RESEARCH ARTICLE

Effect of Cadmium on Germination and Seedling Growth of *Cicer arietinum*, Cv.G130

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Abstract

Heavy metals contamination in agriculture, especially near industrial areas, is very common, and they are toxic and harmful to for the growth of plants. Biologically, cadmium (Cd) is a non-essential element for plants and it reduces the germination and seedling growth of *Cicer arietinum*. In the present study effects of different cadmium chloride concentrations (1, 10 and 50 mg^{-1}) were investigated on seedling growth of *C. arietinum*, L cv. G130. The seedling growth studies were carried out in dark and light conditions. Germination percentage was recorded after 24 hours for both dark and light conditions. During the observation, it was found that the higher concentration of cadmium, particularly 50 mg^{-1}, significantly reduced plant growth. The length of epicotyl and radicle shows gradual inhibition as the cadmium concentration is increased from 10 to 50 mg^{-1} Cd. Similarly, fresh weight and dry weight also decreased with the increased cadmium concentrations. It was noted that the higher concentration of Cd inhibited plant growth and the lower metal concentration showed of plant growth promotion. However, studies reveal that the growth is promoted in 1 mg^{-1} Cd concentration (1 ppm). Results confirmed cadmium's toxic effect on chickpea seedling growth at higher concentrations.

Keywords: Cadmium chloride, *Cicer arietinum*, Germination.

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Introduction

Contamination of heavy metals in an agricultural field near about industries is a serious matter. The use of fertilizers and pesticides, the deposition and combustion (burning) of trash, traffic, and industrial and mining activities are examples of anthropogenic sources of soil pollution with cadmium. For plants, cadmium is a non-essential element. It has significant toxicity and high-water solubility (Nikolić *et al.*, 2014). Cadmium is a non-essential element for plants (Iqbal and Shazia, 2004; Garafalo Chafres *et al.*, 2011). Cadmium causes reduction in the seed germination, root and shoot growth (Vijayaragavan *et al.*, 2011) of plants. It also affects plant parts' chlorophyll and proline content (Tantrey and Agnihotri, 2010). As yet, it has been demonstrated that Cd has no biological function in plants (Souguir *et al.*, 2011). According to reports, many cereals, potatoes, legumes, vegetables, and fruits acquire Cd, and people consume at least 70% of the Cd that comes from plant-based food. (Wagner, 1993). The harmful effect of another heavy metal lead on growth and development of rice also been studies. (Neha Saini *et al.*, 2017)

The chickpea is a member of the Fabaceae (Leguminosae) family, the Faboideae (Papilionaceae) subfamily, the Cicereae tribe, and the Cicer genus, (Sajja *et al.*, 2017). It was developed in southeast Turkey. The Latinized version of the Greek word "kikus," which means "power" or "strong," gave rise to the name Cicer. Chickpea is an herbaceous annual plant with branches that grow from the base. With its dispersed, spreading branches, it resembles a little bush. The majority of the plant's surface is covered in glandular or non-glandular hairs. However, other genotypes are hairless. (Maesen 1987).

This study aimed to examine how cadmium treatment affected seed germination and seedling growth of *C. arietinum*, Linn cv. G 130.

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Conflict of interest: None

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Material and methods

To study the effect of cadmium on seedling growth of *C. arietinum*, Linn cv. G130, experiments were performed with different concentrations (1, 10 and 50 mg-1), of cadmium. Seeds were chosen based on uniformity criteria for investigations on seed germination and seedling growth (size and colour of seeds). The seeds were properly cleaned before being surface sterilized with 0.1% mercuric chloride and kept in different concentration solutions of Cadmium sulfate for 24 hours. One set of surface sterilized seeds kept in distilled water simultaneously for respective hours constituted the experiment's control sets. The seeds were washed for seed germination and seedling growth and transferred to moist filter paper in Petri plates. The seedling growth studies were carried out in dark & light conditions. The germination percentage was recorded after 24 hours. For seedling growth, samples were analyzed on 3rd, 5th and 7th day of radicle emergence. The seedlings were dissected into radicle, epicotyl and cotyledon parts. The seedlings' fresh

Table 1: Effects of different concentrations of cadmium on *C. arietinum*'s linn. Cv. G130 rate of germination, grown in light & dark

	Concentration of cadmium (mg/lt)			
	0	1	10	50
Cultivar	*In light*			
	82.0	86.0	78.0	74.0
G130	*In dark*			
	80.0	84.0	76.0	70.0

weight and dried weight parts were also recorded in length. The fresh weight and dry weight of the remnant cotyledons were measured.

Results

According to obtained data, a higher concentration of cadmium is inhibitory and a lower concentration is the promoter for seedling development and germination (*C. arietinum*, Linn cv. G 30). It has been noted that the growth is encouraged at 1-mg-l Cd content during the study period (1 ppm) (Fig. 1).

Tables 1-3 show the effect of different concentrations of cadmium on germination and subsequent seedling growth of *C. arietinum*, Linn cv. G130 both in light and dark both.

Germination

Results show that there is some promotion of germination percentages at lower concentrations and inhibition at higher concentrations of cadmium. Thus, in 1 mg-l Cd concentration, germination percentage is promoted in both dark& light. Whereas germination percentage in higher cadmium concentrations i.e., 10 mg-l Cd and 50 mg-l Cd, is inhibited by ca. 5 and 10% to control, respectively in cv. G130 grown seed in light. It has been found in other studies that the effect of toxicity of Cd on seed germination, seedling growth, the structural orientation of vascular tissues and photosynthetic pigment content in chickpeas. (Mondal et. al., 2013). The present study was conducted in dark and light (Tables 1-3 and Fig. 1).

Seedling growth of *C. arietinum* in the dark

The result shows that the low concentration of Cd which is 1 mg-l is promotional. Beyond that it is inhibitory to seedling growth at all other higher concentrations. However, the extent of inhibition being more at higher concentrations. In 1 mg-l Cd concentration on 5th day, radicle length is 133.3% of control, while epicotyl length is 120.8% of the control. Thus, the extent of promotion seems to be more in radicle than epicotyl. The length of both epicotyl and radicle also shows that there is a gradual inhibition as the Cadmium concentration is increased from 10mg-l Cd to 50 mg-l Cd. Thus, on the 5th day, radicle length is 86.1% and 80.6% of the control, respectively in 10 and 50 mg-l Cd concentrations. Similarly, inhibition in fresh weight was also observed in all the higher Cadmium concentrations; however, the extent of inhibition varies with organ. Thus, on 5th day radicle fresh weight is 85.7% and 71.4% of control, respectively in 10 and 50 mg-1 Cd concentration (Tables 1-3 and Fig. 1).

Seedling growth of *C. arietinum* in light

Under the condition of light, the result again shows that the seedling growth of pretreated seeds in 1-mg-1 cadmium is promotional, while all other higher concentrations of cadmium shows inhibition in the growth. However, the extent of inhibition increases with increase in Cadmium concentration. Thus, in 1-mg-l Cd concentration, the length of radicle and epicotyl in light-grown seedling is 121.5 and 133.3% of control, respectively

Table 2:. Effect of 24 hours pretreatments of seed with different concentrations of cadmium on the growth of *C. arietinum*, linn. Cv. G130, seedling grown in dark

CONCENTRATION OF CADMIUM, mg/lit												
	0			1			10			50		
DAYS AFTER RADICLE EMERGENCE												
	3	5	7	3	5	7	3	5	7	3	5	7
LENGTH, cm ± SD												
Radicle	2.60 + 0.60	3.60 + 0.60	4.80 ± 0.28	3.80 ± 0.28	4.80 ± 0.28	5.80 ± 0.45	2.50 ± 0.24	3.10 ± 0.45	4.00 ± 0.88	2.00 ± 0.66	2.90 ± 0.28	3.75 ± 0.29
Epicotyl	3.80 ± 0.60	4.80 ± 0.80	5.40 ± 0.80	4.80 ± 0.38	5.80 ± 0.30	6.80 ± 0.80	3.00 ± 0.48	3.80 ± 0.30	4.86 ± 0.30	2.80 ± 0.30	3.20 ± 0.30	4.00 ± 0.40
FRESH, WEIGHT, mg ± SD												
Radicle	10.80 ± 1.00	14.00 ± 2.00	20.00 ± 2.00	12.60 ± 1.60	16.80 ± 2.00	26.60 ± 3.00	8.60 ± 0.80	12.00 ± 0.70	16.80 ± 1.80	7.00 ± 0.60	10.00 ± 1.60	14.00 ± 1.80
Epicotyl	16.80 ± 1.80	26.00 ± 1.32	30.60 ± 1.80	20.50 ± 1.10	30.80 ± 1.80	36.50 ± 0.80	14.40 ± 1.10	24.00 ± 9.32	28.00 ± 2.50	12.40 ± 0.60	20.00 ± 1.48	23.00 ± 2.10
DRY WEIGHT, mg ± SD												
Radicle	3.00 ± 0.10	4.00 ± 0.40	5.40 ± 0.30	3.80 ± 0.16	4.60 ± 0.24	6.60 ± 0.26	2.60 ± 0.08	3.10 ± 0.18	4.80 ± 0.26	2.00 ± 0.08	2.60 ± 0.18	3.86 ± 0.40
Epicotyl	6.00 ± 1.30	8.00 ± 1.10	10.60 ± 1.02	8.00 ± 1.05	10.00 ± 1.80	12.00 ± 1.10	5.00 ± 0.90	7.00 ± 0.88	10.00 ± 1.18	5.00 ± 0.80	6.60 ± 0.70	8.00 ± 0.40

Table 3: Effect of 24 hours pretreatments of seed with different concentrations of cadmium on the growth of *C. arietinum*, linn. Cv. G130, seedling grown in light

SEEDLING PART	*CONCENTRATION OF CADMIUM*											
	0			1			10			50		
DAYS AFTER RADICLE EMERGENCE												
	3	5	7	3	5	7	3	5	7	3	5	7
LENGTH, cm ± SD												
Radicle	3.40 ± 0.80	5.10 ± 0.40	6.60 ± 0.20	4.60 ± 0.60	6.20 ± 0.30	8.60 ± 0.30	3.00 ± 0.30	4.40 ± 0.80	6.00 ± 0 .40	2.00 ± 0.60	3.80 ± 0.80	5.00 ± 0.40
Epicotyl	4.60 ± 0.80	6.00 ± 0.80	7.60 ± 0.40	6.00 ± 0.40	8.00 ± 0.60	10.00 ± 0.50	3.80 ± 0.20	5.00 ± 0.40	7.00 ± 0.80	2.40 ± 0.60	4.60 ± 0.45	6.00 ± 0.20
FRESH, WEIGHT, mg ± SD												
Radicle	14.80 ± 0.60	20.25 ± 2.00	28.10 ± 2.30	20.42 ± 2.10	26.30 ± 2.30	36.00 ± 2.40	12.10 ± 0.20	18.30 ± 0.40	26.70 ± 2.54	10.38 ± 0.60	16.40 ± 0.43	24.40 ± 8.30
Epicotyl	20.40 ± 1.60	28.00 ± 3.70	40.00 ± 4.26	26.80 ± 2.25	37.20 ± 4.30	46.40 ± 4.40	18.10 ± 2.00	26.40 ± 2.60	36.50 ± 4.20	16.20 ± 0.80	20.20 ± 2.40	30.30 ± 3.00
DRY WEIGHT, mg ± SD												
Radicle	4.00 ± 0.60	6.00 ± 0.80	7.00 ± 0.40	5.00 ± 0.60	6.40 ± 0.40	8.00 ± 0.30	3.00 ± 0.60	5.00 ± 0.40	6.70 ± 0.80	2.80 ± 0.60	4.20 ± 0.60	5.00 ± 0.60
Epicotyl	6.60 ± 0.40	9.00 ± 0.30	10.10 ± 0.80	7.30 ± 0.40	8.40 ± 0.30	10.50 ± 0.40	4.40 ± 0.40	6.60 ± 0.30	8.00 ± 0.50	4.80 ± 0.60	6.20 ± 0.60	8.20 ± 0.40

on 5th day of germination. Likewise, at the same day these values in 50 mg-l Cd concentration are ca. 74 and 83% in light-grown seedling as compared to control. Table also shows that like a length of radicle and epicotyl, fresh weight of these seedling parts also promoted and inhibited in lower and higher concentration of cadmium compared to the control in light in this cultivar of *C. arietinum*. Thus, in 1 mg-l Cd concentration, the fresh weight of radicle and epicotyl in light-grown seedling is ca. 130 and 121% of control, respectively on 5th day of germination. However, in 50 mg-1 Cd concentration on the same day fresh weight of radicle and epicotyl is ca. 81 and 72%, respectively in light grown cultivar of *C. arietinum* as compared to the control (Tables 1-3 and Fig. 1).

Discussion

This study showed that the increased cadmium concentration effects the germination and seedling growth of *C. arietinum*. However, there is a little difference in growth of seedlings under the condition of dark and light. Lower cadmium concentration enhances seed germination in both studies but diminishes the germination percentage at higher concentrations. Baryla *et al.*, (2001); Shukla *et al.*, (2003); Wahid *et al.*, (2007) cadmium may change the nutritional content of different plant portions, according to reports. In both tests, the percentages of germination that were hindered by low levels of cadmium showed that these levels were well within the range that *C. arietinum* seedlings could tolerate. However, germination percentages in high-level treatments were negatively impacted, indicating that a higher cadmium concentration was not beneficial for seed germination (Mondal *et al.*, 2013). When crops are grown in cadmium-contaminated soil, there are serious health hazards for consumers. Therefore, it is strongly advised against cultivating crops with short root systems in locations with high cadmium levels. Metals affect the plants studied had varying percentages of germination and early seedling growth reported (Taoufik *et al.*, 2016). Effect of heavy metal also been

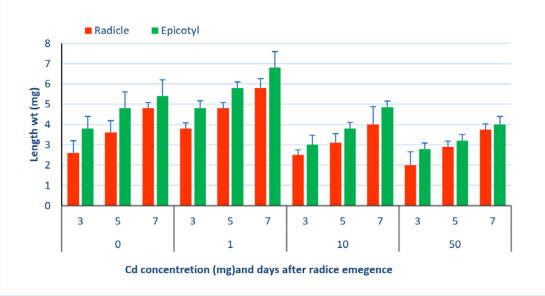

Fig. 1: Effect of 24 hours pretreatments of seed with different concentrations of cadmium on the growth of *C. arietinum*, linn. Cv. G130, seedling grown in dark.

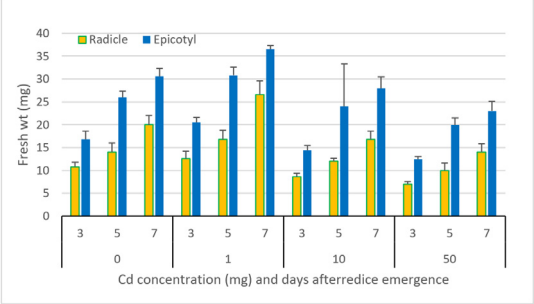

Fig. 2: Effect of 24 hours pretreatments of seed with different concentrations of cadmium on fresh weight

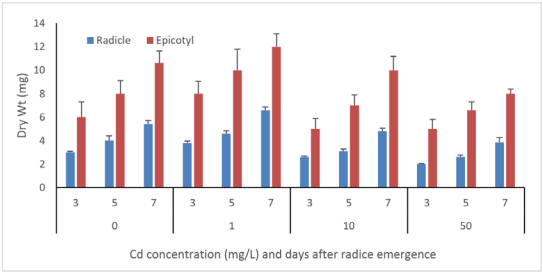

Fig. 3: Effect of 24 hours pretreatments of seed with different concentrations of cadmium on dry weight

reported by several researchers in other crops such as spinach (Spinaciaoleracea) (Hosseini *et al.*, 2012; Bautista *et al.*, 2013), soybean (Glycine max) (Li *et al.*, 2013), chard (Beta vulgaris) and lettuce (Lactuca sativa), (Bautista *et al.*, 2013) and wheat (Triticum aestivum) (Guillermo *et al.*, 2015). Germination parameters were significantly reduced by high metal concentration. However, with low metal concentrations, a little inhibition was observed (Taoufik *et al.*, 2016).

The outcome demonstrated that Cd was discovered to be inhibiting for *C. arietinum* seed germination and seedling growth. The study revealed that low Cd concentration was promotional in both studies, i.e. light and dark conditions. Another study finding also reveals that toxic cadmium inhibits plant growth, but a lower dose may sometimes have a stimulatory effect. (Baweja *et al.*, 2020). The toxicity of Cd in agricultural soil around the world inhibits plant growth and production significantly (Daud *et al.*, 2013).

Conclusion

The lower concentration of Cd showed growth promotion (hermetic effect). Cadmium toxicity in chickpea adversely affect germination and seedling growth. The length of epicotyl and radicle found reduced in high concentrations of cadmium. Likewise, fresh and dry weights also decreased with the increased cadmium concentration, finally affecting the yield. Similarly, the crops cultivated in highly cadmium-contaminated soil would be very health hazardous for the people. It is therefore suggested that, crop with short root systems may be avoided for cultivating in contaminated soil and prefer fresh groundwater for irrigation purposes, and avoid industrial wastewater.

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