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ARTICLE

INHIBITORY EFFECT OF CADMIUM ON GERMINATION AND GROWTH OF *CAPSICUM ANNUM* VAR. *VELLAYANIATHULYA*

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Abstract

Various biotic and abiotic environmental stresses affect the normal growth and development of plants. Cd is one of the abiotic stresses which cause concern due to its toxicity to plants, animals and human beings. A study was conducted on the effect of heavy metal cadmium (Cd) on germination and seedling Growth of *Capsicum annuum* (L.) var. *vellayaniathulya*. Seeds of C.annuum were obtained from Agriculture College of Kerala Agricultural University, Thiruvananthapuram. Three replicates of seeds treated with different concentrations of cadmium chloride (10mM, 20mM, 30mM, 40mM and 50mM) and control were maintained. The effect of different Cd concentrations on germination, seedling length, plant height, number of leaves were studied at different intervals. Eventhough Cd had a stimulatory effect on seed germination at lower concentration, at higher concentrations, it inhibited seed germination. There were significant differences in seedling length, plant height and number of leaves in *Capsicum annuum* plants in relation to Cd stress.

Keywords: Cadmium, *Capsicum annuum*

Introduction

Pollution caused by heavy metals is a serious problem in the world. In the case of plants, it results in growth retardation or at elevated concentrations, the death of the plant. Retardation may be attributed to alterations in biochemical processes (eg. Seed germination, Inhibition of enzyme activity, impaired nutrition, generation of reactive oxygen species etc.) (Arun et al., 2005). Elevated levels of Cd in soil causes a range of plant responses like chlorosis, necrosis, stunted growth, delayed flowering and fruit set, reduced biomass and even death (Hernandez and Cooke, 1997; Shamsi et al., 2008)).

Cadmium is a highly mobile metal which can be easily absorbed by plant roots and transported to various parts of the plant (Sanita di Toppi and Gabbrielli, 1999) and enters the food chain causing risk to human being (Ryan et al., 1982). It has neurotoxic, mutagenic and carcinogenic effects. The extent of metal toxicity depends on various factors such as concentration of metal pollutant, period of exposure and the various biological processes (Kabir et al., 2008). Germination and growth in early stages are the important events in the life of plants. Rascio et al., (1993), reported that Cd limits the processes of growth, germination and development of maize seedlings. Jun- yu et al., (2008) reported that in rice, Cd inhibits radicle and plumule growth. According to Vijayaragavan et al., (2011), germination and development of seedlings of cow pea (Vigna unguiculata L.) was adversely affected by cadmium chloride. Rate of seed germination was not affected significantly by Cd in pea (Ravi et al., 2011). The study conducted by Mousa et al., (2011) revealed that germination rate and seedling growth of Milk thistle (Silybum marianum) was affected by Cd. Kumar et al., (2012), reported a reduction in biomass in chick pea (Cicer arietinum L.) by Cd toxicity. Subin and Steffy (2013) in their study in Cucurbita maxima found that Cd2+ inhibits seed germination and seedling growth.

After long-term exposure to cadmium, reduction of shoot and root elongation, rolling of leaves and chlorosis can occur. Cd was found to inhibit lateral root formation along with the main root became brown, rigid and twisted (Krantev et al., 2008 and Yadav, 2010). Plant growth and yield was negatively affected and delayed at higher Cd concentrations (Schmidt, 2003). Cd has been shown to affect the uptake, transport and use of several elements like Ca, Mg, P and K and also water in plants (Das et al., 1997).

Materials and Methods

Experimental Plant

Capsicum annum (L.) var. Vellayani athulya was the plant selected for the study. This is a green chilli variety with light green, medium pungent fruits having excellent fruit quality. Seeds of C. annum were obtained from Agriculture College of Kerala Agricultural University, Thiruvananthapuram, India. Seeds with uniform size and colour were selected for the study.

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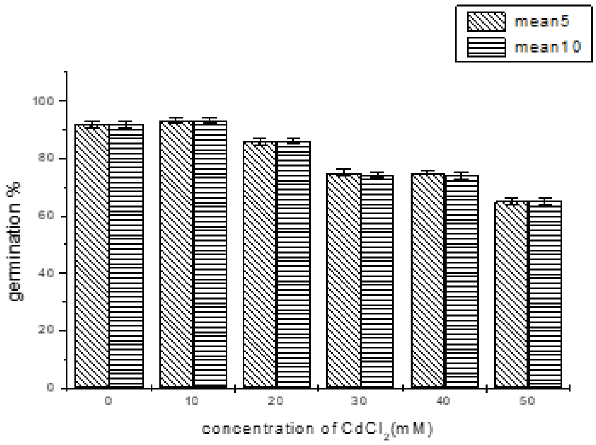

Figure 1 - Effect of $CdCl_2$ on percentage of germination in *C. annum*

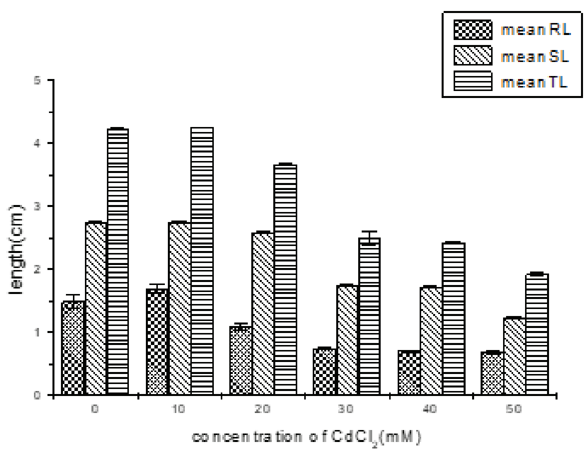

Figure 2 - Effect of $CdCl_2$ on root length (RL), shoot length (SL) and seedling length (TL) (10DAG)

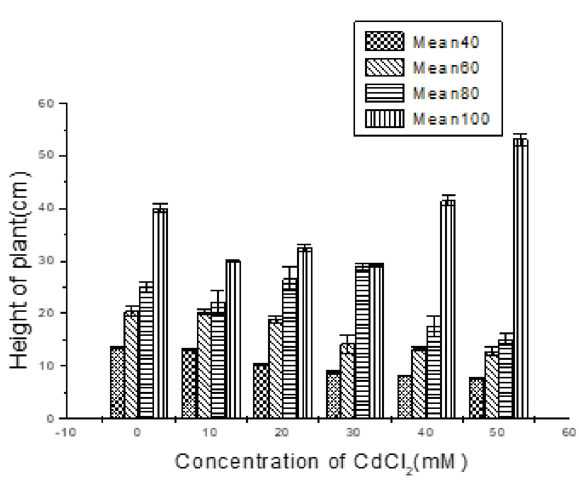

Figure 3 - Effect of $CdCl_2$ on plant height

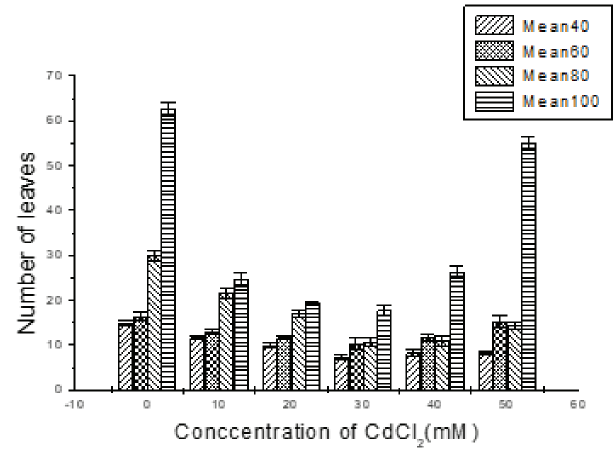

Figure 4 - Effect of $CdCl_2$ on number of leaves in *C. annum*

Morphological studies

Germination studies

Uniform sized seeds were surface sterilized with 0.1% mercuric chloride solution and then washed in distilled water. They were sown in sterile petridishes (15cm) which contained sterile cotton moistened with distilled water and different concentrations of cadmium chloride (10 mM, 20 mM, 30 mM, 40 mM and 50 mM) and designated as T1, T2, T3, T4 and T5 respectively. Seeds soaked with distilled water were taken as control and was designated as T0. Three replicates of each of these concentrations along with control were maintained. 25 seeds were placed in each petridish. The effect of different Cd concentrations on germination and growth was evaluated in terms of percentage (%) of germination, seedling vigor, and tolerance index (T1). The percentage germination of seedlings after 5 days and 10 days were calculated. Seedling length, plant height, number of leaves, relative water content were studied.

Results

Effect on Germination

Seed germination was significantly affected by Cd concentration in 5 days after sowing (DAS) and also in 10 DAS. The germination per cent ranged from 65 ± 1.15 to 93.33 ± 0.66 Maximum germination was in plants treated with 10 mM CdCl2 concentration and minimum in plants treated with 50 mM (Fig 1). At lesser concentrations (10 mM), Cd has a stimulatory effect on germination. As the concentration of CdCl2 increased, germination rate decreased

Effect on seedling length

Root length, shoot length and seedling length were significally affected with increase in concentration of CdCl2. Root length ranged from 0.69 ± 0.02 to 1.7 ± 0.06; shoot length from 1.24 ± 0.02 to 2.75 ± 0.02 and seedling length from 1.93 ± 0.02 to 4.26 ± 0.01 to . Plants treated with 10mM concentration showed greater root length and seedling length (Fig 2). However, after 10 mM concentration, root length and seedling length was observed to decrease with increase in concentration. Shoot length was same for control and 10 mM treated plants. After that, shoot length decreased with increased $CdCl_2$ concentrations.

Effect on plant height

As per the results, plant height showed significant differences among the different groups (Fig 3). Plant height ranged from 7.60 ± 0.26 to 13.42 ± 0.23 in 40 DAG plants, from 12.76 ± 0.85 to 20.40 ± 0.95 in 60 DAG plants, from 15.16 ± 1.24 to 29.00 ± 0.61 in 80 DAG plants and from 29.30 ± 0.35 to 53.20 ± 1.16 in 100 DAG plants. In 40 DAG and 60 DAG plants, maximum plant height was noticed in control plants and minimum in T5 plants. However, in 80 DAG plants, maximum and minimum plant heights were noticed in T3 and T5 plants respectively. In 100 DAG plants, plant height was maximum for T5 plants and minimum for T3 plants.

Effect on number of leaves

Number of leaves also varied significantly (Fig 4)) among the control and test plants as the concentration of Cd increased. Number of leaves ranged from 7.33 ± 0.66 to 15.00 ± 0.58 in 40 DAG plants, from 10.33 ± 1.20 to 16.33 ± 0.88 in 60 DAG plants, from 10.66 ± 0.88 to 30.00 ± 1.15, in 80 DAG plants and from 17.66 ± 1.20 to 62.66 ± 1.45 in 100 DAG. Maximum leaves were observed in control plants and minimum leaves in plants treated with 30 mM CdCl2 concentration. After that, an increase in the number of leaves was noticed.

Discussion

Cd at higher concentrations decreased the per cent of seed germination. However at lower concentration (10mM), Cd had a stimulatory effect on seed germination. Stimulatory effect of Cd at lower concentrion has been reported earlier by Wu and Zhang (2002) in barley; Sreedevi et al. (2008) in black gram. Breckle and Kahle (1992) reported that reduction in seed germination may be due to the interference and alterations in the cell membrane properties by Cd stress, which resulted in reduced water absorption and transport. According to Shafiq et al., (2008) decrease in seed germination can be attributed to the accelerated breakdown of stored food materials in seed as a result of Cd stress. Similar results were reported by Titov et al. (1996), Jun- Yu et al. (2008) and Aydinalp and Marinova (2009).

Although Cd initially had a stimulatory effect on root length, shoot length and seedling length at lower concentrations (Wu et al., 2002; Chen et al., 2011), root, shoot and seedling length were significantly affected among the control and test plants, as the Cd concentrations increased. The results revealed that the reduction in growth may be either due to reduced meristamatic activity or the inhibitory effect of Cd on the activities of hydrolytic enzymes contained in the cotyledon and thus prevent the mobilization of stored food materials to radicle and plumule for the growth of seedling (Shafiq et al., 2008). According to Mostafa and Semin (2011), reduction in growth in Cucurbita maxima may be because of accelerated breakdown of stored food material in seed due to Cd stress.

The significant difference in plant height and number of leaves among control and treated plants were due to the breakdown of normal physiological mechanism (Bahmani et al., 2012).

Conclusion

From the above studies, it can be concluded that although at lower concentrations, Cd stimulates seed germination, at higher concentrations, it inhibits seed germination. It may be due to the change in water absorption rate or due to the accelerated breakdown of stored food materials in seed as a result of Cd stress. There were significant differences in seedling length, plant height and number of leaves in *C. annum* plants in relation to Cd stress.

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