Polyploidy has played an important role in the evolution of genus *Mentha* as evidenced from their chromosome number and their behaviour at meiosis. The highest polyploid species discovered so far are octaploids $2n = 96$ such as *M. arvensis* and *M. aquatica*.

The Japanese mint is also an octaploid and is considered to be a hybrid between two octaploid varieties.

Dietz (1940) was first to induce polyploidy in a *M. piperita* $2n = 64$. Several workers have since induced polyploidy in species of *Mentha* (Ruttle 1939, Ikeda 1960).

Polyploidy was induced by me in *Mentha arvensis* Linn. subsp. *hemplocalyx* Briq. var. *piperascens* Holmes, $2n = 96$ and *M. piperita* Linn. var. *vulgaris* $2n = 72$. The suckers of the two species were soaked in 0.1 per cent aqueous solution of colchicine for 48 hours. For the treatment healthy succulent white suckers were selected and cut into 3 to 4 inches long pieces with two to three nodes in each. The suckers were submerged in the colchicine solution in petridishes and kept for 12 to 48 hours in the solution. It was found that the treatment was most effective in those suckers which were kept in the solution for 48 hours. After 48 hours the suckers were removed from the solution and washed in running water thoroughly before planting them in pots. The treated suckers started sprouting after 10 to 15 days of planting. When the sprouts were 4 to 6
inches tall, they were checked for polyploidy by peeling the lower epidermis of leaves and comparing the size of the stomata with those of the control. The chromosome numbers of those sprouts which had bigger stomata were checked by preparing the squashes of the young leaf primordia in aceto-orceine.

It was observed that some of the sprouts were mixoploids, some were completely diploids and a few tetraploids on the same suckers. The tetraploids and mixoploids sprouts were allowed to grow and diploid sprouts were pulled out. The tetraploid shoots were removed from the parental suckers and planted separately and allowed to grow into plants. The morphological characters, cytological behaviour and the oil percentage of these polyploids and their C$_2$ progeny was studied in details and is given separately.

*Mentha arvensis* Linn. subsp. *haplocalyx* Briq. var. *piperascens* Holmes.

The “tetraploid” is more robust than the “diploid” (ph. 12). Leaves are broader and thicker than in the “diploid.” The colour of the leaves is also more dark green than that of the “diploids.” Flowers are bigger than those in the “diploids.” Peduncle is longer than that of “diploids.” The seed formation is only 33 per cent in the “tetraploid” as compared to 45 per cent in the “diploid.” The morphological characters of the “diploid” and “tetraploids” are given in table 8.
Table - 8

<table>
<thead>
<tr>
<th>Morphological characters</th>
<th>Diploid</th>
<th>Tetraploid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>40 to 60 cm</td>
<td>45 to 60 cm</td>
</tr>
<tr>
<td>Leaf shape</td>
<td>ovato lanceolate</td>
<td>ovate</td>
</tr>
<tr>
<td>Leaf size</td>
<td>3 x 0.8 cm to</td>
<td>3.5 x 1.5 cm to</td>
</tr>
<tr>
<td></td>
<td>5 x 1.5 cm</td>
<td>6 x 3 cm</td>
</tr>
<tr>
<td>Petiole</td>
<td>0.7 to 1.5 cm</td>
<td>1 to 1.3 cm</td>
</tr>
<tr>
<td>Stomata</td>
<td>13 x 10 u to</td>
<td>22 x 15 u to</td>
</tr>
<tr>
<td></td>
<td>21 x 10 u</td>
<td>30 x 15 u</td>
</tr>
<tr>
<td>Flowers per verticil (Average)</td>
<td>21</td>
<td>26</td>
</tr>
<tr>
<td>Peduncle</td>
<td>0.3 cm</td>
<td>1.2 cm</td>
</tr>
<tr>
<td>Pedicel</td>
<td>1.5 mm</td>
<td>2 mm</td>
</tr>
<tr>
<td>Flower length</td>
<td>0.5 cm</td>
<td>0.5 cm</td>
</tr>
<tr>
<td>Flower breadth</td>
<td>0.13 cm</td>
<td>0.2 cm</td>
</tr>
<tr>
<td>Pollen fertility</td>
<td>75 per cent</td>
<td>62 per cent</td>
</tr>
<tr>
<td>Pollen grains</td>
<td>15 to 19 u diam.</td>
<td>22 to 25 u diam.</td>
</tr>
<tr>
<td>Seed formation</td>
<td>45 per cent</td>
<td>38 per cent</td>
</tr>
</tbody>
</table>

The stomata and pollen grains are bigger than those found in the "diploids" (Fig. 35 - 38).

**Cytology:** 2n = 192 somatic chromosomes are found in the root-tip cells and young leaf primordia (Fig. 39), whereas in the control "diploids", there are only 2n = 96 chromosomes. All the progeny of C2 had 2n = 192 chromosomes except one seedling which was a polyploid and had 2n = 96 chromosomes. This was male sterile and showed distinct morphological and physiological characters.
The behaviour of the chromosomes during meiosis in the "diploid" 
*Mentha arvensis* sub.sp. *haplocalyx* var. *piperascens* is described 
earlier under the cytology of *M. arvensis* complex (see page 41). In the tetraploid 
*M. arvensis* sub.sp. *haplocalyx* var. *piperascens*, there are 
found 0 to 6 tetraivalents and 96 to 90 bivalents (Fig. 40). 
The separation of the chromosomes at 1st anaphase is also 
regular, the 96 chromosomes moving to either pole. Second 
division is also regular and results into tetrads. The 
fertility of the pollen grains appears to be 68 per cent 
as compared with 76 per cent in the "diploid." Seed 
formation in the "tetraploid" is 38 per cent and in the 
"diploid" 45 percent.

**C2 Generation:**

Seeds were collected from the "tetraploid" plant 
and the C2 progeny showed variation in the leaf size, leaf 
shape, flower colour, peduncle size, seed formation and 
as well as in the oil percentage. Although the menthol 
was the predominant constituent in the oil obtained from 
all the plants of the C2 progeny.

Colour of the corolla in the progeny varied from 
white to purple the majority being lilac or lilac with 
pinkish or purplish spots. The plants with white, lilac 
and purple, colour of the corolla were found in the following 
numbers:

<table>
<thead>
<tr>
<th></th>
<th>White</th>
<th>Lilac</th>
<th>Purple</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>16</td>
<td>4</td>
</tr>
</tbody>
</table>
Although it is not possible to conclude from the small number of plants but it is obvious that there is segregation for the corolla colour and possibility 2 or more genes are involved in this.

The leaf shape is variable from lanceolate to ovate, the majority of the plants being with leaves in between the two shapes. The number of plants with leaves of different shapes are given in table 9.

Table - 9

<table>
<thead>
<tr>
<th>Total number of plants analysed</th>
<th>Number of plants with ovate leaves</th>
<th>Number of plants with ovato-lanceolate leaves</th>
<th>Number of plants with lanceolate leaves</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>10</td>
<td>14</td>
<td>6</td>
</tr>
</tbody>
</table>

The leaf size of the plants was measured when two year old plants had sent out the sprouts and sprouts were 15 to 20 cm. tall and at the same stage of development. The measurements of the biggest leaf as well as the smallest leaf were taken. The plants were divided into three categories on the basis of length of the leaves: 1) plants in which the length of leaves varied from 12 cm (largest) to 7 cm (smallest); 2) plants in which the length of leaves varied from 9.5 cm to 5.5 cm and 3) plants in which the length of leaves varied from 6 cm to 3.8 cm. The number of plants falling in each category is given in table 10.
The length and breadth of the leaves of the C2 progeny were measured and the length measured was divided by the breadth in the case of each leaf and the ratio was calculated which was somewhat constant in the case of each plant. The plants having the ratio between 1.5 to 2 were grouped together in one class. The plants having the ratio between 2 to 2.5 grouped in second class and the plants with the ratio 2.5 to 2.9 in the third class. The number of plants in each class are given in Table 11.

<table>
<thead>
<tr>
<th>Total number</th>
<th>Number of plants with ratio</th>
<th>Number of plants with ratio</th>
<th>Number of plants with ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>of plants</td>
<td>1.5 - 2</td>
<td>2 - 2.5</td>
<td>2.5 - 2.9</td>
</tr>
<tr>
<td>studied</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>13</td>
<td>29</td>
<td>6</td>
</tr>
</tbody>
</table>

It is obvious that the maximum number of plants are found with the ratio 2 - 2.5 and the minimum number of plants with the ratio 2.5 - 2.9. A number of genes
seems to be involved for the size and shape of the leaves and there is segregation of the leaf shape and size in the C2 generation.

Although the percentage of the oil in M. arvensis is effected by soil and environmental factors in addition to the genetical factors, the C2 progeny has shown a good deal of variation as evidenced from the table 12. 102 plants were analysed for the percentage of oil and the results are based on the analysis of three successive years. Oil percentages is calculated on moisture free basis.

Table - 12.

<table>
<thead>
<tr>
<th>Total number of plants analysed</th>
<th>Number of plants with 2 to 2.9 per cent oil</th>
<th>Number of plants with 3 to 4 per cent oil</th>
<th>Number of plants with 4.1 to 5 per cent oil</th>
<th>Number of plants with more than 5 per cent oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>102</td>
<td>37</td>
<td>54</td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>

Japanese mint possess 3 to 4 per cent oil and "tetraploid" also possess 3 to 4 per cent oil on moisture free basis.

It may be seen that large number of plants possess 3 to 4 per cent of oil and there are only a few plants having more than 4 per cent oil, although the plants possessing 2 to 2.9 per cent oil are again quite frequent.

The time when the oil percentage is maximum and minimum also varies in the "diploid," "tetraploid" and the C2
progeny (Graphs 1 & 2). It may be seen that in "diploid" the maximum percentage of oil is reached in late July or early August but in "tetraploid" and its Cg progeny the maximum percentage of oil is reached in mid September after which there is fall in percentage of oil. The plants in Cg progeny also differ in the initial rise in the oil percentage. In A1 (5) the initial rise is in June; in A3 (28) and A1 (6) the initial rise is in the month of May after which there is a little fall in the percentage or it remains constant for sometime and then there is again the final rise in September.

It may be surmised from the above that there are a number of genetical factors responsible as far as the percentage of oil and the time when the oil is maximum, is concerned and these factors are segregating in the Cg generation.

*Mentha piperita* Linn. var. *vulgare* Linn.

The "tetraploid" *M. piperita* Linn. var. *vulgare* is more dark green compared to the "diploid" and is about 40 to 60 cm. tall, almost same height which is found in the "diploid". The stems are thick in "tetraploid" 2 mm. as compared to 1 mm. in the "diploid". The leaves are larger and thicker in the "tetraploid", the size varying from 5 x 2.8 cm to 2.7 x 1.8 cm. whereas in the "diploid" the leaves are 4.5 x 2.5 cm to 2.2 x 1.3 cm. The petiole in the "tetraploid" is also longer and
thicker, 1.3 cm to 0.6 cm while in the "diploid" it is only 1 cm to 0.3 cm (ph. 13). The "tetraploid" has not flowered so far in Jammu like its "diploid." The "tetraploid" has got larger stomata 24 to 26 u long and 12 to 14 u broad while in the "diploid" the stomata are 16 to 18 u long and 6 to 8 u broad (Figs. 41 & 42). In the root-tip cells of the "tetraploid" are found 2n = 144 (Fig. 45) chromosomes while in the "diploid" only 2n = 72 chromosomes are met.

There has not been any increase in the percentage of oil which was the same 1.3 to 2 per cent on the moisture free basis in the "tetraploid" and the "diploid" plants.
Plate - XI

Photo 12:- *Mentha arvensis* Linn.
sub.* sp. *haplocalyx* Briq.
var. *piperescens* Holmes.
"Tetraploid".

Photo 13:- *Mentha piperita* Linn.
var. *vulgaris*.
"Diploid" on left and "tetraploid" on right.
Figure 35: Stomata in "Diploid" M. arvensis Linn. sub. sp. haplocalyx B. var. piperascence Holmes. X 900.

Figure 36: Stomata in "Tetraploid" M. arvensis Linn. sub. sp. haplocalyx B. var. piperascence Holmes. X 900.
Figure 37: Pollen grain in "Diploid"
M. ervenses Linn. sub.sp. haplocalyx Briq.
var. piperascence Holmes.
X 2800

Figure 38: Pollen grains in "Tetraploid"
M. ervenses Linn. sub.sp. haplocalyx Briq.
var. piperascens Holmes.
X 2800.

Figure 39: 2n = 192 chromosomes in "Tetraploid"
M. ervenses Linn. sub.sp. haplocalyx Briq.
var. piperascens Holmes.
X 3800.

Figure 40: 5 tetraivalents and 86 bivalents in a
P.M.C. "tetraploid" of M. ervenses Linn.
sub.sp. haplocalyx Briq. var. piperascens
Holmes. X 4000.
Graph I:— Showing the variation in oil percentage at different times of the year in "Diploid" and "Tetraploid" *M. arvensis* Linn. sub.sp. *haplocalyx* Briq. var. *piperascens* Holmes.

Graph 2:— Showing the variation in oil percentage at different times of the year in the progeny of the "Tetraploid" *M. arvensis* Linn. sub.sp. *haplocalyx* Briq. var. *piperascens* Holmes. The variation in oil percentage of only three seedlings *A₁*(5), *A₃* (28) and *A₁* (6) is shown in the graph.
PLATE - XV

Figure 41: Stomata of "Diploid" *M. piperita* Linn. var. *vulgaris*. X 1200.

Figure 42: Stomata of "Tetraploid"

*M. piperita* Linn. var. *vulgaris*

X 1200

Figure 43: 2n = 144 chromosomes in "tetraploid"

*M. piperita* Linn. var. *vulgaris*

X 3300.