A thesis titled

"CYTOLOGICAL ANALYSIS OF SYNTHETIC GROUNDNUT"

submitted

by

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upon satisfactory completion of dissertation and project work

under the kind guidance and able supervision of

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as part of fulfillment of the requirements for award of the degree of

M.Tech (Integrated) in Biotechnology

by

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CERTIFICATE OF COMPLETION

To whom so ever it may concern,
This is to certify that Ms P.R. SNEHA PRIYA has successfully completed the project titled "CYTOLOGICAL ANALYSIS OF SYNTHETIC GROUNDNUT" under my direct supervision and guidance, as part of internship programme of her final year study of M.Tech (integrated) degree course in Biotechnology from Dr.D.Y. Patil Biotechnology & Bioinformatics Institute, affiliated to Dr D.Y.Patil University, Pune. She carried out this project work at our state-of-the-art laboratory from 02 nd June 2011 to 30 th Nov 2011.

It is further certified that her project performance, general behavior and conduct found to be highly satisfactory during the entire period of her association with the ICRISAT.

Place: Hyderabad
Date: Nov 2011.

Dr. NALINI MALLIKARJUNA
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DECLARATION

To whom so ever it may concern,

I, P.R.Sneha Priya, final year student of M.Tech (Integrated) course in Biotechnology of Dr.D.Y.Patil Biotechnology & Bioinformatics Institute, Pune, do hereby solemnly declare and certify that the thesis titled "CYTOLOGICAL ANALYSIS OF SYNTHETIC GROUNDNUT" is part of the project and dissertation work carried out by me at INTERNATIONAL CROPS RESEARCH INSTITUTE FOR SEMI ARID TROPICS, Hyderabad, under the supervision and guidance of Dr. Nalini Mallikarjuna, Principal Scientist, Cell Biology.

I hereby further declare that the contents of the above thesis are my original work and no part of the same has neither been copied from any other source nor has been previously submitted by me or anyone else for award of any degree of any other university.

Date: Nov 2011.

Place: Hyderabad. P.R.Sneha Priya

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Date: Nov 2011.

Place: Hyderabad. P.R.SNEHA PRIYA.

CONTENTS

TABLES,FIGURES AND GRAPHS

INTRODUCTION

Introduction 

The domesticated groundnut is an amphidiploid or allotetraploid, meaning that it has two sets of chromosomes from two different species, thought to be *A. duranensis* and *A. ipaensis*.It is likely that these species combine in the wild to form the tetraploid species . *A. monticola*, and it is presumed that domesticated groundnut originated from this species. The process of domestication is a reason for the narrow genetic base of the groundnut. Due to which it is said to have low levels of resistance which further makes it susceptible to various diseases.

To overcome this, new sources of tetraploid groundnut were developed by combining various A and B genome species at ICRISAT which not only broadened the genetic base but contributed in broadening the genetic base and thereby transferring useful traits for making the crop resistant to various diseases.

1(a) History & Origin: 

Many pre-Columbian cultures, such as the Moche, depicted groundnuts in their art. Archeologists have dated the oldest specimens to about 7,600 years, found in Peru and also peanut was probably first cultivated in the valleys of Peru. *Arachis* is a genus of about 90 species of annual and perennial flowering plants in the legume family (Fabaceae), native to South America. At least one species, the groundnut (*Arachis hypogaea*), is a major food crop species of global importance; some of the other species are cultivated for food to a small extent in South America. Other species such as *A. pintoi* are cultivated worldwide as forage and soil conditioner plants, with the leaves providing high-protein feed for grazing livestock and a nitrogen source in agroforestry and permaculture system.

Groundnut is believed to be the native of Brazil to Peru & Argentina, from where it was introduced into Jamaica, Cuba and other West Indies islands. The plant was introduced by Portuguese into Africa from where it was introduced into North America. It was introduced into India during half of sixteenth century from one of the pacific islands of China, where it was introduced earlier from either Central America or North America.

1(b) Production & Distribution  

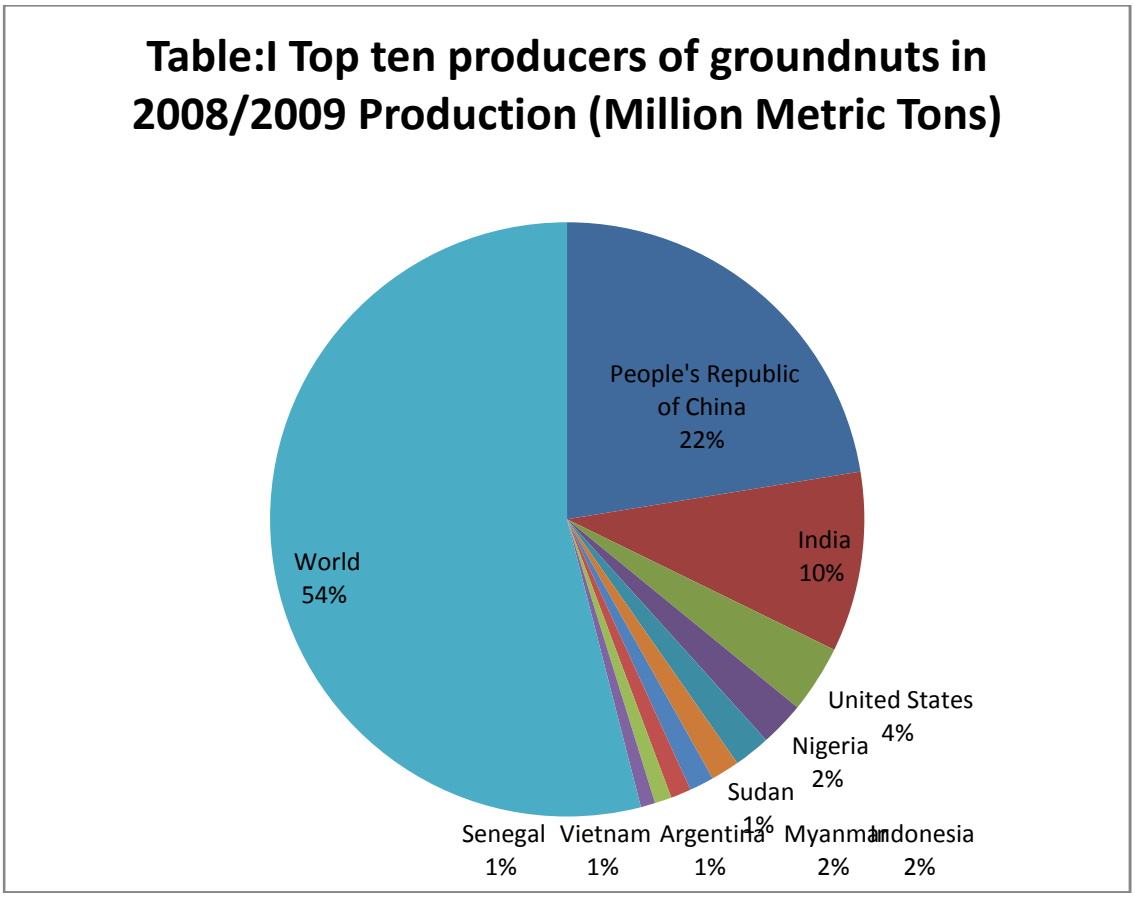
China leads in production of groundnuts, having a share of about 41.5% of overall world production, followed by India (18.2%) and the United States of America (6.8%).

18.9 million hectares and the total production of 17.8 million tones in the world, these countries (ref: Table no. 1) account for 69% of the area and 70% of the production. India occupies second position in both area and production ,in the world. About 7.5 million hectares is put under it annually and the production is about 6 million tones.70% of the area and 75% of the production are concentrated in the four states of Gujrat, Andhra Pradesh, Tamil Nadu, Karnataka and Orrisa which forms about 6% of the total groundnut area in India.

Map:I World map showing Groundnut producing major countries

Country	Production (Million Metric Tons)
People's Republic of China	14.30
India	6.25
United States	2.34
Nigeria	1.55
Indonesia	1.25
Myanmar	1.00
Sudan	0.85
Senegal	0.71
Argentina	0.58
Vietnam	0.50
World	34.43

Source: USDA Foreign Agricultural Service: Table No. 1 Groundnut Area, Yield, and Production



1(c) Cultivation

Groundnuts grow best in light, sandy loam soil. They require five months of warm weather, and an annual rainfall of 500 to 1,000 mm (20 to 39 in) or the equivalent in irrigation water. The pods ripen 120 to 150 days after the seeds are planted. If the crop is harvested too early, the pods will be unripe. If they are harvested late, the pods will snap off at the stalk, and will remain in the soil.

Groundnuts are particularly susceptible to contamination during growth and storage. Poor storage of groundnuts can lead to an infection by the mold fungus *Aspergillus flavus*, releasing the toxic and highly carcinogenic substance aflatoxin. The aflatoxin-producing molds exist throughout the groundnut growing areas and may produce aflatoxin in groundnuts when conditions are favorable to fungal growth.

Harvest: Traditionally, groundnuts are pulled and inverted by hand. After the groundnuts have dried sufficiently, they are threshed, removing the groundnut pods from the rest of the bush.

1(d) Uses

In Indian sub-continent, groundnuts are known as either a light snack by themselves, usually roasted and salted (sometimes with the addition of chilly powder), and often sold roasted in pod on roads, or boiled with salt. They are also made into little dessert or sweet snack pieces by processing with refined sugar and jaggery. Indian cuisine uses roasted, crushed groundnuts to give a crunchy body to salads; they are added whole (without pods) to leafy vegetable stews for the same reason. Another use of groundnut oil as cooking oil. Most Indians use mustard, sunflower, and groundnut oil for cooking.

Other uses: Groundnut butter, Boiled groundnuts , groundnut oil, groundnut flour, make-up, medicines, textile materials, cosmetics, nitroglycerin, plastics, dyes and paints.

SCIENTIFIC CLASSIFICATION

2(a) Scientific Classification of *Arachis hypogaea* 

Groundnut	
	
Scientific Classification	
Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Eudicots
(unranked):	Rosids
Order:	Fabales
Family:	Fabaceae
Subfamily:	Faboideae
Tribe:	Aeschynomeneae
Genus:	*Arachis*
Species:	Arachis hypogaea
Binomial name	
Arachis hypogaea.L	

2(b) Species

There are total 90 species of groundnut(Valls & Simpson 2005, Krapovickas & Gregory 1994)

a.Trierectoides:

1. *A. guaranitica*
2. *A. martii*
3. *A. brevipetiolata*
4. *A. oteroi*
5. *A. hatschbachii*
6. *A. cryptopotamica*
7. *A. major*
8. *A. benthamii*
9. *A. douradiana*

b. Extranervosae:

10. *A. setinervosa*
11. *A. macedoi*
12. *A. marginata*
13. *A. prostrata* (Grassnut)
14. *A. lutescens*

c. Triseminatae:

15. *A. triseminata*

d. Heteranthae:

16. *A. giacomettii*
17. *A. sylvestris*
18. *A. pusilla*

e. Caulorrhizae:

19. *A. repens*

f. Procumbentes:

20. *A. lignosa*
21. *A. kretschmeri*
22. *A. rigonii*
23. *A. chiquitana*
24. *A. matiensis*

g. Rhizomatosae:

25. *A. burkartii*
26. *A. pseudovillosa*
27. *A.nitida*

h.Arachis:

28. *A. glandulifera*
29. *A. cruziana*
30. *A. monticola*
31. *A. magna*
32. *A. ipaënsis*
33. *A. valida*
34. *A. williamsii*
35. *A. batizocoi*
36. *A. appressipila*
37. *A. archeri*
38. *A. benensis*
39. *A. burchellii*
40. *A. cardenasii*
41. *A. correntina* (Burkart)
42. *A. dardani*
43. *A. decora*

44. *A. diogoi*
45. *A. duranensis*
46. *A. glabrata*
47. *A. gracilis*
48. *A. gregoryi*
49. *A. helodes*
50. *A. hermannii*
51. *A. herzogii*
52. *A. hoehnei*
53. *A. hypogaea*
54. *A. interrupta*
55. *A. kempff-mercadoi*
56. *.A. kuhlmannii*
57. *A. linearifolia*
58. *A. microsperma*
59. *A. palustris*
60. *A. paraguariensis .*
61. *A. pflugeae*
62. *A. pietrarellii*
63. *A. pintoi*
64. *A. praecox*
65. *A. retusa*
66. *A. schininii*
67. *A. seridoënsis*
68. *A. simpsonii*
69. *A. stenophylla*
70. *A. stenosperma*
71. *A. subcoriacea*
72. *A. trinitensis*
73. *A. tuberosa*
74. *A. vallsii*
75. *A. villosa*
76. *A. villosulicarpa*

77. *A. africana*
78. *A. namyquarae*
79. *A.glandulifera*
80. *A.cruziana*
81. *A.monticola*
82. *A.magna*
83. *A.ipaensis*
84. *A.valida*
85. *A.williamsii*
86. *A.batizocoi*
87. *A.porphyrocalyx*
88. *A.submarginata*
89. *A.hassleri*
90. *A.krapovickasii*

2(c) Morphology of plant

Fig no. 1:Groundnut plant showing the stalk, leaves and flowers

The groundnut (*Arachis hypogaea*), is a species in the legume or "bean" family (Fabaceae). Groundnuts are known by many other local names such as earthnuts, peanuts, goober peas, monkey nuts, pygmy nuts and pig nuts.

The groundnut was probably first cultivated in the valleys of Peru. It is an annual herbaceous plant growing 30 to 50 cm (1.0 to 1.6 ft) tall. The leaves are opposite, pinnate with four leaflets (two opposite pairs; no terminal leaflet), each leaflet 1 to 7 cm (⅜ to 2¾ in) long and 1 to 3 cm (⅜ to 1 inch) broad. (refer Fig no. I)

2(d) Morphology of flower

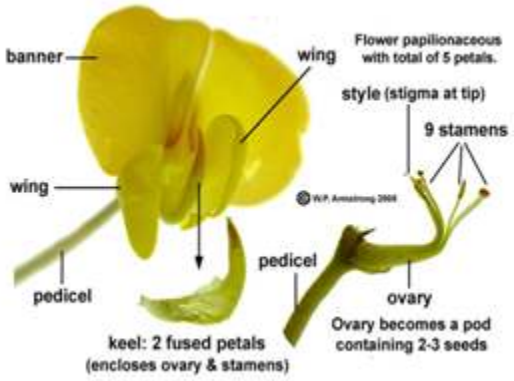


Fig no.2:Grondnut floral parts

Like other members of the subfamily Papilionoideae,the groundnut flower is paplionaceous, typical of a pea blossom. The groundnut flower is produced on a slender stalk(pedicel) near the base of the plant. Each flower consists of five petals : a large banner, two lateral wings and a keel formed by two fused petals.(refer Fig no. 2) The keel petals enclose 9 stamens (androecium) and pistil (gynoecium). The

orange-veined, yellow or orange petaled, pea-like flower of the *Arachis hypogaea* is borne in axillary clusters above ground. Following self-pollination, the flowers fade and wither.

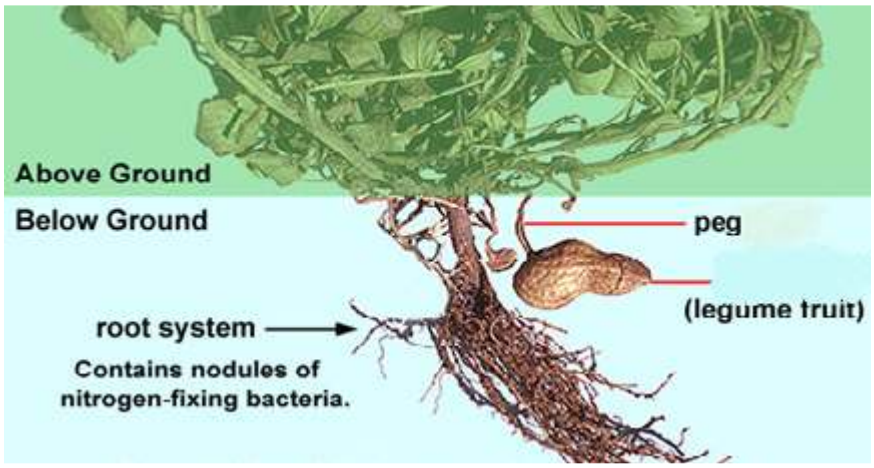


Fig no. 3:Groundnut plant showing peg formation

After self pollination and fertilization inside the flower, the pedicel curves downwards. Cells beneath the ovary begin to divide, producing a "peg" that forces the ovary into the ground. As the peg elongates a cap of cells forms next to the withered style. This cap protects the ovary as it is pushed into the soil. This is in similar function to the root cap at the tip of a root. After the developing ovary has pushed a few centimeters into the soil, downward elongation ceases. The ripening ovary becomes oriented parallel with the ground surface where it completes its development.

AIM & SCOPE

Aim & Objective:

The aim and objective of this project work was carry out cytological analysis of synthetic groundnut produced at ICRISAT. Many of the synthetics have been selfed and advance generation lines are available. Present analysis will throw light on the changes on the generation advance and will identify anomalies if any. It is known in literature that synthetics can sometime revert back to either diploidy or have other chromosomal changes.

Scope:

The brief scope of this project work encompasses:

Collection of floral buds of synthetic groundnuts from glass house

Fixing of Buds

Segregation of buds

Isolation of anthers

Squashing of buds

Separation of chromosomes

Cytological analysis

Tabulation of results

MATERIALS & INSTRUMENTS

4(a) Details of various Groundnut species used:

Floral buds of *Arachis* fixed in between 8:00 am - 8:30 am.

S. no	GR number	R number	Pedigree number	Ploidy
GR NUMBERS				
1.	GR 90 B F4	R 255-2B	ICG 8138 X ICG 3160	Tetraploid
2.	GR 40 A Graft-1	R 257-1	ICG 8206 X ICG 8123	Tetraploid
3.	GR 40 A F3	R 257-1	ICG 8206 X ICG 8123	Diploid
4.	GR 65 B	R 401-F1	ICG 11548-40 X ICG 8123-10	Tetraploid
5.	GR 9A F3	R 268-1 F1P2	ICG 8124 X ICG 8216	Tetraploid
6.	GR 9A F3 P1	R 268-1 F1P2	ICG 8124 X ICG 8216	Tetraploid
7.	GR 9A F3 P2	R 268-1 F1P2	ICG 8124 X ICG 8216	Tetraploid
8.	GR 47 A F3	R 412 F1	ICG 13256 X ICG 8123	Tetraploid
9.	GR 48 A F3	R 412-2 F1	ICG 13256-112 X ICG 8123-6	Diploid
10.	GR 204 A Graft	R 420	ICG 11548 X ICG 8123	Diploid
11.	GR 154 F3	R 401	ICG 11548 X ICG 8123	Tetraploid
R NUMBERS				
12.	R 239-5 F1 Cut		ICG 8959 X ICG 4983	Diploid
13.	R 239-4 F1 Graft		ICG 8959 X ICG 4983	Diploid
14.	R 240-6F2		ICG 8193 X ICG 4983	Diploid
15.	R 257-1		ICG 8206 X ICG 8123	Diploid
16.	R 240-1 F1 Cut		ICG 8193 X ICG 4983	Diploid
17.	R 239-1 F1P1		ICG 8959 X ICG 4983	Diploid
18.	R 414-4 F1		ICG 13230-57 X ICG 8960-131	Diploid
19.	R 419-1 F1 Hybrid		ICG 4983-153 X ICG 8216-25	Diploid
20.	R 384 F1P1 Graft		ICG 4983 A X ICG 8190	Diploid
21.	R 420-4 F1		ICG 8216-25 X ICG 4983-153	Diploid
22.	R 420-7 F1		ICG 8216-25 X ICG 4983-153	Diploid
23.	R 414 F1P1		ICG 13230-57 X ICG 8960-131	Diploid
DOUBLE SYNTHETICS				
24.	R 278-18 X GR 5B P2F2		ICG 8138 X ICG13160 ICG 8960-132 X ICG 8209-70	Tetraploid

4(b) Details of various Chemicals used:
(i) Acetic acid 45%:

(ii) Carnoy's solution I:

Carnoy's I Solution is composed of:

3 parts of absolute alcohol

1-2 drops of $FeCl_2$

1 part of glacial acetic acid

(iii) Carnoy's solution II:

Carnoy's (6:3:1):

Mix:

6 parts 100% EtOH,

3 parts of chloroform, and

1 part of glacial acetic acid (v/v/v).

However, this mixture is not stable, so it must be used immediately after mixing

Uses of Carnoy's solution:

It is used as a fixative agent for both nuclear and mitochondrial DNA in various tissues.

Addition of chloroform can help dissolve fats and oils that would otherwise interfere with observation.

CARNOY'S II AND CARNOY'S I SOLUTIONS

4(c) Details of various stains used:

1. Alexander's stain
2. Acetocaramine stain

Preparation of Alexander's Stain:

The Alexander stain solution used was prepared by adding the following constituents in the order given below and stored in the dark.

10 ml 95% alcohol

1 ml Malachite green (1% solution in 95% alcohol)

50 ml Distilled water

25 ml Glycerol

5 ml Acid fuchsin (1% solution in water)

0.5 ml Orange G (1% solution in water)

4 ml Glacial acetic acid

Add distilled water (4.5 ml) to a total of 100 ml.

Preparation of Acetocaramine stains (1% solution):

Carmine is a basic dye that was prepared from the insect *Coccus cacti*.

Dissolve 10 g carmine (Fisher C579-25) in 1 L of 45% glacial acetic acid, and Heat it over the hot plate by continuous mixing.

Filter into dark bottles and store at 4°C. This solution can be stored for a long time.

Staining can be intensified by adding ferric chloride ($FeCl_2 \cdot 6H_2O$); add 5 ml of a 10 % ferric chloride solution per 100 ml of % acetocaramine.

4(d) details of various Instruments used:

(3)Instruments

Microscopes:

s.no	Instrument	Make &Model no.	Special Instructions
1	Binocular Microscope (refer Fig no.4)	Wild Heerbrugg Model no: 404234	

Fig no.4:Binocular microscope

2	Microscope (refer Fig no.5)	Olympus BH-2 Model no: BHS 215411	Microscope: Maximum zooming capacity: up up to 100x

Fig no. 5:Microscope

3	Microscope with inbuilt camera (refer Fig no. 6)	Microscope: Olympus BH-2 Model no: BHS 214806 Camera: Nikon 4500	Microscope: Maximum zooming capacity: up to 100x. Camera: Maximum zooming capacity: up to 4x. And 4 mega pixels.

Fig no. 6: Microscope with in built camera

4(e) Details of various Tools used:

Microscopic glass slides

Cover slips

Squashier

Forceps

Needle

Immersion

Vials

METHODS

E. RESEARCH METHODOLOGY & INVETIGATION PROCEDURE:

The following Research Methods & Investigation procedures and Techniques have been adopted by me for carrying out Cytological analysis of various species of synthetic groundnut in this Project work:

With the help of various Instruments, Chemicals, Stains and Tools mentioned above, detailed cytological analysis (meiotic analysis on twenty pollen mother cells of each of the 24 groundnut species (diploid, tetraploid and double synthetic types) has been carried out in Laboratory, involving the following techniques & procedures:

1. Collection & fixing of floral buds:

The floral buds are collected from the glass house and are fixed in a vial consisting of cornoy's - II solution, in between 8:00 am to 8:30 am.

Fig no. 7: Figure showing bud fixing

- After for 2 days, transferred the buds to cornoys - I solution.
- After a day, the buds were segregated into different sizes and then squashed.

Fig no.8: Figure showing sorted buds.

2. Segregation of buds

The buds must be sorted out depending upon their sizes.

Fig no. 9: Isolation of anthers from floral buds of synthetic groundnut

3. Isolation of Anthers

- After sorting each bud must be taken separately and separation of anthers must be done.
- The separated anthers of each bud must be placed separately on a thoroughly cleaned glass slide.
- Allow the cornoy's - I solution to evaporate.

4. Squashing of buds Separation of Chromosomes:

Now squash the buds in 2% acetocaramine stain and stir with a iron needle before placing the cover slip. Iron acts as a moderant.

45% Acetic acid can be added to destain the slide by simultaneously pressing and gently warming the slide which will facilitate the separation of chromosomes.

5. Cytological analysis

When the chromosomes have been separated the slide can now be analyzed for pairing of chromosomes and ploidy.

RESULTS

TABLES & FIGURES

1. LIST OF TABLES

2. LIST OF FIGURES

3. LIST OF BAR CHARTS

4. LIST OF FINAL RESULTS AND FINDINGS

6. Observations & Findings:

During this project, I had carried out detailed investigations and Cytological Meiotic Analysis on twenty pollen mother cells of each of the following 24 diploid and tetraploid species of groundnuts. The detailed observations and findings about chromosomal configuration during Metaphase and Anaphase and formation of Tetrads are appended below:

1.R420-4F1(Diploid):

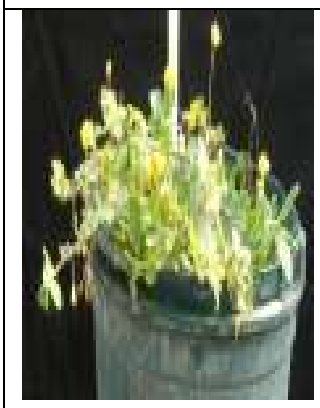
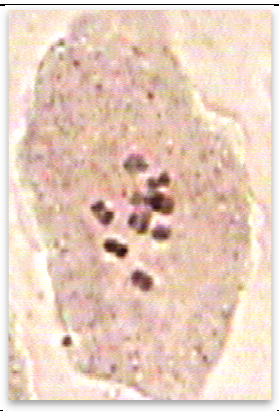
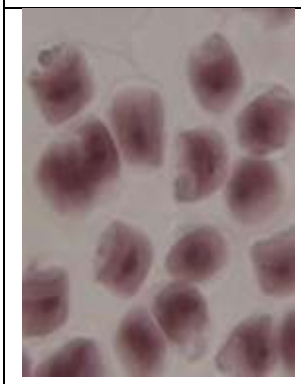
Meiotic analysis on 20 Pollen Mother Cells of R420-4F1 (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in Table 1**.** Meiotic analysis [Fig. (a)-(g)] of the PMC's (pollen mother cells) showed that 100% of the PMC's had 10 bivalents(Table 1) during metaphase (Fig. no .c).The number of bivalents were 10 per PMC. There were no univalents, trivalents or tetravalents.(bar chart no.1,Table 1a). Anaphase (Fig .d) showed normal disjunction of chromosomes in 25% of the PMC's. Unequal distribution of chromosomes was observed in 75% of the cells.75% of the PMC's showed laggards.(Table no. 1,Table no 1b)All the PMC's formed tetrads(Fig. number .e)Micronuclei were not seen in any PMC.(Table no. 1). Pollen fertility of this plant is

Table no 1

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei(+)1	Micronuclei(+)2
1.	-	10	-	-	9	10	1	72	-	-
2.	-	10	-	-	10	8	2	56	-	-
3.	-	10	-	-	9	9	2	44	-	-
4.	-	10	-	-	10	7	3	31	-	-
5.	-	10	-	-	10	10	-	52	-	-
6.	-	10	-	-	6	10	4	26	-	-
7.	-	10	-	-	10	10	-	18	-	-
8.	-	10	-	-	9	10	1	19	-	-
9.	-	10	-	-	10	8	2	11	-	-
10	-	10	-	-	10	8	2	28	-	-
11	-	10	-	-	10	10	-	36	-	-
12	-	10	-	-	9	7	3	37	-	-
13	-	10	-	-	8	10	1	14	-	-
14	-	10	-	-	10	9	3	16	-	-

15	-	10	-	-	10	9	1	26	-	-
16	-	10	-	-	9	10	-	18	-	-
17	-	10	-	-	10	10	1	37	-	-
18	-	10	-	-	10	8	2	15	-	-
19	-	10	-	-	10	7	3	9	-	-
20	-	10	-	-	10	10	-	18	-	-
SUM	-	200	-	-	189	180	31	583	-	-

Microscopic visuals of Pollen Mother Cells of R420-4F1 (Diploid) Plant during metaphase of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Non dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	
			

Bar chart no. 1

The chromosomal configuration of pollen mother cells of R420-4F1 (Diploid) plant during metaphase of meiotic analysis represented in the form of bar chart is furnished below:

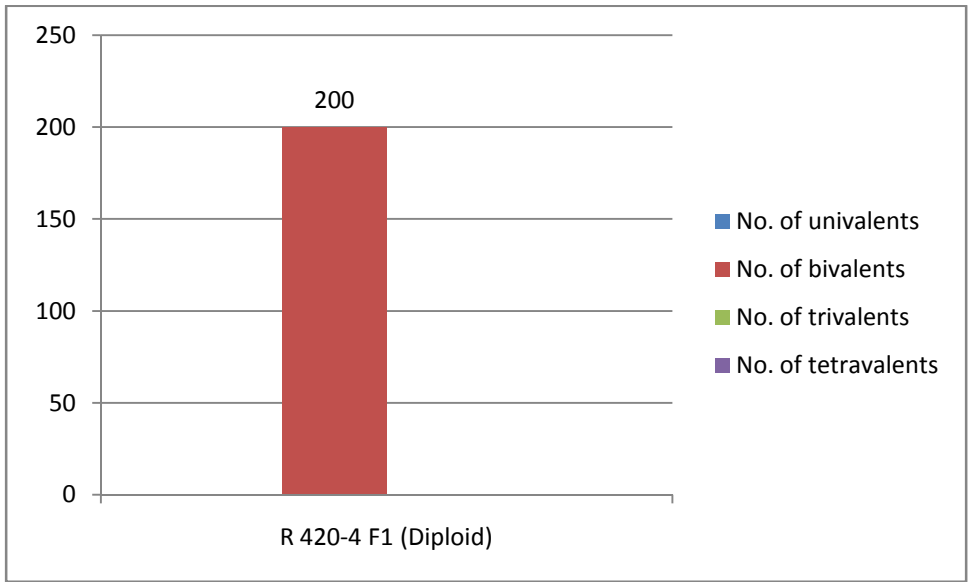


Table no 1a

Final results & findings of pollen mother cells of R420-4F1 (Diploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
100	0	10	0	0

Table no 1b

Final results & findings of pollen mother cells of R420-4F1 (Diploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	formation of Tetrads (%)	Presence of Micronucleus
25	75	75	100	0

2.R 384 F1P1 Graft (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of R 384 F1P1 Graft (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following Table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 10% of the PMC's had 10 bivalents(Table 2,2a) during Metaphase(Fig .c).The number of bivalents were 10 per PMC. The number of univalents ranged from 0-6.There were no trivalents & tetravalents.(Bar chart no. 2)

Anaphase (Fig. d)showed normal disjunction of chromosomes in 100% of the PMC's.Unequal distribution of chromosomes was not observed .So. there were no laggards formed.(Table 2)

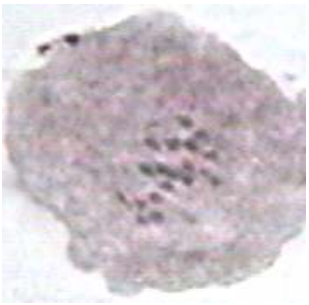
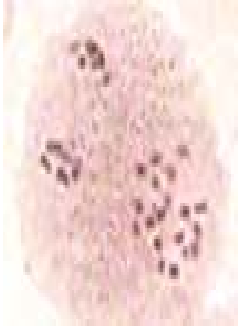
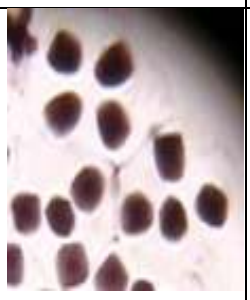
All the PMC's formed tetrads(Fig .e).Micronuclei were not seen in any PMC.(Table 2,2b).Pollen fertility of this plant was 40%.Many sterile pollen were seen.The size of the big pollen was 13-15 μm and the size of small pollen was 11-13 μm.

Table no. 2

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei(+)1	Micronuclei (+2)
1.	2	9	-	-	10	10	-	34	-	-
2.	4	8	-	-	10	10	-	8	-	-
3.	2	9	-	-	10	10	-	12	-	-
4.	4	8	-	-	10	10	-	18	-	-
5.	4	8	-	-	10	10	-	42	-	-
6.	4	8	-	-	10	10	-	28	-	-
7.	2	9	-	-	10	10	-	13	-	-
8.	6	7	-	-	10	10	-	9	-	-
9.	2	9	-	-	10	10	-	6	-	-
10.	4	8	-	-	10	10	-	4	-	-
11.	2	9	-	-	10	10	-	72	-	-
12.	2	9	-	-	10	10	-	16	-	-
13.	2	9	-	-	10	10	-	12	-	-
14.	4	8	-	-	10	10	-	13	-	-
15.	2	9	-	-	10	10	-	56	-	-
16.	-	10	-	-	10	10	-	26	-	-
17.	2	9	-	-	10	10	-	16	-	-

18.	-	10	-	-	10	10	-	18	-	-
19.	-	10	-	-	10	10	-	9	-	-
20.	2	9	-	-	10	10	-	4	-	-
SUM	50	175	-	-	200	200	-	416	-	-

Microscopic visuals of pollen mother cells of R 384 F1P1 Graft (Diploid) plant during metaphase of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Non dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	
			

Bar chart no. 2

The chromosomal formation configuration of pollen mother cells of R 384 F1P1 Graft (Diploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

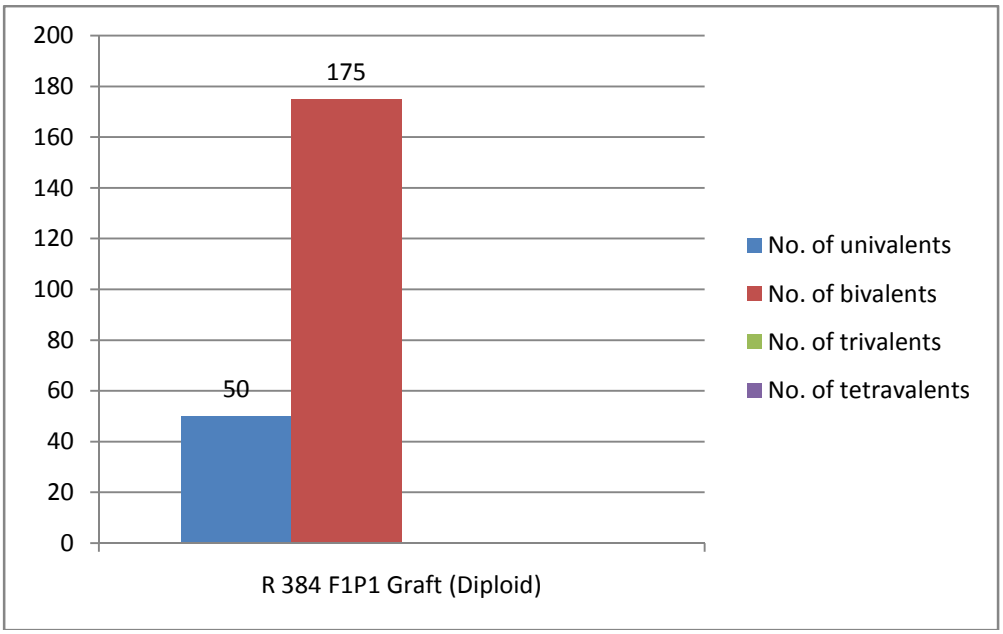


Table 2a

Final results & findings of pollen mother cells of R 384 F1P1 Graft (Diploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
10	0 - 6	10	0	0

Table 2b

Final results & findings of pollen mother cells of R 384 F1P1 Graft (Diploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	Not seen

3. R239-5 F1 Cut (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of R239-5 F1 Cut (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following Table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 40% of the PMC's had 10 bivalents(Table 3,3a) during Metaphase(Fig c).The number of bivalents were 10 per PMC. The number of tetravalents ranged from 0-2.There were no univalents & trivalents .(Bar chart no. 3)

Anaphase (Fig .d) showed normal disjunction of chromosomes in 100% of the PMC's. Unequal distribution of chromosomes was not observed .So, there were no laggards formed.(Table 3,3b)

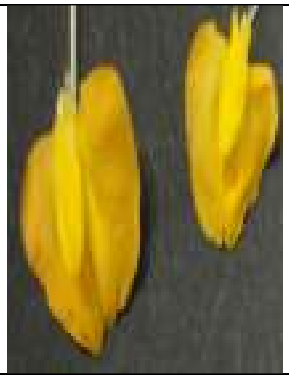
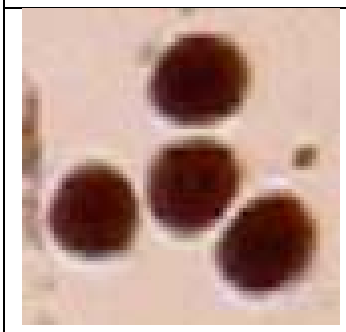
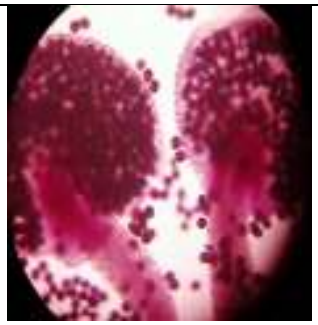
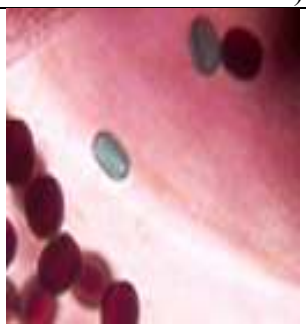
All the PMC's formed tetrads. Micronuclei were not seen in any PMC.(Table 3).Pollen fertility of this plant was found to be 90%.Sterile pollen were very less.The size of the big pollen was 14-16µm and the size of the small pollen was 11-13µ.

Table no. 3

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S.No.	I	II	III	IV	Pole I	Pole II	Laggards	0	(+)1	(+)2
1.	-	8	-	1	10	10	-	32	-	-
2.	-	10	-	-	10	10	-	28	-	-
3.	-	10	-	-	10	10	-	27	-	-
4.	-	10	-	-	10	10	-	19	-	-
5.	-	6	-	2	10	10	-	16	-	-
6.	-	8	-	1	10	10	-	12	-	-
7.	-	10	-	-	10	10	-	26	-	-
8.	-	6	-	2	10	10	-	46	-	-
9.	-	10	-	-	10	10	-	21	-	-
10.	-	10	-	-	10	10	-	6	-	-
11.	-	8	-	1	10	10	-	9	-	-
12.	-	8	-	1	10	10	-	34	-	-
13.	-	6	-	2	10	10	-	25	-	-
14.	-	10	-	-	10	10	-	29	-	-
15.	-	8	-	1	10	10	-	16	-	-
16.	-	8	-	1	10	10	-	18	-	-
17.	-	6	-	2	10	10	-	36	-	-
18.	-	10	-	-	10	10	-	19	-	-
19.	-	6	-	2	10	10	-	22	-	-

20.	-	6	-	2	10	10	-	9	-	-
SUM	-	164	-	18	200	200	-	450	-	-

Microscopic visuals of Pollen Mother Cells of R239-5 F1 Cut (Diploid) Plant during metaphase of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Non dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	
			

Bar chart no .3

The chromosomal formation configuration of Pollen Mother Cells of R239-5 F1 Cut (Diploid) Plant during metaphase of meiotic analysis are also represented in the form of Bar chart and is furnished below:

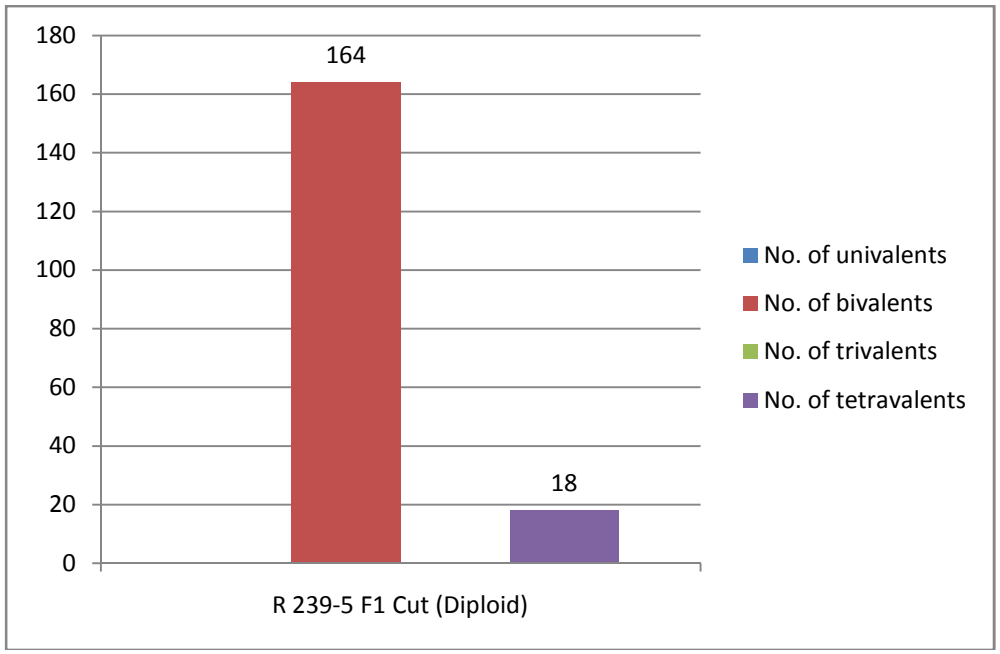


Table 3a

Final Results & Findings of Pollen Mother Cells of R239-5 F1 Cut (Diploid) Plant during Metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
40	0	10	0	0-2

Table 3b

Final Results & Findings of Pollen Mother Cells of R239-5 F1 Cut (Diploid) Plant during Anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	Not seen

4.GR 65 B F1 Graft (Tetraploid):

Meiotic analysis on 20 Pollen Mother Cells of GR 65 B F1 Graft (Tetraploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following Table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that the PMC's had 20 bivalents(Table 4,4a) during Metaphase(Fig c). The number of bivalents ranged from 14-17.Trivalents were also observed and ranged from 0-1 in very few PMC's. The number of tetravalents ranged from 0-2.

Anaphase(Fig d) showed abnormal disjunction of chromosomes in all the PMC's. Unequal distribution of chromosomes was observed in all the cells. PMC's showed laggards formation and ranged from 2-8.(Bar chart no. 4,Table no 4b)

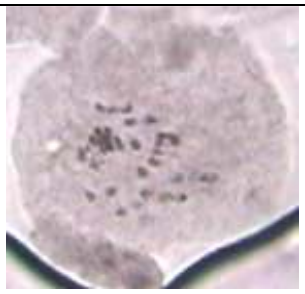
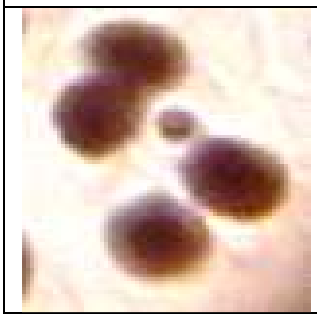
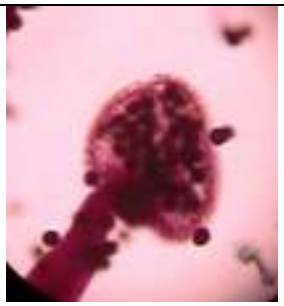
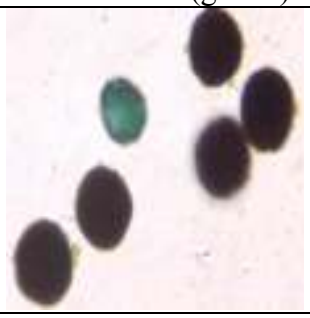
All the PMC's formed tetrads(Fig e).50% of the PMC's had 1-3 micronuclei.(Table no. 4).The pollen fertility of this plant was found to be 95%.Sterile pollen were very less.The size of the big pollen was 14-16µm and the size of the small pollen was 12-14µm.

Table no 4

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	2	15	-	2	18	17	5	36	2	-
2.	4	16	-	1	19	18	3	32	1	-
3.	3	15	1	1	17	19	4	48	3	-
4.	2	17	-	2	16	19	5	59	2	-
5.	4	16	-	1	14	18	8	62	2	-
6.	2	17	-	1	16	18	6	36	-	-
7.	2	15	-	2	15	17	8	24	-	-
8.	2	15	-	2	17	19	4	21	-	-
9.	4	16	-	1	18	18	4	19	-	-
10.	2	15	-	2	19	17	4	21	-	-
11.	5	15	1		20	16	4	18	-	-
12.	2	17	-	1	19	18	3	17	-	-
13.	4	16	-	1	18	19	3	16	-	-

14.	2	17	-	1	18	18	4	32	2	-
15.	2	15	-	2	18	17	5	34	2	-
16.	4	14	-	2	17	18	5	48	3	-
17.	4	16	-	1	16	18	6	22	2	-
18.	2	15	-	2	15	19	6	11	1	-
19.	2	15	-	2	18	17	5	9	-	-
20.	2	17	-	1	19	19	2	14	-	-
SUM	56	314	2	28	347	359	94	579	20	-

Microscopic visuals of Pollen Mother Cells of GR 65 B F1 Graft (Tetraploid) Plant during metaphase of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Non dehiscent anther	g) Pollen: Fertile big & small (dark pink), Sterile (green)	
			

Bar chart no.4

The chromosomal formation configuration of pollen mother cells of GR 65 B F1 Graft (Tetraploid) plant during various phases of meiotic analysis are also represented in the form of bar chart and is furnished below:

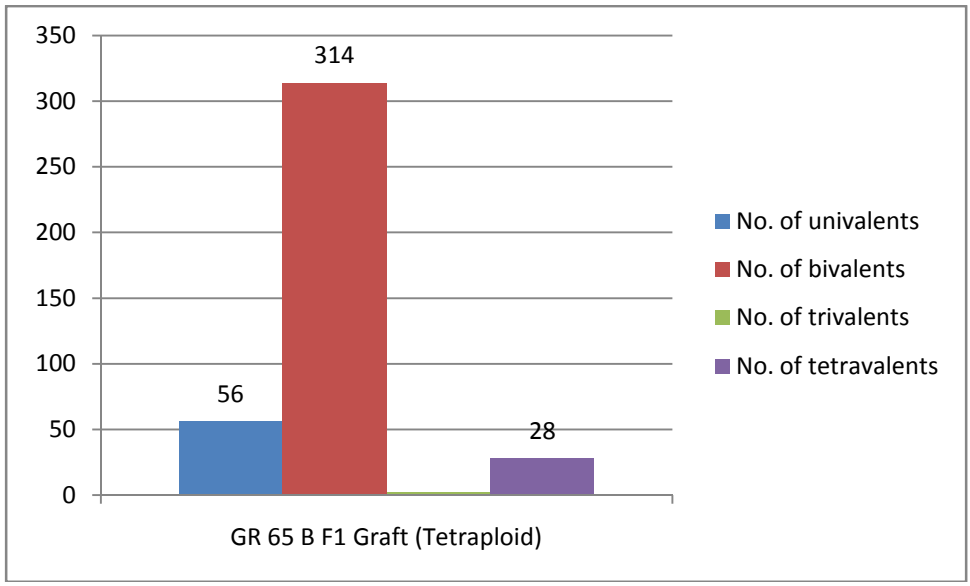


Table 4a

Final results & findings of pollen mother cells of GR 65 B F1 Graft (Tetraploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. / Range of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
20	0	20 (14 to 17)	0 to 1 in very few	0-2

Table 4b

Final results & findings of pollen mother cells of GR 65 B F1 Graft (Tetraploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Abnormal / Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
Not found	Observed in all	2 to 8	100	to 3 in 50 %

5. R 419-1 F1 HYBRID (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of R 419-1 F1 HYBRID (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following Table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 100% of the PMC's had 10 bivalents(Table 5,5a) during Metaphase(Fig c). The number of bivalents were 10 per PMC. There were no univalents, trivalents or tetravalents.(Bar chart 5)

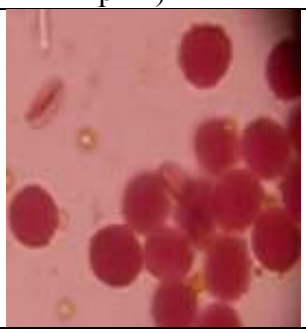
Anaphas(Fig d)e showed normal disjunction of chromosomes in 100% of the PMC's.(Table 5) Unequal distribution of chromosomes was not observed .So, there were no laggards formed.(Bar chart 5,Table 5b) All the PMC's formed tetrads(Fig e).15% of the PMC's had 1-2 micronuclei.(Table 5).The pollen fertility of this plant was found to be 96 %.Sterile pollen were very less. The size of the big pollen was found to be 11-13μ and the size of the small pollen was 8-10 μm.

Table no. 5

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	10	-	-	10	10	-	58	2	-
2.	-	10	-	-	10	10	-	67	1	-
3.	-	10	-	-	10	10	-	43	-	-
4.	-	10	-	-	10	10	-	48	-	-
5.	-	10	-	-	10	10	-	32	-	-
6.	-	10	-	-	10	10	-	29	-	-
7.	-	10	-	-	10	10	-	26	-	-
8.	-	10	-	-	10	10	-	18	-	-
9.	-	10	-	-	10	10	-	19	-	-
10.	-	10	-	-	10	10	-	6	-	-
11.	-	10	-	-	10	10	-	4	-	-
12.	-	10	-	-	10	10	-	89	2	-
13.	-	10	-	-	10	10	-	106	1	-
14.	-	10	-	-	10	10	-	54	-	-
15.	-	10	-	-	10	10	-	47	-	-
16.	-	10	-	-	10	10	-	22	-	-

17.	-	10	-	-	10	10	-	31	-	-
18.	-	10	-	-	10	10	-	19	-	-
19.	-	10	-	-	10	10	-	26	-	-
20.	-	10	-	-	10	10	-	41	-	-
SUM	-	200	-	-	200	200	-	785	6	

Microscopic visuals of pollen mother cells of R 419-1 F1 HYBRID (Diploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Dehiscent anther	g) Pollen: Fertile big & small (dark pink), Sterile (light pink)	
			

Bar chart no.5

The chromosomal formation configuration of pollen mother cells of R 419-1 F1 HYBRID (Diploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

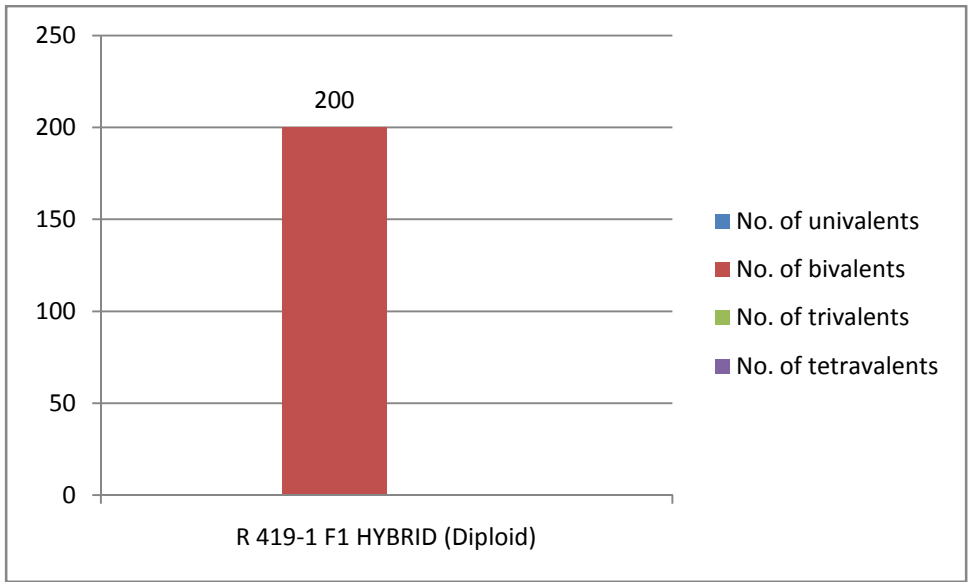


Table 5a

Final results & findings of pollen mother cells of R 419-1 F1 HYBRID (Diploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
100	0	10	0	0

Table 5b

Final results & findings of pollen mother cells of R 419-1 F1 HYBRID (Diploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	to 2 in 15%

6.R 420-7 F1 (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of R 420-7 F1 (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following Table. Meiotic analysis [Fig. (a)-(h)] of the PMC's (Pollen Mother Cells) showed that 100% of the PMC's had 10 bivalents(Table 6) during Metaphase(Fig c). The number of bivalents were 10 per PMC. Tetravalents were observed in 2 PMC's .There were no univalents &trivalents .(Bar chart 6)

Anaphase(Fig d) showed normal disjunction of chromosomes in 100% of the PMC's. Unequal distribution of chromosomes was not observed .So, there were no laggards formed.(Bar chart 6)

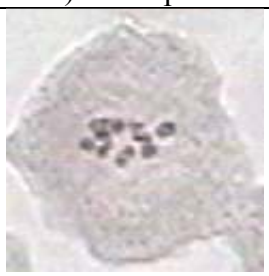
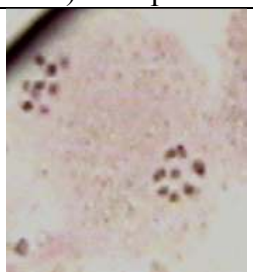
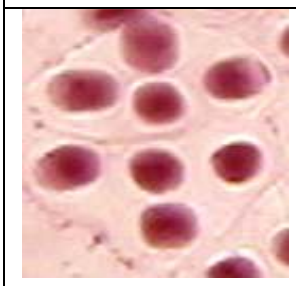
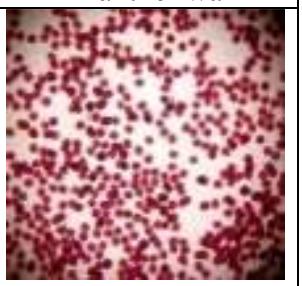
All the PMC's formed tetrads(Fig e).15% of the PMC's had 1-2 micronuclei.(Table no. 6).The pollen fertility of this plant was 98%.The size of the big pollen was 11-13µm and the size of the small pollen was 8-10µm.

Table no.6

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S.No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei(+)1	Micronuclei (+)2
1.	-	10	-	-	10	10	-	46	-	1
2.	-	10	-	-	10	10	-	32	-	-
3.	-	10	-	-	10	10	-	27	-	-
4.	-	8	-	1	10	10	-	19	-	-
5.	-	10	-	-	10	10	-	12	-	-
6.	-	10	-	-	10	10	-	9	-	-
7.	-	10	-	-	10	10	-	52	-	2
8.	-	10	-	-	10	10	-	31	-	-
9.	-	10	-	-	10	10	-	26	-	-
10.	-	10	-	-	10	10	-	23	-	-
11.	-	10	-	-	10	10	-	12	-	-
12.	-	10	-	-	10	10	-	16	-	-
13.	-	8	-	1	10	10	-	55	-	-
14.	-	10	-	-	10	10	-	42	-	-
15.	-	10	-	-	10	10	-	31	-	-

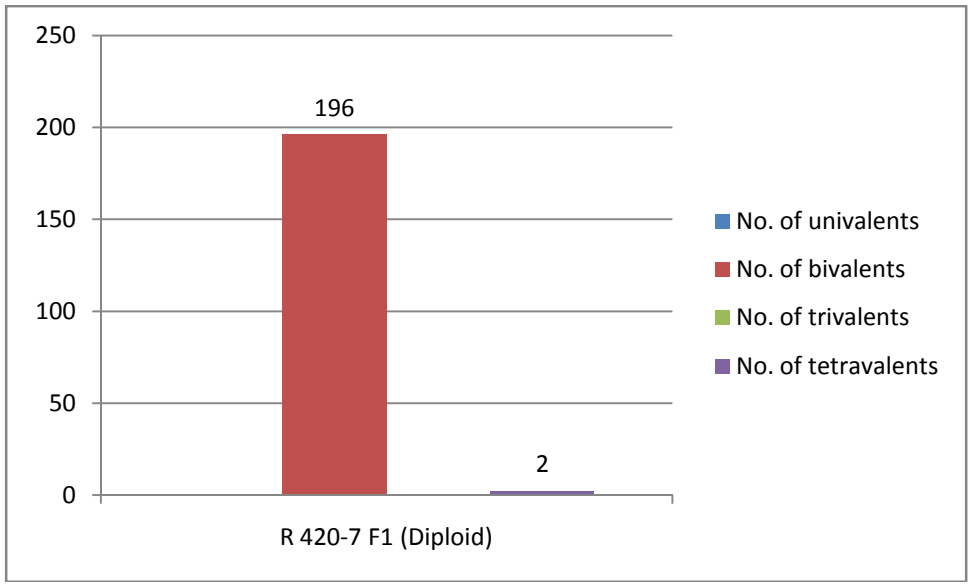
16.	-	10	-	-	10	10	-	11	-	-
17.	-	10	-	-	10	10	-	17	-	-
18.	-	10	-	-	10	10	-	24	-	-
19.	-	10	-	-	10	10	-	23	-	-
20.	-	10	-	-	10	10	-	8	-	-
SUM	-	398	-	2	200	200	-	516	-	-

Microscopic visuals of pollen mother cells of R 420-7 F1 (Diploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	h) Pollen spreading due to mechanical rupture of anther wall
			

The chromosomal formation configuration of pollen mother cells of R 420-7 F1 (Diploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

Bar chart no. 6



Final results & findings of pollen mother cells of R 420-7 F1 (Diploid) plant during metaphase of meiotic analysis is tabled below:

Table 6a

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
100	0	10	0	2

Table 6b

Final results & findings of pollen mother cells of R 420-7 F1 (Diploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	to 2 in 15%

7.GR 9A F3P2 (Tetraploid):

Meiotic analysis on 20 Pollen Mother Cells of GR 9A F3P2 (Tetraploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following Table. Meiotic analysis [Fig. (a)-(h)] of the PMC's (Pollen Mother Cells) showed that 85% of the PMC's had 20 bivalents(Table 7,7a) during Metaphase(Fig c). The number of bivalents were 20 per PMC.The number of bivalents ranged from 18-20.Univalents were also observed and ranged from 0-4 in very few PMC's. There were no trivalents & tetravalents .(Bar chart no.7)

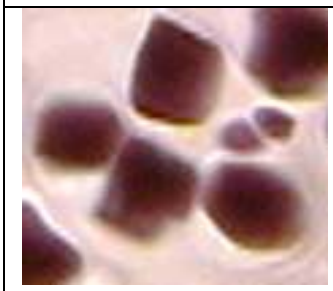
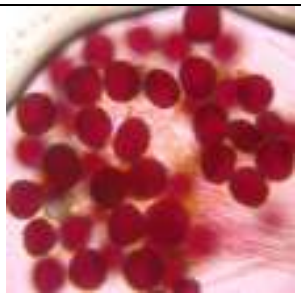
Anaphase(F ig d) showed normal disjunction of chromosomes in all the PMC's. Equal distribution of chromosomes was observed in 100% of the cells.(Table 7,7b) PMC's showed no laggards formation. All the PMC's formed tetrads(Fig e).Micronuclei were not observed.(Bar chart no.7)Pollen fertility of this plant was found to be 90% .The size of the big pollen was 16-18µm and the size of the small pollen was 14-16 µm.

Table no. 7

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	2	19	-	-	20	20	-	54	-	-
2.	-	20	-	-	20	20	-	62	-	-
3.	-	20	-	-	20	20	-	11	-	-
4.	-	20	-	-	20	20	-	19	-	-
5.	-	20	-	-	20	20	-	17	-	-
6.	-	20	-	-	20	20	-	24	-	-
7.	4	18	-	-	20	20	-	29	-	-
8.	-	20	-	-	20	20	-	36	-	-
9.	-	20	-	-	20	20	-	38	-	-
10.	-	20	-	-	20	20	-	12	-	-
11.	-	20	-	-	20	20	-	8	-	-
12.	-	20	-	-	20	20	-	19	-	-
13.	-	20	-	-	20	20	-	27	-	-
14.	-	20	-	-	20	20	-	36	-	-

15.	2	19	-	-	20	20	-	38	-	-
16.	-	20	-	-	20	20	-	42	-	-
17.	-	20	-	-	20	20	-	26	-	-
18.	-	20	-	-	20	20	-	27	-	-
19.	-	20	-	-	20	20	-	21	-	-
20.	-	20	-	-	20	20	-	19	-	-
SUM	8	392	-	-	400	400	-	595	-	-

Microscopic visuals of pollen mother cells of GR 9A F3P2 (Tetraploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrad showing 2 micronuclei	f) Dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	h) Pollen spreading due to mechanical ruptureof anther wall
			

Bar chart no.7

The chromosomal formation configuration of pollen mother cells of GR 9A F3P2 (Tetraploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

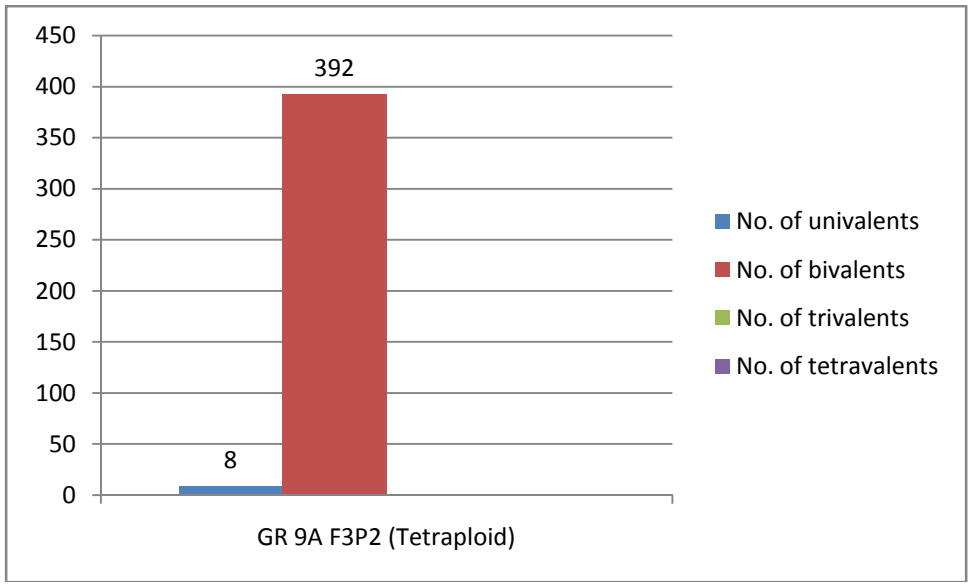


Table 7a

Final results & findings of pollen mother cells of GR 9A F3P2 (Tetraploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 20 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
85	0 to 4 in very few	20 (18 to 20)	0	0

Table 7b

Final results & findings of pollen mother cells of GR 9A F3P2 (Tetraploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	Not seen

8.GR 9A F3P1 (Tetraploid):

Meiotic analysis on 20 Pollen Mother Cells of GR 9A F3P1 (Tetraploid) plant has been carried out as per the above stipulated procedure and the observations were recorded in the following Table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 90% of the PMC's had 20 bivalents(Table 8,8a) during Metaphase(Fig c). The number of bivalents were 20 per PMC.The number of bivalents ranged from 18-20.Univalents were also observed and ranged from 0-4 in very few PMC's. There were no trivalents & tetravalents .(Bar chart 8)

Anaphase(Fig d) showed normal disjunction of chromosomes in all the PMC's.Equal distribution of chromosomes was observed in 100% of the cells(Table no 8,8b). PMC's showed no laggards formation.(Bar chart 8)

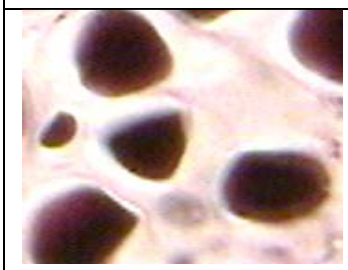
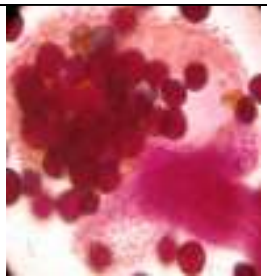
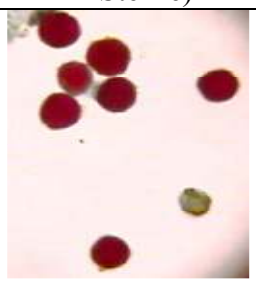
All the PMC's formed tetrads(Fig e).Micronuclei were seen in all of the PMC's and ranged from 1-8(Bar chart no.8).The pollen fertility of this plant was 98%.The size of the big pollen was 15-17µm and the size of the small pollen was 12-14µm.

Table no. 8

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	20	-	-	20	20	-	42	6	-
2.	-	20	-	-	20	20	-	28	4	-
3.	-	20	-	-	20	20	-	16	2	-
4.	-	20	-	-	20	20	-	17	3	-
5.	2	19	-	-	20	20	-	58	8	-
6.	-	20	-	-	20	20	-	69	7	-
7.	-	20	-	-	20	20	-	12	1	-
8.	2	19	-	-	20	20	-	49	5	-
9.	-	20	-	-	20	20	-	54	6	-
10.	-	20	-	-	20	20	-	13	2	-
11.	-	20	-	-	20	20	-	88	8	-
12.	4	18	-	-	20	20	-	62	6	-
13.	-	20	-	-	20	20	-	16	2	-

14.	-	20	-	-	20	20	-	19	2	-
15.	-	20	-	-	20	20	-	43	3	-
16.	-	20	-	-	20	20	-	17	2	-
17.	-	20	-	-	20	20	-	26	2	-
18.	-	20	-	-	20	20	-	32	4	-
19.	-	20	-	-	20	20	-	11	1	-
20.	-	20	-	-	20	20	-	14	1	-
SUM	8	392	-	-	400	400	-	686	75	-

Microscopic visuals of pollen mother cells of GR 9A F3P1 (Tetraploid) R239-5 F1 Cut (Diploid) plant during metaphase of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads showing 1 micronuclei	f) Non dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	
			

Bar chart no. 8

The chromosomal formation configuration of pollen mother cells of GR 9A F3P1 (Tetraploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

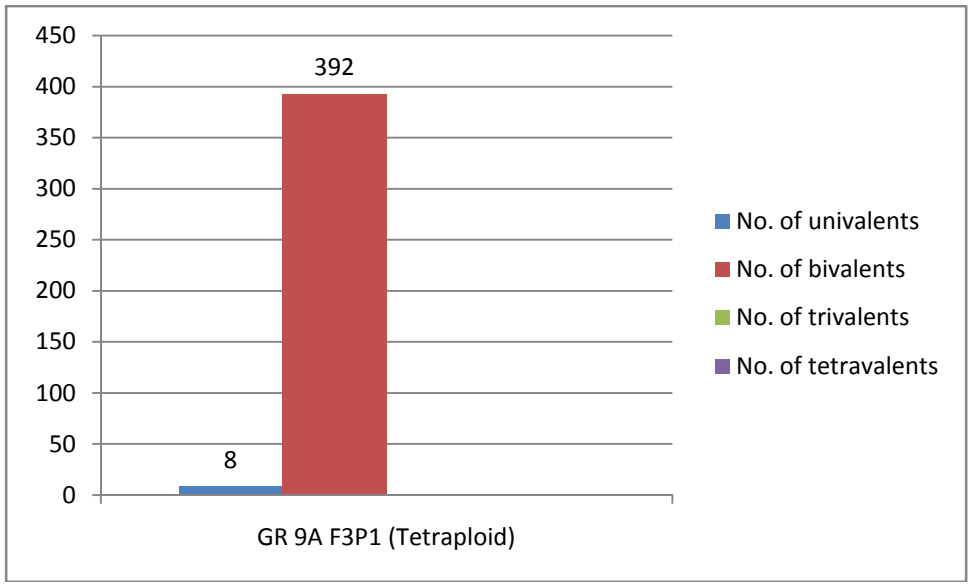


Table 8a

Final results & findings of pollen mother cells of GR 9A F3P1 (Tetraploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 20 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
90	0 to 4 in very few	20 (18 to 20)	0	0

Table 8b

Final results & findings of pollen mother cells of GR 9A F3P1 (Tetraploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	Seen in all (1 to 8)

9.GR 9A F3 (Tetraploid):

Meiotic analysis on 20 Pollen Mother Cells of GR 9A F3 (Tetraploid) plant has been carried out as per the above stipulated procedure and the observations were recorded in the following Table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 95% of the PMC's had 20 bivalents (Table 9,9a) during Metaphase(Fig c). The number of bivalents were 20 per PMC. The number of bivalents ranged from 19-20.Univalents were also observed and ranged from 0-2 in very few PMC's. There were no trivalents & tetravalents.(Bar chart no. 9)

Anaphase(Fig d) showed normal disjunction of chromosomes in all the PMC's. Equal distribution of chromosomes was observed in 100% of the cells(Table no 9,9b). PMC's showed no laggards formation.(Bar chart no.9)

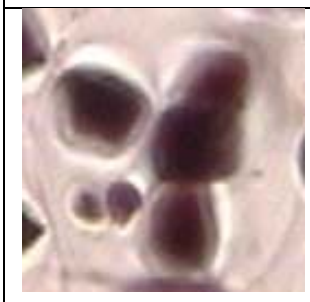
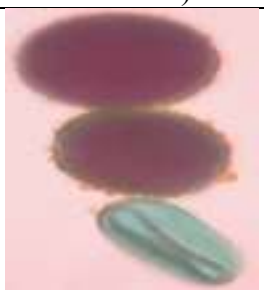
All the PMC's formed tetrads(Fig e). Micronuclei were seen in all of the PMC's and ranged from 1-4.(Table no 9).The pollen fertility of this plant was found to be 85%.The size of the big pollen was 14-16µm and the size of the small pollen was 11-13µm.

Table no 9

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	20	-	-	20	20	-	32	2	-
2.	-	20	-	-	20	20	-	29	2	-
3.	-	20	-	-	20	20	-	44	4	1
4.	-	20	-	-	20	20	-	27	3	-
5.	-	20	-	-	20	20	-	22	1	-
6.	2	19	-	-	20	20	-	19	2	-
7.	-	20	-	-	20	20	-	12	1	-
8.	-	20	-	-	20	20	-	16	2	-
9.	-	20	-	-	20	20	-	26	1	-
10.	-	20	-	-	20	20	-	29	2	-
11.	2	19	-	-	20	20	-	23	2	-
12.	-	20	-	-	20	20	-	21	1	-
13.	-	20	-	-	20	20	-	16	1	2

14.	-	20	-	-	20	20	-	14	2	-
15.	-	20	-	-	20	20	-	42	3	-
16.	-	20	-	-	20	20	-	36	3	-
17.	-	20	-	-	20	20	-	38	4	-
18.	-	20	-	-	20	20	-	31	2	-
19.	-	20	-	-	20	20	-	16	1	-
20.	-	20	-	-	20	20	-	19	1	-
SUM	4	396	-	-	400	400	-	512	40	-

Microscopic visuals of pollen mother cells of GR 9A F3 (Tetraploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads showing 1 micronucleus	f) Non dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	
			

Bar chart no. 9

The chromosomal formation configuration of pollen mother cells of GR 9A F3 (Tetraploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

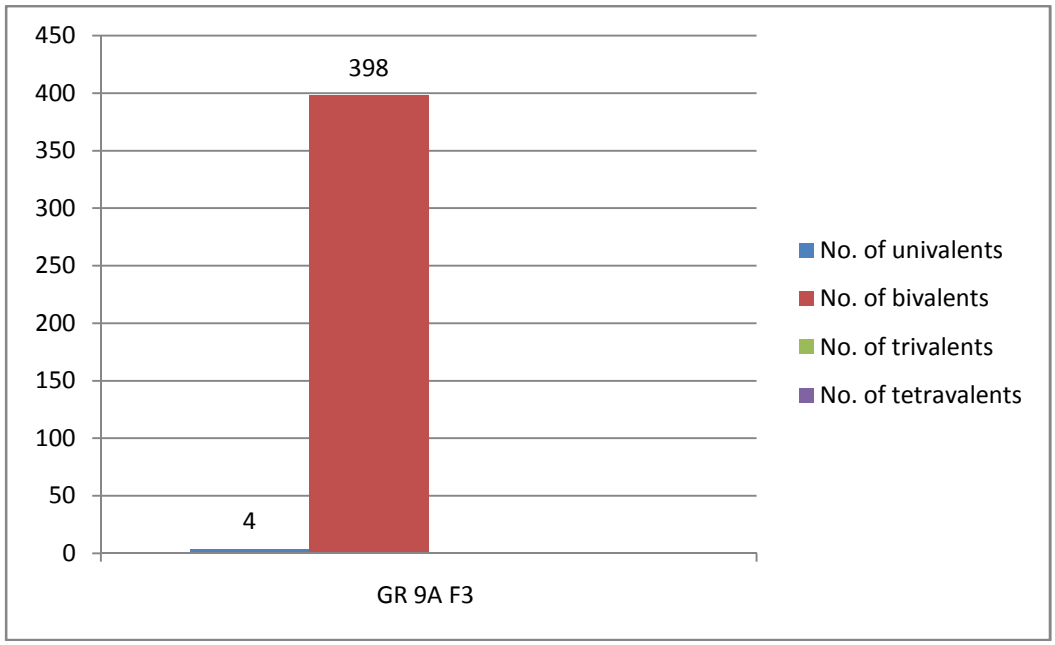


Table 9a

Final results & findings of pollen mother cells of GR 9A F3 (Tetraploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 20 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
95	0 to 2 in very few	20 (19 to 20)	0	0

Table 9b

Final results & findings of pollen mother cells of GR 9A F3 (Tetraploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	Seen in all (1 to 4)

10.GR 154 F3 (Tetraploid):

Meiotic analysis on 20 Pollen Mother Cells of GR 154 F3 (Tetraploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 90% of the PMC's had 20 bivalents (Table 10,10a) during Metaphase(Fig c). The number of bivalents were 20 per PMC. The number of bivalents ranged from 18-20.Univalents were observed and ranged from 0-4 in very few PMC's. There was 1 tetravalent found in only 1 PMC. There were no trivalents.(Bar chart no 10)

Anaphase(Fig d) showed normal disjunction of chromosomes in all the PMC's. Equal distribution of chromosomes was observed in 100% of the cells(Table no 10,10b). PMC's showed no laggards formation.(Bar chart 10)

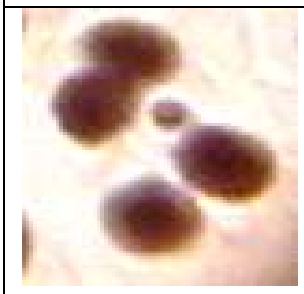
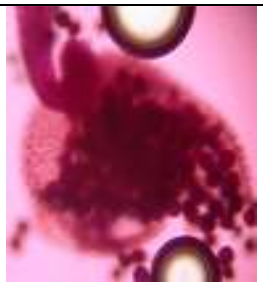
All the PMC's formed tetrads(Fig e). Micronuclei were seen in 90% of the PMC's and ranged from 1-4.((Table no. 10)The pollen fertility of this plant was found to be 50%.The size of the big pollen was 14-16µm and the size of the small pollen was 11-13µm.

Table no 10

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	20	-	-	20	20	-	34	2	-
2.	-	20	-	-	20	20	-	26	1	-
3.	-	18	-	-	20	20	-	23	1	-
4.	-	20	-	-	20	20	-	28	2	-
5.	-	20	-	-	20	20	-	42	4	-
6.	-	20	-	-	20	20	-	31	3	-
7.	2	19	-	-	20	20	-	23	2	-
8.	-	20	-	-	20	20	-	19	2	-
9.	-	20	-	-	20	20	-	11	1	-
10.	-	20	-	-	20	20	-	17	-	-
11.	2	19	-	-	20	20	-	36	3	-
12.	-	18	-	-	20	20	-	22	2	-
13.	-	20	-	-	20	20	-	29	2	-
14.	-	20	-	-	20	20	-	28	2	-

15.	-	20	-	-	20	20	-	17	-	-
16.	-	20	-	-	20	20	-	15	-	-
17.	-	20	-	-	20	20	-	13	1	-
18.	2	19	-	-	20	20	-	24	2	-
19.	-	20	-	-	20	20	-	9	1	-
20.	-	20	-	-	20	20	-	12	-	-
SUM	6	393	-	-	400	400	-	459	31	-

Microscopic visuals of pollen mother cells of GR 154 F3 (Tetraploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads showing 1 micronuclei	f) Anther wall broken due to mechanical rupture	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	
			

Bar chart no 10

The chromosomal formation configuration of pollen mother cells of GR 154 F3 (Tetraploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

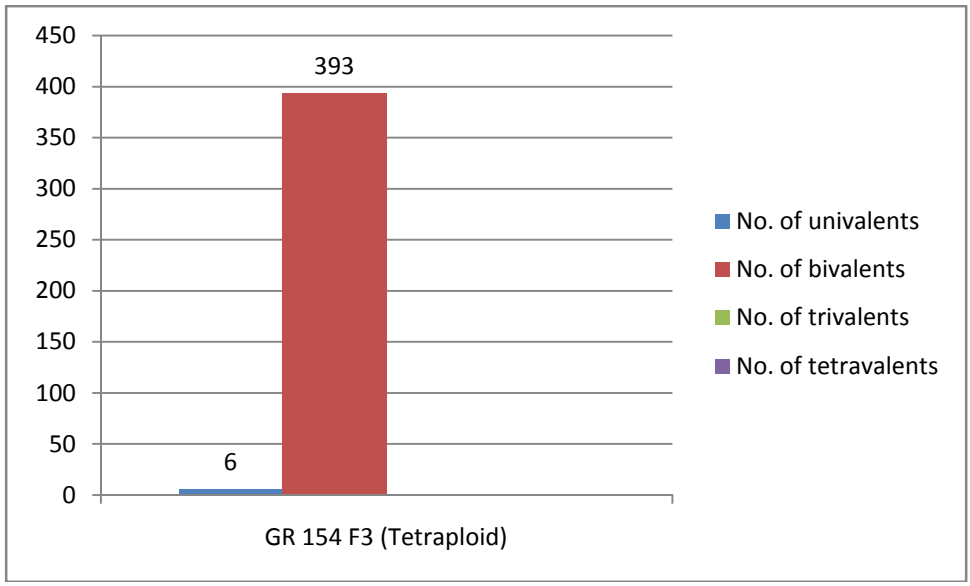


Table 10a

Final results & findings of pollen mother cells of GR 154 F3 (Tetraploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 20 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
90	0 to 4 in very few	20 (18 to 20)	0	1 in one pmc

Table 10b

Final results & findings of pollen mother cells of GR 154 F3 (Tetraploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	Seen in 90% (1 to 4)

11.GR 48 F3 (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of GR 48 F3 (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(h)] of the PMC's (Pollen Mother Cells) showed that 40% of the PMC's had 10 bivalents (Table 11,11a) during Metaphase(Fig c). The number of bivalents were 10 per PMC. The number of univalents ranged from 0-2.There were no trivalents and tetravalents.(Bar chart 11)

Anaphase(Fig d)) showed normal disjunction of chromosomes in 100% of the PMC's. Unequal distribution of chromosomes was not observed(Table 11,11b) .So, there were no laggards formed.(Bar chart 11)

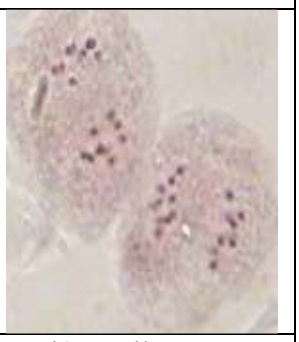
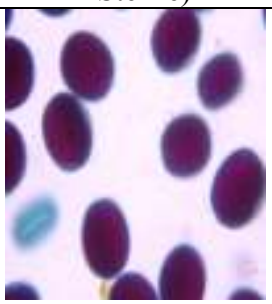
All the PMC's formed tetrads(Fig e). Micronuclei were not seen in any PMC.(Bar chart 11) The pollen fertility of this plant was found to be 98%.The size of the big pollen was 14-16µm and the size of the small pollen was 11-13µm.

Table no 11

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	10	-	-	10	10	-	58	-	-
2.	-	10	-	-	10	10	-	62	-	-
3.	-	10	-	-	10	10	-	12	-	-
4.	2	9	-	-	10	10	-	18	-	-
5.	-	10	-	-	10	10	-	17	-	-
6.	-	10	-	-	10	10	-	43	-	-
7.	-	10	-	-	10	10	-	22	-	-
8.	-	10	-	-	10	10	-	27	-	-
9.	2	9	-	-	10	10	-	36	-	-
10.	-	10	-	-	10	10	-	49	-	-
11.	-	8	-	1	10	10	-	52	-	-
12.	2	9	-	-	10	10	-	12	-	-
13.	-	10	-	-	10	10	-	9	-	-
14.	-	10	-	-	10	10	-	76	-	-

15.	-	10	-	-	10	10	-	16	-	-
16.	-	10	-	-	10	10	-	29	-	-
17.	-	10	-	-	10	10	-	18	-	-
18.	-	10	-	-	10	10	-	32	-	-
19.	-	8	-	1	10	10	-	36	-	-
20.	-	10	-	-	10	10	-	9	-	-
SUM	6	186	-	2	200	200	-	633	-	-

Microscopic visuals of Pollen Mother Cells of GR 48 F3 (Diploid) Plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads showing one micronucleus	f) Dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	h) Pollen spreading due to mechanical rupture of anther wall
			

Bar chart no 11

The chromosomal formation configuration of pollen mother cells of GR 48 F3 (Diploid) plant during metaphase of meiotic analysis are also represented in the form of bar chart and is furnished below:

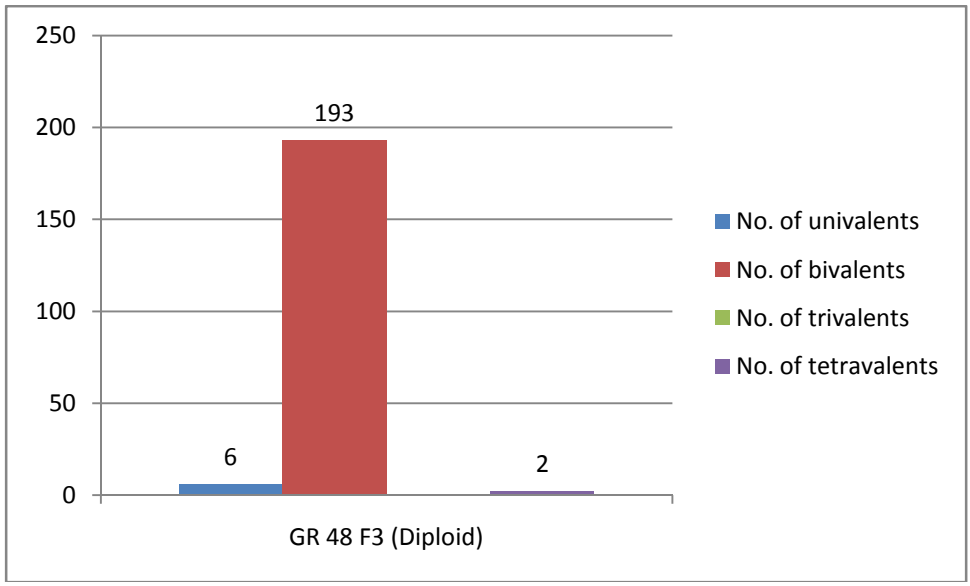


Table 11a

Final results & findings of pollen mother cells of GR 48 F3 (Diploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
40	0 to 2	10	0	0

Table 11b

Final results & findings of pollen mother cells of GR 48 F3 (Diploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	Not seen

12.R 414-4 F1 (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of R 414-4 F1 (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 40% of the PMC's had 10 bivalents (Table 12,12a) during Metaphase(Fig c0. The number of bivalents were 10 per PMC. The number of univalents ranged from 0-2.There were no trivalents and tetravalents.(Bar chart 12)

Anaphase (Fig d)showed normal disjunction of chromosomes in 100% of the PMC's. Unequal distribution of chromosomes was not observed (Table 12,12b).So, there were no laggards formed.(Bar chart 12)

All the PMC's formed tetrads(Fig e). Micronuclei were not seen in any PMC.(Bar chart 12) The pollen fertility of this plant was found to be 87%.The size of the big pollen was 12-14µm and the size of the small pollen was 9-11µm.

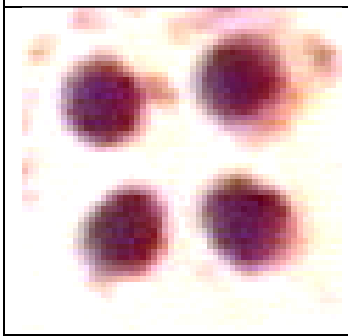
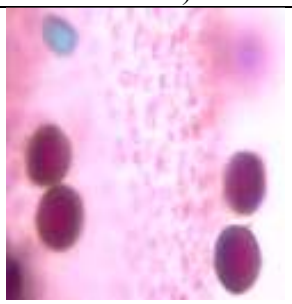
Meiosis in Plant R 414-4 F1 (Diploid)

Table no 12

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	10	-	-	10	10	-	48	-	-
2.	-	10	-	-	10	10	-	36	-	-
3.	-	10	-	-	10	10	-	39	-	-
4.	-	10	-	-	10	10	-	22	-	-
5.	-	10	-	-	10	10	-	12	-	-
6.	-	10	-	-	10	10	-	13	-	-
7.	-	10	-	-	10	10	-	21	-	-
8.	2	9	-	-	10	10	-	19	-	-
9.	-	10	-	-	10	10	-	36	-	-
10.	-	10	-	-	10	10	-	72	-	-
11.	-	10	-	-	10	10	-	88	-	-
12.	-	10	-	-	10	10	-	39	-	-
13.	-	10	-	-	10	10	-	42	-	-
14.	-	10	-	-	10	10	-	26	-	-

15.	-	10	-	-	10	10	-	29	-	-
16.	2	9	-	-	10	10	-	12	-	-
17.	-	10	-	-	10	10	-	19	-	-
18.	-	10	-	-	10	10	-	18	-	-
19.	-	10	-	-	10	10	-	36	-	-
20.	-	10	-	-	10	10	-	44	-	-
SUM	4	196	-	-	200	200	-	671	-	-

Microscopic visuals of pollen mother cells of R 414-4 F1 (Diploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
Tetrads	e) Pollen Fertility (Pink = Fertile & Green = Sterile)	f) Pollen spreading due to mechanical ruptureof anther wall	
			

Bar chart no 12

The chromosomal formation configuration of pollen mother cells of R 414-4 F1 (Diploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

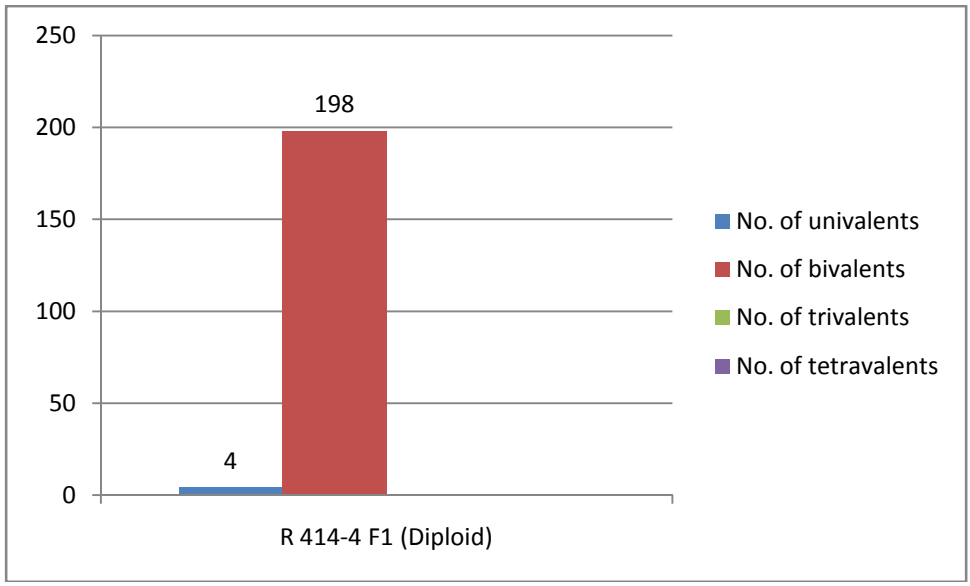


Table 12a

Final results & findings of pollen mother cells of R 414-4 F1 (Diploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
40	0 to 2	10	0	0

Table 12b

Final results & findings of pollen mother cells of R239-5 F1 Cut (Diploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% age formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	Not seen

13.GR 40 A Graft -1 (Tetraploid):

Meiotic analysis on 20 Pollen Mother Cells of GR 40 A Graft -1 (Tetraploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 95% of the PMC's had 20 bivalents (Table 13,13a) during Metaphase(Fig c). The number of bivalents were 20 per PMC. The number of bivalents ranged from 18-20.Univalents were also observed and ranged from 0-4 in very few PMC's. There were no trivalents & tetravalents.(Bar chart no 13)

Anaphase (Fig d)showed abnormal disjunction of chromosomes in 40% of the PMC's. Equal distribution of chromosomes was observed in 60% of the cells(Table no 13,13b). PMC's showed laggards formation and ranged from 0-2.(Bar chart 13)

All the PMC's formed tetrad(Fig e)s. All of the PMC's had micronuclei and ranged from 1-6.

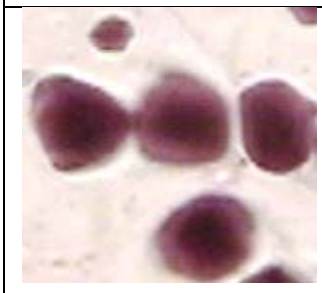
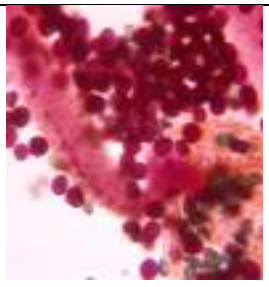
The pollen fertility of this plant was found to be 76%.The size of the big pollen was 14-16µm and the size of the small pollen was 11-13µm.

Table no 13

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	2	19	-	-	18	20	2	26	4	-
2.	-	20	-	-	20	20	-	18	3	-
3.	4	18	-	-	19	20	1	19	2	-
4.	-	20	-	-	20	18	2	9	1	-
5.	-	20	-	-	20	20	-	32	5	-
6.	2	19	-	-	20	20	-	28	6	-
7.	-	20	-	-	19	20	1	6	1	-
8.	-	20	-	-	18	20	2	18	2	-
9.	-	20	-	-	20	20	-	7	1	-
10.	2	19	-	-	20	20	-	24	4	-
11.	-	20	-	-	20	20	-	22	3	-
12.	4	18	-	-	18	20	2	16	2	-
13.	-	20	-	-	20	20	-	17	3	-

14.	-	20	-	-	20	20	-	28	5	-
15.	-	20	-	-	20	20	-	39	6	-
16.	-	20	-	-	20	20	-	18	2	-
17.	-	20	-	-	20	20	-	9	2	-
18.	-	20	-	-	18	20	2	16	2	-
19.	-	20	-	-	19	19	2	12	3	-
20.	-	20	-	-	20	20	-	9	1	-
SUM	14	386	-	-	389	397	14	373	58	-

Microscopic visuals of pollen mother cells of GR 40 A Graft 1 (Tetraploid) plants during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase showing laggards
			
e) Tetrads showing micronuclei	f) Pollen Fertility (Pink = Fertile & Green = Sterile)	g) Pollen spreading due to mechanical ruptureof anther wall	
			

Bar chart no 13

The chromosomal formation configuration of pollen mother cells of GR 40 A Graft -1 (Tetraploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

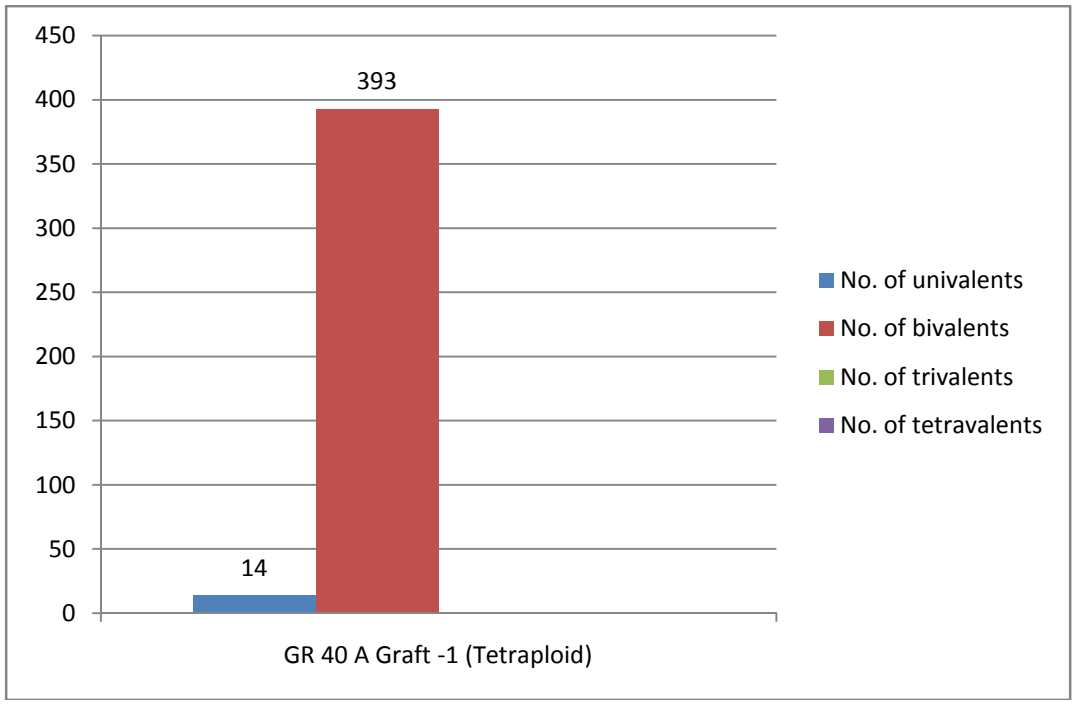


Table 13a

Final results & findings of pollen mother cells of GR 40 A Graft -1 (Tetraploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 20 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
95	0 to 4 in very few	20 (18 to 20)	0	0

Table 13b

Final results & findings of pollen mother cells of GR 40 A Graft -1 (Tetraploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus

40	40	0 to 2	100	1 to 6

14.GR 204 A Graft (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of GR 204 A Graft (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 65% of the PMC's had 10 bivalents(Table 14,14a) during Metaphase(Fig c). The number of bivalents were 10 per PMC and ranged from 8-10 in each PMC. The number of tetravalents ranged from 0-1.There were no univalents & trivalents.(Bar chart 14)

Anaphase9Fig d0 showed normal disjunction of chromosomes in 100% of the PMC's. Unequal distribution of chromosomes was not observed(Table 14,14b) .So, there were no laggards formed.(Bar chart 13)

All the PMC's formed tetrads(Fig e). Micronuclei were not seen in any PMC.(Bar chart 13)

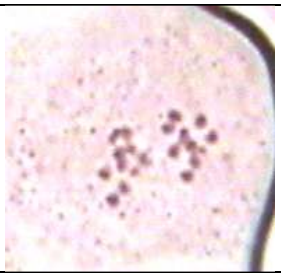
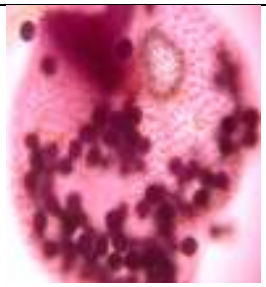
The pollen fertility of this plant was found to be 82%.The size of the big pollen was 12-14µm and the size of the small pollen was 9-11µm.

Table no 14

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	8	-	1	10	10	-	68	-	-
2.	-	10	-	-	10	10	-	12	-	-
3.	-	10	-	-	10	10	-	14	-	-
4.	-	8	-	1	10	10	-	2	-	-
5.	-	8	-	1	10	10	-	28	-	-
6.	-	10	-	-	10	10	-	54	-	-
7.	-	10	-	-	10	10	-	22	-	-
8.	-	10	-	-	10	10	-	36	-	-
9.	-	10	-	-	10	10	-	39	-	-
10.	-	10	-	-	10	10	-	26	-	-
11.	-	10	-	-	10	10	-	24	-	-
12.	-	8	-	1	10	10	-	14	-	-
13.	-	10	-	-	10	10	-	17	-	-
14.	-	10	-	-	10	10	-	22	-	-

15.	-	10	-	-	10	10	-	26	-	-
16.	-	10	-	-	10	10	-	18	-	-
17.	-	8	-	1	10	10	-	19	-	-
18.	-	10	-	-	10	10	-	22	-	-
19.	-	8	-	1	10	10	-	26	-	-
20.	-	8	-	1	10	10	-	32	-	-
SUM	-	196	-	7	200	200	-	521	-	-

Microscopic visuals of pollen mother cells of GR 204 A Graft (Diploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrad	f) Non dehiscent anther		
			

Bar chart no 14

The chromosomal formation configuration of pollen mother cells of GR 204 A Graft (Diploid) plant during metaphase of meiotic analysis are also represented in the form of bar chart and is furnished below:

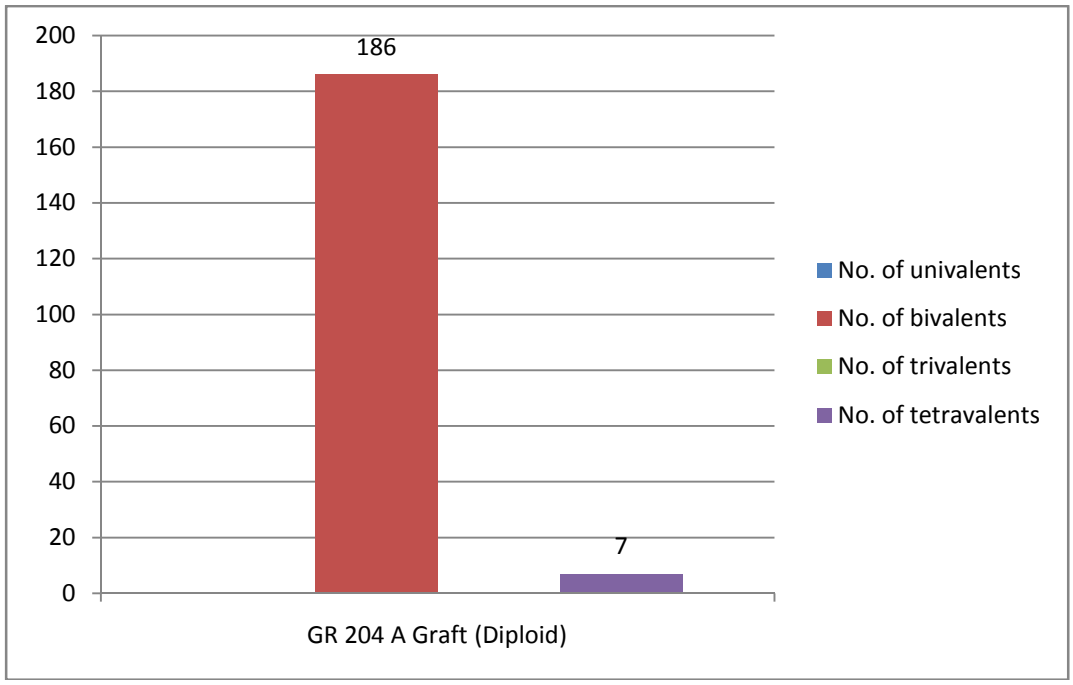


Table 14a

Final results & findings of pollen mother cells of GR 204 A Graft (Diploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
65	0	10 (8 to 10)	0	0-1

Table 14b

Final results & findings of pollen mother cells of GR 204 A Graft (Diploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	Not seen

15.R278-18 X GR 5B P2F2 (Tetraploid):

Meiotic analysis on 20 Pollen Mother Cells of R278-18 X GR 5B P2F2 (Tetraploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(h)] of the PMC's (Pollen Mother Cells) showed that 95% of the PMC's had 20 bivalents(Table 15,15a) during Metaphase(Fig c). The number of bivalents were 20 per PMC. The number of bivalents ranged from 19-20.Tetravalents were also observed and ranged from 0-1 in very few PMC's. There were no univalents and trivalents .(Bar chart 15)

Anaphase(Fig d) showed normal disjunction of chromosomes in all the PMC's. Equal distribution of chromosomes was observed in 100% of the cells(Table 15,15b). PMC's showed no laggards formation.(Bar chart 15)

All the PMC's formed tetrads(Fig e). All of the PMC's had micronuclei and ranged from 1-11.(Bar chart 15)

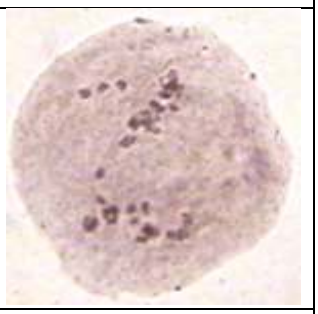
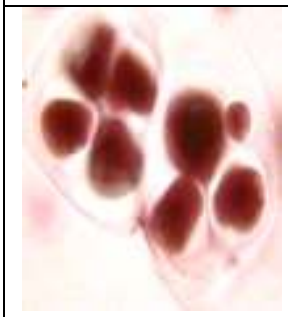
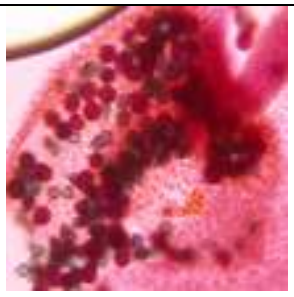
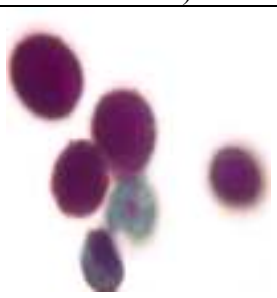
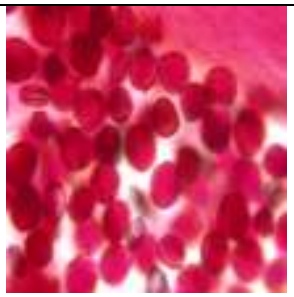
The pollen fertility of this plant was found to be 50%.The size of the big pollen was 14-16µm and the size of the small pollen was 11-13µm.

Table no 15

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	20	-	-	20	20	-	28	4	-
2.	-	20	-	-	20	20	-	36	6	-
3.	-	20	-	-	20	20	-	29	3	2
4.	-	20	-	-	20	20	-	48	8	-
5.	-	20	-	-	20	20	-	27	3	-
6.	-	20	-	-	20	20	-	52	11	2
7.	-	18	-	1	20	20	-	16	2	-
8.	-	20	-	-	20	20	-	19	1	-
9.	-	20	-	-	20	20	-	18	2	-
10.	-	20	-	-	20	20	-	24	3	-
11.	-	20	-	-	20	20	-	39	7	2
12.	-	20	-	-	20	20	-	32	6	-

13.	-	18	-	1	20	20	-	31	4	-
14.	-	20	-	-	20	20	-	22	4	-
15.	-	18	-	1	20	20	-	19	5	-
16.	-	20	-	-	20	20	-	17	3	-
17.	-	20	-	-	20	20	-	27	4	-
18.	-	20	-	-	20	20	-	36	8	3
19.	-	20	-	-	20	20	-	21	5	-
20.	-	20	-	-	20	20	-	9	1	-
SUM	-	397	-	3	400	400	-	550	90	9

Microscopic visuals of pollen mother cells of R278-18 X GR 5B P2F2 (Tetraploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads showing micronucleus	f) Anther wall broken due to mechanical rupture	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	h) Pollen spreading due to mechanical ruptureof anther wall
			

Bar chart 15

The chromosomal formation configuration of pollen mother cells of R278-18 X GR 5B P2F2 (Tetraploid) plant during metaphase of meiotic analysis is also represented in the form of Bar chart and is furnished below:

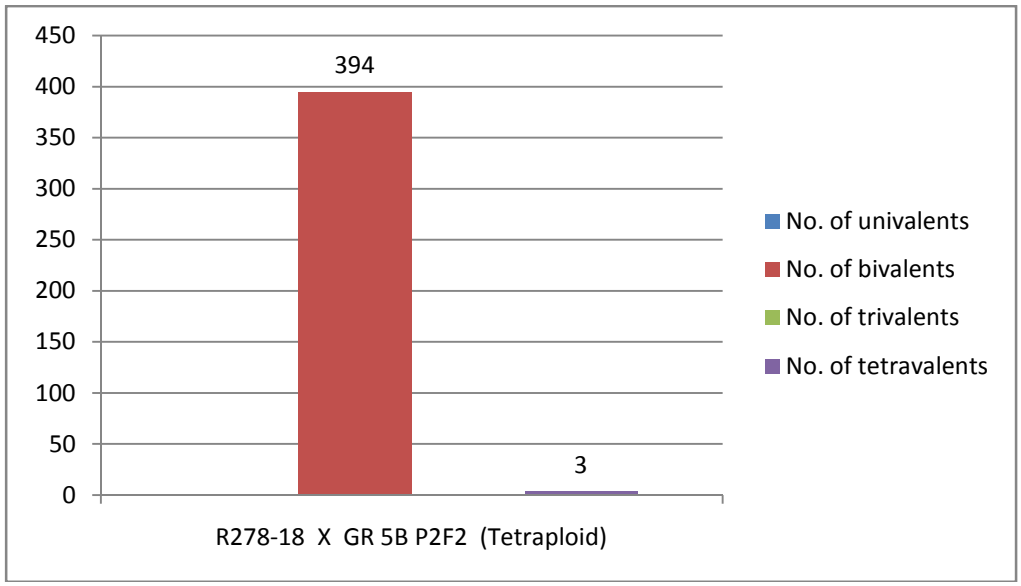


Table 15a

Final results & findings of pollen mother cells of R278-18 X GR 5B P2F2 (Tetraploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 20 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
95	0	20 (19 to 20)	0	0-1 in very few

Table 15b

Final results & findings of pollen mother cells of R278-18 X GR 5B P2F2 (Tetraploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	to 11 in all

16.GR 40A F3 (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of GR 40A F3 (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 75% of the PMC's had 10 bivalents(Table 16,16a) during Metaphas(Fig c). The number of bivalents were 10 per PMC and ranged from 6-10 in each PMC. The number of tetravalents ranged from 0-2.There were no univalents & trivalents.(Bar chart 16)

Anaphase(Fig d) showed normal disjunction of chromosomes in 100% of the PMC's. Unequal distribution of chromosomes was not observed(Table 16,16b) .So, there were no laggards formed.(Bar chart 16)

All the PMC's formed tetrads(Fig e). Micronuclei were seen in 25% of the PMC's and ranged from 0-4.(Bar chart 16)

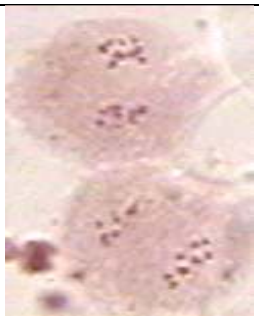
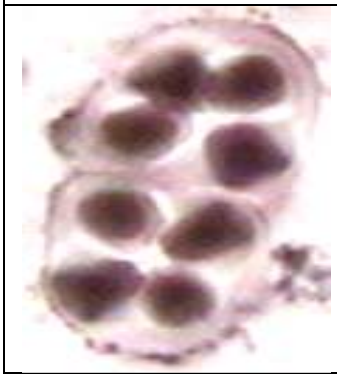
The pollen fertility of this plant was found to be 60%.The size of the big pollen was 12-14µm and the size of the small pollen was 10-12µm.

T able no 16

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	10	-	-	10	10	-	9	-	-
2.	-	10	-	-	10	10	-	29	2	-
3.	-	10	-	-	9	11	-	32	-	-
4.	-	10	-	-	10	10	-	38	-	-
5.	-	10	-	-	10	10	-	46	-	-
6.	-	10	-	-	10	10	-	41	-	-
7.	-	8	-	1	10	10	-	17	-	-
8.	-	6	-	2	10	10	-	19	-	-
9.	-	10	-	-	11	9	-	29	2	-
10.	-	10	-	-	10	10	-	21	-	-
11.	-	10	-	-	10	10	-	16	-	-
12.	-	10	-	-	10	10	-	18	-	-
13.	-	10	-	-	10	10	-	29	3	-
14.	-	8	-	1	10	10	-	36	4	-
15.	-	10	-	-	10	10	-	31	-	-
16.	-	10	-	-	10	10	-	22	2	-

17.	-	10	-	-	10	10	-	24	2	-
18.	-	8	-	1	10	10	-	15	-	-
19.	-	10	-	-	10	10	-	9	-	-
20.	-	10	-	-	10	10	-	11	-	-
SUM	-	190	-	5	200	200	-	492	15	-

Microscopic visuals of Pollen Mother Cells of GR 40A F3 (Diploid) Plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Anther wall broken due to mechanical rupture	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	
			

Bar chart no 16

The chromosomal formation configuration of pollen mother cells of GR 40A F3 (Diploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

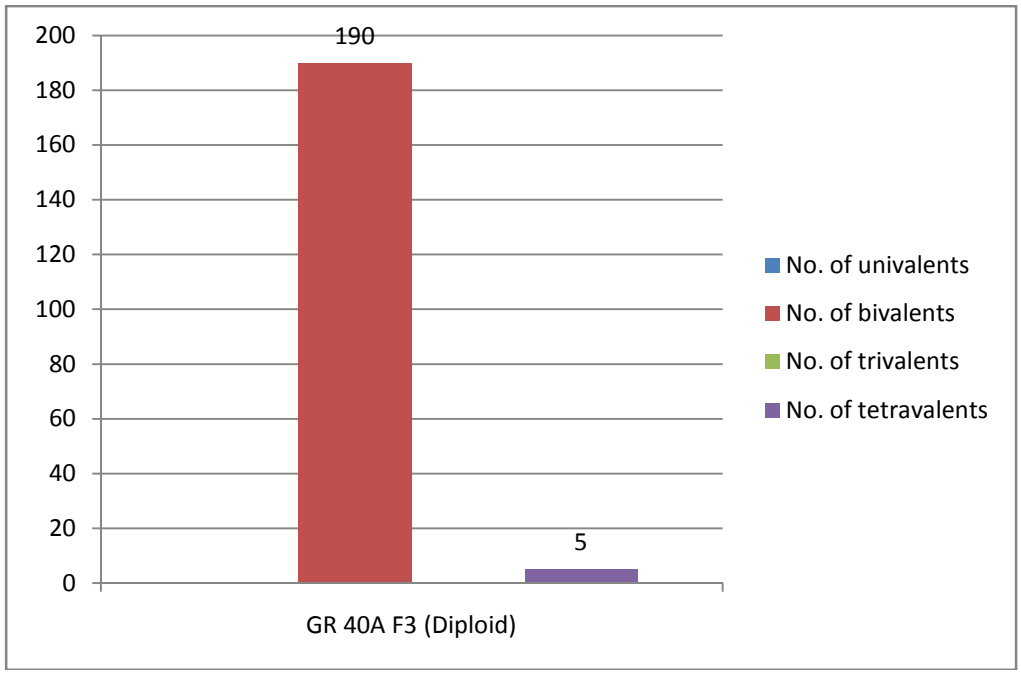


Table 16a

Final results & findings of pollen mother cells of GR 40A F3 (Diploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
75	0	10 (6 to 10 in each)	0	0-2

Table 16b

Final results & findings of pollen mother cells of GR 40A F3 (Diploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	25% (0 to 4)

17.R 240-1 F1 Cut (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of R 240-1 F1 Cut (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 85% of the PMC's had 10 bivalents(Table 17,17a) during Metaphase(Fig c). The number of bivalents were 10 per PMC and ranged from 9-10 in each PMC. The number of tetravalents ranged from 0-1.There were no univalents & trivalents.(Bar chart 17)

Anaphase(Fig d) showed normal disjunction of chromosomes in 100% of the PMC's. Unequal distribution of chromosomes was not observed (Table 17,17b).So, there were no laggards formed(Bar chart 17).

All the PMC's formed tetrads(Fig e). Micronuclei were not seen in any PMC.(Bar chart 17)

The pollen fertility of this plant was found to be 96%.The size of the big pollen was 12-14µm and the size of the small pollen was 9-11µm.

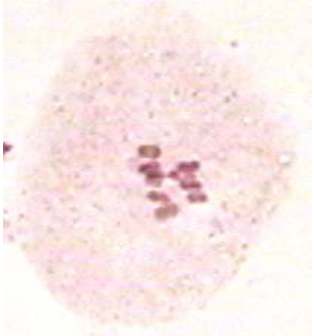
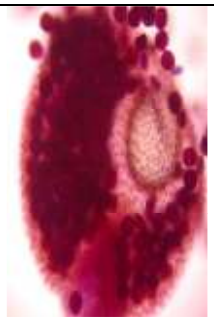
Meiosis in Plant R 240-1 F1 Cut (Diploid)

T able no 17

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	10	-	-	10	10	-	42	-	-
2.	-	10	-	-	10	10	-	31	-	-
3.	-	10	-	-	10	10	-	26	-	-
4.	-	10	-	-	10	10	-	19	-	-
5.	-	10	-	-	10	10	-	12	-	-
6.	-	10	-	-	9	11	-	8	-	-
7.	-	10	-	-	10	10	-	18	-	-
8.	-	10	-	-	10	10	-	22	-	-
9.	-	10	-	-	11	9	-	28	-	-
10.	-	8	-	1	10	10	-	34	-	-
11.	-	8	-	1	10	10	-	28	-	-
12.	-	10	-	-	10	10	-	16	-	-
13.	-	10	-	-	10	10	-	19	-	-

14.	-	10	-	-	10	10	-	46	-	-
15.	-	10	-	-	10	10	-	51	-	-
16.	-	10	-	-	10	10	-	24	-	-
17.	-	10	-	-	10	10	-	32	-	-
18.	-	8	-	1	11	9	-	11	-	-
19.	-	10	-	-	10	10	-	26	-	-
20.	-	10	-	-	10	10	-	33	-	-
SUM	-	197	-	3	199	201	-	526	-	-

Microscopic visuals of pollen mother cells of R 240-1 F1 Cut (Diploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Non dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	
			

Bar chart no 17

The chromosomal formation configuration of pollen mother cells of R 240-1 F1 Cut (Diploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

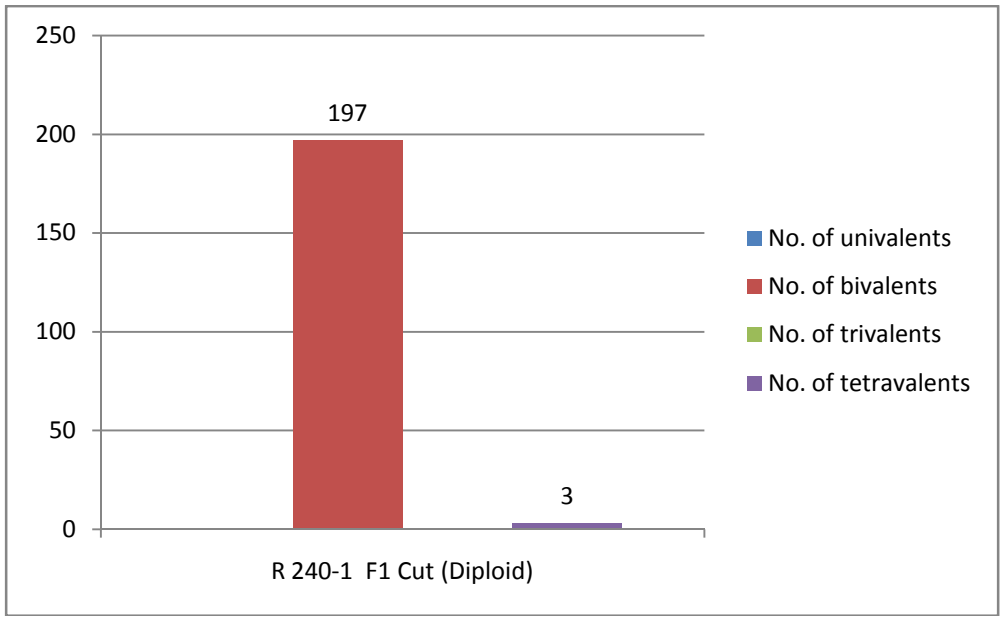


Table 17a

Final results & findings of pollen mother cells of R 240-1 F1 Cut (Diploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
85	0	10 (9 to 10 in each)	0	0-1

Table 17b

Final results & findings of pollen mother cells of R 240-1 F1 Cut (Diploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	Not seen

18.R 240-6 F2 (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of R 240-6 F2 (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 95% of the PMC's had 10 bivalents(Table 18,18a) during Metaphase(Fig c). The number of bivalents were 10 per PMC and ranged from 9-10 in each PMC. The number of univalents ranged from 0-2.There were no trivalents & tetravalents.(Bar chart no 18) Anaphase(Fig d) showed normal disjunction of chromosomes in 100% of the PMC's. Unequal distribution of chromosomes was not observed (Table no 18,18b).So, there were no laggards formed.(Bar chart 18) All the PMC's formed tetrads.(Fig e) Micronuclei were seen in 5% of the PMC's and ranged from 0-1.(Bar chart 18)

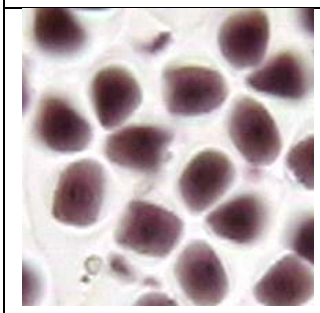
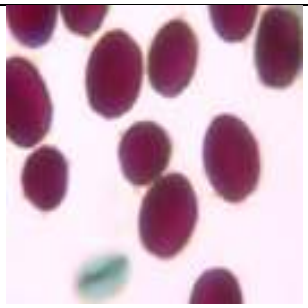
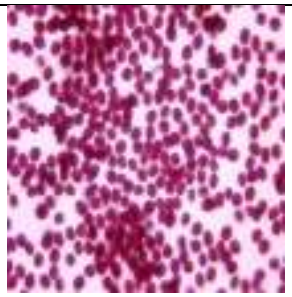
The pollen fertility of this plant was found to be 74%.The size of the big pollen was 12-14µm and the size of the small pollen was 9-11µm.

Table no 18

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	10	-	-	10	10	-	43	-	-
2.	-	10	-	-	10	10	-	48	-	-
3.	-	10	-	-	10	10	-	56	1	-
4.	-	10	-	-	10	10	-	22	-	-
5.	-	10	-	-	10	10	-	11	-	-
6.	-	10	-	-	10	10	-	19	-	-
7.	-	10	-	-	10	10	-	31	-	-
8.	-	10	-	-	10	10	-	16	-	-
9.	-	10	-	-	10	10	-	6	-	-
10.	2	9	-	-	10	10	-	8	-	-
11.	-	10	-	-	10	10	-	32	1	-
12.	-	10	-	-	10	10	-	27	-	-
13.	-	10	-	-	10	10	-	28	-	-
14.	-	10	-	-	10	10	-	63	-	-
15.	-	10	-	-	10	10	-	14	-	-
16.	-	10	-	-	10	10	-	29	-	-

17.	2	9	-	-	10	10	-	31	-	-
18.	-	10	-	-	10	10	-	19	-	-
19.	-	10	-	-	10	10	-	24	-	-
20.	-	10	-	-	10	10	-	31	-	-
SUM	4	198	-	-	200	200	-	558	2	-

Microscopic visuals of pollen mother cells of R 240-6 F2 (Diploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Pollen Fertility (Pink = Fertile & Green = Sterile)	g) Pollen spreading due to mechanical ruptureof anther wall	
			

Bar chart no 18

The chromosomal formation configuration of pollen mother cells of R 240-6 F2 (Diploid) plant during metaphases of meiotic analysis are also represented in the form of bar chart and is furnished below:

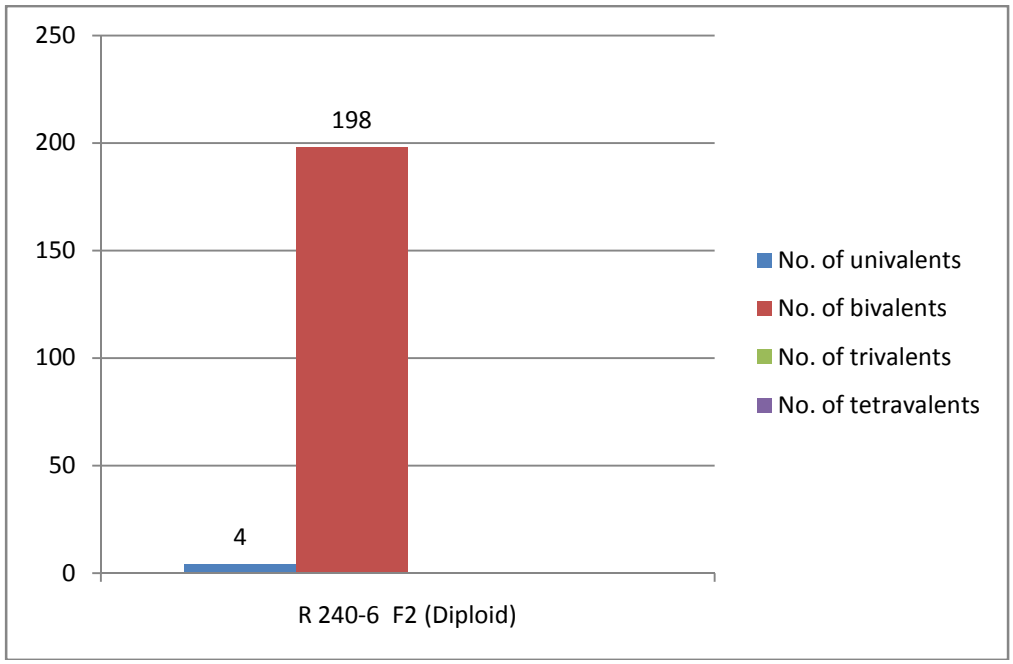


Table 18a

Final results & findings of pollen mother cells of R 240-6 F2 (Diploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
95	0 to 2	10 (9 to 10 in each)	0	0

Table 18b

Final results & findings of pollen mother cells of R 240-6 F2 (Diploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	5% (0 to 1)

19. R 414 F1P1 (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of R 414 F1P1 (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 95% of the PMC's had 10 bivalents(Table 19,19a) during Metaphase(Fig c). The number of bivalents were 10 per PMC and ranged from 9-10 in each PMC. The number of univalents ranged from 0-2.There were no trivalents & tetravalents.(Bar chart 19)

Anaphase (Fig d)showed normal disjunction of chromosomes in 95% of the PMC's. Unequal distribution of chromosomes was observed in 5% of the PMC's.(Table no19,19b) Laggards formation was not observed.(Bar chart 19)

All the PMC's formed tetrads(Fig e). Micronuclei were not seen in any PMC.(Bar chart 19)

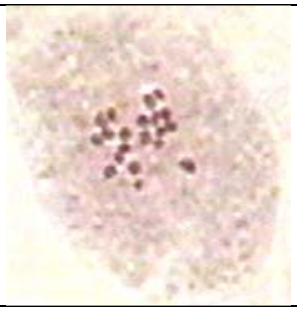
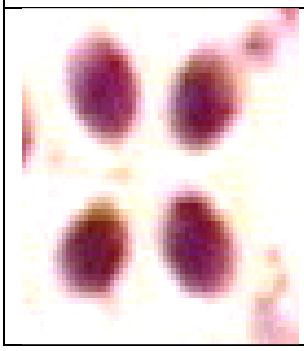
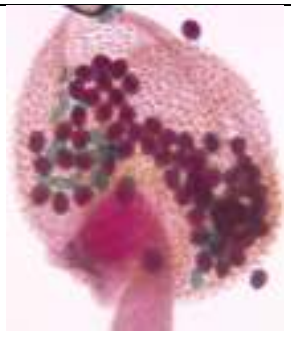
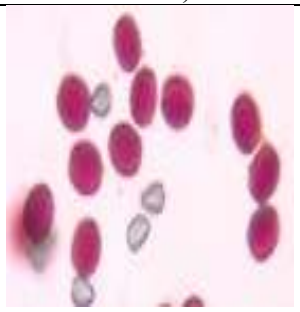
The pollen fertility of this plant was found to be 71%.The size of the big pollen was 12-14µm and the size of the small pollen was 9-11µm.

Table no 19

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	10	-	-	10	10	-	58	-	-
2.	-	10	-	-	10	10	-	62	-	-
3.	-	10	-	-	10	10	-	17	-	-
4.	-	10	-	-	10	10	-	21	-	-
5.	-	10	-	-	10	10	-	18	-	-
6.	2	9	-	-	9	11	-	36	-	-
7.	-	10	-	-	10	10	-	42	-	-
8.	-	10	-	-	10	10	-	27	-	-
9.	-	10	-	-	10	10	-	19	-	-
10.	-	10	-	-	10	10	-	18	-	-
11.	-	10	-	-	10	10	-	25	-	-
12.	-	10	-	-	10	10	-	34	-	-

13.	-	10	-	-	9	9	2	11	-	-
14.	-	10	-	-	10	10	-	16	-	-
15.	-	10	-	-	10	10	-	28	-	-
16.	-	10	-	-	10	10	-	34	-	-
17.	2	9	-	-	10	10	-	43	-	-
18.	-	10	-	-	10	10	-	28	-	-
19.	-	10	-	-	10	10	-	15	-	-
20.	-	10	-	-	10	10	-	9	-	-
SUM	4	198	-	-	198	200	2	561	-	-

Microscopic visuals of pollen mother cells of R 414 F1P1 (Diploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Non dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	
			

Bar chart no 19

The chromosomal formation configuration of Pollen Mother Cells of R 414 F1P1 (Diploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

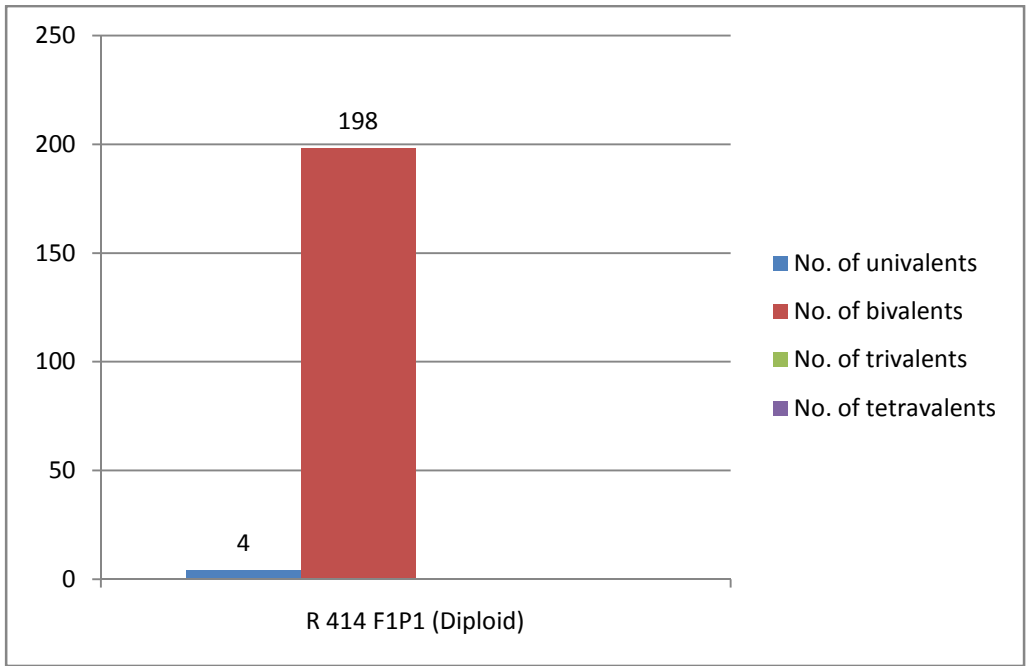


Table 19a

Final results & findings of pollen mother cells of R 414 F1P1 (Diploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
95	0 to 2	10 (9 to 10)	0	0

Table 19b

Final results & findings of pollen mother cells of R 414 F1P1 (Diploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
95	5	Not formed	100	Not seen

20.R 239-1 F1P1 (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of R 239-1 F1P1 (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 97% of the PMC's had 10 bivalents(Table 20,20a) during Metaphase(Fig c). The number of bivalents were 10 per PMC and ranged from 9-10 in each PMC. The number of univalents ranged from 0-2.There were no trivalents & tetravalents.(Bar chart no 20)

Anaphase(Fig d) showed normal disjunction of chromosomes in 95% of the PMC's. Unequal distribution of chromosomes was observed in 5% of the PMC'(Table 20,20b). Laggards formation was not observed.(Bar chart 20)

All the PMC's formed tetrads(Fig e). Micronuclei were not seen in any PMC.(Bar chart no 20)

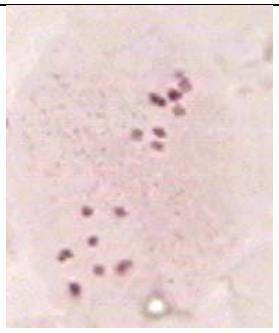
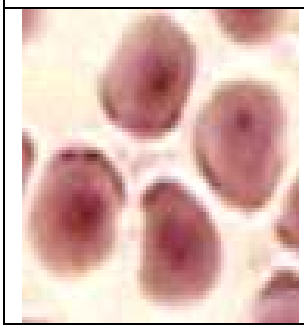
The pollen fertility of this plant was found to be 84%.The size of the big pollen was 11-13µm and the size of the small pollen was 8-10µm.

Table no 20

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	10	-	-	10	10	-	11	-	-
2.	-	10	-	-	10	10	-	29	-	-
3.	-	10	-	-	10	10	-	17	-	-
4.	-	10	-	-	10	10	-	72	-	-
5.	-	10	-	-	10	10	-	8	-	-
6.	-	10	-	-	10	10	-	66	-	-
7.	-	10	-	-	9	11	-	32	-	-
8.	2	9	-	-	10	10	-	16	-	-
9.	-	10	-	-	10	10	-	54	-	-
10.	-	10	-	-	10	10	-	29	-	-
11.	-	10	-	-	10	10	-	15	-	-
12.	-	10	-	-	10	10	-	8	-	-

13.	-	10	-	-	10	10	-	49	-	-
14.	-	10	-	-	10	10	-	27	-	-
15.	-	10	-	-	10	10	-	18	-	-
16.	-	10	-	-	10	10	-	14	-	-
17.	-	10	-	-	11	9	-	38	-	-
18.	-	10	-	-	10	10	-	17	-	-
19.	-	10	-	-	10	10	-	9	-	-
20.	-	10	-	-	10	10	-	19	-	-
SUM	2	199	-	-	200	200	-	548	-	-

Microscopic visuals of Pollen Mother Cells of R 239-1 F1P1 (Diploid) Plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Non dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	
			

Bar chart no 20

The chromosomal formation configuration of Pollen Mother Cells of R 239-1 F1P1 (Diploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

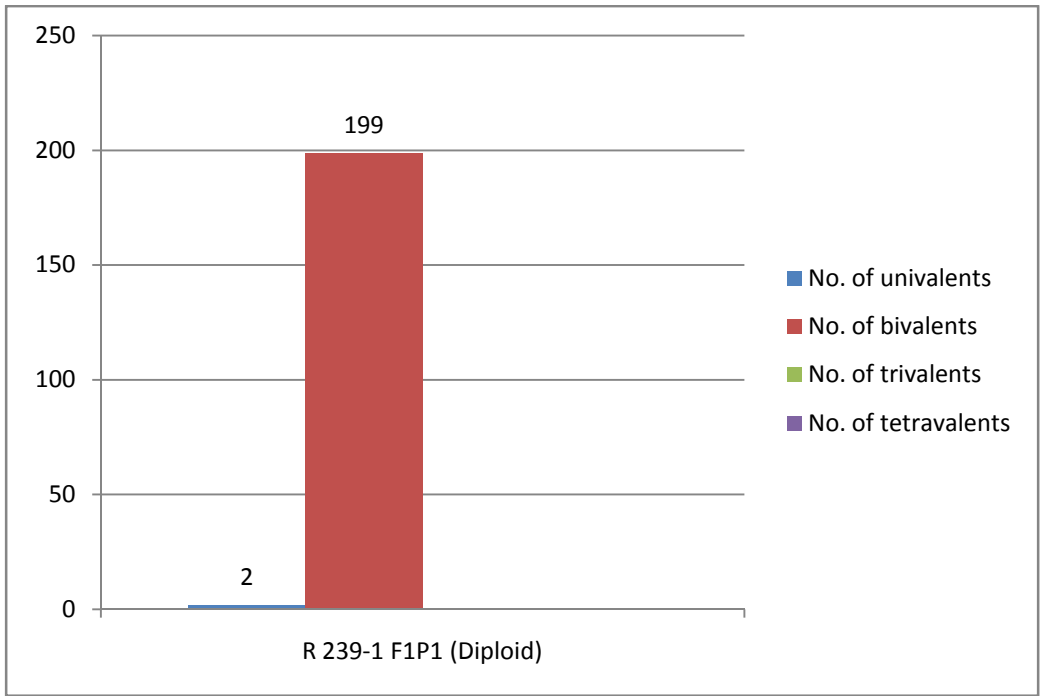


Table 20a

Final results & findings of pollen mother cells of R 239-1 F1P1 (Diploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
97	0 to 2	10 (9 to 10)	0	0

Table 20b

Final results & findings of pollen mother cells of R 239-1 F1P1 (Diploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
95	5	Not formed	100	Not seen

21.R 239-4 F1 Cut (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of R 239-4 F1 Cut (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 5% of the PMC's had 10 bivalents(Table 21,21a) during Metaphase(Fig c). The number of bivalents were 10 per PMC and ranged from 6-10 in each PMC. The number of tetravalents ranged from 0-2.There were no univalents & trivalents.(Bar chart 21)

Anaphase(Fig d) showed normal disjunction of chromosomes in 100% of the PMC's. Unequal distribution of chromosomes was not observed (Table no 21,21b).So, there were no laggards formed..(Bar chart 21)

All the PMC's formed tetrads(Fig e). Micronuclei were not seen in any PMC. (Bar chart 21)

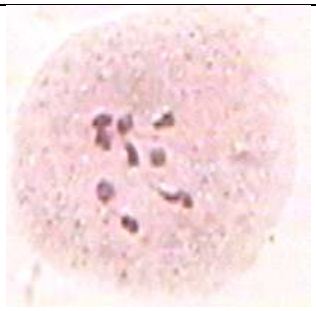
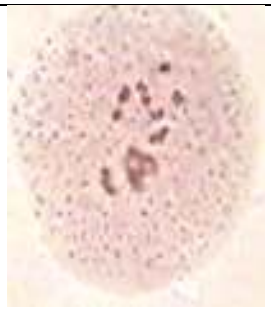
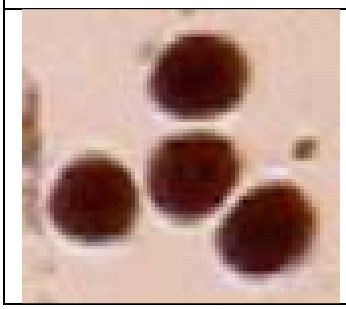
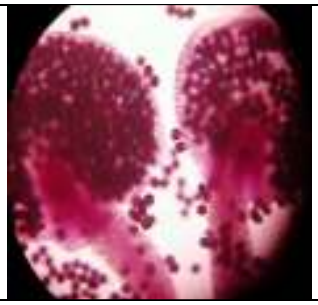
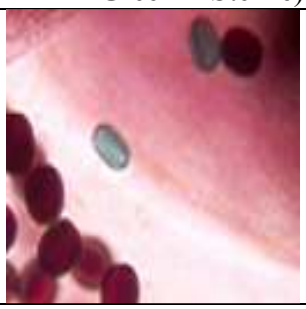
The pollen fertility of this plant was found to be 92%.The size of the big pollen was 12-14µm and the size of the small pollen was 9-11µm.

Table no 21

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	-	6	-	2	10	10	-	18	-	-
2.	-	8	-	1	10	10	-	27	-	-
3.	-	8	-	1	10	10	-	48	-	-
4.	-	6	-	2	10	10	-	69	-	-
5.	-	6	-	2	10	10	-	6	-	-
6.	-	8	-	1	10	10	-	19	-	-
7.	-	6	-	2	10	10	-	22	-	-
8.	-	6	-	2	10	10	-	72	-	-
9.	-	6	-	2	10	10	-	84	-	-
10.	-	8	-	1	10	10	-	26	-	-
11.	-	8	-	1	10	10	-	44	-	-
12.	-	6	-	2	10	10	-	37	-	-
13.	-	6	-	2	10	10	-	19	-	-
14.	-	6	-	2	10	10	-	26	-	-
15.	-	8	-	1	10	10	-	27	-	-

16.	-	6	-	2	10	10	-	32	-	-
17.	-	8	-	1	10	10	-	39	-	-
18.	-	10	-	-	10	10	-	106	-	-
19.	-	8	-	1	10	10	-	11	-	-
20.	-	10	-	-	10	10	-	34	-	-
SUM	-	144	-	28	200	200	-	766	-	-

Microscopic visuals of Pollen Mother Cells of R 239-4 F1 Cut (Diploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Non dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	
			

Bar chart 21

The chromosomal formation configuration of pollen mother cells of R 239-4 F1 Cut (Diploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

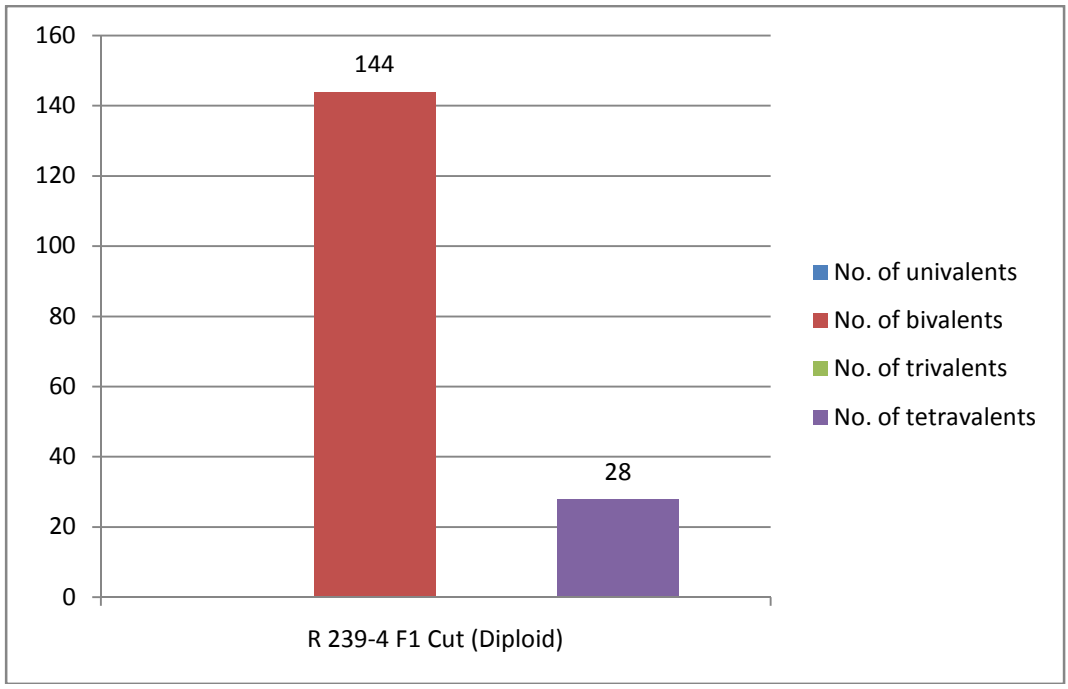


Table 21a

Final Results & Findings of Pollen Mother Cells of R 239-4 F1 Cut (Diploid) Plant during Metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
5	0	10 (6 to 10)	0	0-2

Table 21b

Final Results & Findings of Pollen Mother Cells of R 239-4 F1 Cut (Diploid) Plant during Anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	Not seen

22.R 257-1 F1 (Diploid):

Meiotic analysis on 20 Pollen Mother Cells of R 257-1 F1 (Diploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 97% of the PMC's had 10 bivalents(Table 22,22a) during Metaphase(Fig c). The number of bivalents were 10 per PMC and ranged from 9-10 in each PMC. The number of univalents ranged from 0-2.There were no trivalents & tetravalents.(Bar chart 22)

Anaphase(Fig d) showed normal disjunction of chromosomes in 100% of the PMC's. Unequal distribution of chromosomes was not observed .(Table 22,22b)So, there were no laggards formed. (Bar chart 22)

All the PMC's formed tetrads(Fig e). Micronuclei were not seen in any PMC.(Bar chart 22)

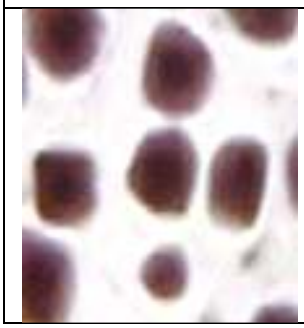
The pollen fertility of this plant was found to be 97%.The size of the big pollen was 14-16µm and the size of the small pollen was 11-13µm.

Table no 22

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	2	9	-	-	10	10	-	37	-	-
2.	-	10	-	-	10	10	-	22	-	-
3.	-	10	-	-	10	10	-	18	-	-
4.	-	10	-	-	10	10	-	48	-	-
5.	-	10	-	-	10	10	-	59	-	-
6.	2	9	-	-	10	10	-	16	-	-
7.	-	10	-	-	10	10	-	12	-	-
8.	-	10	-	-	10	10	-	14	-	-
9.	2	9	-	-	10	10	-	98	-	-
10.	2	9	-	-	10	10	-	44	-	-
11.	-	10	-	-	10	10	-	66	-	-
12.	-	10	-	-	10	10	-	27	-	-
13.	-	10	-	-	10	10	-	29	-	-
14.	-	10	-	-	10	10	-	36	-	-
15.	-	10	-	-	10	10	-	11	-	-
16.	2	9	-	-	10	10	-	9	-	-

17.	-	10	-	-	10	10	-	6	-	-
18.	2	9	-	-	10	10	-	22	-	-
19.	-	10	-	-	10	10	-	21	-	-
20.	2	9	-	-	10	10	-	16	-	-
SUM	14	193	-	-	200	200	-	611	-	-

Microscopic visuals of Pollen Mother Cells of R 257-1 F1 (Diploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Non dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	
			

Bar chart no 22

The chromosomal formation configuration of Pollen Mother Cells of R 257-1 F1 (Diploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

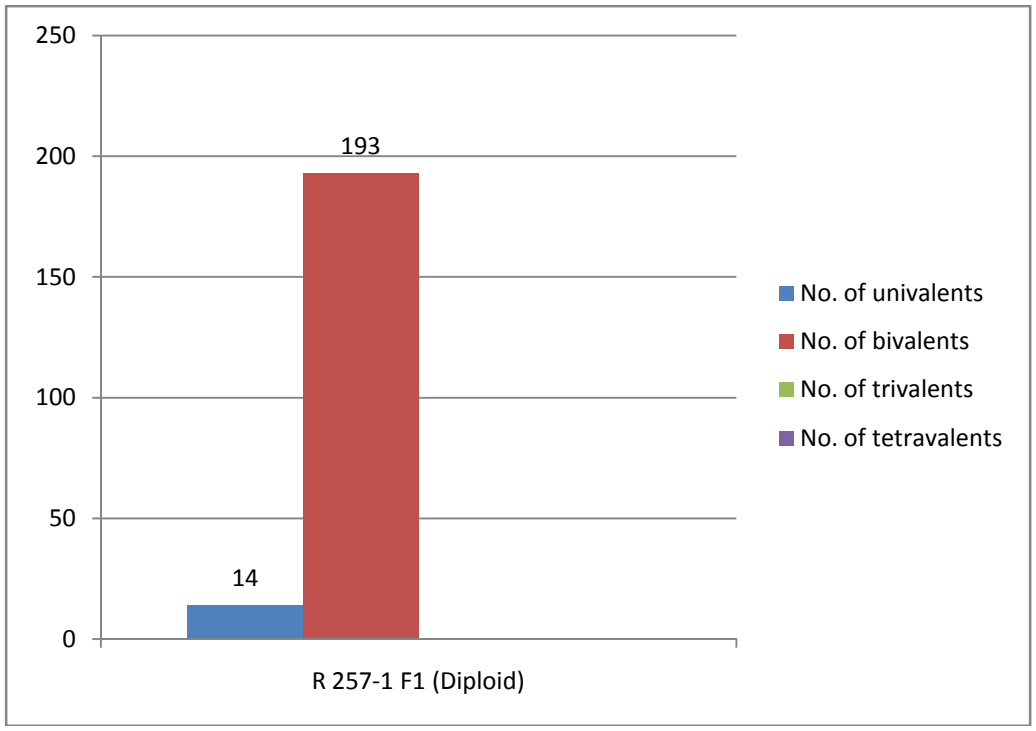


Table 22a

Final results & findings of pollen mother cells of R 257-1 F1 (Diploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
97	0 to 2	10 (9 to 10)	0	0

Table 22b

Final results & findings of pollen mother cells of R 257-1 F1 (Diploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	Not observed	Not formed	100	Not seen

23.GR 90B F4 (Tetraploid):

Meiotic analysis on 20 Pollen Mother Cells of GR 90B F4 (Tetraploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 100% of the PMC's had shown univalents, bivalents, trivalents and tetravalents formation.(Table 23,23a) during Metaphase(Fig c). The number of bivalents were 20 per PMC and ranged from 13-19 in each PMC. The number of univalents ranged from 2-12.The number of trivalents ranged from 0-1 & the number of tetravalents ranged from 0-2. (Bar chart 23)

Anaphase(Fig d) showed abnormal disjunction of chromosomes in 100% of the PMC's. Unequal distribution of chromosomes was observed .(Table 23,23b)So, laggards formation was observed and ranged between 1-6. (Bar chart 23)

All the PMC's formed tetrads(Fig e). Micronuclei were seen in some of the PMC's and ranged between 0-3. (Bar chart 23)

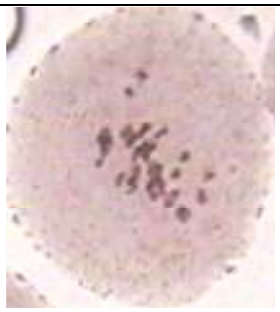
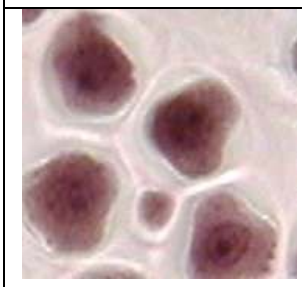
The pollen fertility of this plant was found to be 85%.The size of the big pollen was 14-16µm and the size of the small pollen was 11-13µm.

Table no 23

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	12	14	-	-	19	19	2	36	2	-
2.	2	19	-	-	16	18	6	32	1	-
3.	6	17	-	-	18	19	3	48	3	-
4.	11	13	1	-	20	18	2	59	2	-
5.	4	16	-	1	19	20	1	62	2	-
6.	6	17	-	-	19	19	2	36	1	-
7.	8	16	-	-	18	16	6	24	1	-
8.	2	19	-	-	18	18	4	21	1	-
9.	2	17	-	1	20	19	1	19	-	-
10.	7	15	1	-	19	20	1	21	-	-
11.	-	16	-	2	20	17	3	18	-	-
12.	8	16	-	-	18	20	2	17	-	-
13.	2	19	-	-	18	18	4	16	-	-

14.	2	17	-	1	17	18	5	32	2	-
15.	7	15	1	-	17	17	6	34	2	-
16.	3	17	1	-	18	20	2	48	3	-
17.	12	14	-	-	20	18	2	22	2	-
18.	8	16	-	-	19	20	1	11	1	-
19.	4	14	-	2	19	20	1	9	-	-
20.	2	17	-	1	17	20	3	14	-	-
SUM	108	324	4	8	367	374	57	579	23	

Microscopic visuals of Pollen Mother Cells of GR 90B F4 (Tetraploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Pollen Fertility (Pink = Fertile & Green = Sterile)		
			

Bar chart 23

The chromosomal formation configuration of Pollen Mother Cells of GR 90B F4 (Tetraploid) plant during metaphase of meiotic analysis is also represented in the form of bar chart and is furnished below:

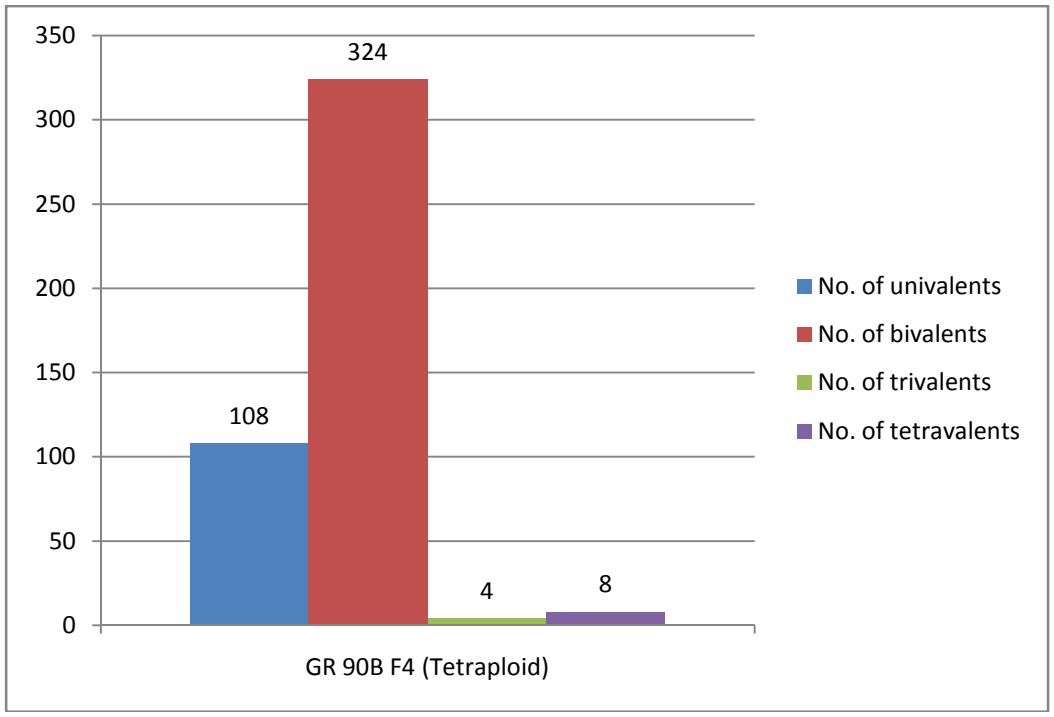


Table 23a

Final results & findings of pollen mother cells of GR 90B F4 (tetraploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
100	2 to 12	20 (13 to 19)	0 to 1	0 to 2

Table 23b

Final results & findings of pollen mother cells of GR 90B F4 (tetraploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
Not found	Observed	Formed (1 to 6)	100	(0 to 3)

24.GR 47 A F3 (Tetraploid):

Meiotic analysis on 20 Pollen Mother Cells of GR 47 A F3 (Tetraploid) plant was carried out as per the above stipulated procedure and the observations were recorded in the following table. Meiotic analysis [Fig. (a)-(g)] of the PMC's (Pollen Mother Cells) showed that 100% of the PMC's had shown univalents, bivalents, trivalents and tetravalents formation. (Table 24,24a) during Metaphase(Fig c). The number of bivalents were 20 per PMC and ranged from 17-19 in each PMC. The number of univalents ranged from 1-6.The number of trivalents ranged from 0-3 . There were no tetravalents observed. (Bar chart 24)

Anaphase(Fig d) showed abnormal disjunction of chromosomes in 100% of the PMC's. Unequal distribution of chromosomes was observed(Table 24,24b) .So, laggards formation was observed and ranged between 1-6. (Bar chart 24)

All the PMC's formed tetrads(Fig e). Micronuclei were seen in some of the PMC's and ranged between 0-3. (Bar chart 24)

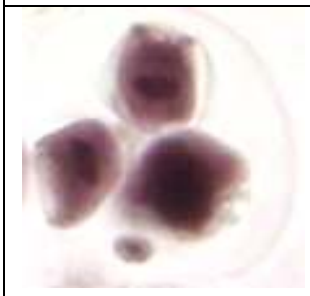
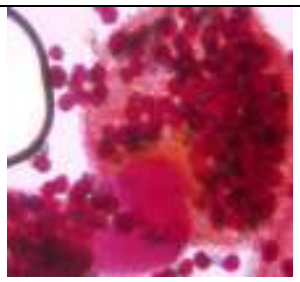
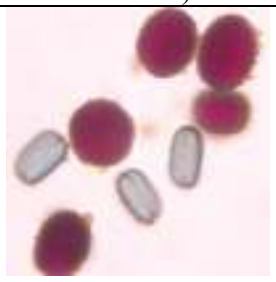
The pollen fertility of this plant was found to be 50%.The size of the big pollen was 14-16µm and the size of the small pollen was 11-13µm.

Table no 24

METAPHASE Chromosomal Configuration					ANAPHASE Chromosomal Configuration			TETRAD Analysis		
S. No.	Univalents	Bivalents	Trivalents	Tetravalents	Pole I	Pole II	Laggards	0	Micronuclei (+)1	Micronuclei (+)2
1.	1	18	1	-	19	17	4	32	2	-
2.	2	19	-	-	18	18	4	26	1	-
3.	3	17	1	-	17	19	4	27	1	-
4.	4	18	-	-	18	19	3	33	2	-
5.	2	19	-	-	19	19	2	21	1	-
6.	1	18	1	-	19	19	2	11	-	-
7.	2	19	-	-	18	17	5	17	-	-
8.	2	19	-	-	18	18	4	29	-	-
9.	4	18	-	-	18	18	4	15	-	-
10.	3	17	1	-	17	17	6	14	-	-
11.	5	16	3	-	19	18	3	22	2	-
12.	4	18	-	-	17	18	5	17	-	-
13.	2	19	-	-	17	19	4	16	-	-

14.	2	19	-	-	18	17	5	12	-	-
15.	1	18	-	-	19	19	2	14	-	-
16.	3	17	1	-	18	19	3	35	3	-
17.	2	19	-	-	18	20	2	34	-	-
18.	6	17	-	-	20	18	2	11	-	-
19.	1	18	-	-	18	20	2	18	-	-
20.	2	19	-	-	20	19	1	16	-	-
SUM	52	362	8	-	365	368	67	420	12	-

Microscopic visuals of Pollen Mother Cells of GR 47 A F3 (Tetraploid) plant during various phases of meiotic analysis are reproduced below:

a) Plant	b) Flower	c) Metaphase	d) Anaphase
			
e) Tetrads	f) Non dehiscent anther	g) Pollen Fertility (Pink = Fertile & Green = Sterile)	
			

Bar chart no 24

The chromosomal formation configuration of pollen mother cells of gr 47 a f3 (tetraploid) plant during metaphase of meiotic analysis are also represented in the form of bar chart and is furnished below:

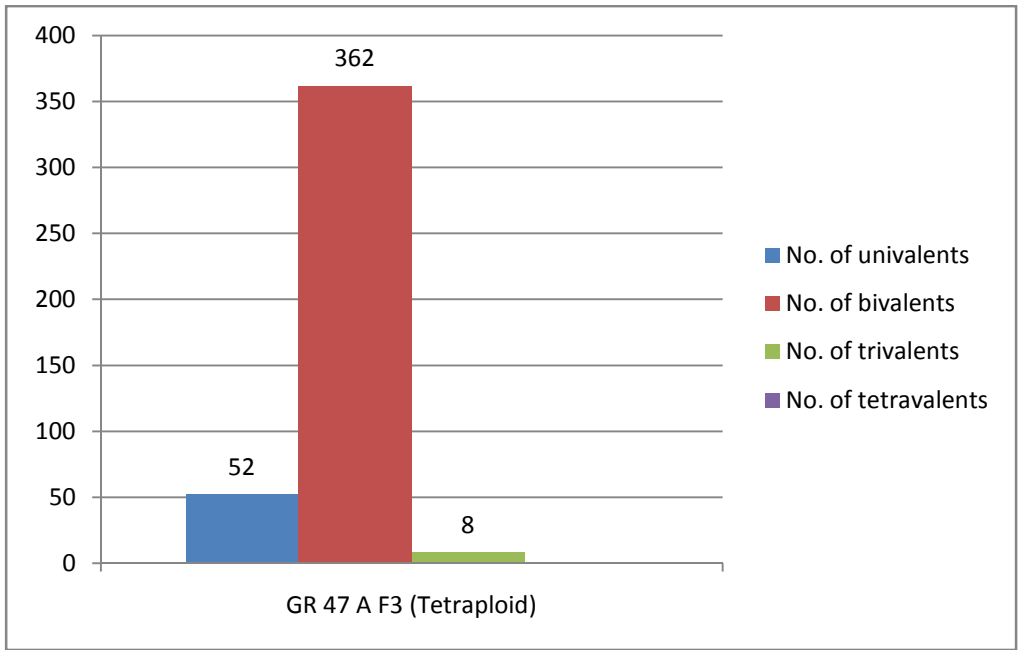


Table 24a

Final results & findings of pollen mother cells of GR 47 A F3 (tetraploid) plant during metaphase of meiotic analysis is tabled below:

% age of PMCs having 10 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
100	1 to 6	20 (17 to 19)	0 to 3	0

Table 24b

Final results & findings of pollen mother cells of GR 47 A F3 (tetraploid) plant during anaphase of meiotic analysis is tabled below:

% age of Normal disjunction of chromosomes	% age of Unequal disjunction of chromosomes	% formation of Laggards	Qty. of formation of Tetrads(%)	Presence of Micronucleus
100	observed	Formed (1 to 6)	100	0 to 3

DISCUSSION

G. DISCUSSION

Meiotic analysis was carried out for various diploid and tetraploid plant species to study the chromosomal behavior between the two parents. It not only helps us to know the chromosomal number but also gives information about the chromosomal pairing.

During this study it was found that R384 F1P1 Graft(Diploid), GR 65B F1 Graft (Tetraploid), GR 9A F3P2(Tetraploid), GR9AF3P1(Tetraploid), GR9AF3(Tetraploid), GR154F3(Tetraploid), GR48AF3(Diploid), R 414-4 F1(Diploid),GR 40AF1Graft(Tetraploid), R240-6F2(Diploid),R414 F1P1(Diploid), R 239-1 F1P1(Diploid), R 257-1 F1(Diploid), GR90BF4(Tetraploid), GR47AF3(Tetraploid), showed more number of univalents during the metaphase. More number of univalents is due to less homology between the two parental species.(Refer table no 25)

Bivalents were found in all the species.

GR65BF1Graft(Tetraploid),GR 90BF4(Tetraploid) and GR47A F3(Tetraploid) showed trivalents.(Refer table no 25)

R239-5F1Cut(Diploid),GR65BF1Graft(Tetraploid),R420-7 F1(Diploid),GR 48AF3(Tetraploid),GR204A Graft(Tetraploid),R 278-18 * GR5BP2F2(Tetraploid),GR 40A F3(Diploid),R 240-1F1 Cut(Diploid),R239-4F1Cut(Diploid),GR90BF4(Tetraploid) showed tetravalents during the metaphase.(Refer table no 25)

R420-7F1(Diploid),GR65BF1Graft(Tetraploid),GR 40AGraft1(Tetraploid),GR90BF4(Tetraploid) and GR 47A F3(Tetraploid) had abnormal disjunction of chromosomes during the anaphase and showed laggards formation. R384 F1P1 Graft(Diploid), R239-5F1Cut(Diploid),R 419-1F1(Diploid), R420-7 F1(Diploid), GR 9A F3P2(Tetraploid), GR9AF3P1(Tetraploid), GR9AF3(Tetraploid), GR154F3(Tetraploid), GR48AF3(Diploid), R 414-4 F1(Diploid), GR204A Graft(Tetraploid),R 278-18 * GR5BP2F2(Tetraploid),GR 40A F3(Diploid), R 239-1 F1P1(Diploid), R 257-1 F1(Diploid) and R240-6F2(Diploid) had equal distribution of chromosomes in both pole 1 and pole 2 during anaphase.(Refer to table no 26)

GR65BF1Graft(Tetraploid), R 419-1F1(Diploid), GR9AF3P1(Tetraploid), GR9AF3(Tetraploid), GR154F3(Tetraploid), GR 40AF1Graft(Tetraploid), R 278-18 * GR5BP2F2(Tetraploid), GR 40A F3(Diploid), R 240-6F2(Diploid), GR90BF4(Tetraploid), and GR47AF3(Tetraploid) showed micronuclei during tetrad formation.

G. DISCUSSIONS & CONCLUSIONS:

Comparative Statement of Final Results & Findings of Pollen Mother Cells of the following 24 diploid and tetraploid species of groundnuts Plants during Metaphase of Meiotic analysis are tabled below:

Table no 25

S. No.	Name & Type of Plant Species	Ploidy	% age of PMCs having 10 Bivalents	% age of PMCs having 20 Bivalents	Qty. of Univalents per PMC	Qty. of Bivalents per PMC	Qty. of Trivalents per PMC	Qty. of Tetravalents per PMC
1	R 420-4 F1	Diploid	40	0	0	10	0	0 to 2
2	R 384 F1P1 Graft	Diploid	10	0	0 - 6	10	0	0
3	R 239-5 F1 Cut	Diploid	40	0	0	10	0	0 to 2
4	GR 65 B F1 Graft	Tetraploid	20	0	0	14 to 17 in all	0 to 1 in very few	0 to 2
5	R 419-1 F1 Hybrid	Diploid	100	0	0	10	0	0
6	R 420-7 F1	Diploid	100	0	0	10	0	2
7	GR 9A F3 P2	Tetraploid	0	85	0 to 4 in very few	18 to 20 in all	0	0
8	GR 9A F3 P1	Tetraploid	0	90	0 to 4 in very few	18 to 20 in all	0	0
9	GR 9A F3	Tetraploid	0	95	0 to 2 in very few	19 to 20 in all	0	0
10	GR 154 F3	Tetraploid	0	90	0 to 4 in very few	18 to 20 in all	0	1 in every pmc
11	GR 48 A F3	Diploid	40	0	0 to 2	10	0	0

12	R 414-4 F1	Diploid	40	0	0 to 2	10	0	0
13	GR 40 A Graft-1	Tetraploid	0	95	0 to 4 in very few	18 to 20 in all	0	0
14	GR 204 A Graft	Diploid	65	0	0	8 to10 in 10 pmc	0	0 to 1
15	R 278-18 X GR 5B P2F2	Tetraploid	0	95	0	19 to 20 in all	0	0 to 1 in very few
16	GR 40 A F3	Diploid	75	0	0	6 to 10 in each	0	0 to 2
17	R 240-1 F1 Cut	Diploid	85	0	0	9 to 10 in each	0	0 to 1
18	R 240-6F2	Diploid	95	0	0 to 2	9 to 10 in each	0	0
19	R 414 F1P1	Diploid	95	0	0 to 2	9 to10	0	0
20	R 239-1 F1P1	Diploid	97	0	0 to 2	9 to10 in all	0	0
21	R 239-4 F1 Graft / Cut	Diploid	5	0	0	6 to 10 in all	0	0 to 2
22	R 257-1 F1	Diploid	97	0	0 to 2	9 to10 in all	0	0
23	GR 90 B F4	Tetraploid	100	0	2 to 12	13 to 19 in all	0 to 1	0 to 2
24	GR 47 A F3	Tetraploid	100	0	1 to 6	17 to 10 in all	0 to 3	0

Comparative Statement of Final Results & Findings of Pollen Mother Cells of the following 24 diploid and tetraploid species of the Groundnut Plants during Anaphase of Meiotic analysis are tabled below:
Table no 26

S. No.	Name & Type of Plant Species	Ploidy	% age of Normal / Equal disjunction / distribution of Chromosomes	% age of Abnormal / Unequal disjunction / distribution of Chromosomes	Formation of Laggards	Formation of Tetrads	Presence of Micronucleus
1	R 420-4 F1	Diploid	25	75	18	In all	Not seen
2	R 384 F1P1 Graft	Diploid	100	Not observed	Not formed	In all	Not seen
3	R 239-5 F1 Cut	Diploid	100	Not observed	Not formed	In all	Not seen
4	GR 65 B F1 Graft	Tetraploid	Not found	Observed in all	2 to 8	In all	1 to 3 in 50 %
5	R 419-1 F1 Hybrid	Diploid	100	Not observed	Not formed	In all	1 to 2 in 15%
6	R 420-7 F1	Diploid	100	Not observed	Not formed	In all	to 2 in 15%
7	GR 9A F3 P2	Tetraploid	100	Not observed	Not formed	In all	Not seen
8	GR 9A F3 P1	Tetraploid	100	Not observed	Not formed	In all	Seen 1 to 8 in all
9	GR 9A F3	Tetraploid	100	Not observed	Not formed	In all	Seen 1 to 4 in all
10	GR 154 F3	Tetraploid	100	Not observed	Not formed	In all	Seen 1 to 4 in 90%
11	GR 48 A F3	Diploid	100	Not observed	Not formed	In all	Not seen

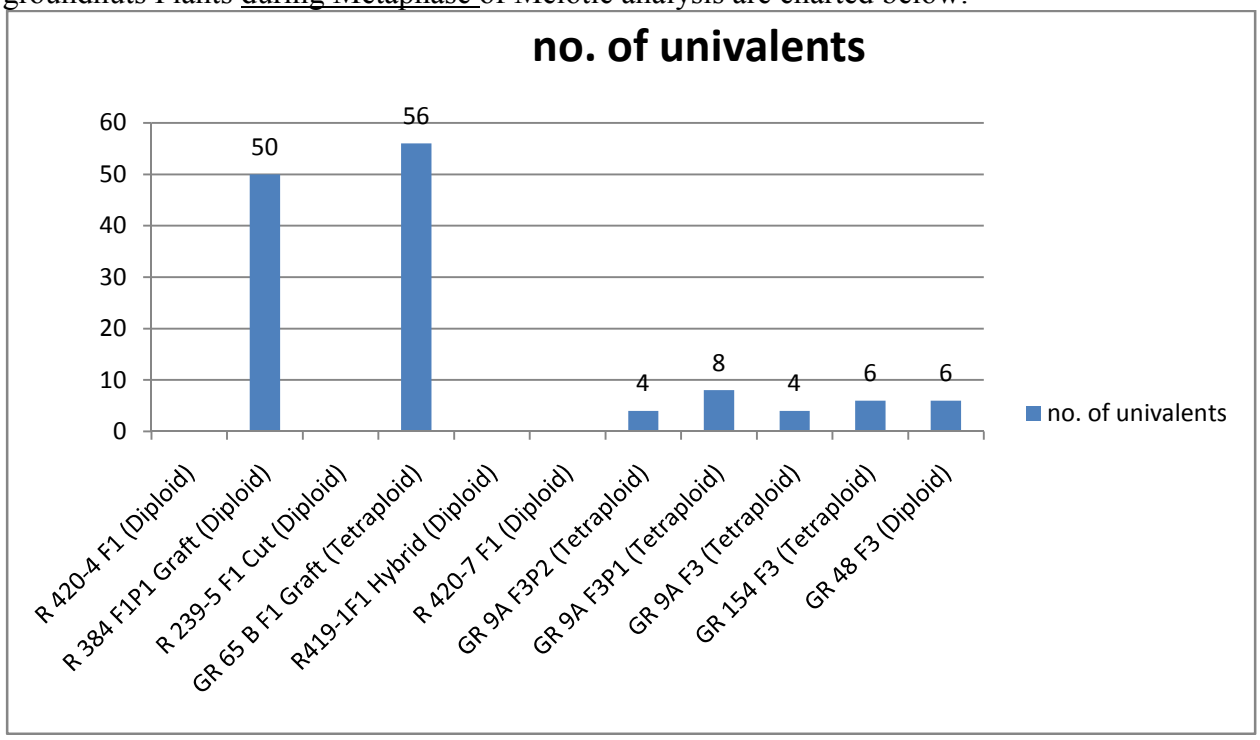
12	R 414-4 F1	Diploid	100	Not observed	Not formed	In all	Not seen
13	GR 40 A Graft-1	Tetraploid	40	40	0 to 2	In all	Seen 1 to 6
14	GR 204 A Graft	Diploid	100	Not observed	Not formed	In all	Not seen
15	R 278-18 X GR 5B P2F2	Tetraploid	100	Not observed	Not formed	In all	1 to 11 in all
16	GR 40 A F3	Diploid	100	Not observed	Not formed	In all	Seen 0 to 4 in 25%
17	R 240-1 F1 Cut	Diploid	100	Not observed	Not formed	In all	Not seen
18	R 240-6F2	Diploid	100	Not observed	Not formed	In all	Seen 0 to 1 in 5%
19	R 414 F1P1	Diploid	95	Observed in 5	Not formed	In all	Not seen
20	R 239-1 F1P1	Diploid	95	Observed in 5	Not formed	In all	Not seen
21	R 239-4 F1 Graft / Cut	Diploid	100	Not observed	Not formed	In all	Not seen
22	R 257-1 F1	Diploid	100	Not observed	Not formed	In all	Not seen
23	GR 90 B F4	Tetraploid	Not found	Observed	Formed in 1 to 6	In all	Seen 0 to 3
24	GR 47 A F3	Tetraploid	100	Observed	Formed in1 to 6	In all	Seen 0 to 3

Thus, in all it took me more than 1000 patient and hard struggled man-hours spread across 6 months between June to November 2011, to successfully carryout the above cytological analysis and establish required results

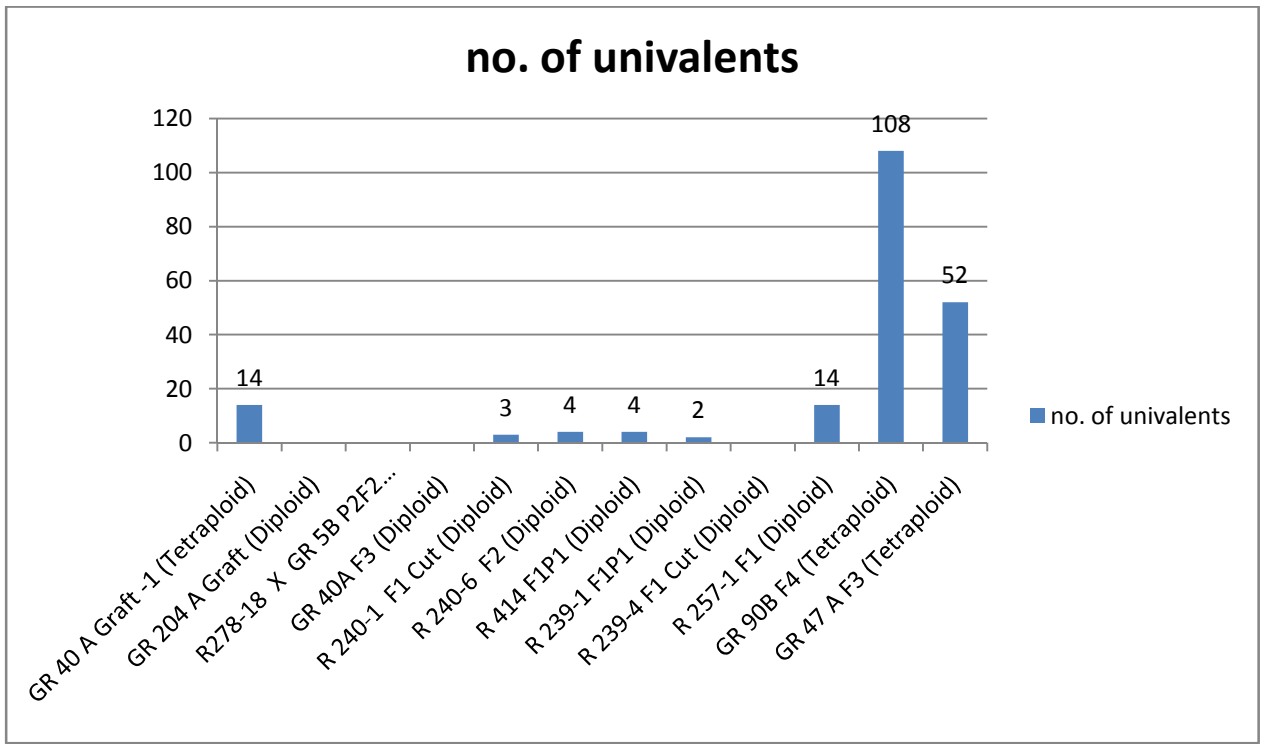
BAR CHARTS

H. LIST OF BAR CHARTS

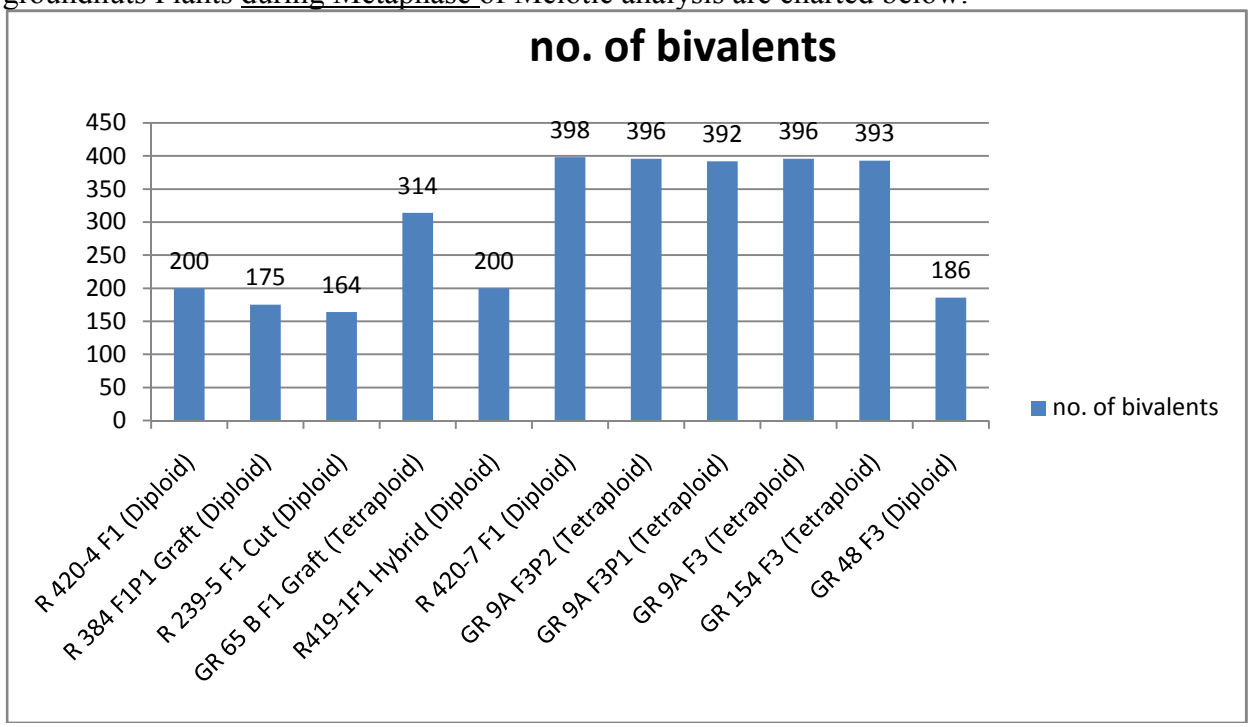
Comparative Final Results & Findings of no. of univalents of 24 diploid and tetraploid species of groundnuts Plants during Metaphase of Meiotic analysis are charted below:



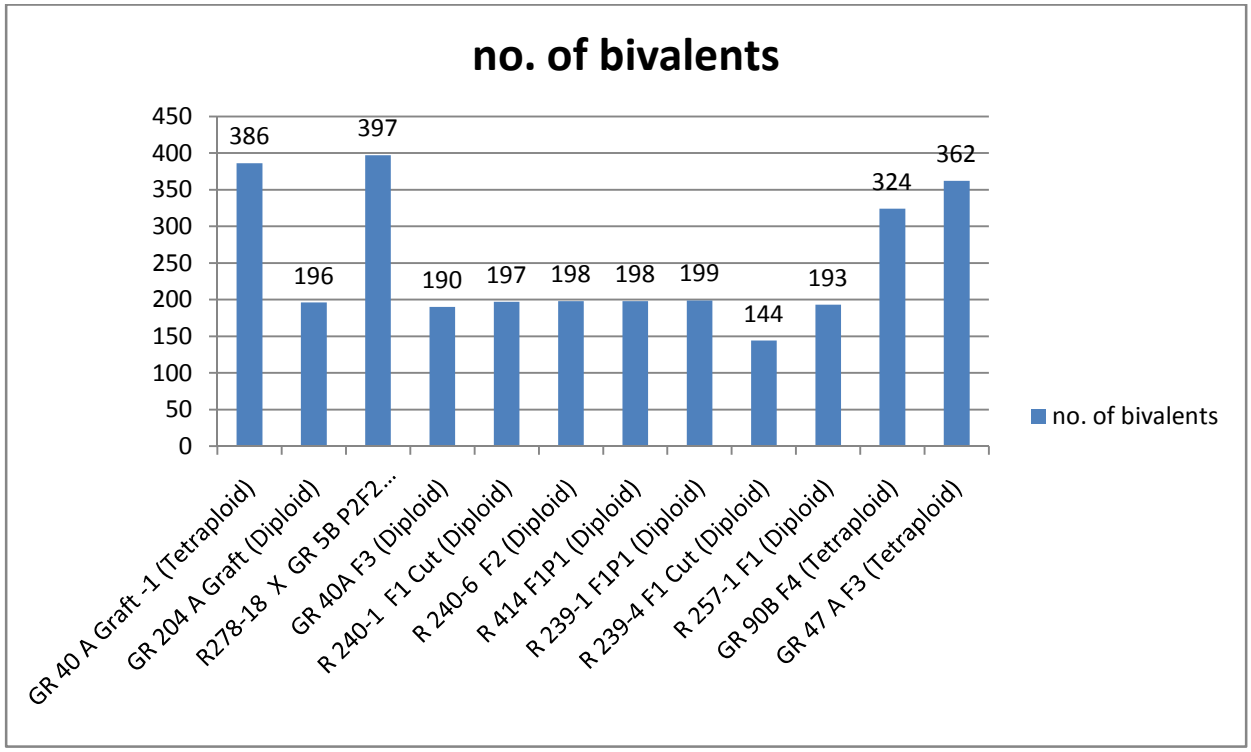
Bar chart No.1a & 1b



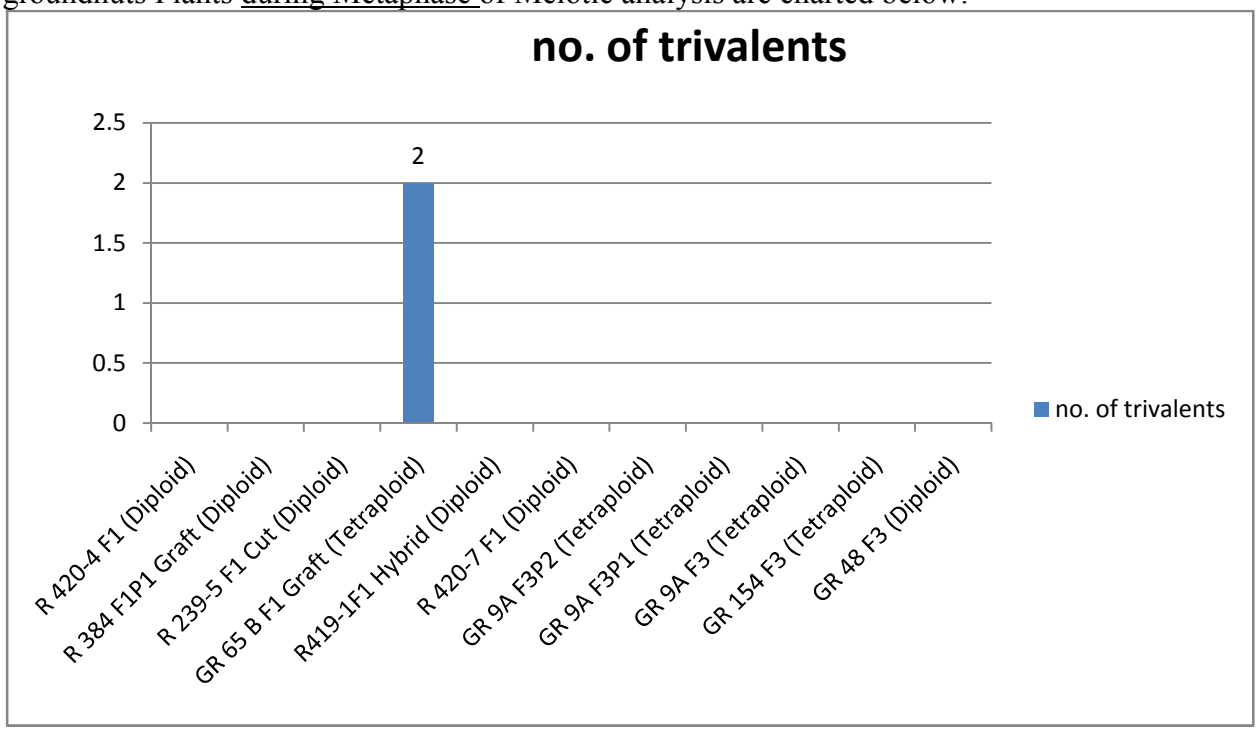
Comparative Final Results & Findings of no. of bivalents of 24 diploid and tetraploid species of groundnuts Plants during Metaphase of Meiotic analysis are charted below:



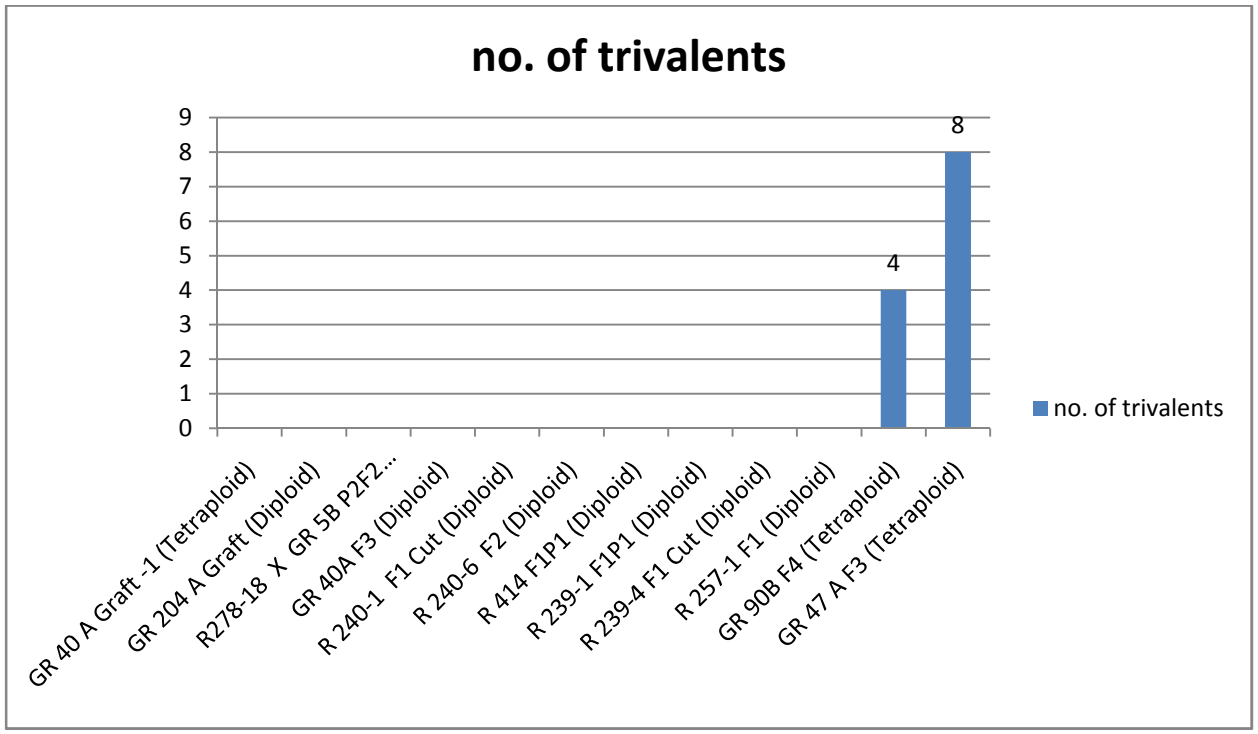
Bar chart no.2a & 2b



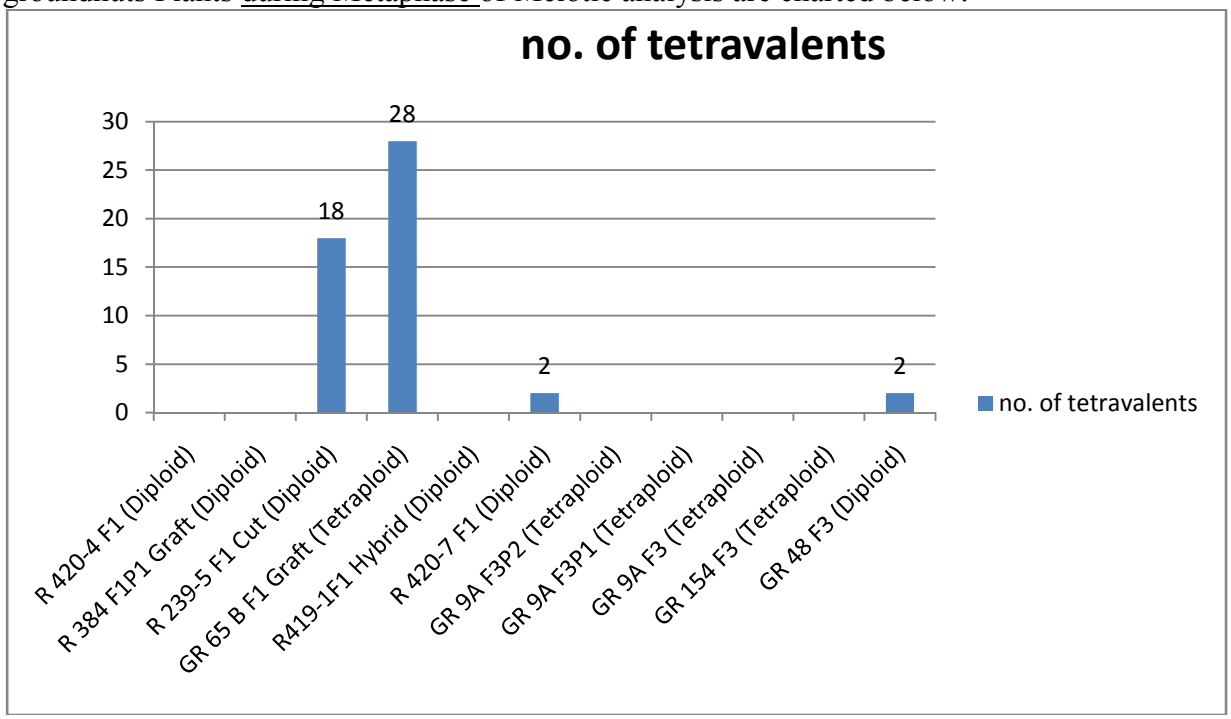
Comparative Final Results & Findings of no. of trivalents of 24 diploid and tetraploid species of groundnuts Plants during Metaphase of Meiotic analysis are charted below:



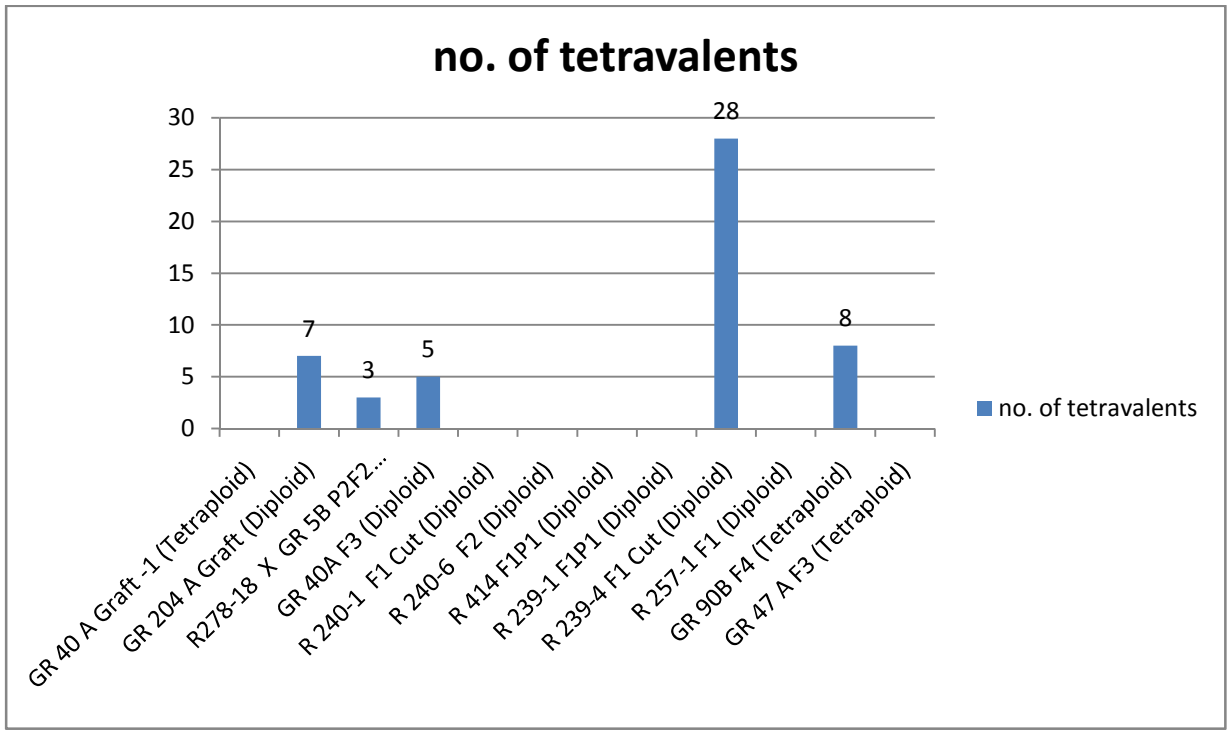
Bar chart no. 3a & 3b



Comparative Final Results & Findings of no. of tetravalents of 24 diploid and tetraploid species of groundnuts Plants during Metaphase of Meiotic analysis are charted below:



Bar chart no. 4a & 4b



GLOSSARY

I. GLOSSARY

S.no.	Word	Meaning
	Synthetic groundnut	Amphidiploid and autotetraploid groundnuts, which are tetraploids are called synthetic groundnut.
	Amphidiploid	A plant originating from hybridization between two species in which the chromosome number is the sum of the chromosome numbers of both parental species. It behaves as an independent species.
	Autotetraploid	An individual or strain whose chromosome complement consists of four copies of a single genome due to doubling of an ancestral chromosome complement
	Tetraploid	It has four times the haploid number of chromosomes in the nucleus
	Allotetraploid	An allotetraploid is a hybrid that has a chromosome set 4 times that of a haploid organism. Allotetraploids are created as a result of both chromosome sets of each parents being present in gametes.
	Diploid	Diploid (indicated by $2n = 2x$) cells have two homologous copies of each chromosome, usually one from the mother and one from the father

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