Ecotoxicology and Environmental Safety 160 (2018) 19–23

Contents lists available at ScienceDirect

Ecotoxicology and Environmental Safety

journal homepage: www.elsevier.com/locate/ecoenv

A new perspective to aberrations caused by barium and vanadium ions on *Lens culinaris* Medik

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ARTICLE INFO

Keywords:
Abnormalities
Aberration
Barium
Vanadium
Lens culinaris

ABSTRACT

This study investigates aberrations caused by barium and vanadium on meristematic cells of *Lens culinaris* Medik. Barium and vanadium ions at various concentrations (0.05 M, 0.1 M, 0.25 M, 0.5 M, and 1.0 M) were exposed to the seeds of the plant at fixed time interval (12 h). After seedlings, with a microscopic examination images were captured about the root tips. Those images showed that several abnormalities occurred on the plant such as chromosome breakings, chromosome dispersion, bridge chromosome, chromosome adherence, ring chromosome. Variety and number of abnormalities were counted and compared to each other statistically. The results show an increase in abnormalities caused by for both ions with increasing treatment time. Chromosome adherence and chromosome breaking have reverse relationship in which number of occurrence for one of them decreases with increase on other one. Fish bone and chromosome adherence have a positive relationship in which number of one increases with the raise in other's number. Exposed metals have caused formation of ligands with proteins which can prevent the persistence of metal ions in DNA protein cross-links that are involved in DNA formation process.

1. Introduction

Metals can move to plants from soils and accumulate inside roots, leaves and shoots (Maestri et al., 2010; Sepet et al., 2014). While some metals stimulate growth of the plants (Bhargava et al., 2012; Tangahu et al., 2011), several others make changes inside the plant chromosomes (Özdemir et al., 2015, 2012). Baranowska-Morek and Wierzbicka (2004) have studied on lead distribution inside plants, and found out a gathering on root tips of the plant. Janas et al. (2010) have found on their investigation that copper ions are accumulated in vacuoles and the cell wall of root cells of *Lens culinaris* (Medik.). Accumulation of metals occurs by binding with proteins and peptides. Six types of alteration have been mentioned as C-mitosis, stickiness, laggards, bridges, fragments and multipolarity (Kuchy et al., 2016; Özkul et al., 2016). Over certain amounts, transition metals can lead oxidation in tissues of plant (Schützendübel and Polle, 2002).

Among those metals, vanadium (V) is a side product of fossil fuels during energy production and several other industries like mining, metallurgical and galvanization (Tham et al., 2001). Oxidative forms of V have higher harmful effect than elemental form. Vanadium was recorded in various commercial nutritional supplements and multivitamins in amounts ranging from 0.0004 mg to 12.5 mg. At high concentrations, V ions shows very toxic effect especially in shoot of soybean, flax and oat plants (Warington, 1954). The plant species, the form of V and the soil type affect toxic effects of V in plants changing from 10 to 1300 mg/kg (World Health Organisation, 2000). Besides, V has also been reported as the inhibitor of seed germination and root elongation (Tham et al., 2001). While it reduces barley and tomato growth at 31 mg/kg-510 mg/kg (Larsson et al., 2013), at low concentrations, V ions were reported as not detrimental to several plants like bush bean plant and sweet basil (Akoumianaki-Ioannidou et al., 2016; Martin and Saco, 1995). Use of heavy oils, tar sands, and bitumen as combustion sources lead to increase V amount in atmosphere which causes kidney diseases in humans (Filler et al., 2017; Schlesinger et al., 2017).

As another metal, barium (Ba) has great impact for plant and animal growth because of its presence in the environment. Mainly, Ba concentration becomes toxic as a result of mining activities measured in the range of 0.13–29.2% (Lamb et al., 2013). In Canada, reported Ba amount in house dust varies from 190 to 1480 mg/kg (Canadian Council of Ministers of the Environment, 2013). High concentrations of Ba may only be found in soils and in food, like nuts and certain plants. Because of the widespread use of Ba in manufactured materials such as tiles, automobile clutch and brake linings, rubber, brick, paint, glass, and other human activities like traffic, this metal may have high concentrations in soils like ranging from 30.9 mg/kg to 1210 mg/kg (McBride et al., 2014). It finds its way in plants directly by foliage and via water and soil and eventually into animals when they consume Ba

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https://doi.org/10.1016/j.ecoenv.2018.05.020
Received 11 February 2018; Received in revised form 8 May 2018; Accepted 11 May 2018
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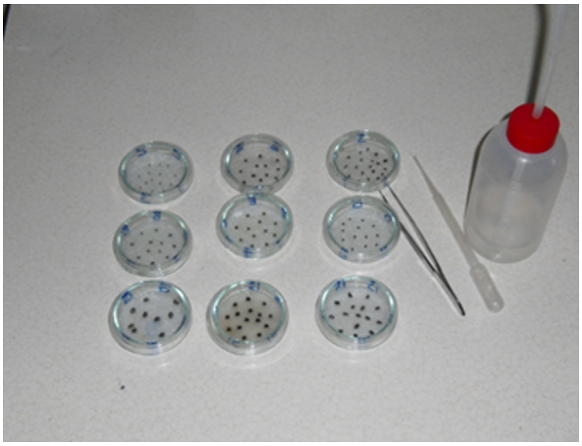

Fig. 1. Seeds left for seedling after exposure of metals.

enriched plants. The main source of barium accumulation in plants is from the soil. Ba amount in soils have been found from 15 mg/L to 3500 mg/L (Agency for toxic substances and disease registry, 2007). The most harmful effect of Ba is on plant growth. The critical threshold level of $BaCl_2$ for plant growth inhibition is quite variable. The inhibition of growth is an outcome of the damage to the physiological, cytological and biochemical processes.

Lentil experiences are being preferred in metal accumulation studies because it is showing off abiotic stresses, salinity, drought, and metal toxicity on its growth and yield (Talukdar, 2013). Lens culinaris has 14 (2 n) chromosomes. Chromose preparation is achieved from meristematic cells of roots of Lens culinaris as suggested in Plant Cytogenetics (Singh, 2003).

Even though metals have positive influence on plant growth at certain level, for higher concentrations, they can either stop or reduce the growth of seedlings. Because biological effects of V and Ba on plant cells show no clear results in previous research efforts (Abreu et al., 2012), this study offers a scenario to present how both metals are related to each other in terms of their cause on chromosomal change in root tips of Lens culinaris.

In this study, two questions were answered:

1. What is the concentration of V and Ba effecting plant growth?
2. How aberrations caused by V and Ba do relate or differ from each other?

2. Material and method

In this study, cytogenetic effects on the seeds of the plant were searched by treatment of metal ions at various concentrations (0.05 mol Ba/L, 0.1 mol Ba/L, 0.25 mol Ba/L, 0.5 mol Ba/L, and 1.0 mol Ba/L) of Ba and (0.05 mol V/L, 0.1 mol V/L, 0.25 mol V/L, 0.5 mol V/L, and 1.0 mol V/L) V at 12 h interval. For this purpose, water soluble solutions of Ba and V have been prepared. Ba was applied as $BaCl_2x2H_2O$ which was purchased from Merck, and as V source, V_2O_5 was used which was purchased from also Park Chemicals.

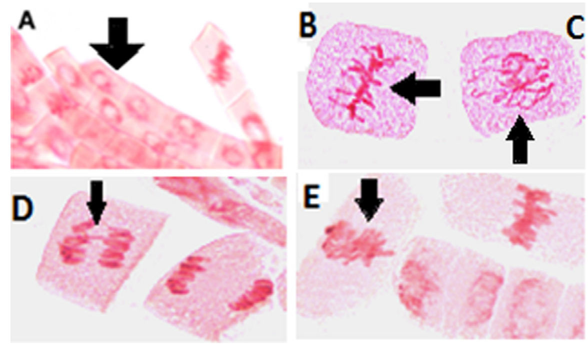

Fig. 2. Examples for Investigated chromosome abnormalities; (A) ring chromosome, (B) fish bones, (C) chromosome dispersions, (D) chromosome breaking, (E) chromosome adherence.

Table 2
Percentages for occurrences of abnormalities in root tip cells of *Lens culinaris* at different concentrations of Ba.

Dose treated (mol/L)	Treatment time (hour)	Investigated abnormality(%) F.B.	C.D.	C.A.	C.B.	B.C.	C.S.	R.C.
0.05	12	14.10	9.10	11.73	7.37	12.73	6.37	0
0.1	12	17.04	10.69	16.35	5.69	6.35	6.35	0
0.25	12	36.40	7.10	18.20	5.10	10.20	9.10	0
0.5	12	–	–	–	–	–	–	–
1.0	12	–	–	–	–	–	–	–

F.B.: Fish Bones, **C.D.**: Chromosome Dispersion, **C.A.**: Chromosome Adherence, **C.B.**: Chromosome Breaking, **B.C.**: Bridge Chromosome, **C.S.**: Chromosome Shrinking, **R.C.**: Ring Chromosome.

Table 3
Percentages for occurrences of abnormalities in root tip cells of *Lens culinaris* at different concentrations of V.

Dose treated (mol/L)	Treatment time (hour)	Investigated abnormality(%) F.B.	C.D.	C.A.	C.B.	B.C.	C.S.	R.C.
0.05	12	19.10	14.50	10.30	5.55	17.45	3.76	0
0.1	12	21.45	15.90	10.05	3.46	9.75	7.57	1.05
0.25	12	26.70	13.60	11.90	9.17	15.67	6.61	0.78
0.5	12	13.48	12.56	9.38	5.51	12.34	5.72	0.20
1.0	12	23.91	4.22	5.42	8.20	24.55	7.05	3.85

F.B.: Fish Bones, **C.D.**: Chromosome Dispersion, **C.A.**: Chromosome Adherence, **C.B.**: Chromosome Breaking, **B.C.**: Bridge Chromosome, **C.S.**: Chromosome Shrinking, **R.C.**: Ring Chromosome.

Before exposure of the metal solutions, plump, and undamaged lentil seeds with same size were exposed to sodium hypochlorite 10% for 10 min in order to prevent seed contamination. After exposure to metal ions for certain time periods, the seeds were washed by distilled

Table 1
The mitotic index of root tip cells of *Lens culinaris* at different concentrations of Ba and V.

Concentrations (mol/L)	Mitotic index ± *S.D. (for Ba)	Mitotic index ± *S.D. (for V)	Time (hour)
.05	**16.70 ± 6.75**	18.89 ± 7.21	**12**
0.1	**14.09 ± 3.90**	16.88 ± 4.40	**12**
0.25	**11.22 ± 3.62**	10.04 ± 3.11	**12**
0.5	–	7.63 ± 2.28	**12**
1.0	–	6.52 ± 2.22	**12**
Control Group	**18.12 ± 6.35**	19.34 ± 3.85	**12**