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STUDY OF CAFFEINE AND NICOTINE EFFECT ON MITOTIC DIVISION IN WHEAT (*TRITICUM AESTIVUM* L.)

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Kay words: *wheat, mitotic division, caffeine, nicotine, cytogenetic analysis*

INTRODUCTION

The reason for choosing the theme was to study the effect of caffeine (coffeinum natrium benzoicum) and nicotine (α-pyridine-β-N-methylpyrrolidine) on mitotic division and chromosome aberrations in anaphase and telophase in wheat roots (*Triticum aestivum* L.) with different concentrations of the above mentioned substances, to see if caffeine and nicotine have a specific action. The study of the effect of caffeine and nicotine was supplemented with observations on seed germination and plant growth.

MATERIAL AND METHODS

Wheat seeds - *Triticum aestivum* L (2n = 6x = 42), of the Fundulea 29 variety, the harvest of 2018 were used.

Caffeine as a pure crystalline substance, white, was purchased from the Toxicology Laboratory belonging to Bacau Health Department.

Nicotine was extracted from cigarettes by applying the Stas-Otto method, modified by Ogier, by boiling in distilled water. Thus, the tobacco of two cigarettes was boiled for 10 minutes in 10 ml of distilled water; after cooling and filtration, an oily, colorless, volatile, odorless liquid is obtained. This liquid has a nicotine concentration of 70%.

Of the investigated substances, both caffeine and nicotine, five concentrations were tested, namely: 0.01; 0.05; 0.1; 0.2 and 0.5%. Dilutions were carried out in distilled water. The wheat fields were divided into lots of 100 and placed on filter paper in Petri dishes.

For control - **control sample** - seed germination and growth was done in tap water. Study samples were conducted on two sets of experiments:

I - 100 seeds / Petri dish were distributed in the 5 dilutions of caffeine and nicotine respectively; kernels were germinated, the plants were allowed to grow on these concentrations of the test substances.

II - 100 seeds / Petri dish were distributed in the 5 dilutions of caffeine and nicotine; At these concentrations, the seeds were left for 24 hours, after which they were thoroughly washed in tap water and then allowed to germinate and evolve to the plants in ordinary water.

In total there were 21 variants, 20 on the substances to be studied and a blank test. As the seeds have germinated, roots have been harvested for the rapid cytogenetic study, according to the Feulgen method.

The mitotic index (I.M.) was calculated according to the formula:

$$IM = \frac{\text{number of cells in mitosis}}{\text{Total number of cells analyzed}} x100$$

The number of cells includes both interphases and cells in metaphase.

For the cytogenetic study, 20 preparations were made for each variant. To study the cell frequency in the division, each of the 5 randomized microscopic fields was studied with the 40X and 10X ocular lenses, all interphase, prophase, metaphase, anaphase and telophase. For the study of the chromosome aberration frequency, the entire surface of the preparation was studied, with normal and defective anaphases and telophases, as well as aberrations.

On the germination and growth of plants, direct observations were made, daily, for two weeks (14 days); biometric measurements of stems and root roots have also been made.

RESULTS AND DISCUSSIONS

For the first set of experiments, the results obtained in germination of seeds and plant growth are shown in Tables 1, 2 and 3.

Although on the 0.01% caffeine variant the seeds germinated (at a reduced rate of 54% at week 14) they continued, they have never evolved and degenerated.

Wheat seeds permanently placed in caffeine solutions, although they germinated very low in the concentration of 0.01%, have not increased.

For the second set of experiments and seeds treated with the 24 hour solutions, after which they were placed in the usual water, the results are recorded in Tables 4, 5, 6 and 7.

It is also worth mentioning that the common plants in the seeds treated with caffeine solutions of 24 hour showed wilting phenomena, small and twisted fingers, etiolated leaves, aspects even more pronounced as the concentration of the treatment solution was higher.

Noteworthy for nicotine treatment for 24 hours, in the 13th and 14th days of treatment, wilting, twisted and etiolate phenomena were observed at all concentrations.

Concerning the study of the frequency of different phases of mitosis and the mitotic index (I.M.), the following results were obtained, recorded in Tables 8, 9 and 10.

In terms of identifying chromosomal aberrations is concerned, the results are recorded in Tables 11, 12 and 13.

Table 1. The germination capacity of wheat seeds placed in solutions with different concentrations of nicotine

Conc.of nicotine	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14
0,01%	—	—	8%	25 %	47 %	72 %	78 %	86 %	90 %	92 %	92 %	95 %	95 %	97 %
0,05 %	—	—	10 %	25 %	33 %	47 %	64	73 %	82 %	90 %	92 %	95 %	95 %	96 %
0,1 %	—	—	—	—	—	5 %	9 %	14 %	28 %	57 %	60 %	62 %	63 %	65 %
0,2%	—	—	—	—	—	—	2%	2%	3%	3%	4%	4%	4%	5%
Sample witness (water)	—	12 %	22 %	55 %	75 %	82 %	90 %	92 %	93 %	94 %	96 %	96 %	96 %	96 %

Table 2. The germination capacity of wheat seeds that are permanently placed in solutions of different caffeine concentrations

Conc.of nicotine	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14
0,01%	—	—	—	—	—	—	2 %	8 %	14 %	14 %	14 %	32 %	50 %	54 %
0,05 %	—	—	—	—	—	—	—	—	—	—	—	—	—	—
0,1 %	—	—	—	—	—	—	—	—	—	—	—	—	—	
0,2%	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sample witness (water)	—	12 %	22 %	55 %	75 %	82 %	90 %	92 %	93 %	94 %	96 %	96 %	96 %	96 %

Table 3. Growth of plants grown from seeds germinated on nicotine solutions

Conc.of nicotine (%)	Dimensions of roots and stems (cm)								
0,01	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14
0,05	—	—	t=3 r=1,17	*t=5,5* r=3,5	t=6,5 t=3,7	t=8 r=4,1	t=8,5 r=4,2	t=9 r=4,3	t=9,2 r=4,5
0,1	—	—	—	—	t=2 r=1,5	t=3,5 r=2,3	t=4,7r=3	t=6,2 r=3,8	t=7,5 t=4,7
0,2	—	—	—	—	—	t=1,7 r=0,2	t=1,8 r=0,2	t=2,3 r=0,3	t=2,8 r=0,4
0,5	—	—	—	—	—	—	—	—	t=0,5 r=0,1
Sample witness (water)	t=3,2 r=2,5	*t=5,5* r=3,5	t=6 r=4	t=6,4 r=4,2	t=6,8 r=4,9	t=8,5 r=5	t=11,2 r=5,2	t=13 r=5,3	t=14 r=5,5

Legend: t = strain; r = root

Table 4. The germination capacity of wheat seeds placed for 24 hours in solutions of different concentrations of nicotine then in tap water

Conc.of nicotine	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14
0,01%+ water	—	—	8 %	12 %	15 %	18 %	25 %	28 %	35 %	47 %	64 %	73 %	80 %	87 %
0,05%+ water	—	—	6 %	14 %	19 %	27 %	36 %	39 %	41 %	47 %	58 %	69 %	77 %	84 %
0,1%+ water	—	—	5 %	12 %	17 %	25 %	32 %	42 %	50 %	55 %	68 %	75 %	81 %	89 %
0,2%+ water	—	—	3 %	5 %	8 %	17 %	25 %	34 %	34 %	48 %	55 %	67 %	78 %	85 %
0,5%+ water	—	—	—	—	5 %	13 %	21 %	30 %	35 %	40 %	53 %	61 %	68 %	78 %
Sample witness (water)	—	12 %	22 %	55 %	75 %	82 %	90 %	92 %	93 %	94 %	96 %	96 %	96 %	96 %

Table 5. The germination capacity of wheat seeds placed for 24 hours in solutions of different concentrations of caffeine and then in tap water

Conc. of nicotine	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14
0,01% + water	—	—	8 %	15 %	32 %	45 %	58 %	69 %	79 %	85 %	90 %	94 %	95 %	95 %
0,05 % + water	—	—	4 %	10 %	15 %	30 %	32 %	38 %	45 %	58 %	65 %	78 %	80 %	82 %
0,1 % + water	—	—	—	5 %	15 %	32 %	35 %	38 %	38 %	42 %	48 %	57 %	65 %	70 %
0,2 % + water	—	—	—	4 %	10 %	23 %	24 %	29 %	32 %	39 %	45 %	52 %	60 %	60 %
0,5 % + water	—	—	—	—	3 %	7 %	11 %	17 %	20 %	25 %	30 %	38 %	40 %	42 %
Sample witness (water)	—	12 %	22 %	55 %	75 %	82 %	90 %	92 %	93 %	94 %	96 %	96 %	96 %	96 %

Table 6. Growth of plants obtained from wheat seeds treated 24 hours with caffeine solutions and then placed in tap water

Conc. of cofeine	Dimensions of roots and stems (cm)								
	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14
0,01%+ water	—	—	t=2,3 r=0,8	t=2,8 r=1,2	t=3,2 r=1,8	t=3,8 r=2,2	t=4,3 r=2,5	t=4,7 r=2,8	t=5 r=3
0,05 + water	—	—	t=0,8 r=0,3	t=1,2 r=0,5	t=1,8 r=0,8	t=3,2 r=1,2	t=3,9 r=1,9	t=4,3 r=2,3	t=4,5 r=2,7
0,1 + water	—	—	t=0,5 r=0,5	t=0,7 r=1,2	t=1,2 r=1,8	t=1,7 r=2,2	t=2,3 r=2,7	t=3,0 r=3,2	t=3,5 r=3,8
0,2 + water	—	—	t=,7 r=0,3	t=1,8 r=0,5	t=2,4 r=,9	t=2,8 r=1,3	t=2,9 r=2,2	t=3,3 r=2,8	t=3,8 r=3,5
0,5 + water	—	—	t=0,,8 r=0,3	t=1,3 r=0,4	t=1,8 r=0,5	t=2,3 r=0,8	t=2,7 r= 1,3	t=3,0 r=1,7	t=3,5 r=2,0
Sample witness	t=3,2 r=2,5	t=5,5 r=3,5	t=6 r=4	t=6,4 r=4,2	t=6,8 r=4,9	t=8,5 r=5	t=11,2 r=5,2	t=13 r=5,3	t=14 r=5,5

Legend: t = strain; r = root

Table 7. Growth of plants obtained from wheat seeds treated 24 hours as nicotine solutions and then placed in tap water

Conc.of nicotine (%)	Dimensions of roots and stems (cm)								
	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14
0,01	—	—	t=4,8 r=1,3	t=5 r=1,7	t=5,6 r=2,2	t=6,0 r=2,6	t=6,4 r=2,9	t=6,9 r=3,2	t=7,3 r=3,5
0,05	—	—	t=5,6 r= 1,7	t=5,9 r=2, 1	t=6,3 r=2,5	t=6,8 T=2,8	t=7,2 r=3, 1	t=7,8 r=3,5	t=8,3 r=3,7
0,1	—	—	t=3,2 r=1,2	t=3,6 r=1,6	t=4 r=1,9	t=4,4 r=2,2	t=4,8 r=2,5	t=5,2 r=2,8	t=5,7 r=3,2
0,2	—	—	t=5,7 r=1,7	t=6,1 r=2,2	t=6,6 r=2,6	t=7,0 r=3,0	t=7,3 r=3,3	t=7,9 r=3,9	t=8,4 r=4,2
0,5	—	—	t=2,9 r=3,8	t=3,8 r=1,5	t=4,2 r=2,0	t=5,3 r=2,4	t=5,8 r=2,9	t=5,5 r=3,2	t=7,0 r=3,7
Sample witness (water)	t=3,2 r=2,5	t=5,5 r=3,5	t=6 r=4	t=6,4 r=4,2	t=6,8 r=4,9	t=8,5 r=5	t=11,2 r=5,2	t=13 r=5,3	t=14 r=5,5

Legend: t = strain; r = root

Table 8. Frequency of different phases of mitosis and mitotic index (I.M.) in meristematic peaks of plants obtained from seeds germinated and grown on nicotine soils.

Conc. of nicotine	Nr. cell analyzed	Prophase	Metaphase	Anaphase	Telophase	I.M.
0,01 %	100^{10}	132	5	20	30	18,7
0,05 %	100^{10}	128	3	18	32	10,8
0,1 %	100^{10}	120	4	21	30	10,7
0,2 %	—	—	—	—	—	—
0,5 %	—	—	—	—	—	—
Sample witness	100^{10}	155	12	30	52	20,4

Table 9. Frequency of different phases of mitosis and I.M. in radicular meristematic peaks of plants obtained from 24 hour treated with caffeine solutions

Conc. of cofeine	Nr. cell analyzed	Prophase	Metaphase	Anaphase	Telophase	I.M.
0,01 % + water	100^{10}	85	3	8	12	10,8
0,05 % + water	100^{10}	65	2	8	9	8,5
0,1 % + water	100^{10}	62	2	6	8	7,8
0,2 % + water	100^{10}	50	1	3	6	6,0
0,5 % + water	100^{10}	48	1	2	6	5,7
Sample witness	100^{10}	155	16	30	52	20,4

Table 10. Frequency of different phases of mitosis and I.M. in the meristematic peaks of plants obtained from 24 hours treated with nicotine solutions

Conc. of cofeine	Nr. cell analyzed	Prophase	Metaphase	Anaphase	Telophase	I.M.
0,01 % + water	100^{10}	128	32	9	20	18,9
0,05 % + water	100^{10}	135	32	9	23	19,9
0,1 % + water	100^{10}	120	31	8	19	17,8
0,2 % + water	100^{10}	118	16	9	25	16,8
0,5 % + water	100^{10}	98	11	3	12	12,4
Sample witness	100^{10}	155	52	12	30	20,4

Table 11. Frequency of chromosomal aberrations in anaphase and telophase highlighted in radicular meristematic peaks of plants obtained and grown on nicotine solutions

Conc. of nicotine	Nr. cell analyzed	Type of aberration	Frequency %
0,01 %	100^{10}	- bridges - retarded chromosomes - picnotics chromosomes	4,49
0,05 %	100^{10}	- polyploid nuclei - unequal separation - fragments	5,38
0,1 %	100^{10}	- fragments - polyploid nuclei - retarded chromosomes - cromozomi retardatari	6,12
0,2 %	—	—	—
0,5 %	—	—	—
Sample witness	**100^{10}**	- bridges - fragments	2,40

Table 12. The frequency of chromosomal aberrations in anaphase and telophase revealed in radicular meristematic peaks of plants obtained from treated 24 hour seeds with nicotine solutions, then with water

Conc. of nicotine	Nr. cell analyzed	Type of aberration	Frequency %
0,01% + water	100^{10}	- bridges - fragments	3,02
0,05% + water	$100^{1°}$	- bridges retarded chromosomes	3,93
0,1% + water	100^{10}	- bridges retarded chromosomes	4,12
0,2% + water	100^{10}	- unequal separation - bridges - retarded chromosomes	4,37
0,5% + water	100^{10}	- picnotics chromosomes - unequal separation -	4,48
Sample witness	100^{10}	- bridges - fragments	2,40

Table 13. Frequency of chromosomal aberrations in anaphase and profase highlighted in radicular marystematic tips of plants obtained by treatment of seeds 24 hours with solutions of caffeine

Conc. of nicotine	Nr. cell analyzed	Type of aberration	Frequency %
0,01% + water	100^{10}	- bridges - retarded chromosomes	3,58
0,05% + water	100^{10}	- bridges - retarded chromosomes - unequal separation	3,67
0,1% + water	100^{10}	- bridges - fragments	4,89
0,2%+ water	100^{10}	- binucleated cells - bridges - fragments	5,02
0,5% + water	$_{100}{}^{10}$	- picnotics chromosomes - binucleated cells - retarded chromosomes	4,29
Sample witness	100^{10}	- bridges - fragments	2,40

From the results analysis show that both nicotine and caffeine have a specific action on the cell division in wheat, with consequences on the processes of germination, growth and development of wheat plants.

As regards the germination of wheat seeds, it is clear from Tables 1, 2, 4 and 5 that in the case of seeds placed under permanent conditions on nicotine solutions (Table 1), they have an inhibitory effect on germination, effect with the more pronounced the higher the nicotine concentration. Thus, if the concentration of 0.01% and 0.05% nicotine ultimately results in a germination process identical to the control sample (96%), while the control has a 90% a. Also at these low concentrations, the germination process starts poorly from day 3 (8% and 10%) and the control starts on germination from day 2, reaching on day 4 to exceed 50% (respectively 55%). At the 0.5% concentration, no germinated caries are obtained, and at the 0.2% nicotine concentration, the germination percentage is strongly inhibited, starts poorly in the 7th day and reaches only 5% in the 14th day.

In the case of seeds that are permanently kept in caffeine solutions, Table 2 shows a strong caffeine inhibiting effect on the wheat seeds germination process, but only a few seeds manage to germinate to the version with 0.01% caffeine, reaching in the 14th day to 54%, compared to the 96% witness. The germination of seeds begins on the researched solution only on day 7 (2%) and increases shyly to

54% in the 14th day. The blank sample in the 7th day already has a germination percentage of 90%.

On the other variants (0.05, 0.1, 0.2 and 0.5% caffeine) no seeds germinated. Of the seeds germinated on the 0.01% caffeine variant, none evolved in the plant (Figure 1).

Fig. 1. Seeds of wheat planted on caffeine solutions (plan two) and blank samples (first plan) after 14 days of culture

In the case of seeds that have been kept for 24 hours on caffeine solutions and then passed to the usual water (Table 5), a substantial improvement of the germination process is observed, especially at low concentrations of 0.01 and 0.05% nicotine, but also concentrations greater than 0.1; 0.2 and 0.5% nicotine, respectively.

However, at high concentrations (0.2 and 0.5% nicotine), the germination process is strongly delayed (day 4 and day 5 compared to day 2 control) and the percentage of germinated seeds is significantly reduced, compared with the control (60% at the concentration of 0.2 and 42% at the concentration of 0.5 on in the 14th day vs. the control having a 96% germination percentage in the 14th day).

Maintenance of nicotine solutions of seeds for 24 hours also induces a mild inhibitory effect on wheat germ staining (Table 4), but not as pronounced as for caffeine (Table 5).

Thus germination begins from day 3 for variants 0.01; 0.05; 0.1 and 0.2% nicotine and on day 5 for 0.5% nicotine concentration (compared to day 2 when the control has a germination percentage of 12%), but on day 14, at all concentrations, at values close to the control over 80% for the first four concentrations and 78% for the nicotine concentration 0.5%, compared to 96% for the control.

The growth of plants on the variants is presented in Tables 3, 6 and 7.

It can be seen in Table 3 that the plants started to grow from seeds kept permanently on nicotine solutions starting on day 8 in the case of nicotine concentration of 0.01%; for the nicotine concentration of 0.05%, the plants begin to increase on day 10 for the 0.1% nicotine concentration on day 11 for the 0.2% nicotine concentration, only on day 14 a insignificant increase of stem and root (fig. 2).

Fig. 2. Wheat seeds placed on nicotine solutions (plan two) and control samples (first plan) after 14 days of culture

Root and stem lenghts are well below those obtained with the control, the best growth was obtained at low 0.01 and 0.05% nicotine, respectively. Thus, on the 14th day at the concentration of 0.01% the strains had an average of 9.2 cm against 14 cm at the control, and the root roots were 4.5 cm from 5.5 cm at the control. In the case of nicotine concentration of 0.05% the situation is somewhat similar in the case of rootstocks, the stems find something smaller (7.5 cm) than the control (14 cm).

At high concentrations (0.1 and 0.2%) the inhibitory effect on plant growth is very significant, the growth of plants being poor at the concentration of 0.1% nicotine and almost absent in 0.2% nicotine.

A better growth of plants is observed on the treated versions only 24 hours with nicotine solutions (Table 7 and Figure 3).

So, on all variants tested with nicotine solutions, the seeds turned to water after 24 hours begin to germinate and, from day 8, the plants start to appear and grow, though late with the witness with a significant increase from day 6 (t = 3.2, r = 2.5mm). Nicotine-treated seeds grew more heavily than the control and on day 14 they reached lower dimensions than these (Table 7), practically half the size of the witness.

Curiously, not very high concentrations are the most inhibitory, but the concentration of 0.1%, the rest of the concentrations allowing approximately equal growth.

Fig. 3. 24-hour nicotine-treated wheat plants (plan two) and control (first plan) on the 14th day of culture

Wheat seeds permanently maintained on caffeine solutions did not increase to any concentration but germinated very low at a concentration of 0.01% caffeine (Table 2, Figure 1). Seeds treated only 24 hours with caffeine solutions and then passed to the water began to form the plantlets and they grew very slowly, starting on day 8, reaching the net sizes lower than the witness, but also those treated 24 hours with nicotine solutions (Table 6, Fig. 4).

Fig. 4. The wheat plants obtained from seeds treated with caffeine 24 hours (plane two) and the control (first plan) after 14 days of culture

It can be seen from Table 4 that in the case of caffeine, the higher the treatment concentration, the stronger the inhibitory effect.

Thus, on day 14 of growth, the caffeine-grown plants have a maximum concentration of 0.5% in the case of the strain of 2 mm root, while the plants treated with nicotine have t = 7, 0 mm; r = 3.7 mm at the same concentration, and the t = 14 mm; r = 5.3 mm.

Regarding the total frequency of cells in mitotic division in the roots, there is generally a decrease compared to the control, both for nicotine and caffeine, in all tested variants (Table 8, 9 and 10)

In the case of nicotine, at low concentrations, inhibition is not so pronounced as compared to control, but at higher concentrations it becomes very evident (Tables 8 and 10).

In the case of caffeine (Table 9), seedlings obtained from seeds treated after 24 hours, showed at their meristematic root radar frequencies of the mitotic divisions that were lower than the control, the lower the frequencies with the higher the caffeine concentration.

Thus, at the concentration of 0.5% nicotine I.M. is 5.7 relative to the control having an I.M. = 20.4 and in the case of caffeine at the same concentration I.M. = 12.4.

Regarding the effect of the two substances, nicotine and caffeine, on the different phases of mitosis, it is found that the highest frequency are the prophases, followed by telophases, anaphases and telophases.

The frequency of total chromosomal aberrations in anaphase and telophase in wheat roots recorded insignificant increases in nicotine variants at the 0.01% sustained maintenance concentration and in all variants treated only within 24 hours.

In these cases the chromosome aberration rate does not exceed 4.49%, slightly higher than the control (2.40%). (Tables 11 and 12).

However, at higher nicotine concentrations, with the permanent maintenance of the plants, there is a slightly higher increase, namely 5.38% at the concentration of 0.05% and 6.12% at the concentration of 0.1%.

In the case of caffeine, since plants were obtained only from treated 24-hour seeds with caffeine solutions, the chromosome aberration rates were increased insignificantly to the control at all concentrations (Table 13), keeping within the limits.

Regarding the types of chromosome aberrations encountered and their frequency, the following were recorded: fragments, bridges, chromosomes remained in the equatorial plate (Figures 5, 6, 7, 8, 9 and 10).

Rarely, anaphases and micro-nucleosus telophases have been encountered. The most frequent were the bridges, followed by fragments and retarded chromosomes (Plate 1).

PLATE 1. Types of chromosomal abnormalities found in wheat treated with nicotine and caffeine solutions

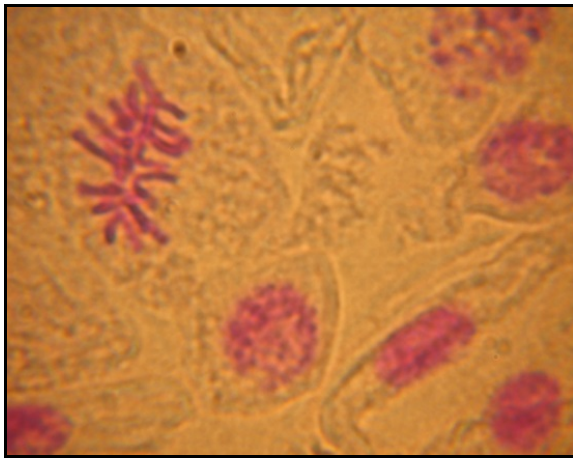

Fig.1. Sticky chromosomes non-orientated in metaphase

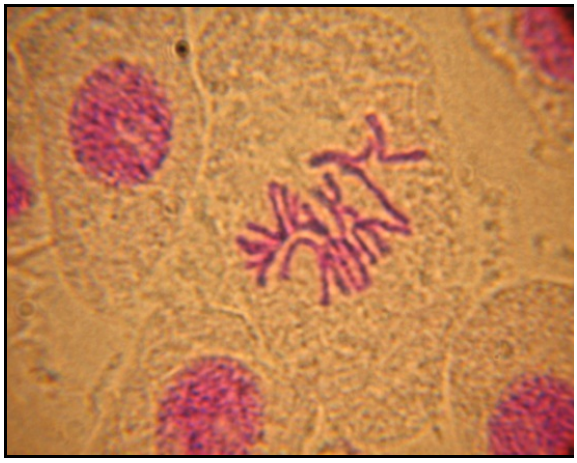

Fig. 2. Chromatidic bridge anaphase in nicotine-treated plants

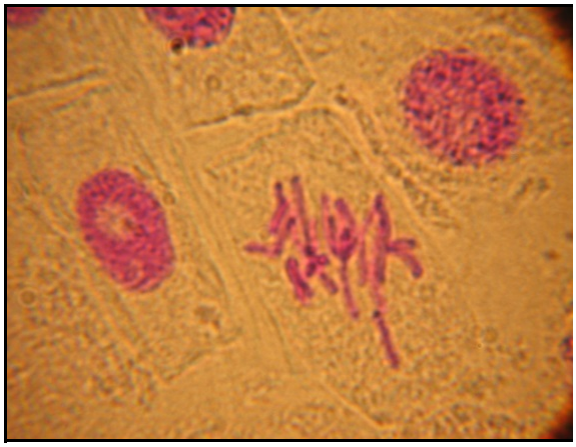

Fig. 3. Chromatidine bridge anaphase in caffeine-treated plants

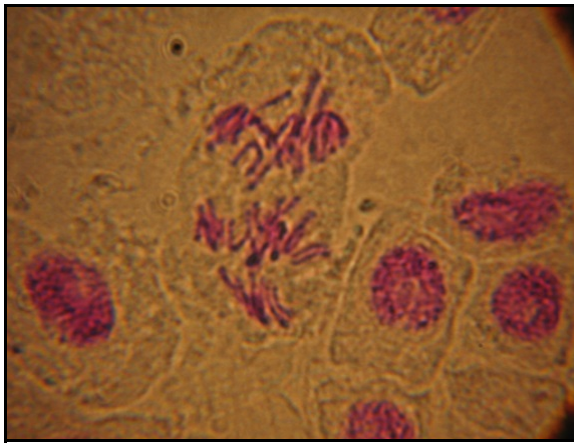

Fig. 4. Ana-telophase with debris and retardant chromosomes in nicotine-treated plants

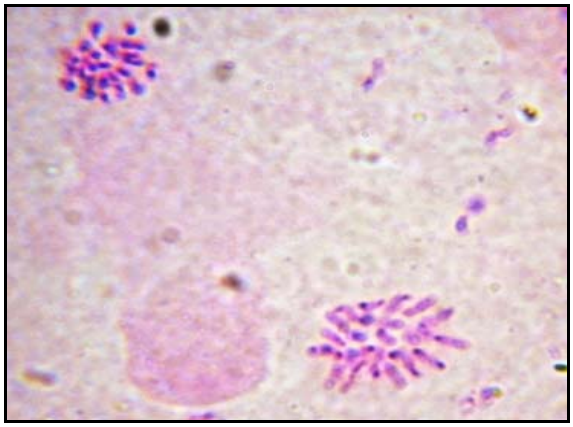

Fig. 5. Normal to caffeine-treated plants

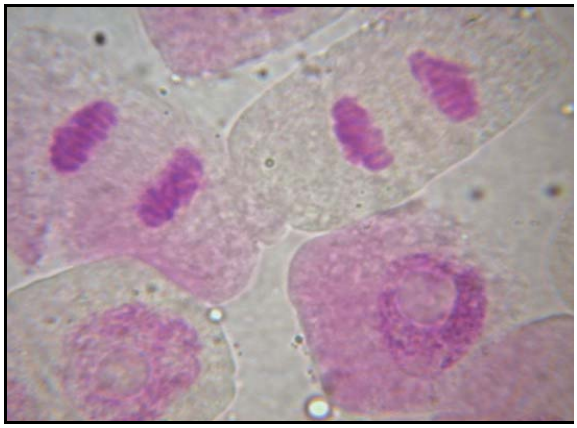

Fig. 6. Normal telophase in nicotine-treated plants

CONCLUSIONS

From the obtained results, the following conclusions can be drawn:

1. Both nicotine and caffeine are substances with specific action on plant growth and cell division.
2. Nicotine produces an inhibitory effect on cell division, an effect which also manifests on the growth of wheat plants. The inhibitory effect is all the more pronounced as the nicotine contact of the plant cells is higher and the higher the nicotine concentration.
3. At high concentrations, nicotine appears to have a weak mutagenic effect, the rate of mutations produced by nicotine found to be significantly higher than the control values.
4. Caffeine has a much stronger inhibitory effect on cell division and plant growth, and permanent maintenance of seeds in caffeine solutions has not allowed germination.
5. Contact with caffeine only 24 hours led to a drastic reduction in plant growth capacity, the growth being very slow, and the plants increased to less than half the size of the control.
6. The strong caffeine inhibitor effect on cell division is comparable to that of a cytostatic.
7. In the case of caffeine no significant increases in chromosome aberration versus control were observed in any working variant.
8. In addition to the inhibitory effect on plant growth, both nicotine and caffeine induced the growth of plants not only small in size but also phenotypically modified with twisted and etiolated leaves.
9. The type of aberrations encountered more frequently were debris, fragments and retarded chromosomes.

ABSTRACT

The paper presents the study of the effect of caffeine (coffeinum natrium benzoicum) and nicotine (α-pyridine-β-N-methylpyrrolidine) on mitotic division and chromosomal aberrations in anaphase and telophase in wheat roots (*Triticum aestivum* L.) of the above mentioned substances. The study was supplemented with observations on seeds germination and plant growth. The study was supplemented with observations on seeds germination and plant growth. Both nicotine and caffeine had an inhibitory effect on cell division, which is also reflected in the growth of wheat plants.

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