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Laboratory-Based Assessment of Seed Germination in Raphanus Sativus Var. Japanese White Following Exposure to Heavy Metals Lead (Pb) and Cadmium (Cd)

Tanesh Indwar

Professor, Botany, B. B. D. Govt. College Chimanpura, Shahpura, Jaipur, Rajasthan, India
indwar@rocketmail.com

Abstract: ***One of the most important constituents of multifactorial environment which exert its operative influence on any and every ontogenic phase in life cycle of a plant, is water. The water gets polluted as the washouts from catchment area brings along with it various metallic ions, e. g. nickel, zinc, cadmium, lead, arsenic, copper, etc. Many of these are highly toxic and often accumulated by plants. The accumulation of toxic metals in crops is receiving a great deal of attention. There are a few reports on the hazardous impact of toxic elements lead and cadmium on the germination of seeds of Raphanus sativus. Raphanus sativus L. a common vegetable crop of India was chosen as an experimental material for the present investigation. Radishes are grown as winter, spring, late summer and autum varieties in different countries mostly in India China and Japan. It is perhaps one of the most quickly and easily grown vegetable of kitchen garden. The variety of radish considered in the present investigation is Japanese white which is an asiatic or tropical type variety of radish. In the present study the seeds of experimental plant Raphanus sativus cultivar Japanese white were examined after treated with various concentrations of heavy metals, Cd (cadmium) and Pb (lead) respectively using their salts i. e. cadmium chloride and lead nitrate under laboratory conditions. Gradual decline was observed in seed germination of Raphanus sativus cultivar Japanese white with increase in heavy metal concentrations. It was observed that in control condition the seeds showed maximum (95 - 100%) germination. Whereas treated seeds showed 40% (Cd) and 50% (Pb) germination. Statistically very highly significant differences were observed between the control and various treatments and also among various treatments (concentrations). No such differences were observed among the chemicals.***

Keywords: Heavy metal lead (Pb) and cadmium (Cd), Radish seeds (Raphanus sativus), variety Japanese white, Laboratory experiments, Highly significant

1. Introduction

The radish plant (Raphanus sativus cultivar japanese white) was used as experimental material for the present research work.
The cultivation of radish is done mostly for their edible roots. The roots are fleshy and pungent and can be grown in pots also, especially in the season of winter.

The seed germination of various crop plants has been studied by many workers after treatment with different heavy metals like copper, cadmium, lead, nickel, etc.

The present research work was carried out to evaluate the effect of various concentrations of heavy metals viz. cadmium and lead on the germination of seeds of cultivar Japanese white of Raphanus sativus in laboratory.

Japanese white is an asiatic or tropical variety of radish. It is an introduction from Japan, suitable as a Rabi crop (October - December sowing). The roots are 30 to 45 cm long, cylindrical, pure white, smooth, crispy, mildly pungent and with a blunt end. It is a variety of radish with large deeply cut leaves. It performs better during winters (or when temperature is low).

Heavy metals are hazardous pollutants as they are toxic, often accumulated and even biomagnified by plant parts including seeds and have deleterious biological effects.

2. Material and Methods

For the present research work certified seeds of Raphanus sativus cultivar japanese white were used for evaluation of the effect of heavy metals cadmium and lead respectively on seed germination in laboratory experiments.

Glass stoppered bottles were used to store seeds. For the uniformity in size and colour of the seeds, a preliminary selection was done. Only for two minutes, seeds were surface sterilized with 0.1%HgCl2. Then distilled water was used to wash the seeds repeatedly.

Solutions of different concentrations (10, 50, 100, 200 and 500 ppm) of CdCl2 (cadmium chloride) and PbNO3 (lead nitrate) seeds were soaked for two hours.

Simultaneously seeds were soaked seperately also in distilled water for control treatment. Sixty seeds were soaked in solutions of different concentrations of toxic elements (Cd, Pb) respectively and also in distilled water for constituting the control.

After removing the seeds from solutions and distilled water, seeds were allowed to germination in petridishes on wet filter paper. Three replicates were there for each treatment as well as for control also. Twenty seeds in each of the three repeatations were germinated for ten days. This research work was done under laboratory conditions for ten days in

diffuse light and 25+/ - degree celsius temperature. For everyday progress of seeds, irrigation was performed (with distilled water).

On the 11th day of the experiment, a number of seeds germinated were recorded. The average values of triplicate experiments were recorded and tabulated. For a period of 10 days daily germination progress was recorded. The appearance of a stub through the seed coat was considered as the criterion for seed germination.

The observations of seed germination of the cultivar Japanese white of Raphanus sativus L. were tabulated and data were then analysed statistically employing
F - test at 1% and 5% level of significance.

3. Result and Discussion

For the present investigation an effort has been made to search out the heavy metals (Cd, Pb) impact on seed germination of Raphanus sativus cultivar Japanese white in laboratory experiments.

Cadmium, one of the most toxic heavy metals [7], [9] exerts adverse effects on various plant processes[10].

Lead is a major heavy metal pollutant and adversely affects the growth and development of various crops plants resulting in decline in productivity and even death.

Higher concentrations of heavy metals like Cd (cadmium), Pb (lead) and Hg (mercury) disturb the plant development, yield and biological equilibrium.

Inhibition of seed germination by metallic elements in some pasture plants and various varieties of Phaseolus aureus have been reported [4], [6].

Reduction was found in seed germination of Fagopyrum esculentum due to heavy metals (Hg, Pb and Mn) toxicity [13].

Characteristics of plant species and cultivars, nature of edible parts, age of plants and some environmental factors are concerned with uptake and translocation of cadmium.

Cadmium induced decrease in the seed germination of soyabean and groundnut was observed [2], [12].

The growth of radical of a certain cucurbit cultivar was suppressed, as compared to hypocotyle when treated with cadmium. Nearly all the concentrations of cadmium, used, were hazardous for seedling growth [5].

Observations revealed that increasing concentrations of cadmium nitrate reduced the percentage germination of Phaseolus aureus var. Pusa baisakhi [15].

It was found that increasing concentrations of cadmium reduced the germination process of some plants [14].

The treatment with cadmium chloride significantly reduced the germination in all the experimental crops [16].

In Sorgham sudanense, the sensitivity to heavy metal application was observed in the order of Cd > Pb>Zn [1].

In present research work statistical analysis (Table 1) also proved that there were highly significant differences between control and the treatments and also among various concentrations themselves. Both the heavy metals were almost equally harmful to seed germination because the differences among various heavy metals were found to be insignificant.

Table 1: Showing the effect of heavy metals lead and cadmium on seed germination (%) in Raphanus sativus cv Japanese white

S. No.	Name of the chemic al	Concentrations (ppm)					
		Control	10	50	100	200	500
1.	Cadmium chloride	95	80	70	63.3	53.3	40
2.	Lead nitrate	100	93.3	80	73.3	65	50

(Values represent the mean of three replicates)

Analysis of Variance: F - ratios:
a) Control Vs Treatments = 43.5***
b) Among Treatments = 16.7222***
c) Among Chemicals = - 4.9835 (Ins)
*** = highly significant

A gradual decline was observed in seed germination of Raphanus sativus cultivar Japanese white with increase in heavy metal concentrations. It was observed that in control conditions the seeds showed maximum (95 to 100%) germination whereas treated seeds showed 40% (cadmium) and 50% (lead) germination. The marked reduction in germination of seeds was noticed at 500 ppm concentration of lead and cadmium.

The germination decreased highly from 50 - 500 ppm concentration of lead and from 10 - 500 ppm concentrations of cadmium.

Statistically very highly significant differences were observed between the control and various treatments and also among various treatments (concentrations). No such differences were observed among the chemicals (cadmium chloride and lead nitrate).

4. Conclusion

In present work it was observed that seed germination in the variety Japanese white of Raphanus sativus was adversely affected by the application of both the heavy metals (Cd and Pb). The number of germinated seeds (i. e., germination percentage) reduced with increasing concentrations of cadmium and lead, specially at higher concentrations showing poor germination.

A decrease in seed germination of Raphanus sativus cultivar japanese white, after treatments with different concentrations of heavy metals, viz. Cadmium and Lead in laboratory experiments, may be concerned with some damage to the tissues in seeds due to the toxicity of heavy metals, decreased rate of some metabolic processes like cell division, suppression of those enzymes which are necessary for seed germination and mobilization of reserve food.

Many researchers have revealed the importance of some enzymes during seed germination. The enzyme activity can be influenced highly by the toxic substances present in the polluted waters. During germination the acid phosphatase enzyme plays an important role.

The major factor in the decrease of germination of gram (Cicer arietinum L.) seeds treated with higher concentrations of waste water[3] may be the suppression of enzymes.

Oxidative damage to tissues, enhanced lipid peroxidation, DNA damage and oxidation of protein sulphhydryl groups are some physiological processes that happen due to the toxicity of heavy metals.

In present investigation the inhibitory effects of heavy metals cadmium and lead on seed germination of Raphanus sativus variety Japanese white are in agreement with the earlier reports.

During the course of present research work l came to know that cadmium was toxic to seed germination of Raphanus sativas cultivar japanese white even at low concentration. It has also been reported that cadmium is phytotoxic at extremely low concentration [8].

The resistance of plants to heavy metals is generally obtained either by avoiding themselves from the influence of stress or by tolerating the internal stress by adapting many mechanisms to the hazardous concentrations of heavy metals [11].

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