Research Article
THE INTERNATIONAL JOURNAL OF BIOLOGICAL RESEARCH (TIJOBR)
ISSN Online: 2618-1444
Vol. 3(1) Jan-March. 2020., 14-23; 2020
http://www.rndjournals.com

Effect of cadmium chloride stress on maize and its management by gibberellic acid (GA)

Ayesha Liaquat[1], Moez Ullah Khan[2*], Muhammad Qasim Kakar[3], Zain Ullah[3], Sana Shaukat[1], Zulnoon Haider[4], Rafia Asghar[5], Ayesha Idrees[1],
[1]Department of Botany, University of Agriculture, Faisalabad, Pakistan.
[2]Department of Plant Pathology, Sindh Agriculture University Tandojam, Sindh, Pakistan
[3]Department of Agriculture & cooperative, Research Wing, Balochistan, Pakistan
[4]Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan.
[5]Department of Plant Pathology, Faculty of Food Crop & Sciences, PMAS Aid Agriculture University
*Corresponding email: moeez.ghilazi@gmail.com

Abstract

Maize is 3rd important cash crop of Pakistan after *Triticum astivium* and *Oryza sativa*. Cadmium is a heavy metal that affects various grain crops and gibberellic acid is a useful hormone against a variety of stress. To determine the effect of GA and Cd, a pot experiment was conducted in the OlD Botanical Garden University of Agriculture Faislabad. Two different maize varieties were used (Neelam and Desi makai). The concentrations of cadmium chloride (0 µM and 200 µM) and Gibberellic acid (0mg and 0.25 mg) were applied under CRD with three replications. Stress was applied after every 10 days and gibberellic acid was applied once in three leaves stage. After 60 days the plants were harvested. Different morphological parameters like fresh and dry root shoot weight, Root and shoot length, number of leaf, plant height and leaf area were recorded. All studied parameters were negatively affected by cadmium chloride while the foliar application of gibberellic acid improved these traits under cadmium chloride stress. Overall, Desi Makai performed better then Neelam in both stress and spray conditions.

Key word: cadmium chloride, gibberellic acid, Maize

Introduction

Maize is an important grain crop in Pakistan and grown in arid to semi-arid regions of the world. Maize seed have great nutritional value with high amount of protein content. Ranking of maize crop in Pakistan is 3rd after wheat and rice (Ahmad *et al.,* 2010). It is used to produce hay and silage which is consumed by animals. It also fulfills nutritional requirements for humans (Fahad *et al.,* 2014). Per acre yield of maize is low in our country. Different factors contribute to low production of maize. Pakistani soils have poor fertility status because of low organic matter effecting nutrient and water uptake. The Cadmium is dangerous pollutant because of its toxicity and high solubility in wate. It is non-toxic at low concentrations but it is much toxic at high concentrations. Cadmium (Cd) is ranked at 7th among the top 20 toxins because of its negative effects on the enzymatic systems of the cells. It contaminates the major areas of agricultural land worldwide because of application of urban composts, pesticides, fertilizers, emissions from waste incinerators, waste water irrigation, residues from metalliferous mining, and the metal smelting industry. At high concentration it inhibits root growth and cell division (Retamal-Salgado et al., 2017). Its toxicity symptoms are similar to Fe chlorosis and also cause necrosis and wilting. Plant growth regulators are natural compounds that can advance, repress or adjust physiological procedures in plants (Tanu *et al.,* 2008). Gibberellins are a vast group of regular items that direct numerous formative procedures in plants, including seed germination, stem elongation, and flower blooming (Shani *et al.,* 2103). Throughout the years in excess of a hundred GAs have been recognized from living beings, among which just couple of mixes are accessible in vast amounts, for example, the moderately shoddy common determined phytohormone named gibberellic acid (Phuoc *et al.,* 2008). The

Gibberellins are involved in plan growth and development at all stages. It enhances the seed germination, trunk enlargement, stem elongation, flowering, leaf expansions, seed development and inhibit senescence as well as delaying ripening. It is also involved to protect the plants from negative impact of abiotic stresses. The objectives of this research was to explore the role of gibberellic acid against heavy metal pressure and the response of gibberellic acid indulgence plants to non-bio accumulative heavy metal anxiety to justify the effect of the stress of cadmium chloride in corn (*Zea mays* L.).

Materials and methods

The current study was performed in Old Botanical Garden of UAF Pakistan. The Seeds of two maize cultivars (Neelum and Desi Makai) were taken from Sargodha city. The research trial was performed under complete randomized design (CRD) with three replications. The seeds were grown in artificial tubs containing 7 kilo gram sand in per pot. Seedlings were thinned after the germination, ten seedlings per pot of almost uniform size were kept. There were used two levels i.e. (0µm and 200µm) $CaCl_2$ and GA i.e. (0mg and 0.25 mg). The following traits like fresh and dry root shoot weight, Root and shoot length, number of leaf, plant height and leaf area.

Results and discussion

Shoot fresh weight (g):

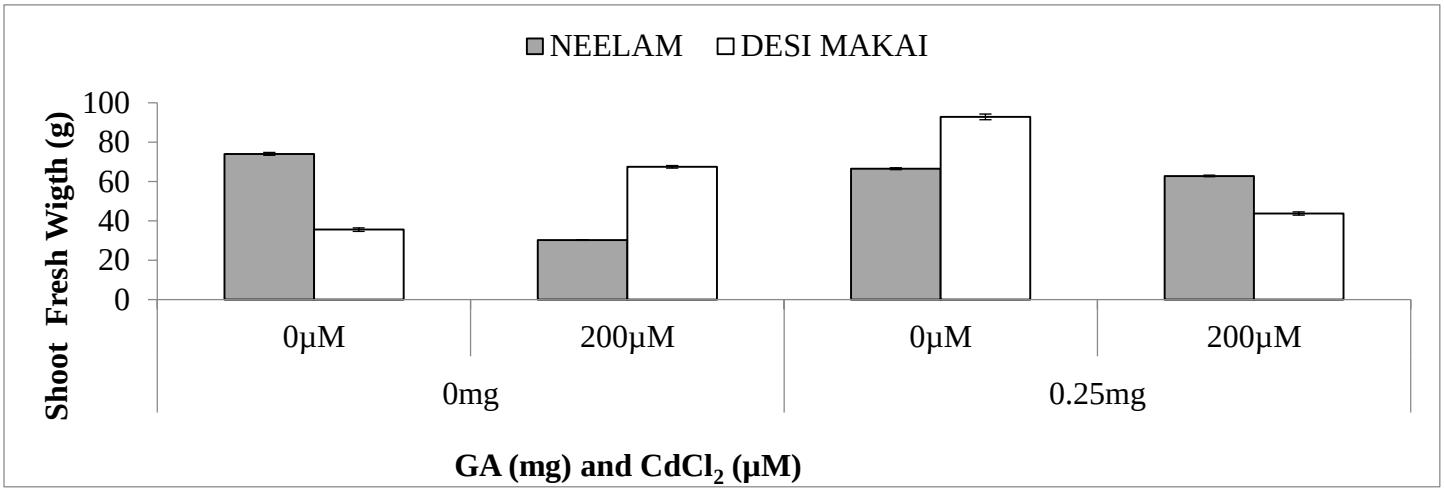
The Analysis of variance for shoot fresh weight (g) of two maize Cultivars (Neelam and Desi makai) in control environment and $CdCl_2$ tension was given in (Fig. 1; Tab. 1). Application of Gibberellic acid cause significantly ($p \leq 0.05$) improved in the fresh shoot weight of Desi Makai on the other hand greatest decline in shoot fresh weight was noted in Neelam when 200µm $CdCl_2$ was used was given in (Fig. 1). On the other hand, greatest raise in fresh shoot weight was detected in Desi makai at 0µm $CdCl_2$ and 0.25mg GA_3 spray (Fig. 1).

Table 1: ANOVA table for Shoot fresh weight of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of Gibberellic acid.

Source of variation	df	MS	F-Value	p-value
Stress	1	2962.5926	997.38839	.0000 ***
Spray	1	440.92654	148.44262	.0000 ***
Varieties	1	497.4972	167.48774	.0000 ***
Stress X Spray	1	42.055537	14.158445	.0017 **
Stress X varieties	1	563.8612	189.82989	.0000 ***
Spray X varieties	1	1377.8926	463.88224	.0000 ***
Stress x spray x varieties	1	3092.8751	1041.2494	.0000 ***
Error	16	2.97035		

Non significant=^{ns}. ***,**,* significant at 0.001, 0.01, 0.05 separately

Fig. 1: Shoot fresh weight of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of GA



THE INTERNATIONAL JOURNAL OF BIOLOGICAL RESEARCH (TIJOBR)
ISSN Online: 2618-1444 Vol. 3(1) Jan-March. 2020., 14-23; 2020
http://www.rndjournals.com

Root Fresh weight (g):

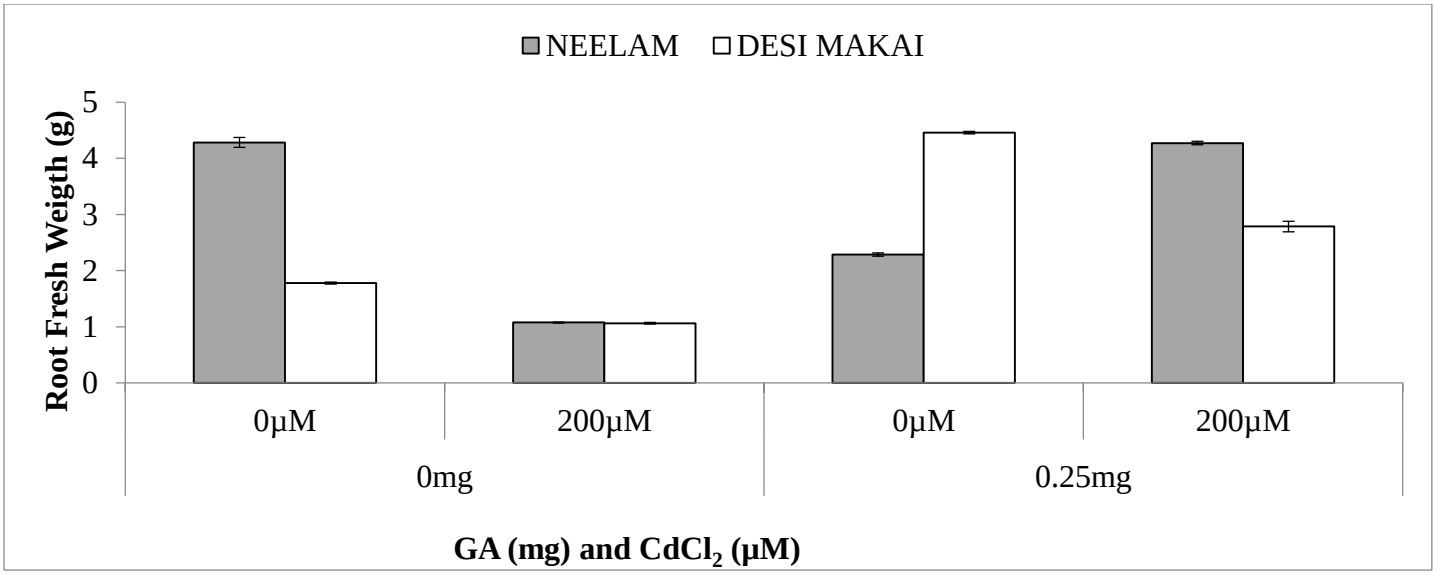
The Analysis of variance for root fresh weight (g) of two maize Cultivars (Neelam and Desi makai) in control environment and $CdCl_2$ tension is given in (Fig. 2; Tab. 2). Foliar application of gibberellic acid cause significant ($p \leq 0.05$) improvement in root fresh weight of desi makai (table. 2). The greatest decline was detected in root fresh weight of both Neelam and Desi makai at 200µm Cadmium chloride stress. Moreover raise in root fresh weight was detected in both Neelum and Desi makai at 0.25mg GA and 0µm $CdCl_2$ was given (Fig. 2). Varietal significant ($p \leq 0.05$) variation was observed among both cultivars. (Table. 2).

Table 2: ANOVA table for Root fresh weight of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of Gibberellic acid.

Source of variation	df	MS	F-Value	p-value
Stress	1	11.746004	1179.0217	.0000 ***
Spray	1	4.8870375	490.54329	.0000 ***
Varieties	1	1.2558375	126.05646	.0000 ***
Stress X Spray	1	6.7310042	675.63404	.0000 ***
Stress X varieties	1	3.8480042	386.24885	.0000 ***
Spray X varieties	1	0.5075042	50.941447	.0000 ***
Stress x spray x varieties	1	14.152704	1420.5977	.0000 ***
Error	16	0.0099625		

Non significant=^{ns}. ***,**,* significant at 0.001, 0.01, 0.05 separately

Fig. 2: Root fresh weight of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of GA.



Shoot Dry Weight (g)

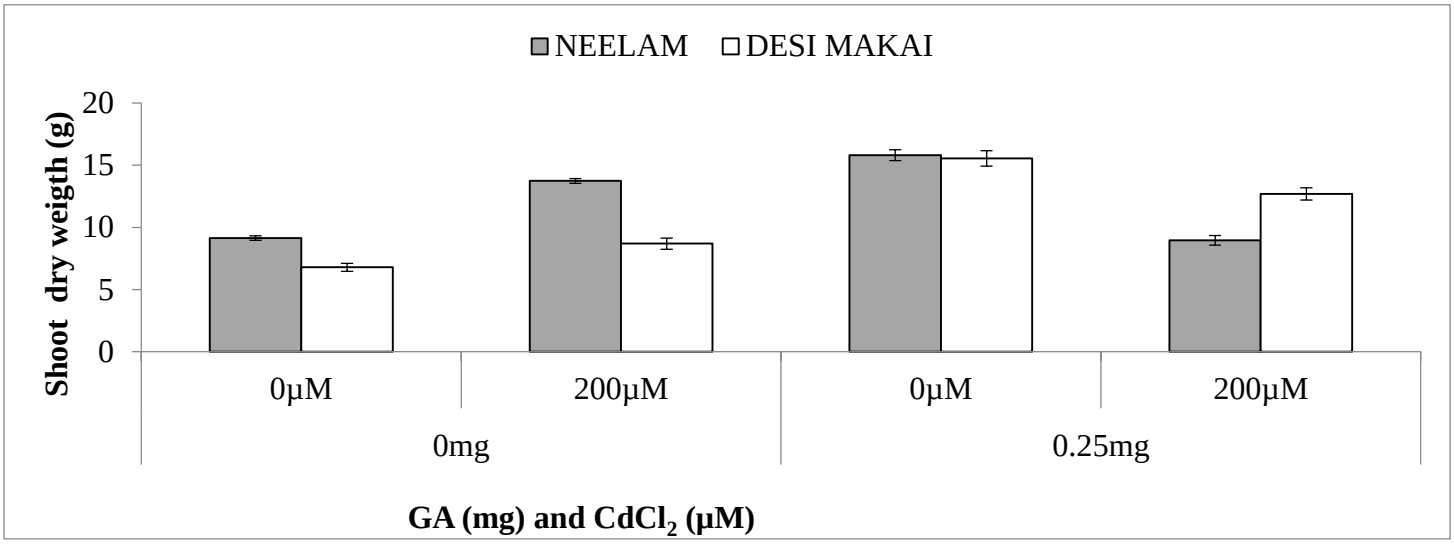
The Analysis of variance for shoot dry weight (g) of two maize Cultivars (Neelam and Desi makai) in control environment and $CdCl_2$ tension was given in (Fig. 3; Tab. 3). Application of Gibberellic acid cause significantly ($p \leq 0.05$) improved in the fresh shoot weight of Desi makai on the other hand greatest decline in shoot fresh weight was noted in Neelam when 200µm $CdCl_2$ was used was given in (Fig. 3). On the other hand, greatest raise in dry shoot weight was detected in Desi makai at 0µm $CdCl_2$ and 0.25mg GA_3 spray (Fig. 3).

Table 3: ANOVA table for Shoot Dry weight of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of Gibberellic acid.

Source of variation	df	MS	F-Value	p-value
Stress	1	81.401667	123.1811	.0000 ***
Spray	1	3.5882667	5.429946	.0332 *
Varieties	1	6.1004167	9.231458	.0078 **
Stress X Spray	1	97.284267	147.21546	.0000 ***
Stress X varieties	1	43.368817	65.6188	.0000 ***
Spray X varieties	1	0.5340167	0.8081009	.3820 ns
Stress x spray x varieties	1	16.170417	24.469889	.0001 ***
Error	16	0.6608292		

Non significant=^{ns}. ***,**,* significant at 0.001, 0.01, 0.05 separately

Fig. 3: Shoot Dry weight of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of GA.



Root Dry Weight (g):

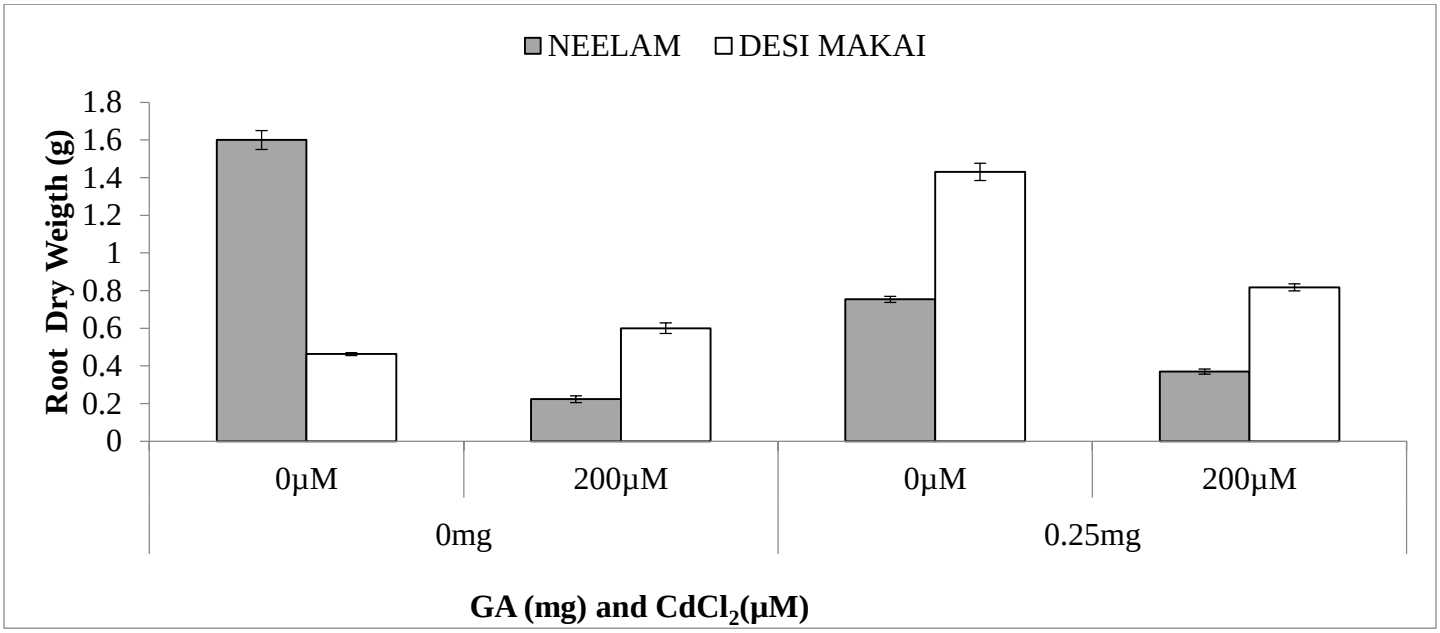
The Analysis of variance for root dry weight (g) of two maize Cultivars (Neelam and Desi makai) in control environment and $CdCl_2$ tension is given in (Fig. 4; Tab. 4). Foliar application of gibberellic acid cause significant ($p \leq 0.05$) improvement in root dry weight of desi makai (table. 4). The greatest decline was detected in root fresh weight of both Neelam and Desi makai at 200µm Cadmium chloride stress. Moreover, raise in root dry weight was detected in both Neelum and Desi makai at 0.25mg GA and 0µm $CdCl_2$ was given (Fig. 4). Varietal significant ($p \leq 0.05$) variation was observed among both cultivars. (Table. 4).

Table 4: ANOVA table for Root Dry weight of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of Gibberellic acid.

Source of variation	df	MS	F-Value	p-value
Stress	1	0.0876042	26.817602	.0001 ***
Spray	1	1.8760042	574.28699	.0000 ***
Varieties	1	0.0495042	15.154337	.0013 **
Stress X Spray	1	0.0222042	6.7971939	.0191 *
Stress X varieties	1	1.3301042	407.17474	.0000 ***
Spray X varieties	1	0.6176042	189.0625	.0000 ***
Stress x spray x varieties	1	1.1397042	348.88903	.0000 ***
Error	16			

Non significant=^{ns}. ***, **, * significant at 0.001, 0.01, 0.05 separately

Fig. 4.4: Shoot Dry weight of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of GA.



Plant Height (cm)

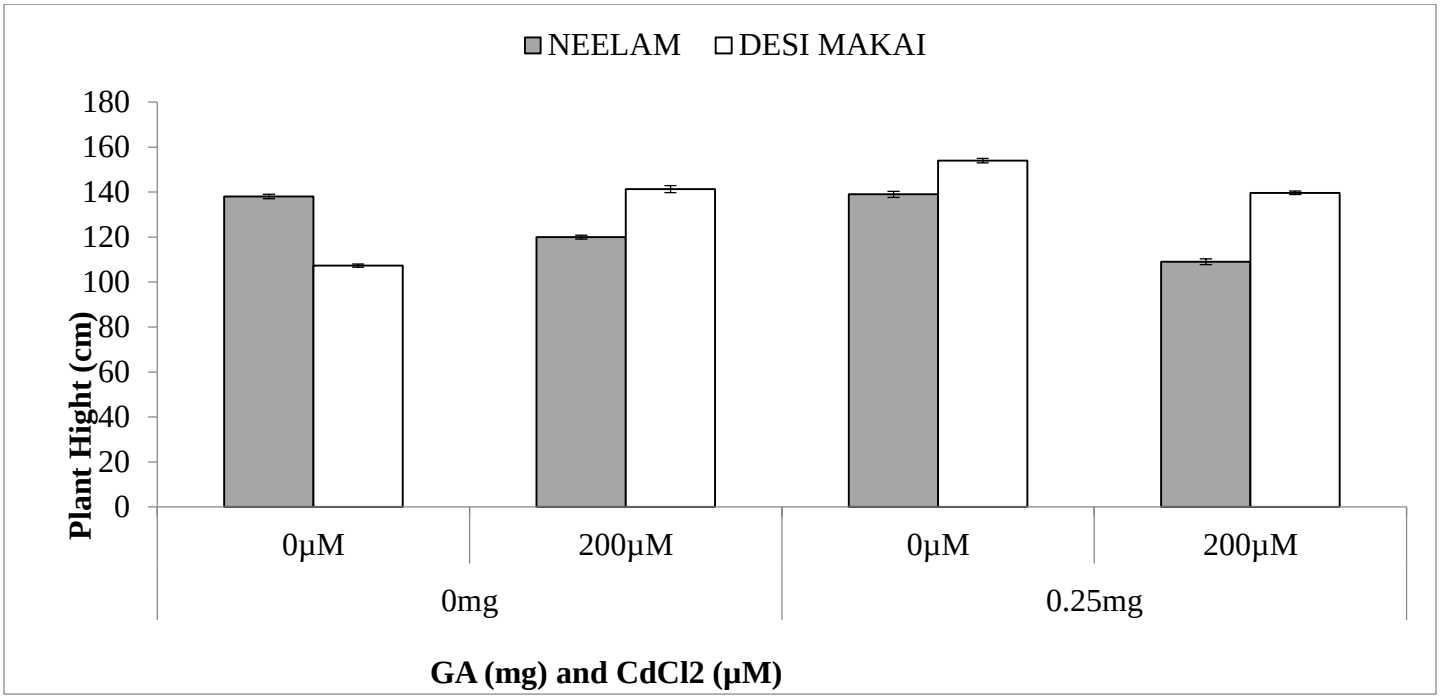
The Analysis of variance for plant height (cm) of two maize Cultivars (Neelam and Desi makai) in control condition and Cadmium chloride stress is given in (Fig. 5; Tab. 5). The foliar application of gibberellic acid increased significantly ($p \leq 0.05$) in plant height of both of the varieties Neelam and Desi makai but maximum reduction observed in plant height of Neelam when 200µm Cadmium chloride was applied was given in (Fig. 5). Desi makai performed better then neelam under 200µm $CdCl_2$ and 0.25mg GA spray. On the other hand highest raise in plant height was detected in Desi makai at 0.25mg GA spray (Fig. 5). Overall both varieties showed excellent performance but Desi makai performed good as compared to Neelam. Varietal significant ($p \leq 0.05$) difference was detected between both cultivars. (Table. 5).

Table 5: ANOVA table for Plant Hight (cm) of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of Gibberellic acid.

Source of variation	df	MS	F-Value	p-value
Stress	1	459.375	94.230769	.0000 ***
Spray	1	301.04167	61.752137	.0000 ***
Varieties	1	495.04167	101.54701	.0000 ***
Stress X Spray	1	1365.0417	280.00855	.0000 ***
Stress X varieties	1	1134.375	232.69231	.0000 ***
Spray X varieties	1	1717.0417	352.21368	.0000 ***
Stress x spray x varieties	1	495.04167	101.54701	.0000 ***
Error	16	4.875<-		

Non significant=^{ns}. ***, **, * significant at 0.001, 0.01, 0.05 separately

Fig 5: Plant height (cm) of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of GA.



Shoot length (cm):

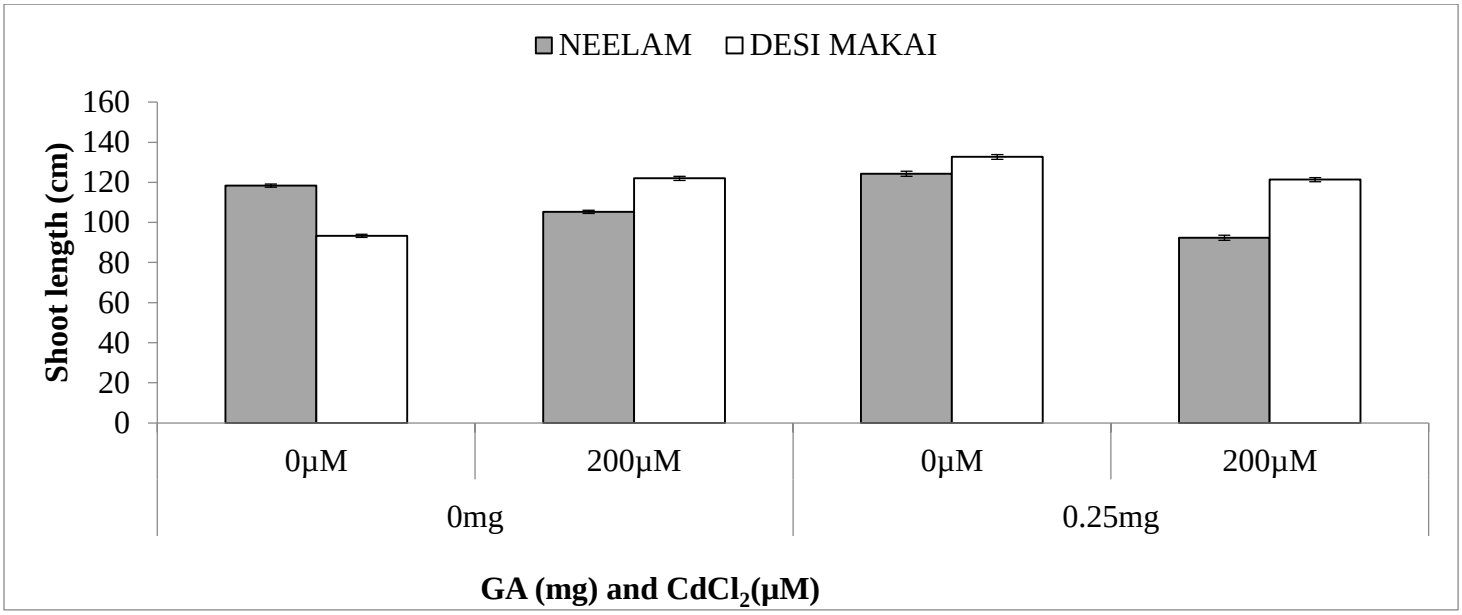
The Analysis of variance for shoot length (cm) of two maize Cultivars (Neelam and Desi makai) in control condition and Cadmium chloride tension is given in (Fig. 6; Tab. 6). Treatment of Gibberellic acid significantly ($p \leq 0.05$) increased in shoot length of both Neelam and Desi makai but Desi makai performed better then Neelam in all conditions (Fig. 6). Moreover, higher decrease in shoot length was detected in Desi makai at 200µm $CdCl_2$ and 0.25mg GA spray (Fig. 6). Varietal significant ($p \leq 0.05$) difference was detected between both cultivars. (Table. 6).

Table 6: ANOVA table for Shoot Dry weight of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of Gibberellic acid.

Source of variation	Df	MS	F-Value	p-value
Stress	1	376.04167	87.621359	.0000 ***
Spray	1	287.04167	66.883495	.0000 ***
Varieties	1	315.375	73.485437	.0000 ***
Stress X Spray	1	1305.375	304.16505	.0000 ***
Stress X varieties	1	782.04167	182.2233	.0000 ***
Spray X varieties	1	1457.0417	339.50485	.0000 ***
Stress x spray x varieties	1	165.375	38.533981	.0000 ***
Error	16	4.2916667		

Non significant=^{ns}. ***,**,* significant at 0.001, 0.01, 0.05 separately

Fig 6: Shoot length (cm) of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of GA.



Root Length (cm)

The Analysis of variance for root length (cm) of two maize Cultivars (Neelam and Desi makai) in control condition and Cadmium chloride tension is given in (Fig. 7; Tab. 7). The foliar treatment of Gibberellic acid significantly ($p \leq 0.05$) enhanced root length of Desi makai and highest decline was detected in root length of Neelam when 200µm cadmium chloride was applied (Fig. 7). Both Neelam and Desi makai performed better under 200µm $CdCl_2$ and 0.25mg GA spray. The higher increase in root length was detected in Desi makai at 0.25mg GA spray (Fig. 7). Overall both verities showed excellent performance but neelam performed good in control condition as compared to Desi maki. Varietal significant ($p \leq 0.05$) difference was detected between both cultivars. (Table. 7).

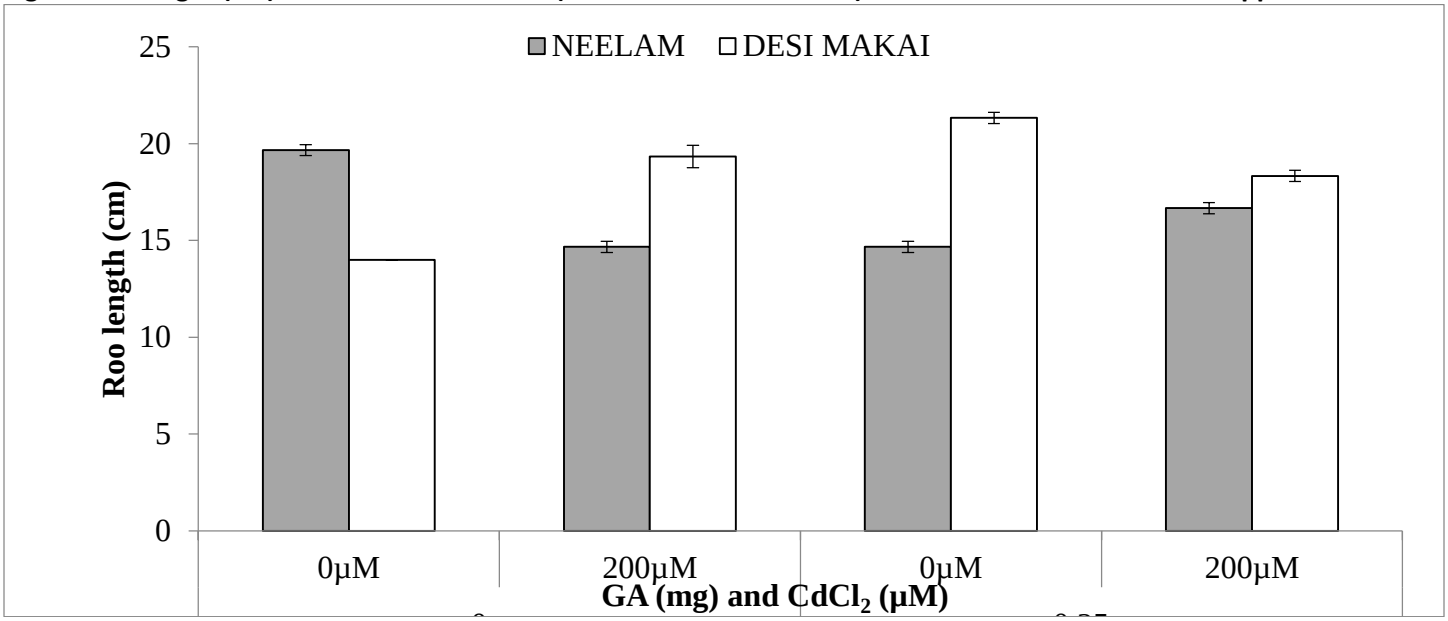
Table 7: ANOVA table for root length (cm) of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of Gibberellic acid.

Source of variation	df	MS	F-Value	p-value
Stress	1	4.1666667	10	.0060 **
Spray	1	0.1666667	0.4	.5360 ns
Varieties	1	20.166667	48.4	.0000 ***
Stress X Spray	1	0.6666667	1.6	.2240 ns
Stress X varieties	1	32.666667	78.4	.0000 ***
Spray X varieties	1	10.666667	25.6	.0001 ***
Stress x spray x varieties	1	88.166667	211.6	0000 ***
Error	16	0.4166667		

Non significant=^{ns}. ***, **, * significant at 0.001, 0.01, 0.05 separately

THE INTERNATIONAL JOURNAL OF BIOLOGICAL RESEARCH (TIJOBR)
ISSN Online: 2618-1444 Vol. 3(1) Jan-March. 2020., 14-23; 2020
http://www.rndjournals.com

Fig 7: Root length (cm) of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of GA.



Number of leaf:

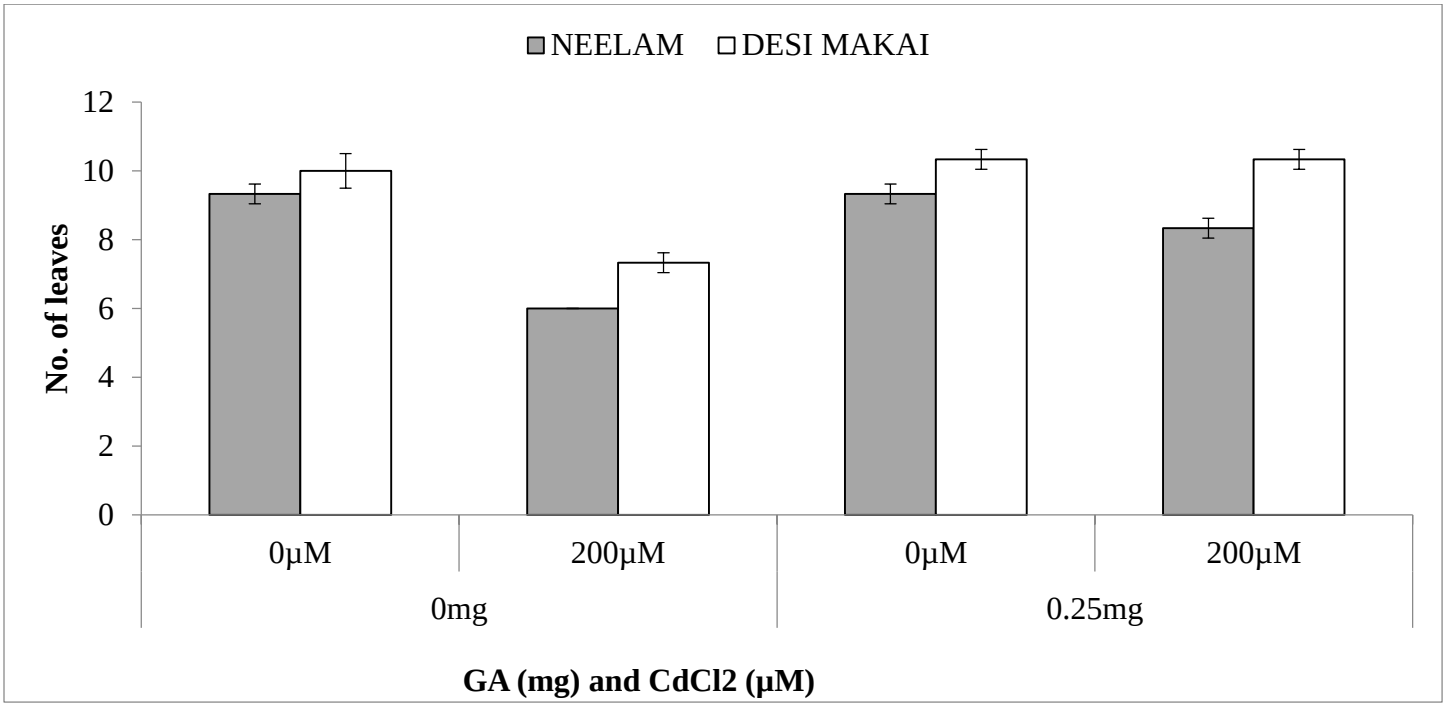
The Analysis of variance for number of leaves of two maize Cultivars (Neelam or Desi makai) grown in control condition and Cadmium chloride stress is given in (Fig. 8; Tab. 8). Application of Gibberellic acid cause significantly ($p \leq 0.05$) increase in number of leaves of both of the varieties Neelam and Desi makai but maximum reduction was observed in number of leaves of Neelam when 200µm Cadmium chloride was applied as given in (Fig. 8). Desi makai performed better then neelam under 200µm $CdCl_2$ and 0.25mg GA spray. Moreover, highest raise in number of leaves was observed in Desi makai at 0.25mg GA spray (Fig. 8). Overall both verities showed excellent performance but Desi makai performed good as compared to Desi maki. Varietal significant ($p \leq 0.05$) difference was detected between both cultivars. (Table. 8).

Table 8: ANOVA table for No. of Leaves of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of Gibberellic acid.

Source of variation	df	MS	F-Value	p-value
Stress	1	12.041667	32.111111	.0000 ***
Spray	1	18.375	49	.0000 ***
Varieties	1	9.375	25	.0001 ***
Stress X Spray	1	9.375	25	.0001 ***
Stress X varieties	1	0.375	1	.3322 ns
Spray X varieties	1	1.0416667	2.7777778	.1150 ns
Stress x spray x varieties	1	0.0416667	0.1111111	.7432 ns
Error	16	0.375		

Non significant=^{ns}. ***, **, * significant at 0.001, 0.01, 0.05 separately

Fig 8: No.of Leaves of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of GA.



Leaf Area (cm):

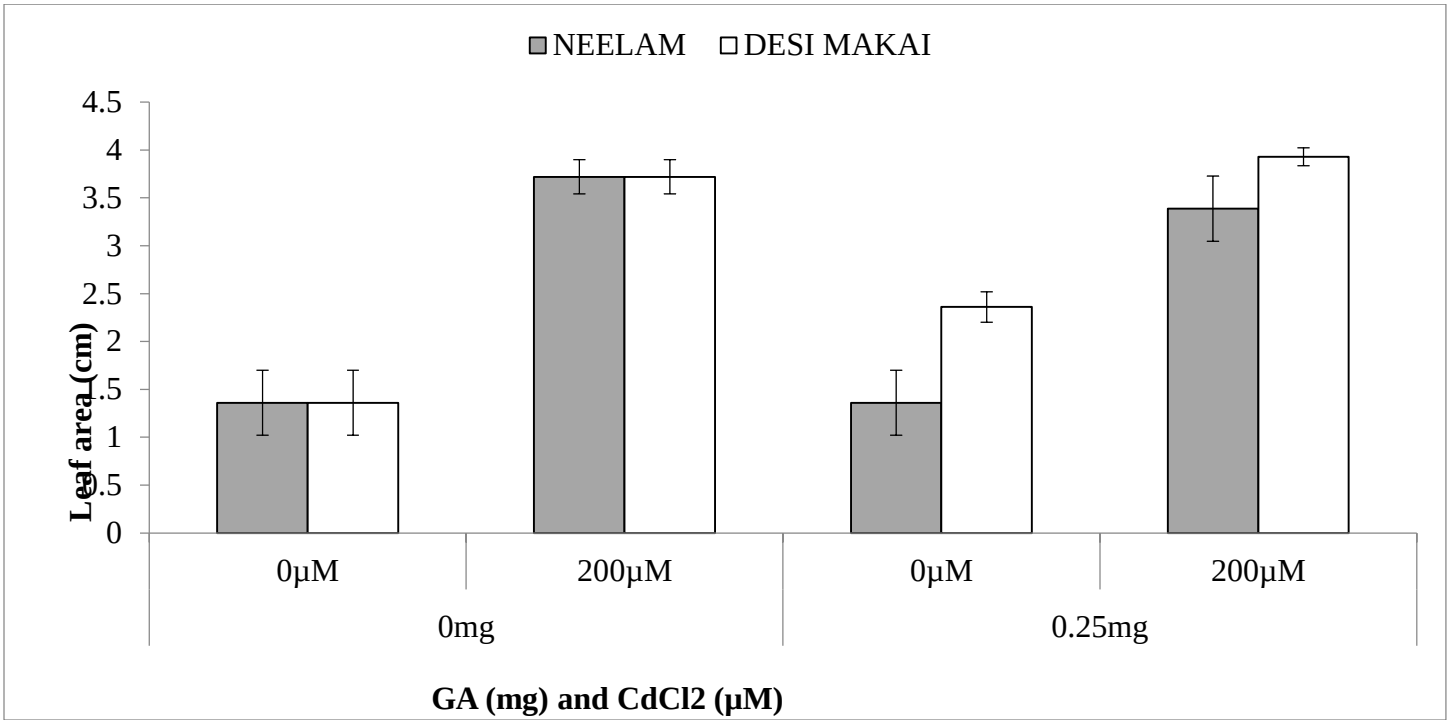
The Analysis of variance for Leaf Area of 2 maize Cultivars (Neelam or Desi makai) grown in control condition and CdCl2 tension is given in (Fig. 9; Tab. 9).Treatment of Gibberellic acid cause significantly ($p \leq 0.05$) reduced in Leaf area of these two varieties Neelam and Desi makai but there was maximum increased in leaf area was observed in both Neelam and Desi makai when 200µm Cadmium chloride was applied was given in (Fig. 9). Both Neelam and Desi makai performed better under 200µm $CdCl_2$ and 0.25mg GA spray. Moreover, highest reduced in leaf area was detected in desi makai or neelam at 0.25mg GA spray (Fig. 9). Both verities showed poor performance at control. Varietal significant ($p \leq 0.05$) varietal difference was detected between both cultivars. (Table. 9).

Table 9: ANOVA table for Leaf Area of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of Gibberellic acid.

Source of variation	df	MS	F-Value	p-value
Stress	1	1.3207042	2.6634931	.1222 ns
Spray	1	20.075104	40.485904	0000 ***
Varieties	1	2.4257042	4.8919709	.0419 *
Stress X Spray	1	0.0057042	0.0115037	.9159 ns
Stress X varieties	1	0.1107042	0.2232595	.6429 ns
Spray X varieties	1	0.1107042	0.2232595	.6429 ns
Stress x spray x varieties	1	0.7597042	1.6047141	.2234 ns
Error	16	0.4958542		

Non significant=^{ns}. ***, **, * significant at 0.001, 0.01, 0.05 separately

Fig. 4.9: Leaf area (cm) of two maize cultivars (Neelam and Desi makai) under $CdCl_2$ stress with foliar application of GA.



References;

1. Ahmad, M., H. A. Alias, R. Bukhsh, A. Ahmad, U. Malik, S. Hussain and M. Ishaque. 2010. Profitability of three maize hybrids as influenced by varying plant density and potassium application. J. Anim Plant Sci. 21: 42-47.
2. Fahad, S., S. Hussain, S. Saud, S. Hassan, H. Muhammad, D. Shan, C. Chen, C. Wu, D. Xiong, S. B. Khan, A. Jan, K. Cui and J. Huang. 2014. Consequences of narrow crop row spacing and delayed *Echinochloa colona* and *Trianthema portulacastrum* emergence for weed growth and crop yield loss in maize. Weed Res. 10: 475-483.
3. Retamal-Salgado, J., J. Hirzel, I. Walter and I. Matus. 2017. Bioabsorption and Bioaccumulation of Cadmium in the Straw and Grain of Maize (Zea mays L.) in Growing Soils Contaminated with Cadmium in Different Environment. Int. J. Environ. Res. 14(1399): 2-15
4. Shani, E., R. Weinstain, Y. Zhang, C. Castillejo, E. Kaiserli, J. Chory, R.Y. Tsien and M. Estelle. 2013. Gibberellins accumulate in the elongating endodermal cells of arabidopsis root. Proc. Natl. Acad. Sci. USA. 110: 4834–4839.
5. Phuoc, L.T., L.N. Mander, M. Koshioka, N. Oyama-Okubo, M. Nakayama and A. Ito. 2008. Confirmation of structure and synthesis of three new 11_-OH C20 gibberellins from loquat fruit. Tetrahedron. 64: 4835–4851.
6. Tuna, A.T., C. Kayab, M. Dikilitas and D. Higgs. 2008. The combined effects of gibberellic acid and salinity on some antioxidant enzyme activities, plant growth parameters and nutritional status in maize plants. Environ. Experiment. Bot. 62: 1–9