The course of meiosis in diploid *Solanum nigrum* was regular. At both diakinesis and metaphase-1, 12 bivalents were invariably seen (Fig. 93). At diakinesis most of the bivalents were ring type with chiasma at both the arms of chromosomes. The mean number of ring bivalents per cell at diakinesis was 7.6, the range being from 5 to 11. The mean number of rod bivalent per cell was 4.4, the range being from 1 to 7. The chiasma frequency per cell and per bivalent was 19.60 and 1.63 respectively (Table 66).

The mean number of ring bivalents at metaphase-1 was 0.96 with a range of 0 to 4. The mean number of rod bivalents per cell at metaphase-1 was 11.04 with a range of 8 to 12. The chiasma frequency per cell and per bivalent at metaphase-1 was 12.96 and 1.08 respectively (Table 67). There was an increase in the mean number of rod bivalents per cell from diakinesis to metaphase-1 with a corresponding decrease in the mean number of ring bivalents.

The distribution of chromosomes at anaphase-I was normal with 12; 12 chromosomes at each pole. The subsequent
Meiotic divisions were normal and the size of pollen grains was uniform.

Nelumbo nucifera var. nucifera

Meiosis was normal and 12 bivalents were invariably seen at diakinesis and metaphase-1 (Fig. 94). At diakinesis most of the bivalents were of ring type with chiasmata at both the arms of chromosomes. The mean number of ring and rod bivalents at diakinesis was 9.04 and 2.96 respectively. The number of ring bivalents varied from 6 to 12 whereas the number of rod bivalents in the cells varied from 0 to 5. The chiasmata frequency per cell at diakinesis was 21.04 whereas it was 1.75 per bivalent (Table 66).

The mean number of ring bivalents per cell at metaphase-1 was 1.66, with a range from 0 to 5. The mean number of rod bivalents per cell at metaphase-1 was 10.32 and range being from 7 to 12. The chiasmata frequency per cell and per bivalent at metaphase-1 was 11.66 and 1.14 respectively. The mean number of rod bivalents per cell increases from diakinesis to metaphase-1 with a corresponding decrease in the mean number ring bivalents. The chiasmata frequency per bivalent at metaphase-1 was less (1.14) (Table 67) than at diakinesis (1.79).

Metaphase-1 was regular with 12,12 chromosomes at poles. The subsequent stages of meiosis were found to be normal.
The course of meiosis was regular. At both diakinesis and metaphase-1 12 bivalents were regularly seen (Fig. 95). Ring bivalents were most common at diakinesis with chiasmata at both the arms of chromosomes. The mean number of ring bivalents per cell at diakinesis was 9.36 with a range from 7 to 12. The mean number of rod bivalents per cell at diakinesis was 2.64 with a range from 0 to 5. The chiasma frequency per cell and per bivalent was 21.32 and 1.77 respectively (Table 66).

The mean number of ring bivalents per cell at metaphase-1 was 1.68, with a range from 0 to 5. The mean number of rod bivalents per cell at metaphase-1 was 10.32 with a range of 7 to 12. The chiasma frequency per cell and per bivalent at metaphase-1 was 13.66 and 1.14 respectively (Table 67). The chiasma frequency per cell and per bivalent was less at metaphase-1 than at diakinesis. The disjunction of chromosomes at anaphase-1 was regular and the subsequent meiotic divisions were normal. The size of pollen grains was uniform.

*Colanum barbaceoides*

The meiosis was normal with 12 bivalents both at diakinesis and metaphase-1 (Fig. 96). At diakinesis mostly ring bivalents were observed with chiasmata at both the
arose of chromosomes. Data on chromosome pairing and chiasmata frequency at diakinesis and metaphase-I are presented in Tables 66 and 67 respectively. The mean number of chiasmata per cell and per bivalent increases from diakinesis to metaphase-I.

The distribution of chromosomes at anaphase-I was normal with 12:12 chromosomes at each pole. The subsequent meiotic divisions were normal and the size of pollen grains was uniform.

**Indian tetraploid Solanum nigrum**

The course of meiosis was normal. At diakinesis and metaphase-I, 24 bivalents were seen (fig. 97). The chiasmata frequency at diakinesis was higher than that at metaphase-I due to the occurrence of large number of ring bivalents. The mean number of ring bivalents per cell, at diakinesis, was 19.44, the range being from 15 to 22. The mean number of rod bivalents per cell at diakinesis was 4.58, the range being from 2 to 9. The chiasmata frequency per cell and per bivalent at diakinesis was 43.44 and 1.81 respectively (Table 66).

The mean number of ring bivalents per cell at metaphase-I was 2.30. It ranged from 0 to 6. The mean number of rod bivalents per cell at metaphase-I was 21.20.
It ranged from 18 to 24. The mean chiasmata frequency per cell and per bivalent at metaphase-1 was 25.80 and 1.11 respectively (Table 67).

Anaphase-I was found to be normal with 24:24 distribution of chromosome at each pole. The subsequent stages of meiosis were regular. The size of pollen grains was uniform.

*Platanus* *villosa*.

The course of meiosis was regular and 24 bivalents were seen at diakinesis and metaphase-1 (Fig. 96). Univalents and multivalents were not observed. At diakinesis mostly ring bivalents were seen. The mean number of ring bivalents per cell at diakinesis was 20.08 with a range of 18 to 23 and the mean number of rod bivalents was 3.92 with a range of 1 to 6. The chiasmata frequency per cell and per bivalent at diakinesis was 44.08 and 1.83 respectively (Table 66).

The mean number of ring bivalents at metaphase-I was 3.04, the range being from 0 to 7 and the mean number of rod bivalents per cell at metaphase-I was 20.96, the range being 17 to 24. The chiasmata frequency per cell and per bivalent at metaphase-I was 27.04 and 1.12 respectively (Table 67).
Anaphase-I was regular with 24:24 distribution of chromosomes at poles. The subsequent meiotic divisions were normal. The size of pollen grains was uniform.

Solanum villosum sp. puniceum.

Meiosis was normal in *Solanum* sp. puniceum. At both diakinesis and metaphase-I 24 bivalents were invariably seen (Fig. 99). Mostly ring bivalents were observed at diakinesis. The mean number of ring bivalents per cell at diakinesis was 17.40 with a range of 13 to 22 whereas the mean number of rod bivalents per cell was 6.60 with a range of 2 to 11. The chiasmata frequency per cell and per bivalent at diakinesis was 41.40 and 1.72 respectively (Table 66).

The mean number of ring bivalents at metaphase-I was 2.80 with a range of 0 to 6 and the mean number of rod bivalents per cell at metaphase-I was 21.20 with a range of 13 to 24. The chiasmata frequency per cell and per bivalent was 26.80 and 1.11 respectively (Table 67). The chiasmata frequency per bivalent at metaphase-I was less (1.11) than that at diakinesis (1.72).

The disjunction of chromosomes at anaphase-I was normal. The subsequent meiotic divisions were regular.

*Solanum luteum*

Meiosis was normal and 24 bivalents were regularly seen both at diakinesis and metaphase-I (Fig. 10C). At
Diakinesis most of the bivalents were of ring type with chiasmata at both the arms of chromosomes. The mean number of ring and rod bivalents per cell at diakinesis was 20.32 and 3.68 respectively. The chiasmata frequency per cell and per bivalent at diakinesis was 44.32 and 1.84 respectively (Table 66).

The mean number of ring and rod bivalents per cell at metaphase-1 was 3.40 and 20.60 respectively. The mean chiasmata frequency per cell was 27.40 and the mean chiasmata frequency per bivalent at metaphase-1 was 1.14 (Table 67). The chiasmata frequency at diakinesis was higher as compared to metaphase-1 due to the occurrence of a large number of ring bivalents.

Normal distribution of chromosomes was noted at anaphase-1. The subsequent meiotic divisions were normal and the size of pollen was regular.

*G. planum retroflexum*

Meiosis was normal with regular formation of 24 bivalents at diakinesis and metaphase-1 (Fig. 101). The chiasmata frequency at diakinesis was higher than metaphase-1 due to the occurrence of large number of ring bivalents. The mean number of ring bivalents per cell at diakinesis was 20.88 and range was from 16 to 24. The
Mean number of rod bivalents per cell at diakinesis was 3.12, and range being from 0 to 0. The mean chiasmata frequency per cell and per bivalent at diakinesis was 44.88 and 1.87 respectively (Table 66).

The mean number of ring bivalents per cell at metaphase-1 was 3.15, they ranged from 0 to 3 and the mean number of rod bivalents per cell was 26.84 which ranged from 10 to 44. The mean chiasmata frequency per cell and per bivalent at metaphase-1 was 27.16 and 1.13 respectively (Table 67).

Anaphase-1 was regular with 24:24 distribution of chromosomes at poles. The subsequent meiotic divisions were normal and the size of pollen grains was uniform.

**Indian hesperioid - *Eupanacra nigristriata***

Meiosis was normal with the formation of 36 bivalents at diakinesis and metaphase-1 (Fig. 102). Univalents and multivalents were not seen. At diakinesis most of the bivalents were of ring type with chiasmata at both the arms of the chromosomes. The mean number of ring bivalents per cell at diakinesis was 24.40 which ranged from 24 to 34 and the mean number of rod bivalents per cell at diakinesis was 7.60. The range was from 2 to 12. The chiasmata frequency per cell and per bivalent was 64.40 and 1.78 respectively (Table 66).
The mean number of ring bivalents per cell at metaphase-I was 4.92, it ranged from 0 to 9 and the mean number of rod bivalents per cell at metaphase-I was 31.08, it ranged from 27 to 36. The chiasmata frequency per cell and per bivalent at metaphase-I was 40.76 and 1.13 respectively (Table 67).

The chiasmata frequency per bivalent at metaphase-I was less (1.13) than that at diakinesis (1.78). Metaphase-I was regular with 36:36 distribution of chromosomes at poles. The subsequent meiotic divisions were normal and the size of pollen grains was uniform.

**French hexaploid Solanum nigrum**

The course of meiosis was regular. At both diakinesis and metaphase-I 16 bivalents were regularly seen (Fig. 103). At diakinesis most of the bivalents were of ring type with chiasmata at both the arms of chromosomes. The mean number of ring bivalents per cell at diakinesis was 29.96, it ranged from 22 to 34. The mean number of rod bivalents per cell at diakinesis was 6.04, it ranged from 2 to 14. The chiasmata frequency per cell and per bivalent at diakinesis was 65.96 and 1.83 respectively (Table 66).

The mean number of ring and rod bivalents per cell at metaphase-I was 4.84 (the range was from 3 to 12) and 31.16 (range from 24 to 36) respectively. The chiasmata
Frequency per cell was 40.64 and per bivalent was 1.13 (Table 67).

Normal disjunction of chromosomes was observed at anaphase-I. The subsequent meiotic divisions were normal and the size of pollen grains was uniform.

*Solanus furcatus*

Normal meiosis was noted with the regular formation of 36 bivalents at diakinesis and metaphase-I (Fig. 104). Univalents or multivalents were not observed. The mean number of ring bivalents per cell at diakinesis was 31.32, it ranged from 24 to 35 and the mean number of rod bivalents per cell was 5.08, it ranged from 1 to 10. The chiasmata frequency per cell and per bivalent at diakinesis was 66.64 and 1.85 respectively (Table 66).

The mean number of ring bivalents and rod bivalents per cell at metaphase-I was 5.44 (range from 1 to 10) and 30.56 (range from 26 to 35) respectively. The chiasmata frequency per cell and per bivalent at metaphase-I was 41.44 and 1.15 respectively (Table 67).

Normal disjunction of chromosomes at anaphase-I was observed. The subsequent meiotic divisions were regular and the size of pollen grains was uniform.
Melosis was normal and 36 bivalents were regularly formed at diakinesis and metaphase-1 (Fig. 105). At diakinesis mostly ring bivalents were found with chiasma at both the arms of chromosomes. The mean number of ring bivalents per cell at diakinesis was 36.36, it ranged from 24 to 35. The mean number of rod bivalents per cell was 5.64, it ranged from 1 to 12. The chiasma frequency per cell and per bivalent at diakinesis was 66.36 and 1.04 respectively (Table 66).

The mean number of ring bivalents per cell at metaphase-1 was 2.26, it ranged from 0 to 6 and the mean number of rod bivalents per cell at metaphase-1 was 33.72, it ranged from 30 to 36. The chiasma frequency per cell and per bivalent at metaphase-1 was 33.26 and 1.06 respectively (Table 67). The chiasma frequency per bivalent at metaphase-1 was less (1.06) than at diakinesis (1.84).

Anaphase-1 was normal with 36:36 distribution of chromosomes at poles. The subsequent meiotic stages were normal and the size of the pollen grains was uniform.

8.2 Melosis in triploid hybrids (r) between A. villosum

and A. puniceum and diploid A. nigrum

The meiotic studies showed a wide range of irregularities. A detailed account of meiotic chromosome behaviour
Both at diakinesis and metaphase-I, univalents were present together with trivalents, quadrivalents and bivalents (Figs. 106 and 107). Most of the pollen mother cells showed loose associations of chromosomes. Quadrivalents were recorded in a very low frequency, the chromosome associations and the mean chiasmata frequency recorded at diakinesis and metaphase-I are presented in Tables 68 and 69 respectively. At diakinesis, the mean chromosomal associations per cell were $1.30, 1.13, 2.04, 0.36$. Univalents, bivalents, trivalents and quadrivalents ranged from 4 to 16, 7 to 15, 0 to 4 and 0 to 1 respectively.

At metaphase-I, the pairing behaviour of the chromosome was found to be extremely variable (Fig. 107). The mean chromosomal associations per cell were $9.84, 10.68, 1.44, 0.12$. The range of univalents, bivalents, trivalents and quadrivalents was from 4 to 16, 7 to 15, 0 to 4 and 0 to 1 respectively. The univalents were mostly found scattered all over the spindle. From diakinesis to metaphase-I, an increase in mean number of univalents per cell with corresponding decrease in mean number of bivalents, trivalents and quadrivalents was found (Tables 68 and 69). The mean number of rod bivalents per cell increased at metaphase-I with a corresponding decrease
in mean number of ring bivalents, at both diakinesis and metaphase-1 the mean number of trivalents was found to be more than the mean number of quadrivalents. The mean chiasma frequency per bivalent at metaphase-1 was lower (0.01) than at diakinesis [1,32].

Anaphase-1 was highly irregular (Figs. 108-110). Only 12 per cent of the pollen mother cells showed equal distribution (10:10) of chromosomes at poles. Most of the pollen mother cells at anaphase-1 showed unequal distribution of chromosomes. Sixty eight per cent of the cells showed lagging chromosomes with varying frequencies (Fig. 108). Bridges with or without fragments were seen in 16 per cent of pollen mother cells (Fig. 110). Dividing univalents were also recorded (Fig. 109). At telophase-1 the micronuclei were not observed. Lagging chromosomes were recorded at anaphase-11 in 30 per cent of the cells. Micronuclei were not observed at telophase-11. Data regarding the percentage of cells showing chromosomal aberrations at anaphase-1, anaphase-11, telophase-1, and telophase-11 are presented in Table 70. The percentage of cells showing lagging chromosomes at anaphase-11 was found to be less than at anaphase-1.
6.3 Meiosis in colchicine induced hexaploids \( (L_2) \) obtained from triploid hybrids \( S_v \) villosus sp. puniceum x diploid \( S_w \) nigrum.

The growing tips of some branches of sterile triploid hybrids were treated with colchicine to raise hexaploid branches. The detail cytology of colchicine treated shoots \( (L_1) \) was not studied due to non-availability of sufficient number of flower buds. Meiosis in \( L_2 \) generation was studied and the results are described below:

Cytology of the plant was mostly normal. Several pollen mother cells showed 36 bivalents at diakinesis and metaphase-I. However, a few cells showed univalents, trivalents and quadrivalents along with bivalents. The analysis of chromosomal associations and chiasma frequency at diakinesis are given in Table 6a. The mean chromosomal associations per cell at diakinesis were 0.71 univalents, 33.55 bivalents, 0.56 trivalents and 0.66 quadrivalents. The number of bivalents per cell ranged from 27 to 36. The bivalents were mostly of ring type with chiasmata in both the arms of chromosomes. The chiasma frequency per cell and per bivalent at diakinesis was 82.61 and 1.74 respectively.

At metaphase-I, the meiosis was mostly normal and a large number of pollen mother cells showed 36 bivalents.
However, a few cells showed the occurrence of univalents, bivalents, trivalents and quadrivalents (Fig. 111). The mean pairing analysis and chiasma frequency are presented in Table 69. The mean chromosomal associations per cell at metaphase-I were 1.28 univalents, 34.10 bivalents, 0.36 trivalents and 0.40 quadrivalents. The number of bivalents per cell ranged from 29 to 36. The number of univalents, trivalents and quadrivalents ranged from 0 to 5, 0 to 2 and 0 to 1 respectively. It is obvious from the Table that the mean number of bivalents and univalents slightly increased at metaphase-I than that at diakinesis with a slight decrease in mean number of trivalents and quadrivalents per cell. The chiasma frequency per cell and per bivalent at metaphase-I was less than that at diakinesis and it was 30.48 and 1.07 respectively.

At anaphase-I, normal distribution of the chromosomes was recorded in 70 per cent of the pollen mother cells (Fig. 112). However, some cells showed unequal distribution of the chromosomes at poles. Lagging chromosomes were recorded in only 8 per cent of the pollen mother cells (Table 70). At anaphase-I, bridges, fragments or dividing univalents were not observed. Micronuclei at telophase-I and telophase-II were not recorded. Anaphase-II was also normal. The data regarding the percentage of chromosomal aberrations at anaphase-I and II, and
telophase-1 and II are presented in Table 70. The product of meiosis was tetrads with regular size and shape.

8.4 Meiosis in triploid hybrids \( \left( \frac{1}{3} \right) \) between \( \textit{W. villosum} \) ssp. \( \textit{puniceum} \) and \( \textit{W. nodiflorum} \) ssp. \( \textit{nodiflorum} \)

Meiosis was highly irregular. A detailed account of meiotic chromosome behaviour of the hybrid is presented below:

The course of meiosis was highly irregular. The mean chromosomal associations per cell at diakinesis were \( 1.72, 13.72, 1.70, 0.28 \). Univalents ranged from 0 to 4, bivalents ranged from 10 to 16, trivalents ranged from 0 to 3 and quadrivalents ranged from 0 to 2. The chiasma frequency per cell and per bivalent at diakinesis was 24.68 and 1.37 respectively (Table 68). The mean number of trivalents was higher than the mean number of quadrivalents per cell.

Metaphase-I showed several chromosomal abnormalities (Figs. 113 and 114). The mean chromosomal associations per cell at metaphase-1 were 10.48 univalents, 10.36 bivalents, 1.44 trivalents and 0.12 quadrivalents. The bivalents ranged from 5 to 14. The maximum number of univalents, trivalents and quadrivalents per cell was 23, 3 and 1 respectively. The mean number of trivalents,
quadrivals and bivalents decreased from diakinesis to metaphase-I with a corresponding increase in the mean number of univalents per cell. Almost all the univalents were scattered all over the spindle (fig. 114). The mean number of rod bivalents was higher at metaphase-I than at diakinesis. The mean chiasmata frequency per cell and per bivalent was 14.86 and 0.62 respectively (Table 69). The chiasmata frequency was found to be at lower level at metaphase-I than at diakinesis.

Anaphase-I showed several meiotic irregularities (figs. 115 and 116). Rarely normal distribution of the chromosomes at poles was observed (fig. 116). Unequal distribution of chromosomes at poles was noted in 32 per cent of the pollen mother cells. Lagging chromosomes were found in 48 per cent of the cells and they ranged from 1 to 10. Bridges were found with or without fragments in 12 per cent of pollen mother cells. Rarely fragments without bridges were noted. Micronuclei were observed in 12 per cent of pollen mother cells at telophase-I. Lagging chromosomes were also recorded at anaphase-II in 24 per cent of the cells. At telophase-II micronuclei were not observed. Data regarding the percentage of cells showing chromosomal aberrations at anaphase-I and II and telophase-I and II are presented in Table 70.
Meiosis in colchicine induced hexaploids (L2) obtained from triploid hybrids L. villosum spp. punicum x L. nodiflorum spp. nodiflorum.

Cytology of colchicine induced shoots (L1) was not studied in detail as sufficient number of flower buds were not available. Meiosis in plants of L2 generation was studied and the results are given below.

Cytology of the plants was mostly normal. A large number of pollen mother cells showed 36 bivalents both at diakinesis and metaphase-I. The mean chromosomal associations and chiasma frequency per cell and per bivalent at diakinesis are presented in Table 68. At diakinesis in addition to bivalents a few cells showed the occurrence of univalents, trivalents and quadrivalents. The mean chromosomal associations per cell at diakinesis were 1.25 univalents, 32.43 bivalents, 0.94 trivalents and 0.84 quadrivalents. The bivalents were mostly of ring type. The mean number of ring bivalents per cell at diakinesis was 25.83 whereas the mean number of rod bivalents per cell was 6.60. Trivalents ranged from 0 to 3. The maximum number of quadrivalents did not exceed from 2. The mean chiasma frequency per cell and per bivalent at diakinesis was 61.08 and 1.69 respectively.
Most of the pollen mother cells showed the formation of 36 bivalents at metaphase-I. However, a few cells showed univalents, trivalents and quadrivalents in addition to bivalents (Fig. 117). Bivalents were mostly of rod type. The mean chromosomal associations per cell at metaphase-I were 2.70 univalents, 32.90 bivalents, 0.50 trivalents and 0.50 quadrivalents. Bivalents ranged from 26 to 36, the range of univalents, trivalents and quadrivalents was from 0 to 6, 0 to 3 and 0 to 2 respectively. The mean number of bivalents per cell at diakinesis and metaphase-I has no significant difference. While the mean number of trivalents and quadrivalents per cell was less at metaphase-I than at diakinesis with an increase in mean number of univalents per cell. The chiasmata frequency per cell was 37.00 whereas the mean chiasma frequency per bivalents was 1.03 (Table 69).

Anaphase-I was normal in most of the pollen mother cells. Equal distribution of the chromosomes (36:36) at poles was noted in 60 per cent of the cells. Some of the cells showed laggards and unequal distribution of the chromosomes at poles. The percentage of chromosomal aberrations at anaphase-I and II, and telophase-I and II are presented in Table 70. Bridges, fragments or dividing univalents were not recorded at anaphase-I, telophase-I.
8.6 Meiosis in triploid hybrids (F₁) between B. villosum
sect. uniceum and B. americanum

Several meiotic abnormalities were observed during the course of cytological investigations. The results are described below:

At diakinesis univalents, trivalents and quadri-
valents were recorded along with bivalents. The mean number of univalents, bivalents, trivalents and quadrivalents per cell was 1.96, 13.20, 2.12 and 0.32 respectively. Univalents ranged from 0 to 6, bivalents ranged from 12 to 18, triva-
lents from 0 to 4 and quadrivalents from 0 to 1. The chiasmata frequency per cell and per bivalents at diakinesis was 23.96 and 1.33 respectively (Table 6c). Most of the bivalents at diakinesis were of ring type and appeared to have terminal associations. The frequency of trivalents was higher at diakinesis than that at metaphase-I.

Metaphase-I showed varying numbers of scattered univalents (Figs. 118 and 119). The mean number of univa-
lents, bivalents, trivalents and quadrivalents per cell at metaphase-I was 9.64, 10.32, 1.80 and 0.08 respectively. The mean number of bivalents, trivalents and quadrivalents per cell decreased from diakinesis to metaphase-I with an
increase in number of univalents per cell. At metaphase-1 mostly rod bivalents were recorded and ring bivalents were of rare occurrence. The chiasmata frequency per cell and per bivalent was lower at metaphase-1 as compared to diakinesis (Table 66 and 69).

Anaphase-I was highly abnormal and it was characterized by the occurrence of lagging chromosomes (Figs. 120-123) of varying frequencies (Table 70). In 92 per cent of the pollen mother cells the distribution of the chromosomes at poles was irregular. However, 8 per cent of pollen mother cells showed normal distribution of chromosomes. Unequal distribution of chromosomes at poles was recorded in 40 per cent of the pollen mother cells. Lagging chromosomes were observed in 52 per cent of pollen mother cells. The percentage of cells having lagging chromosomes was higher at anaphase-I than at anaphase-II (Table 70). Dividing univalents were also recorded in 32 per cent of cells (Figs. 120 and 121). At telophase-I micronuclei were seen in 12 per cent of cells. However, micronuclei at telophase-II were not recorded. The product of meiosis was tetrads. The tetrads were irregular in size and shape. The chromosomal aberrations at anaphase-I, telophase-I, anaphase-II and telophase-II are presented in Table 70.
Heiosis in colchicino induced hexaploids (C2) obtained from triploid hybrids = villosum sp. puniceum x americanum

Heiosis in colchicino induced shoots C2 was not studied in detail due to shortage of sufficient number of flower buds. Cytology of C2 plants was studied in detail and described below:

At diakinesis, most of the cells showed 36 bivalents. However, some of the cells showed univalents, trivalents and quadrivalents in addition to bivalents. The mean chromosomal associations per cell at diakinesis were 2.50 univalents, 31.03 bivalents, 1.33 trivalents and 0.75 quadrivalents. The number of univalents per cell ranged from 0 to 5, bivalents ranged from 26 to 36, the range of trivalents and quadrivalents was from 0 to 3 and 0 to 2 respectively. At diakinesis most of the bivalents were of ring type and appeared to have terminal associations. The mean number of ring bivalents was 25.24 whereas the mean number of rod bivalents per cell was 5.79 (Table 6A).

At metaphase, several pollen mother cells showed univalents, trivalents and quadrivalents in addition to bivalents (Fig. 124). However, some of the cells showed normal formation of bivalents. The mean number of univalents, bivalents, trivalents and quadrivalents per cell at
metaphase-1 was 4.76, 31.52, 1.00 and 0.36 respectively. The maximum number of univalents was 10. It ranged from 0 to 10. The range of bivalents was from 25 to 36. Trivalents ranged from 0 to 3 and the maximum number of quadrivalents was 2. The mean number of trivalents and quadrivalents decreased at metaphase-1 than at diakinesis, with an increase in mean number of univalents and bivalents per cell. At metaphase-1, mostly rod bivalents were observed. The mean chiasmata frequency per cell at metaphase-1 was 37.44 whereas the mean chiasmata frequency per bivalent was 1.04 (Table 69).

At anaphase-1, normal distribution of chromosomes at poles was noted in 56 per cent of the pollen mother cells. Unequal distribution of chromosomes was recorded in 30 per cent of the pollen mother cells. Lagging chromosomes were noted in 14 per cent of the pollen mother cells. Bridges, fragments or dividing univalents were not recorded (Table 70). Micronuclei were not seen at telophase-1 and telophase-l. 1, anaphase-11 was normal (Table 70). The product of meiosis was tetrads with regular size and shape. The size of pollen grains was uniform.

8.8 Meiosis in tetraploid hybrids (\( \frac{1}{4} \)) between Indian tetraploid C. nigrum and C. villosum ssp. puniceum

The meiotic behaviour of chromosomes is summarised in Tables 68, 69 and 70. The meiosis was mostly normal.
At diakinesis 24 bivalents were observed in several pollen mother cells whereas, univalents were recorded in a very few cells. The maximum number of univalents was 2. Trivalents and quadrivalents were not recorded. The mean chromosomal associations per cell at diakinesis was 24 univalents and 23.88 bivalents. At diakinesis a large number of ring bivalents with terminal chiasmata were recorded. The mean chiasma frequency per cell was 36.92 whereas the mean chiasma frequency per bivalent was 1.53 (Table 66). Out of fifty cells studied only 6 cells showed univalents.

At metaphase-1, 80 per cent of the pollen mother cells showed 24 bivalents (Fig. 123) whereas the rest of the cells showed univalents in addition to bivalents. The maximum number of univalents was 4. The bivalents were mostly rod type. The mean chromosomal associations per cell at metaphase-1 was 0.48 univalents and 23.76 bivalents. The mean number of univalents per cell increases with a corresponding decrease in mean number of bivalents per cell. The chiasma frequency per cell and per bivalent was 25.56 and 1.06 respectively (Table 69).

Anaphase-1 was normal with 24,24 chromosomes at each pole. Lagging chromosomes, unequal distribution of the chromosomes at poles, bridges with or without fragments
were not seen at anaphase-I. Micronuclei were not found at telophase-I and telophase-II (Table 70). Lagging chromosomes were also not recorded at anaphase-II. Tetrads were normal.

Tetraploid hybrids (F₁) between S. villosum and S. villosum × S. puniceum

The meiotic behaviour was mostly normal and was summarised in Tables 68, 69 and 70. At diakinesis 24 bivalents were recorded in several pollen mother cells, whereas univalents and multivalents were recorded in a very few cells. The mean chromosomal associations per cell at diakinesis were 0.76 univalents, 22.64 bivalents, 0.28 trivalents and 0.28 quadrivalents. Bivalents were mostly of ring type with terminal chiasmata. Maximum number of univalents was 4, it ranged from 0 to 4. Bivalents ranged from 18 to 24. The maximum number of trivalents and quadrivalents was 2. The mean chiasma frequency per cell and per bivalent at diakinesis was 41.56 and 1.73 respectively.

At metaphase-I, 60 per cent of the pollen mother cells showed 24 bivalents (Fig. 126) whereas the rest of the pollen mother cells showed univalents and trivalents in addition to bivalents (Fig. 127). The maximum number
of univalents recorded was 6, it ranged from 0 to 6.
The mean chromosomal associations per cell at metaphase-I were $4.2 + 22.8 + 9.3$. Bivalents ranged from 19 to 24 and the maximum number of trivalent was 2. The bivalents were mostly of rod type. The mean chiasmata frequency per cell and per bivalent at metaphase-1 was 24.56 and 1.03 respectively (Table 69).

Normal distribution of chromosomes (24,24) at anaphase-II was recorded in 84 per cent of pollen mother cells. Unequal distribution of chromosomes were observed in only 4 per cent of the cells. Lagging chromosomes were observed in 12 per cent of the pollen mother cells (Table 70). Maximum number of lagging chromosome did not exceed from 1. Bridges with or without fragments were not observed. Telophase-I, anaphase-II and telophase-II were normal (Table 70).

8.10 Tetraploid hybrids (F1) between S. luteum and S. villosum ssp. puniceum

The course of meiosis was generally normal. A large number of pollen mother cells showed 24 bivalents at diakinesis and metaphase-I. At diakinesis most of the bivalents were of ring type with chiasmata at both the arms of the chromosomes. Data on chromosome associations
and chiasmata frequency at diakinesis and metaphase-I are presented in Tables 68 and 69 respectively. The mean chromosomal associations per cell at diakinesis were 0.76 univalents, 22.64 bivalents, 0.28 trivalents and 0.28 quadrivalents. The bivalents ranged from 10 to 24. The maximum number of univalents was 4 and the maximum number of trivalents and quadrivalents did not exceed more than 2. At diakinesis univalents were recorded in 32 per cent of the pollen mother cells, trivalents and quadrivalents were recorded in 36 and 24 per cent of pollen mother cells respectively. The chiasmata frequency per cell and per bivalent at diakinesis was 41.56 and 1.54 respectively (Table 68).

Metaphase-I was mostly normal and 60 per cent of pollen mother cells showed 24 bivalents. The bivalents were mostly of rod type. In a few cells univalents and trivalents were recorded. Quadrivalents were not seen. The mean chromosomal associations per cell at metaphase-I were 1.16 univalents, 22.80 bivalents and 0.36 trivalents. Maximum number of univalents recorded was 6. Univalents were present in 36 per cent of pollen mother cells (Fig. 128) while the trivalents were recorded in only 20 per cent of the cells. The range of bivalents and trivalents was 19 to 24 and 0 to 3 respectively. The mean chiasmata frequency per cell and per bivalent at metaphase-I was
24, 56 and 1.02 respectively (Table 69). Quadrivalents were present at diakinesis but they were not found at metaphase-I. The chiasma frequency per bivalent was less at metaphase-I (1.02) than at diakinesis (1.54).

Anaphase-I was normal (24:24) in 84 per cent of pollen mother cells. Unequal distribution of chromosomes at poles was recorded in only 4 per cent of pollen mother cells. Lagging chromosomes were observed in 12 per cent of the cells. The laggards ranged from 0 to 1. Bridges with or without fragments were not observed. The subsequent stages of meiosis were normal (Table 70).

8.11 60-triploid hybrids \( \overline{6} \) between \( 6. \) villosum ssp. puniceum and \( 6. \) retroflexum

The course of meiosis was mostly regular. At diakinesis 64 bivalents were found in 64 per cent of the pollen mother cells. However, 20 per cent of the cells showed univalents. The maximum number of univalents was 2. Trivalents and quadrivalents were seen in a few cells. The maximum number of trivalents was 2 whereas the maximum number of quadrivalents was 1 only. The bivalents ranged from 20 to 24. At diakinesis the mean chromosomal associations per cell were \( 0.32_1 + 23.12_{11} + 0.32_{111} + 0.04_{1v} \). The chiasma frequency per cell and per bivalent...
At diakinesis was 41.66 and 1.73 respectively (Table 60). At diakinesis mostly ring bivalents were observed with terminal chiasmata.

At metaphase-1, the mean chromosomal associations per cell were 0.88 univalents, 23.00 bivalents and 4.0 trivalents. Normal 24 bivalents were recorded in 44 per cent of pollen mother cells. Univalents were found in 44 per cent of pollen mother cells (Fig. 130). Trivalents were recorded in 44 per cent of the cells (Fig. 129). Quadrivalents were not seen at metaphase-1. However, quadrivalents were found at diakinesis in 8 per cent of pollen mother cells. The chiasmata frequency per cell was 25.16 whereas the mean chiasmata per bivalent was 1.04 (Table 69). The chiasmata frequency per cell and per bivalent decreased from diakinesis to metaphase-1.

At anaphase-I, normal distribution of chromosomes at poles were recorded in 52 per cent of pollen mother cells. Unequal distribution of chromosomes were observed in 48 per cent of pollen mother cells. Lagging chromosomes were noted in only 16 per cent of the cells (Fig. 131). The maximum number of lagging chromosomes was 2. Anaphase-II and telophase-I and II were normal (Table 70).
Two plants with \( 2n=44 \) and \( 2n=46 \) chromosomes were isolated from \( F_1 \) progeny of tetraploid hybrids. Cytological characters of the plants are described below:

8.11.1 Plants with \( 2n=44 \) chromosomes

Cytology of the plants was abnormal. The meiotic behaviour of the chromosomes is given in Tables 69 and 70. At metaphase-I, the pollen mother cells showed univalents in addition to bivalents. The maximum number of univalents was 32, the range being from 20 to 32. Trivalents were rarely seen (Fig. 132). Quadrivalents were not recorded. The mean chromosomal associations per cell at metaphase-I were 30.33 univalents and 6.63 bivalents. The number of bivalents per cell ranged from 6 to 12. Bivalents were mostly of rod type. The mean chiasma frequency per cell and per bivalent was 0.52 and 0.39 respectively (Table 69).

Anaphase-I was irregular; most of the pollen mother cells showed lagging chromosomes and unequal distribution of chromosomes at poles. However, a few cells (8 per cent) showed equal distribution of chromosomes at poles. Lagging chromosomes were observed in 52 per cent of the cells.
Micronuclei were recorded in 8 per cent of pollen mother cells. At anaphase-I, 16 per cent of the cells showed lagging chromosomes. Micronuclei were not recorded at telophase-II. The percentage of chromosomal aberrations at anaphase (I and II) and telophase (I and II) are presented in Table 70. The product of meiosis was mostly tetrads.

**8.11.1.2 Plants with juvenile chromosomes**

Meiosis was found to be irregular in a considerable frequency. In several pollen mother cells, besides bivalents, univalents and trivalents were also recorded at metaphase-I (Fig. 133). Analysis of chromosome behaviour at metaphase-I is given in Table 69. The mean chromosomal associations per cell at metaphase-I were 4.40 univalents, 19.60 bivalents and 0.80 trivalents. Quadrivalents were not recorded. Univalents ranged from 0 to 10. The maximum number of bivalents was 23, the range being from 16 to 23. The maximum number of trivalents did not exceed from 2. The chiasma frequency per cell was 23.90 whereas the mean number of chiasmata per bivalent was 1.03.

Anaphase-I showed several meiotic irregularities. However, 28 per cent of pollen mother cells exhibited normal (23;23) distribution of chromosomes at poles. Unequal distribution of chromosomes was recorded in 36
per cent of the pollen mother cells. Lagging chromosomes were seen in 16 per cent of the cells (Fig. 134). Bridges were not observed. Fragments were seen in 12 per cent of pollen mother cells. Micronuclei at telophase-I were observed in 12 per cent of the pollen mother cells.

Naphase-II and telophase-II were normal. The percentage of chromosomal aberrations at anaphase (I and II) and telophase (I and II) are presented in Table 70. The product of meiosis was tetrads.

8.12 Meiosis in tetraploid hybrids (F1) between Indian hexaploid S. nigrum and S. sarrachoides

The cytological studies showed a number of meiotic irregularities. Univalents, trivalents and quadrivalents were recorded both at diakinesis and metaphase-I (Fig. 135). A detailed account of meiotic behaviour of chromosomes is presented in Tables 60, 69 and 70.

Diakinesis was characterized by the presence of univalents, trivalents, quadrivalents along with bivalents. The mean chromosomal associations per cell at diakinesis were 4.84 univalents, 15.92 bivalents, 2.08 trivalents and 1.24 quadrivalents. Univalents, bivalents, trivalents and quadrivalents ranged from 0 to 11, 12 to 20, 0 to 3 and 0 to 2 respectively. The mean number of chiasmata
per cell at diakinesis was 29.72 whereas the mean number of chiasmata per bivalent at diakinesis was 1.23 (Table 66).

The mean chromosomal associations per cell at metaphase-I were 19.72 univalents, 11.04 bivalents, 1.56 trivalents and 0.32 quadrivalents. The maximum number of univalents was 26. Univalents were scattered all over the spindle (Fig. 136). The range of bivalents, trivalents and quadrivalents at metaphase-I was from 9 to 14, 0 to 3 and 0 to 1 respectively. The mean number of bivalents, trivalents and quadrivalents per cell decreased at metaphase-I than at diakinesis with an increase in mean number of univalents per cell. The chiasmata frequency per cell and per bivalent at metaphase-I was 16.08 and 0.66 respectively (Table 69). The chiasmata frequencies at metaphase-I was lower than at diakinesis.

At anaphase-I, the distribution of chromosomes at poles was highly irregular (Figs. 137 and 138). Only 4 per cent of the pollen mother cells showed 24:24 distribution of chromosomes at poles and 96 per cent of the cells showed abnormal distribution of chromosomes. Out of 96 per cent pollen mother cells, 52 per cent showed lagging chromosomes (Fig. 137) and 44 per cent showed unequal distribution of chromosomes at poles. The maximum
number of lagging chromosomes at anaphase-1 was 9.
bridges without fragments were seen in 12 per cent of
pollen mother cells. Data on aberrations of chromosomes
at anaphase-1, telophase-1, anaphase-II and telophase-II
are presented in Table 70.

At telophase-1, 16 per cent pollen mother cells
showed micronuclei. Anaphase-II was generally normal,
only 8 per cent of the cells showed pentads. Micronuclei
at telophase-II was noted in only 4 per cent of pollen
mother cells.

6.13 Meiosis in tetraploid hybrids (F1) between French
hexaploid F. nigrum and F. sarrachoides

The cytological studies showed a wide range of
meiotic abnormalities. A detailed account of meiotic
chromosome behaviour of the hybrid is presented below:

At diakinosis, univalents were present together
with trivalents, quadrivalents and bivalents. The mean
chromosomal associations per cell at diakinesis were
4.23 univalents, 17.66 bivalents, 1.38 trivalents and
0.71 quadrivalents. The bivalents ranged from 14 to
22. The maximum number of univalents, trivalents and
quadrivalents was 1, 4 and 2 respectively. The mean chias-
mata frequency per cell and per bivalent at diakinesis
was 29.20 and 1.39 respectively (Table 69).
At metaphase-I large number of univalents were frequently scattered all over the spindle (Figs. 139 and 140). The maximum number of univalents recorded was 18. The mean chromosomal associations per cell at metaphase-I were 12.88 univalents, 15.12 bivalents, 1.4 trivalents and 0.2 quadrivalents (Fig. 139). The bivalents ranged from 10 to 19 and they were mostly of rod type. Ring bivalents were rarely occurred (0.76 per cell). Bivalents, trivalents and quadrivalents per cell decreased at metaphase-I than at diakinesis with an increase in mean number of univalents per cell. The mean chiasmata frequency per cell and per bivalent at metaphase-I was 19.16 and 0.79 respectively (Table 69). The chiasmata frequency per bivalent at metaphase-I was less (0.79) than at diakinesis (1.39).

The distribution of chromosomes at poles was also irregular at anaphase-I (Figs. 141 and 142). Only 16 per cent of the pollen mother cells showed equal distribution (24:24) of chromosomes at poles. Unequal distribution of chromosomes at poles was recorded, in 40 per cent of the cells. Lagging chromosomes were found in 44 per cent of pollen mother cells. The maximum number of lagging chromosomes was 7. Bridges with or without fragments were not seen. Micronuclei were seen in 16 per cent of pollen mother cells at anaphase-I. At anaphase-II, 12 per cent
of cells showed laggards. Micronuclei at telophase-II were not recorded. Data regarding the percentage of cells showing chromosomal aberrations at anaphase-I, II; telophase I and II are presented in Table 70.

8.14 Meiosis in tetraploid hybrids (F₁) between C. furcatum and C. parvichoides

The hybrid showed a wide range of meiotic irregularities. A detailed account of meiotic chromosome behaviour of the hybrids is presented below:

The course of meiosis was highly abnormal at diakinesis and metaphase-I. Most of the cells showed univalents, bivalents, trivalents and quadrivalents of varying frequencies (Fig. 143). Data on chromosome associations and chiasmata frequency at diakinesis and metaphase-I are presented in Tables 68 and 69 respectively.

The mean chromosomal associations per cell at diakinesis were 3.68 univalents, 17.26 bivalents, 2.16 trivalents and 0.44 quadrivalents. The bivalents per cell ranged from 14 to 21. Mostly the chromosomes showed loose associations. Most of the bivalents at diakinesis were of ring type and appeared to have terminal associations. The maximum number of univalents recorded in a cell was 6, the range being from 1 to 6. The frequency of trivalents was higher than that of quadrivalents and
ranged from 1 to 4 per cell. The quadrivalents ranged from 0 to 1. The chiasmata frequency per cell and per bivalent at diakinesis was 30.80 and 1.27 respectively (Table 66).

Metaphase-I showed varying number of scattered univalents (Fig. 143) which were present all over the spindle region. The mean number of univalents, bivalents, trivalents and quadrivalents per cell at metaphase-I was 0.12, 16.60, 2.00 and 0.20 respectively. The mean number of bivalents, trivalents and quadrivalents per cell decreased from diakinesis to metaphase-I with an increase in mean number of univalents per cell. The chiasmata frequency per cell and per bivalent at metaphase-I was 21.80 and 0.90 respectively (Table 69). The chiasmata frequency per cell and per bivalent was lower at metaphase-I than at diakinesis.

Anaphase-I was irregular and it was characterised by lagging chromosomes (Figs. 144-146) of varying frequencies (Table 70). Most of the cells showed irregular distribution of chromosomes. However, in 28 per cent of the cells 24-24 chromosomes were seen at poles. At anaphase-I, 48 per cent of the pollen mother cells showed lagging chromosomes (Fig. 144). The maximum number of lagging observed was 7. Dividing univalents were seen in 36 per cent of the pollen mother cells (Fig. 144).
Unusual distribution of chromosomes was recorded in 24 per cent of the pollen mother cells and 4 per cent of the cells showed bridges with fragments. At telophase-I, only 8 per cent of the pollen mother cells showed micronuclei (Fig. 147). At anaphase-II, 16 per cent of cells were recorded with lagging chromosomes. Micronuclei at telophase-II were not observed. The product of meiosis was tetrads of regular shape and size.

8.14.1 \( F_3 \) progeny of tetraploid hybrids \( L. \) furcatum \( \times \) S. sarrachoides

Four plants with \( 2n=36, \) 45, 48 and 54 chromosomes were isolated from \( F_3 \) progeny of tetraploid hybrids \( (L. \) furcatum \( \times \) S. sarrachoides). Cytology of the plants is given below.

8.14.1.1 Plant with \( 2n=36 \) chromosomes

Cytology of this plant showed several meiotic abnormalities. The meiotic behaviour of chromosomes is summarized in Tables 69 and 70. At metaphase-I, several pollen mother cells showed univalents and trivalents in addition to bivalents (Fig. 148). The mean number of univalents, bivalents and trivalents was \( 11.10, \) 10.60 and 1.20 respectively. The maximum number of univalents was 16, the range being from 9 to 16. The univalents were scattered all over the spindle. Bivalents ranged
from 8 to 14. The bivalents were mostly of rod type and showed loose association. The ring bivalents at metaphase-I were of rare occurrence. The maximum number of trivalents recorded did not exceed from 3, the range being from 0 to 3. The mean number of chiasmata per cell was 13.50 whereas the mean number of chiasmata per bivalent was 0.75 (Table 69).

Anaphase-I was highly irregular. Most of the pollen mother cells showed abnormal distribution of chromosomes at poles. However, a few cells showed normal distribution of chromosomes at poles (Table 70). Lagging chromosomes were recorded in 60 per cent of the pollen mother cells. Unequal distribution of chromosomes was observed in 36 per cent of cells. At telophase-I micronuclei were seen in 12 per cent of the cells. Lagging chromosomes were not recorded at anaphase-II. Telophase-II was normal. Data regarding the percentage of cells showing chromosomal aberrations at anaphase (I and II) and telophase (I and II) are presented in Table 70.

8, 14, 1, 2 plants with 2n=45 chromosomes

Plants showed a wide range of meiotic irregularities. Univalents, trivalents and quadrivalents were recorded in addition to bivalents. A large number of univalents were present. They were scattered all over the
spindle. At metaphase-I, the mean chromosomal associations per cell were 13.20 univalents, 13.20 bivalents, 1.40 trivalents and 0.30 quadrivalents (Fig. 150). The maximum number of univalents was 21, the range being from 5 to 21. The range of bivalents was from 9 to 20. Most of the bivalents were of rod type. The maximum number of trivalents was 3. It ranged from 0 to 3. The meiotic behaviour of chromosomes at metaphase-I is summarised in Table 69. The chiasmata frequency per cell at metaphase-I was 17.50 whereas the mean number of chiasmata per bivalent was 0.78.

Anaphase-I showed irregular distribution of chromosomes at poles. Unequal distribution of chromosomes is most common and recorded in 66 per cent of the pollen mother cells. Lagging chromosomes were noted in 32 per cent of the pollen mother cells. Dividing univalents were observed in 8 per cent of the cells. Bridges and fragments were not recorded (Table 70). Micronuclei were not observed at telophase-I and II. At anaphase-II, lagging chromosomes were seen in 8 per cent of the pollen mother cells (Table 70).

8.14.1.3 Plants with 2n=40 chromosomes

Squashes of pollen mother cells showed a wide range of meiotic abnormalities. At metaphase-I, univalents, bivalents, trivalents and quadrivalents were recorded
(Fig. 149 and Table 69). The mean number of univalents, bivalents, trivalents and quadrivalents per cell at metaphase-I was 12.20, 16.30, 0.60 and 0.20 respectively. Univalents ranged from 6 to 16. The maximum number of bivalents was 20 and they ranged from 12 to 20. The maximum number of trivalents and quadrivalents did not exceed from 2 and 1 respectively. Bivalents were mostly of rod type and showed loose association. The chiasma frequency per cell and per bivalent at metaphase-I was 19.50 and 0.81 respectively (Table 69).

Most of the pollen mother cells showed irregular distribution of chromosomes at poles. However, 8 per cent of pollen mother cells showed regular (24:24) distribution of chromosomes. Lagging chromosomes were found in 44 per cent of the cells. Unequal distribution of chromosomes at poles was recorded in 48 per cent of the cells (Table 70). Bridges, fragments or dividing univalents were not observed. Micronuclei at telophase-I and II were not seen. Lagging chromosomes at anaphase-II were not found (Table 70). The product of meiosis was tetrad.

8.14.1.4 Plants with 2n=54 chromosomes

Meiosis was highly irregular (Fig. 151 and 152). Several pollen mother cells were analysed at metaphase-I and found that the frequency of univalents, bivalents, trivalents and quadrivalents per cell was 14.10, 17.70,
Univalents ranged from 12 to 19. Most of the bivalents were of rod type. The maximum number of rod bivalents was 21, the range being from 15 to 21. The range of trivalents was from 0 to 3. The maximum number of quadrivalents did not exceed from 1. The mean number of chiasmata per cell was 21.60 whereas the mean number of chiasmata per bivalent was 0.80 (Table 69).

Anaphase-I was irregular and it was characterised by laggards and unequal distribution of chromosomes at poles (Table 70). However, 24 per cent of the cells showed normal distribution (27;27) of chromosomes at poles. Micronuclei were recorded in 20 per cent of the cells at telophase-I. Lagging chromosomes were also noted at anaphase-II in 10 per cent of pollen mother cells (Table 70). Telophase-II was normal.

F3 progeny of plants with 2n=54 chromosomes

From the F3 population of the plant with 2n=54 chromosomes, three plants with 2n=56, 68 and 72 chromosomes were isolated. Meiotic behaviour of chromosomes of these plants is described below.
Cytological observation of the plant revealed several meiotic abnormalities. Several pollen mother cells were examined and analysed at metaphase-I. Univalents, trivalents and quadrivalents were recorded in addition to bivalents (Fig. 153 and Table 69). The mean chromosomal associations per cell at metaphase-I were 5.00 univalents, 23.40 bivalents, 14.00 trivalents and 0.30 quadrivalents. The maximum number of univalents was 10 and range being from 2 to 10. The maximum number of bivalents per cell was 27, the range being from 20 to 27. Bivalents were mostly of rod type. Trivalents ranged from 0 to 3. The number of quadrivalents did not exceed from 1. The chiasma frequency per cell and per bivalent was 27.30 and 0.97 respectively (Table 69).

Anaphase-I was irregular and characterized by the laggards and unequal distribution of chromosomes (Table 70). However, very few cells showed equal distribution (28, 28) of chromosomes at poles (Table 70). Micronuclei, at telophase-I, were recorded in 20 per cent of the cells. Lagging chromosomes were found in 20 per cent of the cells at anaphase-II. Telophase-II was normal (Table 70).
8.14.2.2 Plant with 8n=68 chromosomes

The squashes of pollen mother cells showed meiotic irregularities. Several pollen mother cells were studied at metaphase-I (Table 69). Bivalents were frequently found along with univalents, and trivalents (Fig. 154). The mean chromosomal associations per cell at metaphase-I were 11.40 \ (+24.11 + 1.211). Quadrivalents were not recorded. Univalents ranged from 8 to 19. The maximum number of bivalents was 30, the range being from 20 to 30. Trivalents ranged from 0 to 3. The mean chiasma frequency per cell was 29.60 whereas the mean chiasma frequency per bivalent was 0.87.

Anaphase-I was irregular. Lagging chromosomes and unequal distribution of chromosomes were recorded in 25 and 35 per cent of the pollen mother cells. However, normal distribution of chromosomes were seen in 40 per cent of the cells (Table 70). Micronuclei were neither seen at telophase-I nor at telophase-II. Lagging chromosomes were also recorded at anaphase-II (Table 70). The product of meiosis was tetrads.

8.14.2.3 Plant with 8n=72 chromosomes

Meiosis was mostly normal (Fig. 155). Several pollen mother cells were examined and analysed at metaphase-I (Table 69). Sixty four per cent of the cells showed 36 bivalents at metaphase-I. Thirty six per cent of the cells
showed univalents and trivalents. Quadrivalents were of rare occurrence. The mean chromosomal associations per cell at metaphase-I were 2.00 univalents, 34.20 bivalents, 0.40 trivalents and 0.10 quadrivalents. Univalents ranged from 0 to 4. The maximum number of bivalents was 36, the range being from 31 to 36. The maximum number of trivalents and quadrivalents did not exceed from 1. Bivalents were mostly of rod type. The mean chiasma frequency per cell and per bivalent at metaphase-I was 36.60 and 1.01 respectively (Table 69).

Anaphase-I showed 36:36 distribution of chromosomes at poles (72 per cent of the cells). However, 28 per cent of cells showed unequal distribution and lagging chromosomes (Table 70). Telophase-I, anaphase-II and telophase-II were normal. The product of meiosis was tetrads with regular size and shape.

8.15 Cytology of pentaploid hybrids \( \times _{1} \) between French hexaploid \( \times _{2} \) mignon and \( \times _{3} \) villosum sp. puniceum

The meiotic behaviour of the chromosomes was highly irregular. A detailed account is given below:

The meiosis was highly irregular. Diskinesis and metaphase-I showed large number of univalents, bivalents, trivalents and quadrivalents. At diskinesis the mean
Chromosomal associations per cell were 6.20 univalents, 22.52 bivalents, 2.66 trivalents and 0.20 quadrivalents. The maximum number of univalents per cell recorded was 11 and it ranged from 0 to 11. The range of bivalents per cell at diakinesis was from 20 to 27. The bivalents were generally of ring type and appeared to have terminal associations. The maximum number of trivalents per cell was 4 and they ranged from 0 to 4. The maximum number of quadrivalents did not exceed more than 1. The mean chiasmata frequency per cell and per bivalent at diakinesis was 41.64 and 1.38 respectively (Table 66).

At metaphase-I, the mean chromosomal associations per cell were 11.24 univalents, 22.60 bivalents, 1.08 trivalents and 0.04 quadrivalents. The range of univalents was from 7 to 16. The univalents were scattered all over the spindle (Figs. 156-160). The maximum number of bivalents per cell was 26, the range being from 9 to 26. Mostly rod bivalents were recorded. The maximum number of trivalents and quadrivalents was 3 and 1 respectively. The mean number of bivalents per cell at diakinesis and metaphase-I was almost the same (i.e., 22.52 per cell at diakinesis and 22.60 per cell at metaphase-I). The mean number of trivalents and quadrivalents per cell decreased from diakinesis to metaphase-I with an increase in mean number of univalents per cell. The mean chiasmata frequency per cell and per bivalent was
lower at metaphase-I than at diakinesis and it was 25.08 and 0.83 respectively (Table 70).

The distribution of chromosomes at poles was highly abnormal (Figs. 161-163 and Table 70). In 12 per cent pollen mother cells 30:30 distribution of chromosomes at poles was seen. However, in 88 per cent of cells the distribution of chromosomes was abnormal. Lagging chromosomes were seen in 52 per cent of the cells. The maximum number of laggards was 7 which ranged from 2 to 7. Unequal distribution of chromosomes at poles was recorded in 24 per cent of the pollen mother cells. Bridges with or without fragments were noted in 24 per cent of the cells (Table 70).

 Micronuclei at telophase-I were present in 20 per cent of the pollen mother cells. Lagging chromosomes were recorded in 24 per cent of the pollen mother cells at anaphase-II. Micronuclei at telophase-II were not recorded (Table 70).

8.15.1 $F_2$ progeny of pentaploid hybrid (French hexaploid $S. nigrum$ and $S. villosum$ ssp. $punicum$)

In the $F_2$ generation of pentaploid hybrid (French hexaploid $S. nigrum$ x $S. villosum$ ssp. $punicum$), only one plant developed and reached to its maturity. Its chromosome count in pollen mother cells revealed 2n=64 chromosomes. The cytology of the plant is described below:
Meiosis was irregular in several pollen mother cells at metaphase-I (Table 69). In addition to bivalents, univalents and trivalents were also recorded (Fig. 164). The mean chromosomal associations per cell was 6.40 univalents, 27.60 bivalents and 0.80 trivalents. Univalents ranged from 4 to 11. The maximum number of bivalents per cell was 30, the range being from 25 to 30. The bivalents were mostly of rod type. The maximum number of trivalents did not exceed from 2. Quadrivalents were not recorded. The mean chiasma frequency per cell was 3.10 whereas the mean chiasma frequency per bivalent was 0.94 (Table 69).

Fusion of two pollen mother cells were recorded in 20 per cent (Fig. 165). Sufficient cells were not available for analysis at anaphase I, II telophase I and II.

6.16 Meiosis in hexaploid hybrids (F1) between Indian hexaploid T. nigrum and F. opacum

The hybrids showed a wide range of meiotic abnormalities. At diakinesis and metaphase-I, univalents, bivalents, trivalents and quadrivalents were present (Tables 68 and 69). At diakinesis the mean number of univalents, bivalents, trivalents and quadrivalents per cell was 1.29, 33.62, 0.62 and 0.37 respectively. The maximum number of univalents was 4 and it ranged from 0 to 4. The bivalents ranged from 30 to 36 per cell. Most of the bivalents were of ring type and appeared to have terminal associations. The mean
number of ring and rod bivalents per cell at diakinesis was 20.40 and 13.22 respectively. The maximum number of trivalents and quadrivalents did not exceed from 2 and 1 respectively. The mean chiasmata frequency per cell and per bivalent at diakinesis was 54.52 and 1.51 respectively (Table 68).

At metaphase-I the mean number of univalents, bivalents, trivalents and quadrivalents was 3.52, 32.96, 0.8 and 0.08 respectively (Figs. 167 and 168). Univalents ranged from 0 to 9. The maximum number of bivalents was 36 (Fig. 166) and it ranged from 30 to 36. Bivalents were mostly of rod type, the mean number of rod and ring bivalents per cell at metaphase-I was 32.72 and 0.24 respectively. The maximum number of trivalents was 2. The quadrivalent did not exceed from 1. The mean number of quadrivalents per cell at metaphase-I decreased than that at diakinesis with slight increase in mean number of univalents, bivalents and trivalents per cell. The mean chiasmata frequency per cell and per bivalent at metaphase-I was less than that at diakinesis and it was 35.12 and 0.97 respectively (Table 69).

Distribution of chromosomes at anaphase-I was also irregular (Figs. 169-171). Equal distribution of chromosomes (36:36) at poles was recorded in 48 per cent of the pollen mother cells (Fig. 169). Unequal distribution of the
chromosomes at poles was noted in 16 per cent of the pollen mother cells (Fig. 170). The percentage of cells having lagging chromosomes was 32 (Fig. 171 and Table 70), bridges without fragments were seen in 12 per cent of the cells. Dividing univalents were not recorded. Micronuclei were not observed at telophase-I and II. Lagging chromosomes at anaphase-II were recorded in only 8 per cent of the cells. The product of meiosis was tetrad.

8.17 Meiosis in hexaploid hybrids (F₁) between French hexaploid L. nigrum and L. opacum

The meiotic behaviour of chromosomes of the hybrids was irregular (Figs. 172-175) and Tables 60, 69 and 70). At diakinesis and metaphase-I, univalents, bivalents and trivalents were recorded. Quadrivalents were observed at diakinesis but it was not seen at metaphase-I. The mean chromosomal associations per cell at diakinesis were 2.64 univalents, 32.53 bivalents, 1.12 trivalents and 0.32 quadrivalents. Univalents ranged from 0 to 7. The maximum number of bivalents per cell was 36, the range being from 29 to 36. The bivalents were mostly of ring type and appeared to have terminal associations. The maximum number of trivalents was 2. The quadrivalents did not exceed from 1. The mean chiasmata frequency per cell and per bivalent at diakinesis was 55.44 and 1.54 respectively (Table 68).
The meiotic behaviour of chromosomes at metaphase-1 was irregular (Figs. 172-174). The mean chromosomal associations per cell at metaphase-1 were $5.56 \pm 3.84$. The maximum number of univalents per cell was 15, it ranged from 2 to 15. The bivalents ranged from 27 to 33. Bivalents were mostly of rod type. The maximum number of trivalents per cell did not exceed more than 2. The mean number of bivalents and trivalents decreased from diakinesis to metaphase-1 with an increase in mean number of univalents per cell. The mean chiasma frequency per cell and per bivalent at metaphase-1 was 34.44 and 0.95 respectively (Table 60). The chiasma frequency per cell of and per bivalent was less at metaphase-1 than that at diakinesis.

At anaphase-1, the distribution of chromosomes at poles was irregular in 60% of the pollen mother cells. However, 40% of the cells showed equal distribution of chromosomes (36:36) at poles (Fig. 175). Twenty percent of the cells showed unequal distribution of chromosomes at poles (Table 70). Lagging chromosomes were noted in 20% of the cells. The maximum number of lagging chromosomes was 4. Bridges with or without fragments were observed in 20% of the pollen mother cells (Table 70). Micronuclei were not seen at telophase-1.
and telophase-I. Naphase-II was also normal, the product of meiosis was tetrads.

0.18 Meiosis in hexaploid hybrids \( H \) between \( b. \) furcatum
and \( b. \) opacum

The meiosis of the hybrid showed a wide range of meiotic irregularities. A detailed account of meiotic chromosome behaviour of the hybrids is given in Tables 60, 69 and 70.

The course of meiosis was abnormal (Figs. 176-181). At diakinesis and metaphase-I, most of the cells showed univalents, bivalents, trivalents and quadrivalents (Fig. 176 and 177). The mean number of univalents, bivalents, trivalents and quadrivalents per cell at diakinesis was 3.48, 31.96, 0.84 and 0.52 respectively. The maximum number of univalents per cell was 8. It ranged from 0 to 9. The range of bivalent was from 28 to 36. The bivalents were mostly of ring type and appeared to have terminal association. The maximum number of trivalents and quadrivalents did not exceed from 2. The mean chiasma frequency per cell and per bivalent at diakinesis was 53.28 and 1.48 respectively (Table 60).

At metaphase-I, the mean chromosomal associations per cell was 7.24 univalents, 30.72 bivalents, 0.96 trivalents and 0.12 quadrivalents. The maximum number of
univalent per cell was 22, they ranged from 2 to 22.
Bivalents ranged from 23 to 35. Bivalents were mostly of
rod type. The range of trivalents was from 0 to 2. The
maximum number of quadrivalents found was 1. The mean number
of bivalents and quadrivalents per cell decreased from
diakinesis to metaphase-I with an increase in mean number
of univalents and trivalents per cell. The mean chiasmata
frequency per cell was 35.76 whereas the mean chiasmata
frequency per bivalent was 0.99 (Table 69).

At anaphase-I, normal distribution of chromosomes
(36:36) at poles was recorded in 60 per cent of the pollen
mother cells (Fig. 178). Unequal distribution of chromo-
somes at poles was observed in 16 per cent of the pollen
mother cells (Fig. 179). Sixteen per cent of cells showed
lagging chromosomes (Fig. 180). The maximum number of
laggard was 11. Chromatin bridges were found in 4 per cent
of the cells. Fragments were not recorded. Eight per cent
of the cells showed dividing univalents (Fig. 181).
Micronuclei were seen in 4 per cent of the cells at
telophase-I. Anaphase-II and telophase-II were normal
(Table 70). The product of meiosis was tetrads.
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<th>No. of Bivalents per cell Range</th>
<th>No. of Trivalents per cell Mean</th>
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** = Standard Error
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SE = Standard Error
Explanation of Figures

Fig. 93 Metaphase-I with 12,11 in diploid *nigrum.*

Fig. 94 Metaphase-I with 12,11 in *podiflorum* spp.

Fig. 95 Metaphase-I with 12,11 in *americanum.*

Fig. 96 Metaphase-I with 12,11 in *alpina.*

Fig. 97 Metaphase-I with 24,11 in Indian tetraploid *nigrum.*

Fig. 98 Metaphase-I with 24,11 in *villosus.*

Fig. 99 Metaphase-I with 24,11 in *villosum* spp. *puniceum.*

Fig. 100 Metaphase-I with 24,11 in *luteum.*
Explanation of Figures

Fig. 101 Metaphase-1 with 24,1 in *retroflexum.*
Fig. 102 Metaphase-1 with 36,1 in Indian hexaploid *nigrum.*
Fig. 103 Metaphase-1 with 36,1 in French hexaploid *nigrum.*
Fig. 104 Metaphase-1 with 36,1 in *furcatum.*
Fig. 105 Metaphase-1 with 36,1 in *opacum.*
Fig. 106-110 Meiosis in triploid (F,_) hybrids obtained from the cross between *villosum* asp. *uniceum* and diploid *nigrum.*
Fig. 106 Metaphase-1 with 8,1 + 11,1 + 2,11
Fig. 107 Metaphase-1 with 16,1 + 10,11
Fig. 108 Anaphase-1 with several lagging chromosomes.
Explanation of Figures

Fig. 109  Anaphase-I with divided univalents

Fig. 110  Anaphase-I with bridge and laggards.

Figs. 111-112  Meiosis in colchicine induced hexaploids (C₆) obtained from triploid hybrid of
S. villosum spp. punicum x diploid S. nigra.

Fig. 111  Metaphase-I with 2₁ + 30₁₁ + 2₁₁₁ + 1₁V

Fig. 112  Anaphase-I with 36;36 chromosomes at poles

Fig. 113-116  Meiosis in triploid hybrids (F₁) obtained from the cross between S. villosum spp. punicum x S. nodiflorum spp. nodiflorum.

Fig. 113  Metaphase-I with 15₁ + 9₁₁ + 1₁₁₁
Fig. 114  Metaphase-I with 9₁ + 6₁₁₁ + 1₁₁₁ + 1₁V
Fig. 115  Anaphase-I with several laggards.
Fig. 116  Anaphase-I with lagging and divided univalents.
Explanations of Figures

Fig. 117 Metaphase-I with $4_1 + 34_{11}$ in colchicine induced hexaploid ($C_2$) obtained from triploid hybrid $F_1$ of $S. \text{villosum}$ ssp. $\text{puniceum}$ and $S. \text{nodiflorum}$ ssp. $\text{nodiflorum}$.

Figs. 118-123 Meiosis in triploid ($F_1$) hybrids obtained from the cross between $S. \text{villosum}$ ssp. $\text{puniceum}$ and $S. \text{americanum}$.

Fig. 118 Metaphase-I with $9_1 + 9_{11} + 3_{111}$.

Fig. 119 Metaphase-I with $11_1 + 8_{11} + 3_{111}$.

Figs. 120-123 Anaphase-I with several divided univalents and laggards.

Fig. 124 Metaphase-I with in colchicine induced hexaploid ($C_2$) obtained from $F_1$ triploid hybrids of $S. \text{villosum}$ ssp. $\text{puniceum}$ and $S. \text{americanum}$. 
Explanations of Figures

Fig. 125 Metaphase-I with 24_II in tetraploid hybrids (F_1) obtained from the cross between Indian tetraploid L. nigrum and L. villosum asp. puniceum.

Figs. 126-127 Meiosis in F_1 hybrids obtained from the cross between L. villosum and L. villosum asp. puniceum.

Fig. 126 Metaphase-I with 24_II

Fig. 127 Metaphase-I with 1_1 + 22_II + 1_II

Fig. 128 Metaphase-I with 23_II + 2_1 in F_1 hybrids obtained from the cross between L. luteum and L. villosum asp. puniceum.

Figs. 129-131 Meiosis in F_1 hybrids obtained from the cross between L. villosum asp. puniceum and L. retroflexum.

Fig. 129 Metaphase-I with 6_1 + 18_II + 2_III

Fig. 130 Metaphase-I with 2_1 + 23_II

Fig. 131 Anaphase-I with one laggard.

Figs. 132-134 Meiosis in F_2 progeny of tetraploid hybrids obtained from the cross between L. villosum asp. puniceum and L. retroflexum.

Fig. 132 Metaphase-I with 16_1 + 11_II + 2_III in plant with 2n=44 chromosomes.

Fig. 133 Metaphase-I with 23_II + 2_1 in plant with 2n=44 chromosomes.

Fig. 134 Metaphase-I with 18_II + 2_III in plant with 2n=44 chromosomes.
Explanations of Figures

Fig. 133 Metaphase-I with $20_1 + 13_{11}$ in plant with $2n=46$ chromosomes.

Fig. 134 Anaphase-I showing laggards in plant with $2n=46$ chromosomes.

Figs. 135-138 Meiosis in tetraploid hybrids ($F_1$) obtained from the cross between Indian hexaploid $S$. nigro and $S$. sarrachoides.

Fig. 135 Metaphase-I with $16_1 + 13_{11} + 2_{III}$

Fig. 136 Metaphase-I with several univalents

Fig. 137 Anaphase-I with laggards.

Fig. 138 Anaphase-I showing bridges.

Figs. 139-142 Meiosis in tetraploid hybrids ($F_1$) obtained from the cross between French hexaploid $S$. nigro and $S$. sarrachoides.

Fig. 139 Metaphase-I with $18_1 + 10_{21} + 2_{III} + 1_{IV}$
Explanation of Figures

Fig. 140 Metaphase-I with $17_1 + 11_1 + 3_1$

Figs. 141-142 Anaphase-I with several lagging chromosomes.

Figs. 143-147 Meiosis in tetraploid hybrids ($F_1$) obtained from the cross between *S. furcatum* and *S. sarachoides*.

Fig. 143 Metaphase-I with $6_1 + 14_1 + 2_1$

Fig. 144 Anaphase-I with divided univalents

Fig. 145 Anaphase-I with several laggards

Fig. 146 Anaphase-I with divided univalents

Fig. 147 Telophase-I with micronuclei.
Figs. 148-152 F₂ progeny of tetraploid hybrids obtained from the cross between *S. furcatum* and *S. sarrachoides*

Fig. 148 Metaphase-I with 10₁ + 6₁₁ + 1₁V in Plant with 2n=36 chromosomes.

Fig. 149 Metaphase-I with 2₅₁ + 1₀₁₁ + 1₁₁₁ in Plant with 2n=48 chromosomes.

Fig. 150 Metaphase-I with 2₇₁ + 9₁₁ in Plant with 2n=45 chromosomes.

Figs. 151 Metaphase-I with 1₆₁ + 1₆₁₁ + 2₁₁₂ Plant with 2n=54 chromosomes.

Fig. 152 Metaphase-I with 1₆₁ + 1₃₁₁ + 4₁₁₁ Plant with 2n=54 chromosomes.

Figs. 153-155 F₃ progeny of the plant with 2n=54 chromosomes.

Fig. 153 Metaphase-I in Plant with 2n=56 chromosomes.

Fig. 154 Metaphase-I in Plant with 2n=68 chromosomes.

Fig. 155 Metaphase-I in Plant with 2n=72 chromosomes.
Fig. 156-163 Meiosis in pentaploid hybrid (F₁) obtained from the cross between French hexaploid B. nigren and B. villosum ssp. puniceus.

- Fig. 156 Metaphase-I with 11₁ + 23₁₁ + 1₁₁₁
- Fig. 157 Metaphase-I with 11₁ + 20₁₁ + 3₁₁₁
- Fig. 158 Metaphase-I with 17₁ + 20₁₁ + 1₁₁₁
- Fig. 159 Metaphase-I with 13₁ + 22₁₁ + 1₁₁₁
- Fig. 160 Metaphase-I with 10₁ + 25₁₁.
- Fig. 161 Anaphase-I with two divided univalents.
- Fig. 162-163 Anaphase-I with several laggards.
Explanation of Figures

Figs. 164-165 $F_2$ plant with $2n=64$ chromosomes obtained from pentaploid hybrid between French hexaploid $A. 	ext{nigra}$ and $A. 	ext{villosa}$ spp. $A. 	ext{punicum}$.

Fig. 164 Metaphase-I with $2n = 36_{11} + 1_{11}$

Fig. 165 Fusion of two pollen mother cells.

Figs. 166-171 Meiosis in hexaploid hybrids ($F_1$) obtained from the cross between Indian hexaploid $A. 	ext{nigra}$ and $A. 	ext{coracum}$.

Fig. 166 Metaphase-I with $36_{11}$

Fig. 167 Metaphase-I with $2_1 + 35_{11}$

Fig. 168 Metaphase-I with $2_1 + 35_{11} + 2_{11}$

Fig. 169 Anaphase-I with normal ($36_{11}36_{11}$) distribution of chromosomes at poles.

Fig. 170 Anaphase-I with unequal distribution ($38_{11}34$) of chromosomes at poles.

Fig. 171 Anaphase-I with several laggards.
Figs. 172-175 Meiosis in hexaploid hybrids (F₁) obtained from the cross between French hexaploid *A. nigrescens* and *A. opacum*.

- **Fig. 172** Metaphase-I with \(6_2 + 31_{11}\)
- **Fig. 173** Metaphase-I with \(10_1 + 31_{11}\)
- **Fig. 174** Metaphase-I with \(7_1 + 33_{11} + 1_{111}\)
- **Fig. 175** Anaphase-I with 36:36 distribution of chromosomes at poles.

Figs. 176-179 Meiosis in hexaploid hybrids (F₁) between *A. foetidum* and *A. opacum*.

- **Fig. 176** Metaphase-I with \(10_1 + 31_{11}\)
- **Fig. 177** Metaphase-I with \(20_1 + 23_{11} + 2_{111}\)
- **Fig. 178** Anaphase-I with equal (36:36) distribution of chromosomes at poles.
Explanation of Figures

Figs. 179-181 Meiosis in hexaploid hybrids (F₁) between Z. furcatum and Z. opacum.

Fig. 179 Anaphase-I with unequal distribution (38,34) of chromosomes at poles.

Fig. 180 Anaphase-I with several laggards

Fig. 181 Anaphase-I with dividing univalents.