Summary
SUMMARY

The thesis Symbolize the result carried out on the “Physico-Chemical Study of Fluoride Content Level of Some Plants Cultivated In Devli Town of Tonk District”. The physiological and biochemical effects of fluoride on *Hordeum vulgare* (Barley) *variety RD 2052*, *Cicer arietinum* (Chickpea) *variety C888* and *Triticum aestivum* (Wheat) *variety Raj 3077*.

The aim of the present study is to find out the entry of fluoride in different components of environment and their affects on growth of crop plant. In this study an attempt has been made to investigate as to how much concentration of fluoride is accumulated in the crop plant. This study is divisible into two; i.e. field observations and pot experiments.

Field observations were carried out in Devli Tehsil of Tonk district which is a small town situated 135 Km away from the main city of Jaipur.

Pot experiments were conducted in Indira Gandhi Centre for Human Ecology, Environmental and population Studies, University of Rajasthan, Jaipur, India.

FIELD OBSERVATIONS

In Field experiment, Seven different villages in Devli Tehsil (Tonk district) of Rajasthan (i.e. S1-kanwarpura, S2-Heerapura, S3-Bhanwarthala, S4-Ramthala, S5-Sangrampura, S6-Rajmahal, S7-Dabarkala). Field observations included collection samples of soil, water and plant material from the agricultural field at Pre-flowering, peak-flowering and post-flowering stages on *Hordeum vulgare*, *Cicer arietinum* and *Triticum aestivum*. These samples were brought to the laboratory and analyzed.

*Hordeum vulgare* (Barley) *variety RD 2052*

In field observation included collection of Ground water samples, soil and plant samples during the period of November 2011 to March 2012.

WATER ANALYSIS

Water samples were collected from agricultural field at seven different villages (five samples per village) in Devli Tehsil. Water samples were analyzed for pH,
Total Dissolved Solid, Electrical conductivity, Alkalinity, Chlorides, Calcium hardness, Total hardness and Fluoride Concentrations at Pre-flowering, Peak-flowering and Post-flowering Stages of *Hordeum vulgare*.

**pH**

The pH of the water samples collected from the study area ranged from 7.48±0.054 to 9.17±0.043 at post-flowering stage.

**Electrical conductivity**

The electrical conductivity of the water samples collected from the study area ranged from 1719±2.011 µmhos/cm to 4536±10.120 µmhos/cm at post-flowering stage.

**Total dissolved solids**

The total dissolved solid of the water samples collected from the study area ranged from 1048±7.665mg/L to 3219±10.501 mg/L at post-flowering stage.

**Chlorides concentration**

The chlorides concentration of the water samples collected from the study area ranged from 189 ±6.139mg/l to 1392 ±10.011mg/L at post-flowering stage.

**Alkalinity concentration**

The chlorides concentration of the water samples collected from the study area ranged from 137±8.105 mg/L and 882±4.723 mg/L at post-flowering stage.

**Calcium hardness**

The calcium hardness of the water samples collected from the study area ranged from 359±6.321 mg/L to 29 ±3.568mg/L at post-flowering stage.

**Total hardness**

The total hardness of the water samples collected from the study area ranged from 1019 ±5.892mg/L to 114±9.176 mg/L at post-flowering stage.
Fluoride concentration

The Fluoride concentration in the water samples collected from the study area ranged from 0.83±0.011 ppm to 16.47 ±0.212ppm at post-flowering stage.

SOIL ANALYSIS

Water samples were collected from agricultural field at seven different villages (five samples per village) in Devli Tehsil. Soil samples were analyzed for pH, Electrical conductivity, Chlorides, Organic matter and Fluoride concentration at three stages (Pre-flowering, Peak-flowering and Post-flowering) of the test species *Hordeum vulgare*.

pH

The Ph of the soil samples collected from the study area ranges from the study area ranged from 8.02±0.011 to 9.13± 0.023at post-flowering stage.

Electrical conductivity

The electrical conductivity of the soil samples collected from the study area ranged from 5484±9.145 µmhos/cm to 6962±8.452 µmhos/cm at post-flowering stage.

Chlorides concentration

The chlorides concentration of the soil samples collected from the study area ranged from 5.623±0.019mg/100g to 15.524 0.072 at post-flowering stage.

Organic matter

The organic matter of the soil samples collected from the study area ranged from 1.676± 0.047 to 1.498±0.094 percent at post-flowering stage.

Fluoride concentration

The Fluoride concentration in the soil samples collected from the study area ranged from 0.674±0.064 mg/g to 10.233±0.067 mg/g at post-flowering stage.

PLANT ANALYSIS

Plant samples were collected from the agricultural fields (five samples per village) in Devli Tehsil of Tonk district. Plants were harvested at Pre-flowering,
Peak-flowering and Post-flowering stages. To determine the effects of fluoridated water, the plant growth parameters i.e. root length, shoot length, ear length, root dry weight, shoot dry weight, Grain dry weight were estimated and chlorophyll, carbohydrate, nitrogen, and phosphorous were also analyzed in the *Hordeum vulgare*.

Bio-chemical and Physiology parameters like chlorophyll content of leaves, Carbohydrate content, Plant Nitrogen, Protein and Phosphorous were analyzed and recorded.

**Root length**

The maximum root length was recorded at post-flowering stage. Root length in the plant samples collected from the study area (S1 to S7) ranged between 36.54±1.987cm to 30.82 ±1.609 cm.

**Shoot length**

The maximum shoot length was recorded at post-flowering stage. Shoot length in the plant samples collected from the study area (S1 to S7) ranged between 78.17 ±1.569cm to 76.04 ± 1.489cm.

**Pod length**

The maximum Pod length was recorded at post-flowering stage. Ear length in the plant samples collected from the study area (S1 to S7) ranged between 17.38±1.224 cm to 15.32±1.297 cm

**Root dry weight**

The maximum root dry weight was recorded at post-flowering stage. Root dry weight in the plant samples collected from the study area (S1 to S7) ranged between stage 0.908± 0.074 gm to 0.769± 0.011 gm

**Shoot dry weight**

The maximum shoot dry weight was recorded at post-flowering stage. Shoot dry weight in the plant samples collected from the study area (S1 to S7) ranged between 5.453±0.216 gm to 3.286±0.149 gm.
Grains dry weight

The maximum grain dry weight was recorded at post-flowering stage. Grain dry weight in the plant samples collected from the study area (S1 to S7) ranged between 2.478±0.089gm to 2.043±0.027 gm.

Chlorophyll

The highest amount of total chlorophyll was recorded at post-flowering stage. Total chlorophyll in the plant samples collected from the study area (S1 to S7) ranged between 39.712 ±0.083 mg/g to 29.346± 0.012

Carbohydrate

The highest amount of carbohydrate content was recorded at peak-flowering stage. The plant samples collected from the study area (S1 to S7) ranged between 76.02±0.052 mg/g to 6.386 ± 0.021 mg/g.

Phosphorous

The highest amount of phosphorous content was recorded at peak-flowering stage. The plant samples collected from the study area (S1 to S7) ranged between 3.459 ±0.084mg/g to 2.993± 0.013 mg/g.

Nitrogen

The highest amount of nitrogen content was recorded at peak-flowering stage. The plant samples collected from the study area (S1 to S7) ranged between 2.969±0.027 percent to 2.572±0.018 percent.

Protein

The highest amount of protein content was recorded at peak-flowering stage. The plant samples collected from the study area (S1 to S7) ranged between. 18.556± 0.071 percent to 16.075±0.052 percent.

Fluoride concentration

The maximum fluoride concentration was recorded at post-flowering stage. Fluoride content in the plant samples collected from the study area (S1 to S7) ranged in leaves were (0.553±0.006mg/g to16.288±0.006 mg/g). Stem (0.496 ±0.005 mg/g
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to 13.693±0.005 mg/g), Root (0.402±0.006mg/g to 12.967 ±0.007) and in grains (0.357±0.007 mg/g to 9.115 ±0.008 mg/g).

*Cicer arietinum* (chickpea) variety C888

In field observation included collection of Ground water samples, soil and plant samples during the period of November 2012 to March 2013.

WATER ANALYSIS

Water samples were collected from agricultural field at seven different villages (five samples per village) in Devli tehsil. Water samples were analyzed for pH, Total Dissolved Solid, Electrical conductivity, Alkalinity, Chlorides, Calcium hardness, Total hardness and Fluoride Concentrations at Pre-flowering, Peak-flowering and Post-flowering Stages of *Cicer arietinum*.

**pH**

The pH of the water samples collected from the study are ranged from 7.39 to 9.25 at post-flowering stage.

**Total dissolved solids**

The total dissolved solid of the water samples collected from the study area ranged from 1048mg/L to 3219 mg/L at post-flowering stage.

**Electrical conductivity**

The electrical conductivity of the water samples collected from the study area ranged from 1719 µmhos/cm to 4536 µmhos/cm at post-flowering stage.

**Chlorides concentration**

The chlorides concentration of the water samples collected from the study area ranged from 181 mg/L to 1416 mg/L at post-flowering stage.

**Alkalinity concentration**

The chlorides concentration of the water samples collected from the study area ranged from 122 mg/L to 896 mg/L at post-flowering stage.
Calcium hardness
The calcium hardness of the water samples collected from the study area ranged from 362 mg/L to 32 mg/L at post-flowering stage.

Total hardness
The total hardness of the water samples collected from the study area ranged from 1014 mg/L to 122 mg/L at post-flowering stage.

Fluoride concentration
The Fluoride concentration in the water samples collected from the study area ranged from 0.92 ppm to 2.96 ppm at post-flowering stage.

SOIL ANALYSIS
Water samples were collected from agricultural field at seven different villages (five samples per village) in Devli Tehsil. Soil samples were analyzed for pH. Electrical conductivity, Chlorides, Organic matter and Fluoride concentration at three stages (Pre-flowering, Peak-flowing and Post-flowing) of the test species Cicer arietinum.

pH
The Ph of the soil samples collected from the study area ranges from the study area ranged from 7.94 to 8.07 at post-flowering stage.

Electrical conductivity
The electrical conductivity of the soil samples collected from the study area ranged from 5023 µmhos/cm to 6398 µmhos/cm at post-flowering stage.

Chlorides concentration
The chlorides concentration of the soil samples collected from the study area ranged from 5.428 mg/100g to 15.227 mg/100g at post-flowering stage.

Organic matter
The organic matter of the soil samples collected from the study area ranged from 1.562 to 1.447 percent at post-flowering stage.
Fluoride concentration

The Fluoride concentration in the soil samples collected from the study area ranged from 0.729 mg/g to 9.174 mg/g at post-flowering stage.

PLANT ANALYSIS

Plant samples were collected from the agricultural fields (five samples per village) in Devli Tehsil of Tonk district. Plants were harvested at Pre-flowering, Peak-flowering and Post-flowering stages. To determine the effects of fluoridated water, the plant growth parameters i.e. root length, shoot length, ear length, root dry weight, shoot dry weight, Grain dry weight were estimated and chlorophyll, carbohydrate, nitrogen, and phosphorous were also analyzed in the *Cicer arietinum*. Bio-chemical and Physiology parameters like chlorophyll content of leaves, Carbohydrate content, Plant Nitrogen, Protein and Phosphorous were analyzed and recorded.

Root length

The maximum root length was recorded at post-flowering stage. Root length in the plant samples collected from the study area (S1 to S7) ranged between 40.82 cm to 34.67 cm.

Shoot length

The maximum shoot length was recorded at post-flowering stage. Shoot length in the plant samples collected from the study area (S1 to S7) ranged between 52.06 cm to 47.78 cm.

Pod length

The maximum Pod length was recorded at post-flowering stage. Ear length in the plant samples collected from the study area (S1 to S7) ranged between 2.63 cm to 1.37 cm.

Root dry weight

The maximum root dry weight was recorded at post-flowering stage. Root dry weight in the plant samples collected from the study area (S1 to S7) ranged between stage 1.379 gm to 1.272 gm.
Shoot dry weight

The maximum shoot dry weight was recorded at post-flowering stage. Shoot dry weight in the plant samples collected from the study area (S1 to S7) ranged between 6.853 gm to 6.046 gm.

Seeds dry weight

The maximum grain dry weight was recorded at post-flowering stage. Grain dry weight in the plant samples collected from the study area (S1 to S7) ranged between 3.591 gm to 3.464 gm.

Chlorophyll

The highest amount of total chlorophyll was recorded at post-flowering stage. Total chlorophyll in the plant samples collected from the study area (S1 to S7) ranged between 34.428 mg/g to 28.586 mg/g.

Carbohydrate

The highest amount of carbohydrate content was recorded at peak-flowering stage. The plant samples collected from the study area (S1 to S7) ranged between 57.89 mg/g to 49.64 mg/g.

Nitrogen

The highest amount of nitrogen content was recorded at peak-flowering stage. The plant samples collected from the study area (S1 to S7) ranged between 4.326 percent to 3.867 percent.

Protein

The highest amount of protein content was recorded at peak-flowering stage. The plant samples collected from the study area (S1 to S7) ranged between 27.038 percent to 24.169 percent.

Phosphorous

The highest amount of phosphorous content was recorded at peak-flowering stage. The plant samples collected from the study area (S1 to S7) ranged between 3.806 mg/g to 3.014 mg/g.
Fluoride concentration

The maximum fluoride concentration was recorded at post-flowering stage. Fluoride content in the plant samples collected from the study area (S1 to S7) ranged in Root were (1.097 mg/g to 16.422 mg/g), Stem (1.294 mg/g to 14.289 mg/g), Leaves Stem (0.982 mg/g to 9.930 mg/g) and in Seeds (0.778 mg/g to 7.326 mg/g).

*Triticum aestivum* (Wheat) variety Raj 3077

In field observation included collection of Ground water samples, soil and plant samples during the period of November 2013 to March 2014.

WATER ANALYSIS

Water samples were collected from agricultural field at seven different villages (five samples per village) in Devli tehsil. Water samples were analyzed for pH, Total Dissolved Solid, Electrical conductivity, Alkalinity, Chlorides, Calcium hardness, Total hardness and Fluoride Concentrations at pre-flowering, peak-flowering and Post-flowering Stages of *Triticum aestivum*.

pH

The pH of the water samples collected from the study are ranged from 7.45±0.098 to 9.41±0.068 at post-flowering stage.

Total dissolved solids

The total dissolved solid of the water samples collected from the study area ranged from 1057±12.669mg/L to 3249±9.055 mg/L at post-flowering stage.

Electrical conductivity

The electrical conductivity of the water samples collected from the study area ranged from 1736±10.488µmhos/cm to 4569±9.823µmhos/cm at post-flowering stage.

Chlorides concentration

The chlorides concentration of the water samples collected from the study area ranged from 196±10.932 mg/L to 1437±11.769mg/L at post-flowering stage.
Summary

Alkalinity concentration

The chlorides concentration of the water samples collected from the study area ranged from 138±9.975 mg/L to 918±10.730mg/L at post-flowering stage.

Calcium hardness

The calcium hardness of the water samples collected from the study area ranged from 374±14.153 mg/L to 39±8.746 mg/L at post-flowering stage.

Total hardness

The total hardness of the water samples collected from the study area ranged from 1026±10.794 mg/L to 138±10.173 mg/L at post-flowering stage.

Fluoride concentration

The Fluoride concentration in the water samples collected from the study area ranged from 1.19±0.121 ppm to 16.94±0.092 ppm at post-flowering stage.

SOIL ANALYSIS

Water samples were collected from agricultural field at seven different villages (five samples per village) in Devli Tehsil. Soil samples were analyzed for pH, Electrical conductivity, Chlorides, Organic matter and Fluoride concentration at three stages (Pre-flowering, Peak-flowering and Post-flowering) of the test species *Triticum aestivum*.

pH

The pH of the soil samples collected from the study area ranges from the study area ranged from 8.15±0.094 to 9.21±0.023 at post-flowering stage.

Electrical conductivity

The electrical conductivity of the soil samples collected from the study area ranged from 6124±8.195 μhmhos/cm to 7594±10.182 μhmhos/cm at post-flowering stage.
Chlorides concentration

The chlorides concentration of the soil samples collected from the study area ranged from 6.048±0.321 mg/100g to 16.673±0.721 mg/100g at post-flowering stage.

Organic matter

The organic matter of the soil samples collected from the study area ranged from 1.968±0.291 % to 1.783±0.335 percent at post-flowering stage.

Fluoride concentration

The fluoride concentration in the soil samples collected from the study area ranged from 0.952±0.066 mg/g to 0.846±0.111mg/g at post-flowering stage.

PLANT ANALYSIS

Plant samples were collected from the agricultural fields (five samples per village) in Devli Tehsil of Tonk district. Plants were harvested at Pre-flowering, Peak-flowering and Post-flowering stages. To determine the effects of fluoridated water, the plant growth parameters i.e. root length, shoot length, ear length, root dry weight, shoot dry weight, Grain dry weight were estimated and chlorophyll, carbohydrate, nitrogen, and phosphorous were also analyzed in the *Triticum aestivum*.

Bio-chemical and Physiology parameters like chlorophyll content of leaves, Carbohydrate content, Plant Nitrogen, Protein and Phosphorous were analyzed and recorded.

Root length

The maximum root length was recorded at post-flowering stage. Root length in the plant samples collected from the study area (S1 to S7) ranged between 4.62±1.947 cm to 28.86±1.704 cm

Shoot length

The maximum shoot length was recorded at post-flowering stage. Shoot length in the plant samples collected from the study area (S1 to S7) ranged between 74.28±2.814 cm to 71.83±1.869 cm.
Ear length
The maximum Pod length was recorded at post-flowering stage. Ear length in the plant samples collected from the study area (S1 to S7) ranged between 16.42±1.694cm to 14.78±1.801 cm.

Root dry weight
The maximum root dry weight was recorded at post-flowering stage. Root dry weight in the plant samples collected from the study area (S1 to S7) ranged between stage 0.854±0.032 gm to 0.682±0.021 gm.

Shoot dry weight
The maximum shoot dry weight was recorded at post-flowering stage. Shoot dry weight in the plant samples collected from the study area (S1 to S7) ranged between 4.853±0.087gm to 3.876±0.092 gm.

Seeds dry weight
The maximum grain dry weight was recorded at post-flowering stage. Grain dry weight in the plant samples collected from the study area (S1 to S7) ranged between 2.073±0.017 gm to 1.798±0.010 gm.

Chlorophyll
The highest amount of total chlorophyll was recorded at post-flowering stage. Total chlorophyll in the plant samples collected from the study area (S1 to S7) ranged between 40.102±0.053 mg/g to 34.828±0.084mg/g.

Carbohydrate
The highest amount of carbohydrate content was recorded at peak-flowering stage. The plant samples collected from the study area (S1 to S7) ranged between 69.78±0.089mg/g to 58.43±0.143 mg/g.

Phosphorous
The highest amount of phosphorous content was recorded at peak-flowering stage. The plant samples collected from the study area (S1 to S7) ranged between 3.924±0.017mg/g to 3.284±0.082mg/g.
Nitrogen

The highest amount of nitrogen content was recorded at peak-flowering stage. The plant samples collected from the study area (S1 to S7) ranged between 3.213±0.008% to 2.822±2.026%.

Protein

The highest amount of protein content was recorded at peak-flowering stage. The plant samples collected from the study area (S1 to S7) ranged between 12.713±0.078% to 9.988±0.104%.

Fluoride concentration

The maximum fluoride concentration was recorded at post-flowering stage. Fluoride content in the plant samples collected from the study area (S1 to S7) ranged in Leaves were (1.681 mg/g to 17.046 mg/g), stem (1.427mg/g to 14.589 mg/g), root (1.259 mg/g to 13.424 mg/g) and in Seeds (1.068 mg/g to 9.672 mg/g).

FIELD OBSERVATIONS

Ground water samples were collected during 2011 to 2012 from 30 different villages belonging to Devli tehsil of Tonk district. These collected water samples were analyzed for physico-chemical characteristics i.e. pH, Electrical conductivity, Alkalinity, Total dissolved solids, Chlorides, Calcium hardness, Total hardness and Fluoride concentration. During the study period fluoride analysis was also carried out yearly. The concentration of fluoride in water samples varied from 0.7 ppm (as the lowest concentration) to 16.5 ppm (as the highest concentration) in the study area.

GROUND WATER ANALYSIS

Ground water samples collected from 30 different village (five samples per village) in Devli Tehsil. Fluoridated water samples were analyzed for pH, total dissolved solid, electrical conductivity, Alkalinity, Chlorides, Calcium hardness, Total hardness and Fluoride concentrations during 2011 to 2012.

pH

The pH of the water samples collected from the study area (Kawarpura and Daberkala) ranged from 7.43±0.010 to 9.38±0.0.08 in 2011 and 7.49 ±0.120 to 9.42±0.119 in 2012.
Summary

Total dissolved solids

The total dissolved solid of the water samples collected from the study area (Kawarpura and Daberkala) ranged from 1026±6.32 mg/L to 3276±10.37 mg/L in 2011 and 1078±11.467 mg/L to 3293±13.472 mg/L in 2012.

Electrical conductivity

The electrical conductivity of the water samples collected from the study area (Kawarpura and Daberkala) ranged from 1730±6.81 µmhos/cm to 4578±12.38 µmhos/cm in 2011 and 1752±11.068 µmhos/cm to 4598±11.068 µmhos/cm in 2012.

Chlorides concentration

The chlorides concentration of the water samples collected from the study area (Kawarpura and Daberkala) ranged from 182±1.58 mg/L to 1428±8.67 mg/L in 2011 and 209±11.895 mg/L to 1464±12.826 mg/L in 2012.

Alkalinity concentration

The chlorides concentration of the water samples collected from the study area (Kawarpura and Daberkala) ranged from 134±8.39 mg/L to 916±10.17 mg/L in 2011 and 167±11.023 mg/L to 948±10.932 mg/L in 2012.

Calcium hardness

The calcium hardness of the water samples collected from the study area (Kawarpura and Daberkala) ranged from 173.170±6.013 mg/L to 540.390±14.801 mg/L in 2011 and 173.170±6.013 mg/L to 540.390±14.801 mg/L in 2012.

Total hardness

The total hardness of the water samples collected from the study area (Kawarpura and Daberkala) ranged from 370±5.78 mg/L to 32±5.24 mg/L in 2011 and 386±11.747 mg/L to 56±13.601 mg/L in 2012.

Fluoride concentration

The Fluoride concentration in the water samples collected from the study area (Kawarpura and Daberkala) ranged from 0.56±0.130 mg/L to 16.23±0.250 mg/L in 2011, and 0.78±0.112 mg/L to 16.52±0.106 mg/L in 2012.
SOIL ANALYSIS

Soil samples were collected from 30 different villages (five samples per village) in Devli Tehsil. Soil samples were taken from the same site where water samples were collected earlier. Soil samples were analyzed for pH, electrical conductivity, Chlorides, Organic matter and Fluoride concentrations during 2011 to 2012.

pH

The pH of the soil samples collected from the study area (Kawarpura and Daberkala) ranged from 7.18±0.034 to 9.14±0.013 in 2011 and 7.26±0.049 to 9.23±0.011 in 2012.

Electrical conductivity

The electrical conductivity of the soil samples collected from the study area (Kawarpura and Daberkala) ranged from 1458±3.122 µmhos/cm to 3924±6.528 µmhos/cm in 2011 and 1496±3.062 µmhos/cm to 4148±10.340 µmhos/cm in 2012.

Chlorides concentration

The chlorides concentration of the soil samples collected from the study area (Kawarpura and Daberkala) ranged from 4.782±8.145 mg/100g to 15.657±7.156 mg/100g in 2011 and 4.801±8.132 mg/100g to 15.873±10.526 mg/100g in 2012.

Organic matter

The organic matter of the soil samples collected from the study area (Kawarpura and Daberkala) ranged from 1.039±0.042 percent to 0.279±0.092 percent in 2011 and 1.109±0.018 percent to 0.348±10.340 percent in 2012.

Fluoride concentration

The Fluoride concentration in the soil samples collected from the study area (Kawarpura and Daberkala) ranged from 0.357±0.006mg/g to 11.266±0.860mg/g and in 2011 and 0.402±0.005mg/g to 11.358±0.883mg/g in 2012.
EXPERIMENTAL WORK

The experimental studies were undertaken by selected *Hordeum vulgare* variety *RD 2052*, *Cicer aritinum* variety C888 and *Triticum aestivum* variety Raj 3077.

POT EXPERIMENT

These plants were grown in the laboratory and seven different levels were prepared viz. control (Double Distilled water) 3ppm; 6ppm; 9 ppm; 12ppm; 15ppm; and 18ppm. These plants were exposed to the above given level throughout the tenure of the experiment, Plants were harvested at Pre-flowering, Peak-flowering and Post-flowering stages. Five plants per level were harvested at each stage.

To determine the effects of fluoridated water, the plant growth parameters i.e. root length, shoot length, Ear and pod length root dry weight, shoot dry weight, Grain and seed dry weight were estimated and chlorophyll, carbohydrate, protein, nitrogen and phosphorous were also analyzed in the test species.

*Hordeum vulgare* variety *RD 2052*

**Root length**

The root length was adversely affected with maximum reduction of 2.250, 4.369, 6.260, 7.695, 9.423 and 11.021 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm at post-flowering stage respectively.

**Shoot length**

The shoot length was adversely affected with maximum reduction of 1.492, 2.882, 3.884, 4.886, 6.051 and 7.134 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18 ppm at post-flowering stage respectively.

**Ear length**

The pod length was adversely affected with maximum reduction of 2.411%, 4.521%, 6.179%, 7.008%, 8.289% and 9.269% percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18 ppm at post-flowering stage respectively.
Summary

Root dry weight
The root dry weight was adversely affected with maximum reduction of 8.740, 16.463, 22.358, 25.610, 30.488 and 34.350 percent at treatment levels 3ppm, 6ppm, 9 ppm, 12 ppm, 15ppm and 18 ppm at post-flowering stage respectively.

Shoot dry weight
The shoot dry weight was adversely affected with maximum reduction of 11.732, 19.115, 30.665, 35.490, 42.909 and 48.684 at treatment levels 3ppm, 6ppm, 9 ppm, 12 ppm, 15ppm and 18 ppm at post-flowering stage respectively.

Grains dry weight
The ear dry weight was adversely affected with maximum reduction of 7.778%, 15.410%, 22.204%, 27.258%, 33.554% and 39.188% at treatment levels 3ppm, 6ppm, 9 ppm, 12 ppm, 15ppm and 18 ppm at post-flowering stage respectively.

Chlorophyll
The highest amount of total chlorophyll was recorded at post-flowering stage. The amount of chlorophyll was adversely affected with maximum reductions of 4.826%, 9.540%, 14.385%, 19.057%, 23.851% and 28.677% at treatment levels 3ppm, 6ppm, 9 ppm, 12 ppm, 15ppm and 18 ppm respectively.

Carbohydrate
The highest amount of carbohydrate content was recorded at peak-flowering stage. The amount of carbohydrate was adversely affected with maximum reductions of 4.477, 7.535, 9.285, 10.332, 12.013 and 13.542 percent at treatment levels 3ppm, 6ppm, 9 ppm, 12 ppm, 15ppm and 18 ppm respectively.

Phosphorous
The highest amount of phosphorous content was recorded at post-flowering stage. The amount of phosphorous was adversely affected with maximum reductions of 4.252%, 9.374%, 15.043%, 19.845%, 23.548% and 25.743% percent at treatment levels 3ppm, 9 ppm, 12 ppm, 15ppm and 18ppm respectively.
Nitrogen

The highest amount of nitrogen content was recorded at pre-flowering stage. The amount of nitrogen was adversely affected with maximum reductions of 2.579, 5.339, 8.458, 10.678, 13.557 and 16.077 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

Protein

The highest amount of protein content was recorded at pre-flowering stage. The amount of protein was adversely affected with maximum reductions of 2.582%, 5.336%, 8.456%, 10.682%, 13.562% and 16.076% at treatment levels 3ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

Fluoride concentration

The highest amount of fluoride content was found at post-flowering stage. The concentration of fluoride was adversely affected with maximum percent reductions of 6.251mg/g, 12.072mg/g, 18.345mg/g, 22.691mg/g, 26.078mg/g and 29.454mg/g in the leaves at treatment levels of 3ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

The highest amount of fluoride content was found at post-flowering stage. The concentration of fluoride was adversely affected with maximum percent reductions of 6.480mg/g, 11.716mg/g, 17.466mg/g, 21.440mg/g, 24.520mg/g and 27.607mg/g in the stem at treatment levels of 3ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

The highest amount of fluoride content was found at post-flowering stage. The concentration of fluoride was adversely affected with maximum percent reductions of 7.065mg/g, 13.226mg/g, 19.903mg/g, 24.659mg/g, 28.455mg/g and 32.256mg/g in the root at treatment levels of 3ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

The highest amount of fluoride content was found at post-flowering stage. The concentration of fluoride was adversely affected with maximum percent reductions of 7.154mg/g, 11.070mg/g, 16.398mg/g, 19.994 mg/g, 22.762mg/g and
25.532 mg/g in the edible (Grains) portion at treatment levels of 3ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

Soil used in the pot experiment was also analyzed for pH, electrical conductivity, chlorides, organic matter and fluoride by employing methods as described earlier;

**pH:-**

The pH of the pot soil samples at post-flowering stages was 7.29, 7.21, 7.53, 7.75, 7.79, 7.86 and 7.92 at treatment levels 3ppm, 6ppm, 9ppm,12ppm,15ppm and 18 ppm respectively.

**Electrical conductivity:-**

The electrical conductivity of the pot soil samples at post-flowering stages was 3932 µhmhos/cm, 4024 µhmhos/cm, 4118 µhmhos/cm, 4236 µhmhos/cm, 4349 µhmhos/cm, 4417 µhmhos/cm and 4478µhmhos/cm at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

**Chlorides concentration:-**

The chlorides concentration of the pot soil samples at post-flowering stages was 3.928 mg/100g, 5.203 mg/100g, 6.596 mg/100g, 8.244mg/100g, 9.653mg/100g, 10.978 mg/100g and 11.907 mg/100g at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

**Organic matter:-**

The organic matter content of the pot soil samples at post-flowering stages was 0.769, 0.758, 0.746, 0.732, 0.821, 0.711 and 0.689 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

**Fluoride concentration:-**

Fluoride concentration in pot soil samples at post-flowering stages was 0.434 mg/g, 2.338 mg/g, 3.915 mg/g , 5.002mg/g, 6.109 mg/g, 7.231mg/g and 7.493mg/g at treatment 3ppm, 6ppm, 9ppm,12ppm,15ppm and 18 ppm respectively.
Cicer arietinum (Chickpea) variety C888

Root length
The root length was adversely affected with maximum reduction of 2.895, 5.619, 5.089, 9.451, 11.409 and 13.240 percent at treatment levels 3 ppm, 6 ppm, 9 ppm, 12 ppm, 15 ppm and 18 ppm at post-flowering stage respectively.

Shoot length
The shoot length was adversely affected with maximum reduction of 3.569, 6.559, 8.755, 10.372, 12.203 and 13.941 percent at treatment levels 3 ppm, 6 ppm, 9 ppm, 12 ppm, 15 ppm and 18 ppm at post-flowering stage respectively.

Pods length
The pod length was adversely affected with maximum reduction of 14.612, 27.854, 38.813, 47.489, 57.991 and 67.580 percent at treatment levels 3 ppm, 6 ppm, 9 ppm, 12 ppm, 15 ppm and 18 ppm at post-flowering stage respectively.

Root dry weight
The root dry weight was adversely affected with maximum reduction of 4.983, 9.450, 13.058, 15.292, 18.385 and 21.134 percent at treatment levels 3 ppm, 6 ppm, 9 ppm, 12 ppm, 15 ppm and 18 ppm at post-flowering stage respectively.

Shoot dry weight
The shoot dry weight was adversely affected with maximum reduction of 9.766, 18.593, 25.447, 26.694, 32.575 and 35.487 percent at treatment levels 3 ppm, 6 ppm, 9 ppm, 12 ppm, 15 ppm and 18 ppm at post-flowering stage respectively.

Seeds dry weight
The ear dry weight was adversely affected with maximum reduction of 5.354, 10.582, 15.599, 17.622, 20.784, and 25.506 percent at treatment levels 3 ppm, 6 ppm, 9 ppm, 12 ppm, 15 ppm and 18 ppm at post-flowering stage respectively.

Chlorophyll
The highest amount of total chlorophyll was recorded at post-flowering stage. The amount of chlorophyll was adversely affected with maximum reductions
Summary

of 4.399, 8.563, 12.217, 14.993, 18.280 and 21.266 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

Carbohydrate

The highest amount of carbohydrate content was recorded at peak-flowering stage. The amount of carbohydrate was adversely affected with maximum reductions of 4.633, 8.610, 12.568, 15.926, 18.439, 20.521 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

Phosphorous

The highest amount of phosphorous content was recorded at post-flowering stage. The amount of phosphorous was adversely affected with maximum reductions of 5.556, 11.479, 18.995, 24.183, 29.248 and 32.230 percent at treatment levels 3ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

Nitrogen

The highest amount of nitrogen content was recorded at pre-flowering stage. The amount of nitrogen was adversely affected with maximum reductions of 3.465, 7.174, 11.225, 14.641, 18.448 and 22.108 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

Protein

The highest amount of protein content was recorded at pre-flowering stage. The amount of protein was adversely affected with maximum reductions of 2.307, 4.791, 7.545, 9.717, 12.244 and 14.551 percent at treatment levels 3ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

Fluoride concentration

The highest amount of fluoride content was found at post-flowering stage. The concentration of fluoride was adversely affected with maximum percent reductions of 6.247mg/g, 12.412mg/g, 19.493mg/g, 24.308mg/g, 27.990 mg/g and 31.674mg/g in the root at treatment levels of 3ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.
The highest amount of fluoride content was found at post-flowering stage. The concentration of fluoride was adversely affected with maximum percent reductions of 0.424mg/g, 12.373mg/g, 19.394mg/g, 24.163mg/g, 27.809mg/g and 231.450 mg/g in the stem at treatment levels of 3ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

The highest amount of fluoride content was found at post-flowering stage. The concentration of fluoride was adversely affected with maximum percent reductions of 5.960mg/g, 10.769mg/g, 16.063mg/g, 20.063mg/g, 23.427mg/g and 26.793mg/g in the leaves at treatment levels of 3ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

The highest amount of fluoride content was found at post-flowering stage. The concentration of fluoride was adversely affected with maximum percent reductions of 5.130mg/g, 9.134mg/g, 13.897mg/g, 17.411mg/g, 20.315mg/g and 23.202mg/g in the edible (Seeds) portion at treatment levels of 3ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

Soil used in the pot experiment was also analyzed for pH, electrical conductivity, chlorides, organic matter and fluoride by employing methods as described earlier;

**pH:-**

The pH of the pot soil samples at post-flowering stages was 7.23, 7.15, 7.48, 7.65, 7.74, 7.81 and 7.86 at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

**Electrical conductivity:-**

The electrical conductivity of the pot soil samples at post-flowering stages was 3678µmhos/cm, 3784µmhos/cm, 3861µmhos/cm, 3978µmhos/cm, 4063µmhos/cm, 4137µmhos/cm and 4219µmhos/cm at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.
Summary

Chlorides concentration:-

The chlorides concentration of the pot soil samples at post-flowering stages was 3.879mg/100g, 5.142mg/100g, 6.508mg/100g, 8.083mg/100g, 9.215mg/100g, 10.798mg/100g and 11.704mg/100g at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

Organic matter:-

The organic matter content of the pot soil samples at post-flowering stages was 0.715, 0.706, 0.695, 0.682, 0.671, 0.663 and 0.649 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

Fluoride concentration:-

Fluoride concentration in pot soil samples at post-flowering stages was 0.372 mg/g, 2.124 mg/g, 3.612 mg/g, 4.634mg/g, 5.681mg/g, 6.742mg/g and 6.993mg/g at treatment 3ppm, 6ppm, 9ppm,12ppm,15ppm and 18 ppm respectively.

*Triticum aestivum* (wheat) *variety Raj 3077*

Root length

The root length was adversely affected with maximum reduction of 3.678, 6.659, 8.091, 9.330, 10.685 and 11.963 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm at post-flowering stage respectively.

Shoot length

The shoot length was adversely affected with maximum reduction of 1.377, 2.636, 3.523, 4.060, 4.783 and 5.413 percent at treatment levels 3ppm, 6ppm, 9 ppm,12ppm, 15ppm and 18 ppm at post-flowering stage respectively.

Ear Length

The Ear length was adversely affected with maximum reduction of 2.851, 5.393, 7.319, 8.243, 10.015 and 11.633 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm at post-flowering stage respectively.
Summary

Root dry weight

The root dry weight was adversely affected with maximum reduction of 9.751, 17.687, 22.449, 26.077, 30.162 and 33.787 percent at treatment levels 3ppm, 6ppm, 9 ppm, 12ppm, 15ppm and 18ppm at post-flowering stage respectively.

Shoot dry weight

The shoot dry weight was adversely affected with maximum reduction of 4.766, 9.030, 12.291, 13.712 and 16.137 and 18.227 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm at post-flowering stage respectively.

Grains dry weight

The ear dry weight was adversely affected with maximum reduction of 4.535, 14.934, 23.119, 25.774, 30.531 and 36.173 percent at treatment levels 3ppm, 6ppm, 9 ppm, 12ppm, 15ppm and 18ppm at post-flowering stage respectively.

Chlorophyll

The highest amount of total chlorophyll was recorded at post-flowering stage. The amount of chlorophyll was adversely affected with maximum reductions of 3.356, 6.525, 9.405, 11.657, 14.316 and 16.789 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

Carbohydrate

The highest amount of carbohydrate content was recorded at peak-flowering stage. The amount of carbohydrate was adversely affected with maximum reductions of 5.162, 9.865, 12.225, 15.012, 17.308 and 19.192 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

Phosphorous

The highest amount of phosphorous content was recorded at post-flowering stage. The amount of phosphorous was adversely affected with maximum reductions of 2.227, 10.276, 15.002, 19.119, 23.631 and 27.820 percent at treatment levels 3ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.
Nitrogen

The highest amount of nitrogen content was recorded at pre-flowering stage. The amount of nitrogen was adversely affected with maximum reductions of 2.371, 4.743, 7.403, 11.914 and 14.170 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

Protein

The highest amount of protein content was recorded at pre-flowering stage. The amount of protein was adversely affected with maximum reductions of 2.369, 4.738, 7.403, 9.421, 11.910 and 14.168 percent at treatment levels 3ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

Fluoride concentration

The highest amount of fluoride content was found at post-flowering stage. The concentration of fluoride was adversely affected with maximum percent reductions of 5.856mg/g, 11.242mg/g, 17.042mg/g, 20.458mg/g, 24.189mg/g and 27.311mg/g in the leaves at treatment levels of 3ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

The highest amount of fluoride content was found at post-flowering stage. The concentration of fluoride was adversely affected with maximum percent reductions of 6.702mg/g, 11.503mg/g, 16.977mg/g, 20.756mg/g, 23.691mg/g and 26.630mg/g in the stem at treatment levels of 3ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

The highest amount of fluoride content was found at post-flowering stage. The concentration of fluoride was adversely affected with maximum percent reductions of 6.632mg/g, 12.270mg/g, 18.400mg/g, 22.735mg/g, 26.275mg/g and 29.769mg/g in the root at treatment levels of 3ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

The highest amount of fluoride content was found at post-flowering stage. The concentration of fluoride was adversely affected with maximum percent reductions of 6.752mg/g, 10.399mg/g, 15.332mg/g, 18.708mg/g, 21.290mg/g and
23.872mg/g in the edible (Grains) portion at treatment levels of 3ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

Soil used in the pot experiment was also analyzed for pH, electrical conductivity, chlorides, organic matter and fluoride by employing methods as described earlier;

**pH:**

The pH of the pot soil samples at post-flowering stages was 7.36, 7.48, 7.61, 7.76, 7.85, 7.92 and 7.98 at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18 ppm respectively.

**Electrical conductivity:**

The electrical conductivity of the pot soil samples at post-flowering stages was 4062µmhos/cm, 4197µmhos/cm, 4269µmhos/cm, 4382µmhos/cm, 4475µmhos/cm, 4548µmhos/cm and 4593µmhos/cm at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

**Chlorides concentration:**

The chlorides concentration of the pot soil samples at post-flowering stages was 3.986mg/100g, 5.279mg/100g, 6.692mg/100g, 8.349mg/100g, 9.818mg/100g, 11.192mg/100g and 12.132mg/100g at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

**Organic matter:**

The organic matter content of the pot soil samples at post-flowering stages was 0.893, 0.872, 0.857, 0.843, 0.831, 0.825 and 0.809 percent at treatment levels 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.

**Fluoride concentration:**

Fluoride concentration in pot soil samples at post-flowering stages was 0.463 mg/g, 2.521 mg/g, 4.189 mg/g, 5.334mg/g, 6.503mg/g, 7.687mg/g and 7.984mg/g at treatment 3ppm, 6ppm, 9ppm, 12ppm, 15ppm and 18ppm respectively.