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IMPACT ANALYSIS OF MAGNETIC FIELD ON MITOTIC CELL CYCLE IN *ALLIUM SATIVUM* L.

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The impact of magnetic field was first observed by Dave (1972) in the mitotic cell cycle of *Pisum sativum*. Thereafter its effect on the mitosis of other plants has also been observed. But so far no explanation on the biophysical basis has been given by them. The present work deals with the detailed investigation of various types of effects caused due to magnetic field on the mitotic cell cycle in *Allium sativum* L. The paper deals in detail with 27 types of anomalies observed under six different treatments. The attempt has been made to explain these anomalies on the basis of biophysical postulates. This is the first attempt where sound physical explanation has been advanced to explain the experimental findings. It has also been observed that the mitotic index decreases when the duration of magentic field is increased and the number of abnormal cells goes on increasing with the increasing duration of exposure to magnetic field.

Key Words : Magnetic field, mitotic cell cycle, *Allium sativum*

It is well known that various Physical forces affect living systems variously and magnetic forces must also have affected the living system. Brannen and Wayland (1980) have stressed that absolute reaction rate theory and the thermodynamic treatment of energy of activation provide a base for the study of biological responses to the magnetic fields. It has also been pointed out that though the dominant characteristic of chemical reaction is its dependence on temperature, but in biological systems the energy of activation, reflecting the changes in the molecular energy at the time of the occurrence of the reaction, stands as another important characteristic. The presence of electromagnetic and magnetic fields can exert such forces upon molecules that may result in specific molecular reactions. The anomalies arising in cell division and the chromosomes are reported chiefly due to X-rays, ultraviolet rays, heat treatments, etc. amongst the physical parameters and a variety of organic and inorganic compounds amongst chemicals. The effect of magnetic fields on the cell cycle as well as on chromosomes do not find any mention in these reviews. Preliminary observations are made by Dave (1972) on the effects of magnetic field upon the mitotic cell division on *Pisum sativum*, (Goswami 1973 and 1977). Goswami and Dave (1975) and Goswami *et al.* (1983) studied the effect of magnetic field on mitotic cell division in *Allium cepa, Allium sativum, Pisum sativum* and *Vicia faba*. They have, however, not been able to explain the mechanisms involved in these effects. The present investigation has thus been undertaken with a view to obtain qualitative as well as quantitative data from well planned experiments which could be statistically analysed.

MATERIALS AND METHODS

To study the effect of magnetic field on the mitotic cell cycle, the root tips of *Allium sativum* have been taken. The buds were kept on moist saw dust spread over the tray in the laboratory at room temperature. After 3 to 4 days the roots having length about 2 to 3 cm were washed in tap water and placed in polythene bags with few drops of water. These polythene bag having roots were hung in between the two poles (North- South) of magnetic field generated by electromagnet. In a separate polythene bag some roots were kept and hung in distilled water to serve as control.

After placing the material in between the magnetic poles the gap was checked. 2 Am current was passed and the time was recorded. The experiments conducted are indicated in table-1.

Each experiment was conducted twice and every time control was placed separetely. The materials of treatment with magnetic field or glucose recovery or control were washed with distilled water after completion of the experiment and root tips were fixed in acetic alcohol fixative (1:1 ratio) at room temperature for 12 to 24 hours. Then the root tips were preserved in 70% and placed in refrigerator at 80-12°C.

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Table 1: Experimental plan for various treatments of magnetic field on *Allium sativum*.

Treatments number	Strength of magnetic field (in Gauss)	Duration of Treatments: Magnetic field (in hour)	Duration of Treatments: Glucose recovery (in hour) (1% glucose)	Magnetic field (in hour)	Glucose recovery (in hour) 1%glucose)
1.	Control 1	-	-	-	-
2.	Control 2	-	-	-	-
3.	$1.2x10^5$	1	-	-	-
4	$1.2x10^5$	1	½-	-	-
5.	$1.2x10^5$	1	½1	1	-
6.	$1.2x10^5$	1	½1	1	½
7.	$0.12x10^5$	2.30	-	-	-
8.	$0.12x10^5$	2.30	24	-	-

The slides were prepared in aceto-orcein as per the method detailed by Sharma and Sharma (1980). From these slides the changes in mitosis and chromosomes were studied both qualitatively and quantitatively. From the data obtained mitotic index was determined and the quantitative data have statistically been analysed through ANOVA.

OBSERVATIONS

In control no abnormalities were observed either in the mitotic division or the chromosomes. The abnormalities observed under various treatments are indicated in table 2 and Figs. 1 to 27.

Table-2 indicates that maximum abnormalities were observed under treatment No. II and minimum under Treatment No. I. The abnormalities like bridges binucleate cell, chromosome break, C-mitosis, disturbed position, erosion, micronuclei, pycnosis, ringlike formation, stickiness, tropokinesis were found in all the treatments. Chromatid separation was observed only in treatment III, chromosome gap, irregular spindle formation and irregular telophase with bridge was observed only in treatment-VI. While uncoiling of chromosome was observed in treatment-II (Figs. 1 to 27).

The mitotic indices under various treatments show that there is considerable decrease in the mitotic indices under all the treatments as compared to the same under control (Table 3). The analysis indicates that the variation is statistically significant (Table 4 and 5).

DISCUSSION

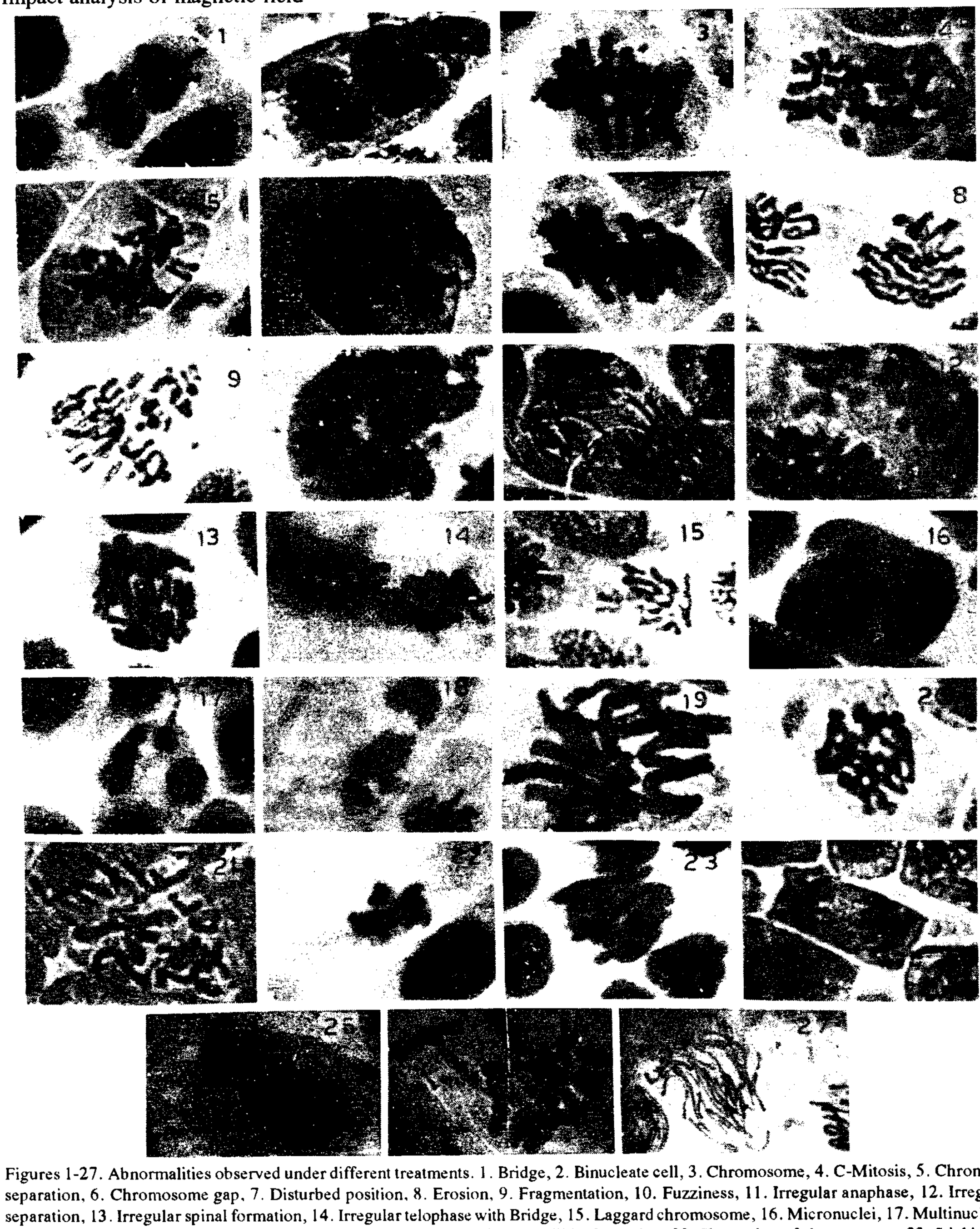
The effect of various agents like chemical mutagens, X-rays have been studied by most of the

Table 2: Abnormalities observed under different treatments.

S. No.	Types of abnormalities (Figs.1 to 27)	Treatments I	II	III	IV	V	VI
1.	Bridge	+	+	+	+	+	+
2.	Binucleate cell	+	+	+	+	+	+
3.	Chromosome break	+	+	+	+	+	+
4.	C-Mitosis	+	+	+	+	+	+
5.	Chromatid separation	-	-	+	-	-	-
6.	Chromosome gap	-	-	-	-	-	+
7.	Disturbed position	+	+	+	+	+	+
8.	Erosion	+	+	+	+	+	+
9.	Fragmentation	+	+	+	+	+	+
10.	Fuzziness	-	+	+	+	+	+
11.	Irregular anaphase	+	+	+	+	+	+
12.	Irregular separation	+	+	+	+	+	+
13.	Irregular spindle formation	-	-	-	-	-	+
14.	Irregular telophase with Bridge	-	-	-	-	-	+
15.	Laggard Chromosome	-	-	+	+	+	+
16.	Micronuclei	+	+	+	+	+	+
17.	Multinucleate cell	-	+	+	+	+	+
18.	Multipolar formation	-	+	+	+	+	+
19.	Pseudochiasmata	-	+	+	+	+	+
20.	Pycnosis	+	+	+	+	+	+
21.	Ring like formation	+	+	+	+	+	+
22.	Shortening of chromosome	-	+	+	+	+	+
23.	Stickiness	+	+	+	+	+	+
24.	Tropokinesis	+	+	+	+	+	+
25.	Trinucleate cell	-	+	+	+	+	+
26.	Thickening of chromosome	-	+	+	+	+	+
27.	Uncoiling of chromosome	-	+	-	-	-	+
	Number of Abnormalities	14	22	23	22	22	25

workers. The effect of magnetic field on the mitosis as shown by Dave (1972), Goswami (1973 and 77), Goswami and Dave (1975) and Goswami *et al.* (1983) have demonstrated several anomalies but they have not been to give any conclusive mechanism of these anomalies. The presented experimental plan (Table 1) has yielded results pointing towards the mechanism of the action of magnetic field in generation of these anomalies.

The observations reveal that under control conditions no abnormalities occur while the treated materials exhibit as many as 27 types of abnormalities (Table-2, Figs 1-27). Such a large number of abnormalities under the influence of single physical factor have not been observed by earlier workers. The anomalies pertaining to the chromosomes, spindles, poles, cytokinesis, etc. have been demonstrated for the first time. It has also been observed that mitotic index decreases as the duration of exposure increases



Figures 1-27. Abnormalities observed under different treatments. 1. Bridge, 2. Binucleate cell, 3. Chromosome, 4. C-Mitosis, 5. Chromatid separation, 6. Chromosome gap, 7. Disturbed position, 8. Erosion, 9. Fragmentation, 10. Fuzziness, 11. Irregular anaphase, 12. Irregular separation, 13. Irregular spinal formation, 14. Irregular telophase with Bridge, 15. Laggard chromosome, 16. Micronuclei, 17. Multinucleate cell, 18. Multipolar formation, 19. Pseduchiasmata, 20. Pycnosis, 21. Ring likke formation, 22. Shrotening of chromosome, 23. Stickiness, 24. Tropokinesis, 25. Trinucleate cell, 26. Thickening of chromosome, 27. Uncoiling of chromosome.

(Table-3, 4 and 5). At this point it can be said that magnetic field causes the cells to remain in the non-dividing phase, either the cell is arrested in G1 phase, or S phase.

Table 3: Mitotic index and frequency of abnormal cells during various treatment of magnetic field

Experiment number	Strength of magnetic field (in Gauss)	Duration of Treatments				Frequency of total dividing cells (Mitotic index) (Average of 10)	Frequency of abnormal cells under division (Average of 10)	Frequency mitotic frequency
		Magnetic field in hour	Glucose recovery in hour (1% Glucose)	Magnetic field in hour	Glucose recovery in hour (1% Glucose)			
1.	Control 1	-	-	-	-	13.71	0.00	13.71
2.	Control	-	-	-	-	13.35	0.00	13.35
3.	$1.2x10^5$	1	-	-	-	8.04	1.57	6.47
4.	$1.2x10^5$	1	½	-	-	7.12	2.19	4.93
5.	$1.2x10^5$	1	½	-	-	6.93	3.01	3.92
6.	$1.2x10^5$	1	½	1	½	5.86	4.03	1.83
7.	$0.12x10^5$	2.30	-	-	-	5.46	4.30	0.96
8.	$0.12x10^5$	2.30	24	-	-	5.21	4.84	0.37

Table 4: Analysis of Variance for mitotic index

S. No.	Source of variance	D.F	S.S.	M.S.S.	Ratio	F. Value	
1.	Replication	9	5.49	0.61	0.12	2.80	(4.51)
2.	Treatment	7	814.57	116.37	23.64	2.15	(2.93)
3.	Error	63	310.14	4.92	-	-	

*Value in parentheses indicate value at p=0.001.

Table 5: Analysis of Variance for Frequency of Abnormal cells

S. No.	Source of variance	D.F	S.S.	M.S.S.	Ratio	F. Value	
1.	Replication	9	19.98	2.22	0.63	2.80	(4.51)
2.	Treatment	7	1644.35	234.91	6.695	2.15	(2.93)
3.	Error	63	221.03	3.51	-	-	

*Value in parentheses indicate value at p=0.001.

It would be worthwhile to mention here that the magnetic field is capable of initiating a large variety of abnormalities. Khare and Bhatnagar (1965) have demonstrated the generation of magnetoelectret in waxes, resins and plastics. Diarc (1931, 1948) propounded the theory of magnetic poles and gave the idea of magnetoelectric monopoles. Cope (1978a, 1979a) has advocated that the presence of magnetoelectret in the cell represents the monopole and dipole systems. Cope (1979b) has stated that steady magnetic field could probably cause electric charge polarization in living systems by the same mechanism responsible for the phenomena in waxes, resins and plastics. Cope (1981) has pointed out that mitochondria, melanin granules and rods of retina fall within the calculated size of cellular magnetodetectors and hence these can be considered to be specific receptors of the cell. Dumbadze (1983) has demonstrated chromosome break, despiralization and fuzziness of chromosomes caused by the magnetic field in the cultivated human lymphocytes. These observations are similar to the observations made during the present investigations.

Ripamonti *et al.* (1982) have demonstrated that the magnetic field is responsible in altering the intracellular Ca^{2+} transient which in its own turn controls the condensation and despirulization processes of the chromosome. Sharma and Sharma (1980) and Sharma (1985) have shown that fragmentation, chromosome break, etc. culminate the cell cycle thus arresting the growth of the cancerous cells. Khandelwal and Mishra (1990) have reported a generation of similar abnormalities by treating the cells with anticancer drugs like methotrextate, endoxan, 5-fluorouracil and g-radiation. In view of these facts together with the observation that all these anomalies are induced by the magnetic field it can be concluded magnetic field can prove a very potent anticancer agent which would be much useful for the control of cancer.

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