Meiosis in a Double Aneuploid Plant Carrying 2n=20 Chromosomes: Monosomic-Trisomic Condition (2n- I + i = 20)

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Abstract- *Coix* L. is known for its chromosomal variations, including aneuploidy, polyploidy, and hybridization, often seen in species growing in overlapping habitats. Meiotic abnormalities have been reported in *Coix* species like *C. aquatica, C. gigantea* and *C.lacryma-jobi*. A rare double aneuploid monosomic-trisomic condition (2n−I+i) was observed in a self-pollinated population of *C. gigantea*. Morphologically similar to diploid plants, it was studied for its meiotic behavior, focusing on monosomic and trisomic chromosomes. During meiosis, these chromosomes behaved normally in some cases but exhibited abnormalities in others, leading to tetrads with varying micronuclei. These anomalies indicated that monosomic and trisomic chromosomes were occasionally incorporated into gametes rather than being eliminated. This study sheds light on the dynamic chromosomal behavior in *Coix* and provides valuable insights into double aneuploidy in the genus.

Keywords- Double aneuploid *Coix*, Meiosis, Monosomy, Trisomy

I. INTRODUCTION

Coix L., a genus renowned for its chromosomal variability, consists of three ill-defined species in India (Mangelsdorf and Reeves 1939; Nirodi 1955; Barve and Sangeetha 2008). It commonly exhibits aneuploidy (nullisomic to tetrasomy), polyploidy, and hybridization between species, making it a model for studying chromosomal behavior. Chromosomal irregularities during cell division—specifically in anaphase of meiosis or mitosis can result in unequal chromosome distribution, leading to aneuploid progeny. These anomalies usually span the range from nullisomy (2n−2) to tetrasomy (2n+2) (Nirodi, 1955; Venketshvarlu and Rao, 1956; Koul and Paliwal, 1964). Further variations within aneuploid chromosomal constitutions arise from centromere misdivision of univalent chromosomes during meiosis I and II, giving rise to iso- and / or telocentric chromosomes. Kush (1973) classified thirty-two types of aneuploidy, while Saikumar et al. (1982) documented instances of double aneuploids, including tetrasomic-trisomic forms in *Pennisetum* (2n+2+1).

In this study, a self-pollinated population of *C. gigantea* yielded a rare and complex aneuploid condition: a double aneuploid monosomic-trisomic plant (2n=20), which exhibited both a monosomic condition for the largest chromosome and a trisomic condition for a smaller chromosome. This particular plant had one chromosome missing (monosomic for the largest chromosome) and, simultaneously, an additional homologous chromosome (trisomic for the smaller chromosome), resulting in a chromosomal complement of 2n=20 (2n−1 + i). The plant's chromosomal configuration was consistent with a diploid complement but with the additional complexity of monosomy for one chromosome and trisomy for another.

The plant was morphologically similar to typical diploid plants, making it difficult to distinguish it from other individuals in the population. This study aimed to examine the meiotic behavior of the monosomic and trisomic chromosomes during the different stages of meiosis, using single-plant cytology to assess chromosomal segregation. While the monosomic and trisomic chromosomes generally behaved as normal chromosomes during meiosis I, a significant number of meiocytes displayed irregularities during meiosis II. These irregularities led to the formation of tetrads with varying numbers of micronuclei, indicating that some of the aberrant chromosomes were incorporated into gametes instead of being eliminated, as would be expected in a normal meiotic process.

This investigation provides valuable insights into the dynamics of chromosomal behavior in *Coix*, especially concerning double aneuploidy. The findings highlight the complexity of chromosomal interactions in the genus and underscore the potential for further research into meiotic abnormalities and their implications for plant breeding and evolution.

II. MATERIALS AND METHODS

The seeds of *Coix gigantea* were collected from Uttar, District Kolhapur, and the plants were grown in the Botanical Garden of Pratibha Niketan Mahavidyalaya, Nanded. Before flowering, all plants in the field were assigned serial numbers and tagged. As flowering commenced, male racemes of appropriate size were harvested and fixed in a 1:3 acetic acid: alcohol solution. The samples were stored at room temperature for a short period and then refrigerated until meiotic analysis was conducted.

For cytological analysis, single-plant cytology was employed. Meiotic cells were stained with 1% aceto-carmine. Multiple slides were prepared from each plant, and the meiotic stages and chromosome counts were observed. Microphotographs were taken from temporary slides using an Olympus research microscope at 100X magnification.

III. RESULTS AND DISCUSSION

The majority of PMCs at diakinesis exhibited a regular chromosomal configuration of 8 II + iii + I, with eight bivalents, a trivalent formed by small chromosomes, and a single large monosomic chromosome (Fig A & B). Some cells showed a 9 II + I + I configuration (Table 1).

Table -1: Diakinesis showing Chromosomal configuration

Total No. of PMCs scored	8II+ iii+ I	9II+ i+ I
98	43	55

At metaphase I, the typical configuration consisted of 8 II + a trivalent of small chromosomes oriented at the equator, forming the metaphase plate. In cells exhibiting the 9 II + I + I configuration, the two univalents either moved precociously to opposite poles (Fig-C) or passed to the same pole. Some metaphase cells also contained additional univalents, along with the monosomic chromosome and univalents of the smaller chromosome, which either moved precociously to the poles or were randomly distributed within the cell (Fig-D, Table 2).

Table -2: Metaphase – I showing the behaviour of monosome and trisome

Total No. of PMCs scored	Randomly placed monosome	Precocious monosome at one pole	Precocious monosome and small univalent		Unorientated monosome and small univalent
			At one pole	At opposite pole	
193	59	21	17	45	51

In general, the trivalent segregated as bivalents and univalents, resulting in a normal chromosomal distribution of 8 I + I + I → 2 i + 8 I (Fig-E& F). However, due to the precocious movement of univalents, some cells showed irregular distributions, such as 8 I + i → 2 i + I + 8 I (9 I + 11 I) (Fig.-E& F) and 8 I → 3 i + I + 8 I (8 I → 12 I) (Fig-G). A few cells exhibited lagging univalents or late-separating bivalents (Fig-H, Table 3).

Table -3: Anaphase-I/Telophase –I showing the distribution of chromosomes

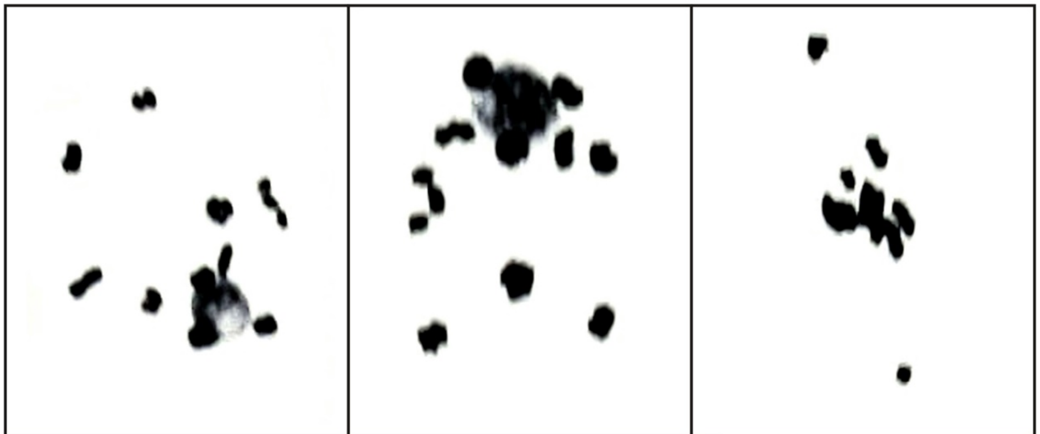
Total No. of PMCs scored	8I+ I+I----2i + 8I (10---10)	8I+i ----2i+I+ 8I (9I+ 11I)	8I----3i+I+ 8I (8I---12I)	10I—I---9I	10I—i---9I	9I—I+I—8I
115	34	14	3	17	41	6

Meiosis II was somewhat disturbed, with excluded univalents observed at prophase II (Fig-I). The process also showed signs of stickiness, and a variable number of lagging univalents or chromatids were recorded in some cells (Fig-J to L, Table 4).

Table -4: Tetrads showing variable number of micronuclei

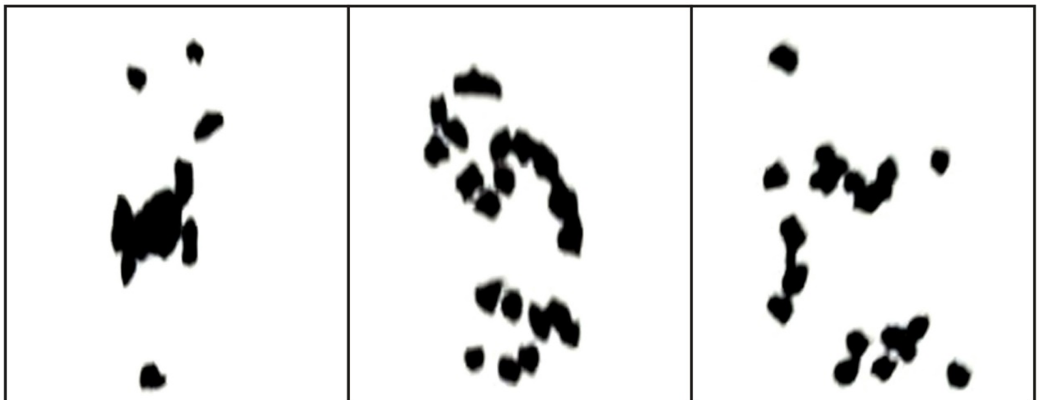
Total No. of PMCs scored	Tetrad without any micronuclei (clean)	Tetrad with one big micronucleus	Tetrad with one small micronucleus	Tetrad with two micronuclei
172	101	28	25	18

Plate 1: Meiosis in Plant Carrying 2n=20 Chromosomes (Monosomic-Trisomic 2n- I + i)



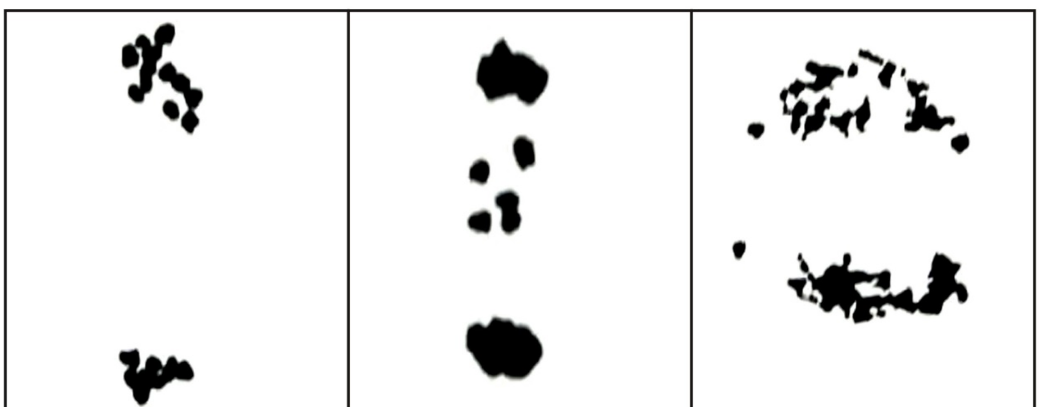
(A & B) Diakinesis showing 8II+III+i

(C) Metaphase-I showing precociously moving monosome & small univalent at opposite pole.



(D) Metaphase-I showing precociously placed two small univalents to one ploe & other small univalent to opposite pole.

(E & F) Anaphase-I showing 11I---- 9I distribution of chromosomes



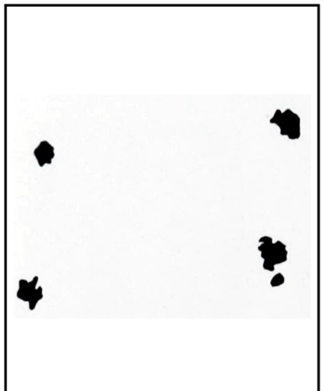
(G) Anaphase-I showing 12I----8I distribution

(H) Telophase-I showing two bivalents & univalents as laggards.

(I) Prophase- II showing univalents excluded from the groups.

Plate 1: Meiosis in Plant Carrying 2n=20 Chromosomes (Monosomic-Trisomic 2n- I + i)

(J to L) Anaphase-II and Telophase-II showing variable number of univalent laggards.



(M) Tetrad showing Univalent micronucleus in one of the cells

It was observed that n-2, n-1, n+1 and n+2 gametes are functional, as monosomic and trisomic plants (2n = 20) were obtained in the selfed progeny of monosomic-trisomic plants. This suggests that the n-2 gamete is also functional, and its mating with the n gamete resulted in the formation of a nullisomic plant (2n = 18). The univalency of the smaller bivalent and the inclusion of the univalent into a tetrad with an n constitution likely contributed to the formation of n+1 gametes. These plants also produced n-1 gametes. The chance mating of n-1 and n+1 gametes during self-fertilization could have led to the formation of 2n = 20 (monosomic/trisomic for the small chromosome).

Nullisomic-trisomic conditions typically arise from misdivision during meiosis. In some cases, they may be modified into isochromosomes or eliminated during cell division. According to Darlington (1939), monosomic-trisomic plants are generally unstable and cannot survive in nature. However, in this study, the addition of one small chromosome did not significantly disrupt meiosis. Although some meiotic divisions showed lagging or precious movement of the monosomic and trisomic chromosomes, the overall tetrad formation was mostly normal. A large number of clean tetrads were observed, indicating that both the nullisomic condition for one chromosome and the trisomic condition for another persisted through meiosis, rather than being eliminated.

This persistence suggests that the instability typically associated with monosomic-trisomic plants may not be as detrimental in *Coix gigantea*, as the plant's genome appears to tolerate these variations without affecting survival. This could allow for continued chromosomal variation in subsequent generations, potentially leading to further genetic diversity within the population.

IV. CONCLUSION

The plant, having one fewer larger chromosome (monosome) and one additional smaller chromosome (trisome), behaves somewhat abnormally during meiosis and attempts to eliminate the extra chromosome. However, in the end, it manages the condition, ultimately leading to many normal and clean tetrads by the end of meiosis II. This meiosis results in possible gametic combinations such as n = 8, n = 9, n = 10, n = 11, and n = 12, which may give rise to potential hypo- or hyper-aneuploidy in subsequent generations.

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