Nature & Environment
Vol. 21 (2), July 2016: 33-40
Website: www.natureandenvironment.com

ISSN (Print) : 2321-810X
ISSN (Online) : 2321-8738

RESEARCH ARTICLE

# Toxicological Effect of Cadmium Chloride ($CdCl_2$) on Growth and Productivity of *Abelmoschus esculentus* (OKRA)

**Astik Kumar Buts and Manorma Singh**
PG Department of Botany, D.S. College, Aligarh, U.P., India
Email: dr.astikbuts1968@gmail.com

Received: 18th April 2016, Revised: 21st May 2016, Accepted: 27th May 2016

## ABSTRACT

*The experiment was conducted to evaluate the toxicological effect of Cadmium chloride on growth and productivity of Abelmoschus esculentus taking its variety i.e. Azad bhindi- 1. The seeds of Abelmoschus esculentus (Okra) were treated with 0.1%, 0.2%, 0.3%, 0.4% & 0.5% concentration of $CdCl_2$ before sowing in experimental plot and resulting plants were considered as $M_1$ generation. The seeds obtained from $M_1$ generation under different concentration treatment were again treated with corresponding concentration of $CdCl_2$ and shown in the experimental plot to obtain $M_2$ generation. The germination percentage in the field, seedling survival percentage, height of plants, number of pods per plant and weight of 100 seeds showed deleterious effect with increasing the treatment concentration in both generations. However only 0.1% treatment concentration initiate slightly branching process. 0.5% treatment concentration showed 9-14 percentage loss in the 100 seeds weight and 44-49 percentage loss in no. of pods per plant which was maximum. The plants of $M_2$ generation developed little better tolerance at lower concentration treatment. Considering all the parameters taken for study, it clearly showed negative (toxic) impact on overall growth and productivity of Abelmoschus esculentus in comparison to control. The toxic effect increases with increasing the treatment concentration of Cadmium Chloride.*

***Key words:*** *Abelmoschus esculentus, Cadmium chloride, Growth, Productivity*

## INTRODUCTION

India is fruit and vegetables basket of the world. It ranks 2nd in fruits and vegetables production in the world after China. In India, vegetables are cultivated in about 8.495 million hectares while fruits are cultivated in about 6.383 million hectares. Asia leads in the production and availability of vegetables among all continents.

Vegetables are major constituent of human's daily diet. It provides nutritional and economic security producing higher return per unit area and time. Most vegetables are short duration crops and provide very high yield and high economic returns to the farmer.

*Abelmoschus esculentus* (Okra) is one of the most popular, tasty and gelatinous vegetables of Indian diet. It provides carbohydrate, protein, vitamin C, anti-oxidant and contain anti-diabetic properties. Seeds of Okra are a source of oil. Many workers reported medical applications of Okra as a plasma replacement and blood volume expander (kumar *et al*, 2010; Adetuyi *et al*, 2008; Lengsfeld *et al*, 2004).

Many high yielding varieties have been introduced to enhance the productivity of crops. These high yielding varieties are susceptible to many pathogens. Several fungicides and other chemical compounds are used to control pathogens. The use of chemical fertilizer, insecticides, herbicides, pesticides, migration of contaminants to non-contaminated lands and sewage sludge spreading contaminate the ecosystem. The contaminants may include organic and inorganic compounds, oils and tars, heavy metals, explosives and hazardous waste and explosives which in turn have deleterious impact on growth and development of crops.

Several workers have drawn special attention towards toxicological effect of metals on plants, animals and human health. Cadmium is one of the highly dispersed metals by human activities (Kabata-pendias and Dudka, 1990) and highly used in industry and consumer products like

batteries, metal-coating, pigments, plastics etc. Cadmium is a toxic element of primary importance (Brecckle and Kahle, 1992). Lasat (2002) reported that Cd, Cu, Mo, Ni, Pb and Zn have most damaging effect on crops. Many workers have reported inhibitory effect of heavy metals on germination (Morzeck and Funicelli, 1982; Brown and Wilkins, 1986; Shafic and Iqbal, 2005).

Amer and Farah (1985) reported reduction in mitotic index in both physical and chemical mutagens. Pandit and Prasanna (1999) reported reduction in germination and inhibition of root and body development on *Sorghum bicolour* L. exposed to different concentration of cadmium. Yasir and Shahin (2006) reported that increasing concentration of Cadmium inhibit the germination of seeds and growth of roots. The mitotic abnormalities also increased. Muhammad *et al,* (2008) reported the effect of Lead and Cadmium on the germination and seedling growth of *Leucaena leucocephala* and its' tolerance.

Chandra Shekar *et al,* (2011) reported that germination percentage, survival percentage, plant height, root length, pollen viability increases, and total chlorophyll content increases at lower concentration of Cd but higher concentration of Cd showed inhibitory effect.

Buts *et al,* (2011, 2014) reported that Lead nitrate treatment showed decrease in germination percentage, seedling survival percentage, plant height and pod formation in *Lens esculentus* and *Abelmoschus esculentus*

The present study was under taken to evaluate the toxicological effect of Cadmium chloride on growth and productivity of *Abelmoschus esculentus* (Okra) during their whole life cycle up to two generations. Parameters taken for study are percentage germination, seedling survival, height of the plants, no. of branches per plant, days taken for initiation of flowering, period of harvesting, number of pod per plant and weight of seeds in $M_1$ and $M_2$ generations.

## MATERIAL AND METHODS

Seeds of *Abelmoschus esculentus* were procured from Saac Sabji Anusandhan Kendra, Kanpur. Okra is an important member of Malvaceae family. It is polyploid with 2n=8x=72 to 144 chromosomes. Healthy seeds of equal size and shape were selected for treatment with $CdCl_2$. Molecular weight of $CdCl_2$ is 183.32 (Cd=61.32% and Cl=38.68%). Before sowing in the field, seeds were soaked overnight in distilled water. Then soaked 100 seeds were placed in each petri-dishes containing concentration of 0.1%, 0.2%, 0.3%, 0.4% and 0.5% for 6 hours in the laboratory. After treatment, these seeds were allowed to germinate in petri-dishes lined with filter paper and cotton wool. After radicle emergence, these were sown in the experimental field. 100 seeds were soaked in distilled water only for overnight were sown in the experimental field as control. The seeds were sown in lines keeping a distance 75-80 cm between rows. Rows were made in east-west direction to capture sunlight best. Distance between rows provides space for ease in movement during spraying, side dressing, and harvesting. The emergence of hypocotyl and cotyledons above surface of the soil is taken as an index of germination. Regular operation and irrigation was made. Neither chemical nor any fertilizer was used to avoid any confusion. Seeds were shown in first week of July and harvesting was done during period of November. Growth parameters were studied during this period.

After harvesting, collected seeds were stored in glass containers separately. The weight of 100 seeds was taken from control and treated plants, Seeds quality was also observed. The stored seeds of $M_1$ generation were again treated with the corresponding concentrations I.e. 0.1%, 0.2%, 0.3%, 0.4% and 0.5% of $CdCl_2$ by same method as mentioned above for $M_1$generation and sown in the prepared field. Now this generation was considered as $M_2$ generation. The growth parameters as well as productivity were recorded like $M_1$ generation and finally phenotypic variability and productivity were calculated.

## RESULTS AND DISCUSSION

The results obtained in the present experiment have been shown in Table 1 and 2 and Graph 1-5 and expressed together with discussion in separate headings as under:

**Table 1:** Toxicological effect of $CdC_2$ on growth & productivity of *Abelmoschus esculentus* (Okra) in $M_1$ Generation

| Treatment with Cadmium Chloride | Germination (%) in field | Seedling survival (%) in field | Average Height of plant (m) (±SD) | No. of branches per plant | Days taking 1st flowering | Period of harvesting | No. of pods per plant (±SD) | Weight of 100 seeds (gram) (±SD) |
|---|---|---|---|---|---|---|---|---|
| Control | 90 | 84 | 1.2±0.15 | Nil | 48-55 | 56-113 | 18.1 ± 3.36 | 5.384± 0.09257 |
| 0.1% | 88 | 78 | 1.1±0.20 | 0.02±0.03 | 50-57 | 59-113 | 14.1± 3.34 | 5.338± 0.14649 |
| 0.2% | 84 | 75 | 1.0±0.27 | Nil | 50-57 | 59-113 | 13.35± 3.0 | 5.233± 0.17796 |
| 0.3% | 80 | 70 | 1.0±0.21 | Nil | 50-57 | 59-113 | 12.31±2.84 | 5.226± 0.12096 |
| 0.4% | 75 | 62 | 1.0±0.096 | Nil | 50-57 | 59-113 | 10.3 ±2.84 | 5.198± 0.11528 |
| 0.5% | 68 | 55 | 0.81±0.12 | Nil | 50-57 | 59-113 | 9.3±3.34 | 4.896± 0.06557 |

**Table 2:** Toxicological effect of $CdC_2$ on growth & productivity of *Abelmoschus esculentus* (Okra) in $M_2$ Generation

| Treatment with Cadmium Chloride | Germination (%) in field | Seedling survival (%) in field | Average Height of plant (m) (±SD) | No. of branches per plant | Days taking 1st flowering | Period of harvesting | No. of pods per plant (±SD) | Weight of 100 seeds (gram) (±SD) |
|---|---|---|---|---|---|---|---|---|
| Control | 100 | 80 | 1.1±0.13 | Nil | 48-55 | 57-120 | 18.42±3.14 | 5.346± 0.10995 |
| 0.1% | 84 | 78 | 1.0±0.13 | 0.02±0.02 | 48-55 | 57-120 | 16.21 ± 3.34 | 5.433± 0.06603 |
| 0.2% | 84 | 76 | 1.0±0.18 | Nil | 52-59 | 61-120 | 15.47±2.56 | 5.345± 0.11283 |
| 0.3% | 78 | 68 | 0.97±0.16 | Nil | 52-59 | 61-120 | 14.37±4.11 | 5.196± 0.14734 |
| 0.4% | 70 | 60 | 0.91±0.21 | Nil | 52-59 | 61-120 | 12.16 ±2.69 | 4.864± 0.14367 |
| 0.5% | 68 | 57 | 0.84±0.16 | Nil | 52-59 | 61-120 | 10.32±2.86 | 4.60± 0.12288 |

**EFFECT $CdCl_2$ ON SEED GERMINATION**

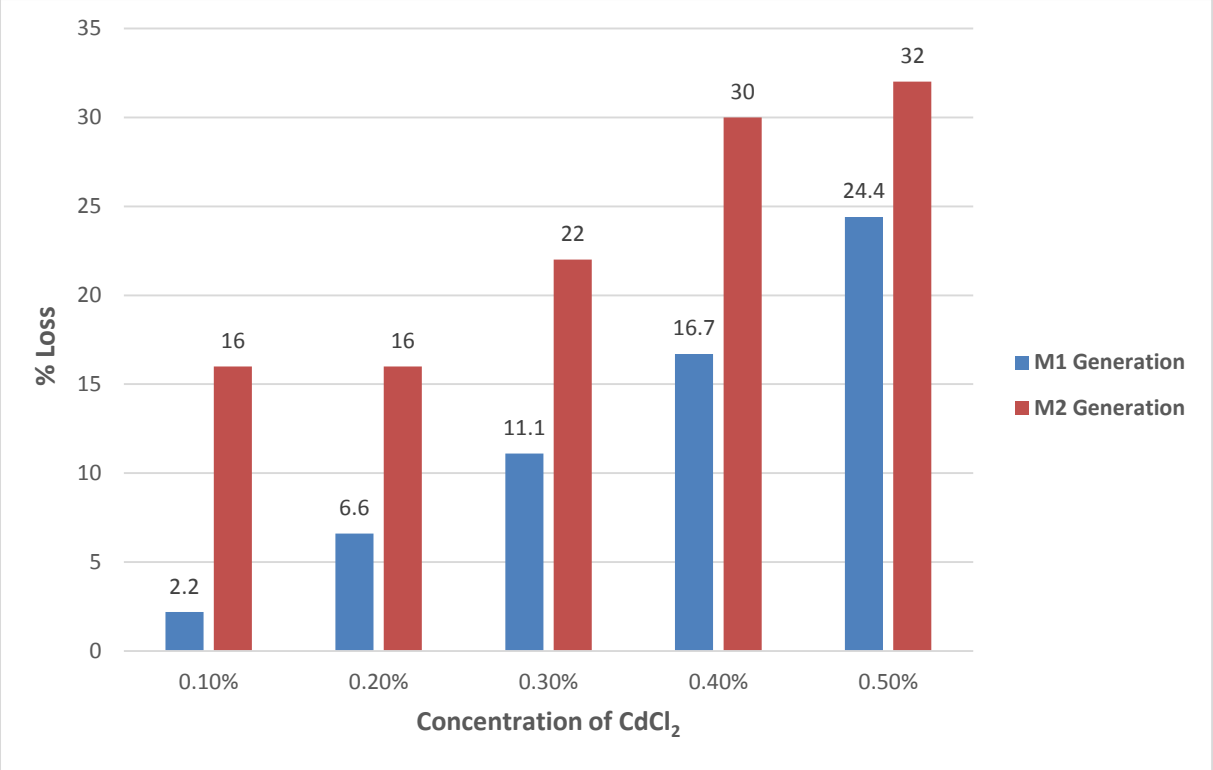
The average seed germination of Azad bhindi-1 are 88%, 84%, 80%, 75% & 68% in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration respectively in comparison to 90% under control in $M_1$ generation. The average seed germination of Azad bhindi-1 are 84%, 84%, 78%, 70% and 68% in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration respectively in comparison to 100% under control in $M_2$ generation.

Thus the observation clearly indicate that Cadmium chloride adversely affect the seed germination in both generation. The reduction in seed germination is gradual as per increase in treatment concentration of cadmium chloride (Graph 1).

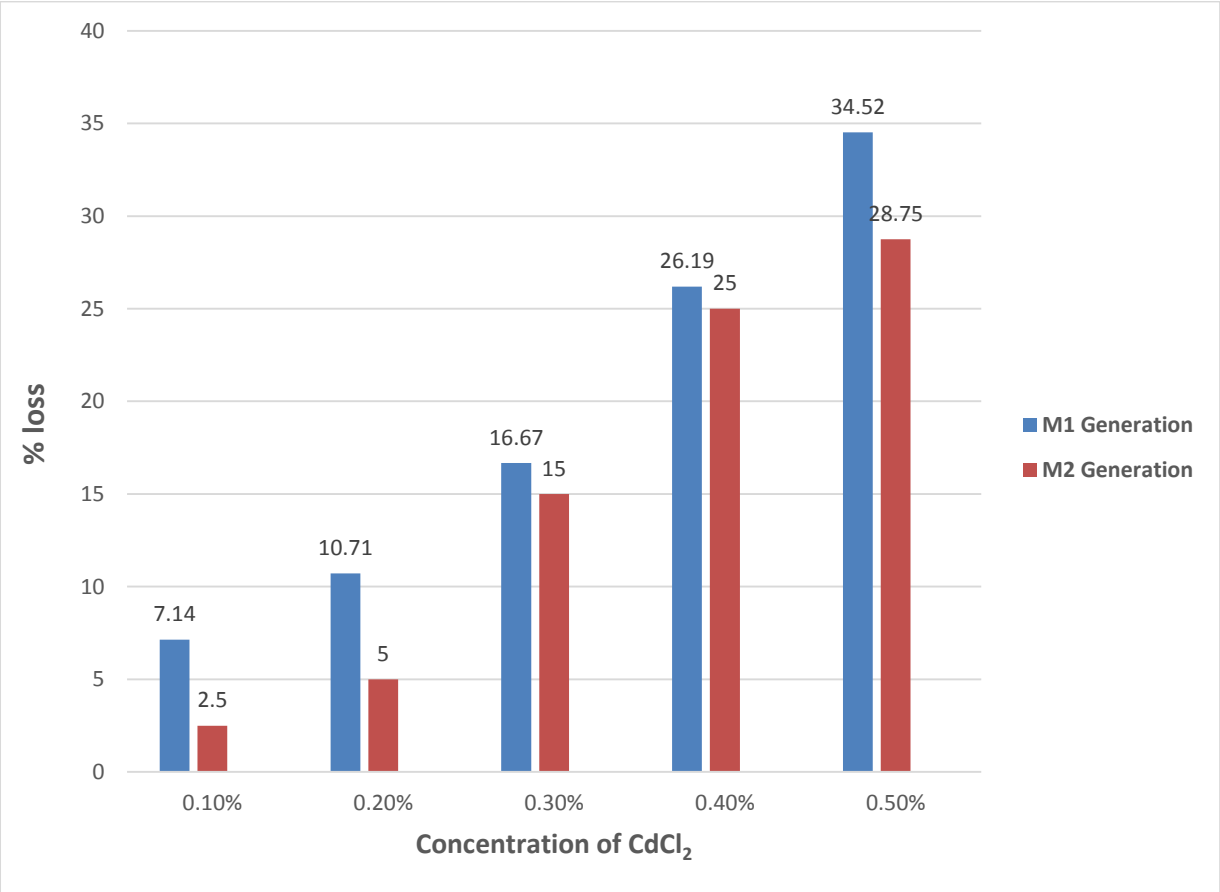
**EFFECT OF $CdCl_2$ ON SEEDLING SURVIVAL**

The average seedling survival of are 78%, 75%,70%, 62%, and 55% in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration respectively in comparison to 84% under control in $M_1$ generation. In $M_2$ generation, the seedling survival are 78%, 76%, 68%, 60% and 57% in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration respectively in comparison to 80% under control.

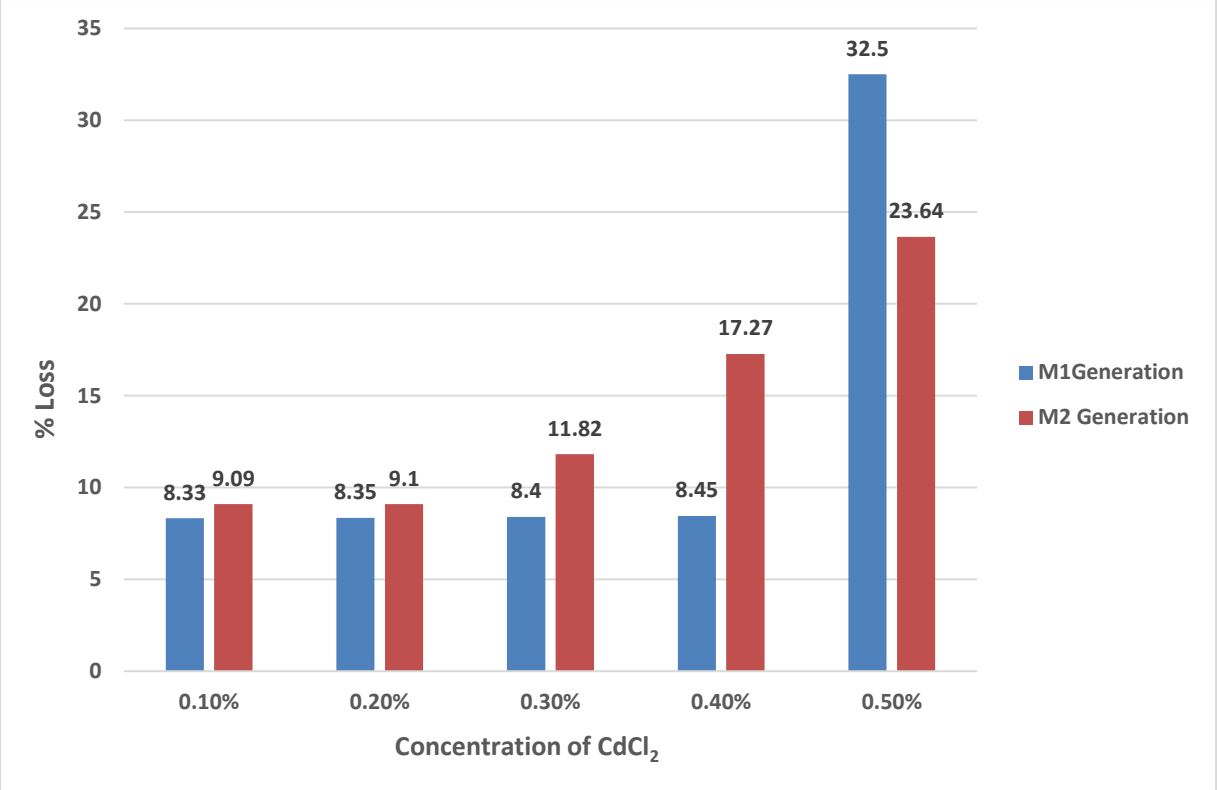
Thus, there is a reduction in the seedling survival with increasing the treatment concentration in both generations which are much significant in higher concentration treatment. The 0.5% $CdCl_2$ reduces seedling survival up to 43% which shows its' detrimental effect significantly (Graph 2).



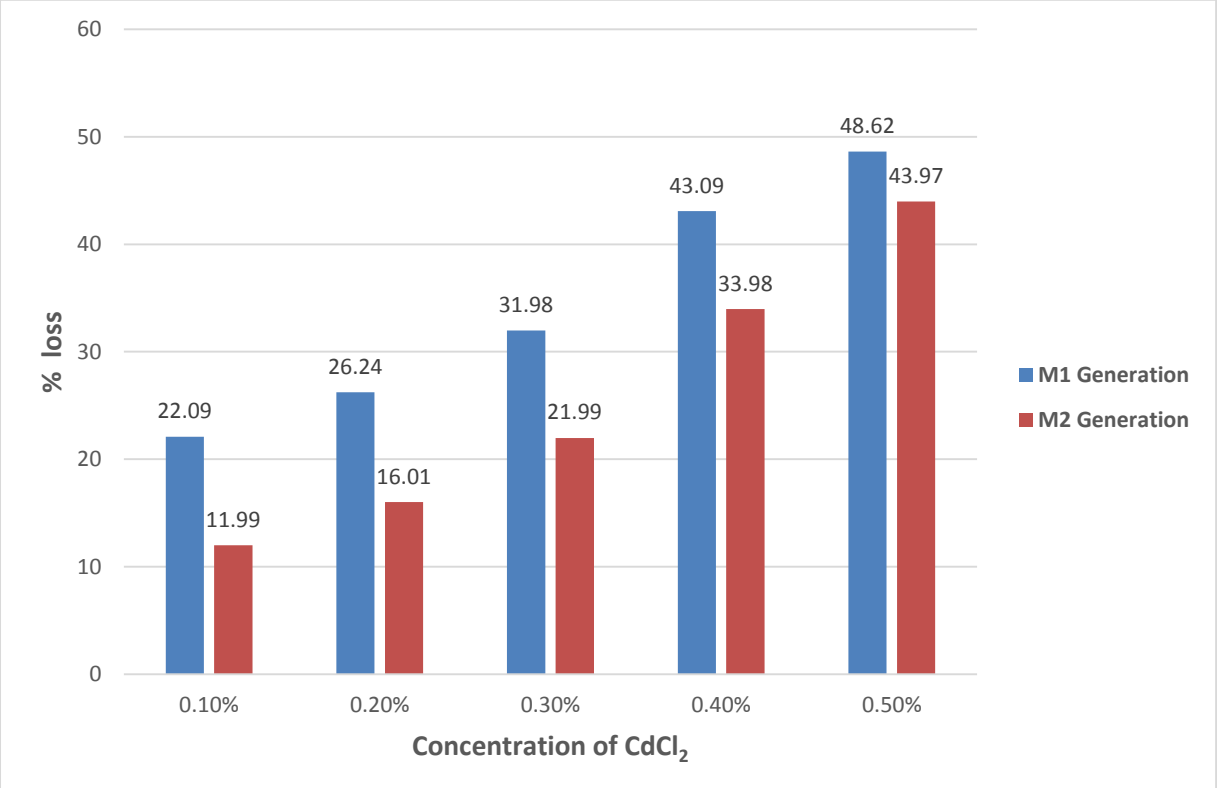

**Graph 1:** Average Seed Germination (loss or gain)



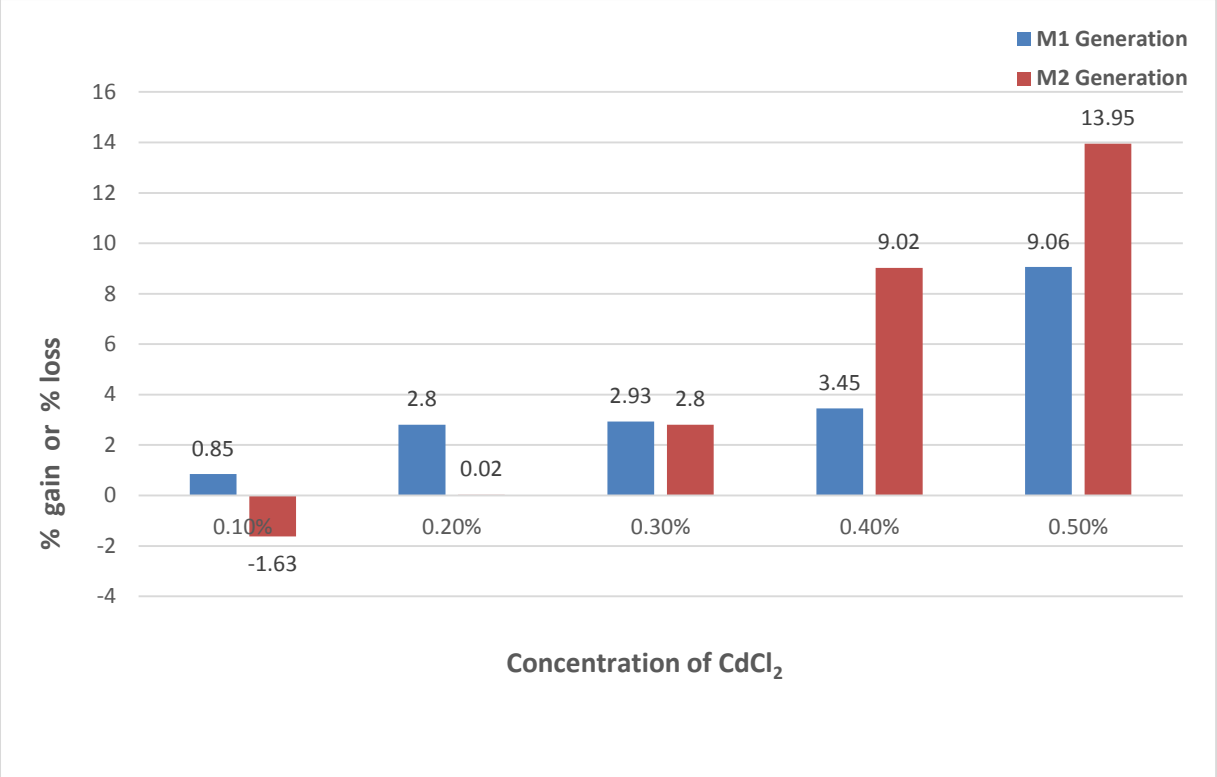

**Graph 2:** Seedling Survival in Field (loss or gain)




**Graph 3:** Average Height of plants (loss or gain)




**Graph 4:** Average no. of pods per plant (loss or gain)




**Graph 5:** Average weight of 100 seeds (gain or loss)

**EFFECT OF $CdCl_2$ ON HEIGHT OF PLANTS**

The plant height was recorded at the time of its maturity of all plants. It was measured from ground level to the point of peduncle and expressed in meter. The average plant's heights are 1.10m, 1.0m, 1.0m, 1.0m and 0.81m in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration respectively in comparison to 1.2m under control in $M_1$ generation. In $M_2$ generation, the average height of the plants are 1.0m, 1.0m, 0.97m, 0.91m and 0.84m in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration respectively in comparison to 1.1m under control.

Thus all treatment concentrations adversely affect the plant height but it is very significant in 0.5% treatment concentration where reduction of the average height are 32.5% and 23.6% in $M_1$ and $M_2$ generation respectively in comparison to control. It indicates development of a little better tolerance towards $CdCl_2$ toxicity (Graph 3).

**EFFECT OF $CdCl_2$ ON NUMBER OF BRANCHES**

Only 0.1% treatment concentration of $CdCl_2$ induced a few branches in both generations which are 0.05 & 0.02 in $M_1$ and $M_2$ generation respectively. Therefore, lower than 0.1% treatment concentration of $CdCl_2$ may further be investigated for branching process. The treatment concentration more than 0.1% of $CdCl_2$ has no effect on branching process in okra.

**EFFECT OF $CdCl_2$ ON INITIATION OF FLOWERING**

Initiation of first flowering is delayed for 2-2 days in all treatment concentration in $M_1$ generation in comparison to control. In $M_2$ generation, it is delayed for 4-4 days in 0.2%, 0.3%, 0.4% and 0.5% treatment concentration in comparison to control. It indicates development of a little tolerance in 0.1% treatment concentration in $M_2$ generation.

**EFFECT OF $CdCl_2$ ON PERIOD OF HARVESTING**

The period of harvesting was shrink for 3-4 days in both generations among treated plants. More or less there is no significant effect on survived plants regarding period of harvesting up to 0.5% treatment concentration.

**EFFECT OF $CdCl_2$ ON PODS PER PLANT**

The average number of pods per plant are 14.1, 13.35, 12.31, 10.3 and 9.3 in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration in comparison to 18.1 under control in $M_1$ generation. In $M_2$ generation, these are 16.21, 15.47, 14, 37, 12.16 and 10.32 in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration in comparison to 18.42 under control.

Above observations clearly indicate the reduction of 22.09%, 26.24%, 31.98%, 43.01% and 48.62% pods per plant in 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration in comparison to control in $M_1$ generation. Similarly, there is a reduction of 11.99%, 16.01%, 21,99%, 33.98% and 48.62% pods per plant in 0,1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration of $CdCl_2$ in $M_2$ generation.

Thus, the productivity of *Abelmoschus esculentus* is drastically reduced under the stress of $CdCl_2$. With increasing the treatment concentration, reduction in productivity also increases. The toxic effect of $CdCl_2$ is so pronounced that production reduced up to 48.62% and 43.97% under the stress of 0.5% treatment concentration in $M_1$ and $M_2$ generation respectively. However, development of tolerance towards the stress is noticed in $M_2$ generation (Graph 4).

**EFFECT OF $CdCl_2$ ON WEIGHT OF 100 SEEDS**

The average weight of 100 seeds are 5.338 gm, 5.233 gm, 5.226 gm, 5.198 gm, and 4.896 gm in $M_1$ generation and 5.433 gm, 5.345 gm, 5.196 gm, 4.864 gm and 4.6 gm in $M_2$ generation under the stress of 0.1%, 0.2%, 0.3%, 0.4% and 0.5% treatment concentration of $CdCl_2$ while it is 5.384 gm and 5.346 gm under control in $M_1$ and $M_2$ generation respectively.

Thus average weight of seeds also showed reducing trend with increasing the treatment concentration in both generations. However, there is a development of tolerance up to 0.3% treatment concentration in $M_2$ generation but losses are more in $M_2$ generation in 0.4% and 0.5% treatment concentration as it is 3.45% & 9.06% in $M_1$ and 9.02% & 13.95% in $M_2$ in comparison to control (Graph 5).

On the basis of the observations recorded in present investigation, it may be concluded that Cadmium chloride is highly toxic for the growth and yield of *Abelmoschus esculentus.* All the treatment concentration taken for study affect the growth and yield. However up to 0.3% treatment concentration, the losses occurred in $M_1$ generation is slightly recovered in $M_2$ generation probably due to development of tolerance towards the stress of $CdCl_2$.0.4% & 0.5% treatment concentration not only adversely affect the growth parameters taken for study rather it also reduce productivity up to 48%. This happens under single dose treatment in each generation. Therefore, $CdCl_2$ is highly toxic for okra and it may enter in human body through bio-accumulation and affect human health.

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