 7I – 6I distribution at telophase-I went through meiosis-II regularly and later produced normal tetrads (fig. 10) with 7 - 7 – 6 -6 chromosomal constitution. The unequal distribution observed at anaphase-I showed similar segregation at anaphase-II leading to tetrads with 8

– 8 – 5 – 5 or 9 – 9 – 4 – 4 chromosomal constitution (fig. 11). Thus, these trisomics were observed to be a source of normal ($n = 6$), sub-haploid ($n = 4, 5$) and super-haploid ($n = 7, 8, 9$) gametes and thereby, a rich source of further aneuploids including higher polysomics, in the population. Irrespective of having disturbed meiosis to some extent, the selfed progeny of these trisomics consisted of higher polysomics like tetrasomy and pentasomy indicating the survival and functioning of the hyperploid gametes. The $2n = 13$ tertiary trisomic plants showed an average seed fertility of 67%.

The tertiary trisomics may appear spontaneously in the progenies of normal disomics, but their frequency is extremely low. In general, interchange heterozygotes that throw tertiary trisomics in their progenies have been described in maize (Burnham, 1930, 1934), pea (Sutton, 1939), *Oenothera lamarckiana* (Emerson, 1936), *Clarkia amoena* (Hakansson, 1940) *Oenothera blandina* (Catcheside, 1954), barley (Burnham *et al.*, 1954; Hagberg, 1954; Ramage, 1960; Tsuchiya, 1960), tomato (Khush and Rick, 1967; Gill, 1978), *Phaseolus vulgaris* (Ashraf and Bassett, 1987), *Pennisetum glaucum* (Tyagi, 1975; Singh *et al.*, 1982; Sai Kumar *et al.*, 1985), *Secale cereale* (Sybenga, 1966; Janse, 1985, 1987), and lentil (Ladizinsky *et al.*, 1990). Cytological analysis of these plants mostly showed that the configurations produced by the tertiary chromosome and related normal chromosomes presented the normally expected pattern. Chromosome association of trivalents, univalents and pentavalents were frequent in these trisomics, though their ratio varied. The trivalent configuration was more frequent in these plants at diakinesis and metaphase- I, than the univalent and pentavalent configuration. In the *Coix* tertiary trisomics also, trivalent configuration was predominant followed by the pentavalent and univalent configurations. Other types of configurations were relatively infrequent.

Tertiary trisomics originate from an interchange heterozygote in the following way. An interchange heterozygote occasionally forms a non co oriented quadrivalent configuration at diakinesis and metaphase-I, and a 3:1 random disjunction of chromosomes at anaphase-I will generate $n + 1$ gametes (Avery *et al.*, 1959). In the present studies, $2n = 12$ *Coix* plants and $2n = 11$ chromosome variants were found to produce $n + 1$ gametes to some extent due to the unequal segregation of the univalents to the opposite poles. These plants showed interchange quadrivalents at diakinesis and

unequal segregation of the quadrivalents led to unequal distribution of univalents to opposite poles. This resulted in the formation of aneuploid gametes, especially $n+1$, with an interchanged chromosome. Chance mating of n and $n+1$ gametes having interchanged extra chromosome might have resulted in the formation of tertiary trisomic in $2n=12$ *Coix* taxon. A few $2n=13$ plants showing tertiary trisomics were also isolated from the open pollinated domesticated population and were selfed. As expected, these are observed to be the rich sources of n and $n+1$ gametes to produce more tertiary trisomics in the population.

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