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# Effect of Sodium Fluoride on Germination Seedling Growth in Wheat (*Triticum aestivum*) VAR UP2382

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**ABSTRACT**

The growth and yield of several crops have been shown to be drastically decrease by Fluoride. Therefore, in the present study we have tried to investigate the adverse effects of fluoride on growth, photosynthetic pigments, chlorophyll stability index in wheat (*Triticum aestivum*) seedlings. Growth pattern of wheat seedlings was monitored at regular intervals for 15 days under different concentrations by estimating the shoot and root length, number of root, fresh and dry weight. Seedlings of wheat were grown sterilized in petri dishes during on growth of seedlings in different concentrations of fluoride (20,40,80,120 and 160mg/L) were selected for detailed study. The germination %, shoot and root length, number of root, fresh and dry weight of the wheat seedlings was found maximum in treatment $T_0$- control and minimum was recorded in treatment $T_5$- 160 mg/L. The results showed that the shoot and root length, number of root, fresh and dry weight were reduced by 47.89,58.66, 18.60, 47.24 and 63.03 % at $T_5$- 160mg/L respective value of control. The photosynthetic pigment content was investigated in the presence of different concentrations of fluoride. The photosynthetic pigment content was severely affected with increasing concentrations of fluoride. Also, fresh and dry weight were decrease in order of increase in NaF concentration from$T_0$-control to $T_5$-160mg/L. The photosynthetic pigments chl *a*, chl *b*, total chl of the wheat seedlings was in treatment $T_0$-control and was recorded in treatment $T_5$- 160 mg/L. It was also recorded chl *a*, chl *b*, total chl were in order of increase in NaF concentration from $T_0$- control to$T_5$-160mg/L. The chlorophyll stability index of the wheat seedlings was found maximum in treatment $T_0$-control and minimum was recorded in treatment $T_5$-160 mg/L. It was also recorded chlorophyll stability index was decrease in order of increase in NaF concentration from $T_0$-control to $T_5$-160mg/L.

**الملخص العربي**

هدف هذه الدراسة الى دراسة الآثار الضارة للفلورايد على نبات القمح (*Triticum aestivum*). وذلك عن طريقة دراسة تأثيره النمو وعملية التمثيل الضوئى ومؤشر ثبات الكلوروفيل في نبات القمح. حيث تمت مراقبة نمط نمو شتلات القمح على فترات منتظمة لمدة 15 يوم عند معاملتها بتركيزات مختلفة الفلورايد (20، 40، 80، 120، 160 ملجم/لتر) وتم تقدير طول الجذور وطول المجموع الخضري والجذري والوزن الرطب والجاف. وأظهرت النتائج ان أعلى نسبة الإنبات وطول الجذورو المجموع الخضري والوزن الرطب والجاف لشتلات القمح كانت في معاملة الشاهد وتم تسجيل الحد الأدنى عند معاملتها بالفلورايد بتركيز160 ملجم/لتر. كما أبينت النتائج انخفاض في الطول وعدد الجذور والوزن الطازج والجاف عند معاملة بتراكيز مختلفة من الفلورايد وخاصة عند التركيز 160 ملجم/لتر.

## INTRODUCTION

Fluorine is the 13th abundant element on the earth. It cannot exist outside controlled environment without combining with other substances to become fluoride. It is a very common element on planet earth, being almost ubiquitous in nature, and is mostly present as the fluoride ion ($F^-$) or bound in minerals or soils. The main natural sources to fluorides are thus by weathering of rocks and minerals together with releases from volcanic activity (WHO, 2002). Fluoride presents in soil, water, air and plants in varying concentrations but is not considered essential for the normal growth of plants (Weinstein and Davison, 2004). Fluoride ion at high concentrations is known to cause several health hazards to human population and livestock including dental and skeletal fluorosis. Fluoride affects a wide range of physiological processes including plant growth, chlorosis, leaf tip burns and leaf necrosis. Even at fairly low ambient concentrations, fluoride (F) can cause a number of physiological and biochemical changes in plants without visible signs of injury. However, continuous use of high fluoride water adversely affects crop growth. Phosphatic fertilizers, especially superphosphates, are the most important source of fluoride in agriculture. High levels of fluoride inhibit germination, cause ultrastructure malformations, reduce photosynthetic capacities, alter membrane permeability, reduce productivity, decrease biomass, and inflict other physiological and biochemical disorders in plants. In short, fluoride can modify or disrupt metabolic processes and cause foliar lesions in plants (Gautam and Bhardwaj, 2010).

Anthropogenic sources of fluoride contamination to the environment are directly connected to the steel, phosphate fertilizer, aluminum and ceramics industry as well as nonferrous metal foundries and welding processes as some of the major contributors to environmental contamination. Further, of fluoride containing pesticides, use of super phosphate fertilizers and fluoridation of drinking water leads to emissions of fluorides to the environment (WHO, 2002). Acute toxic effects of fluoride poisoning are seldom observed in nature, mostly after volcanic eruptions, major accidents with hydrogen fluoride or from of pesticides or by accidental ingestion of rodent poison. The low concentrations of fluoride enhanced vegetation growth (hormesis). However, it is well known that flour is quite toxic to plants (Landis *et al.* 2011). Fluoride can either enter the plants with the uptake of soil water through the roots or by the leaf stomata, where it passes into the intercellular spaces where it reaches the mesophyll from where it can be absorbed into the cells (Threshow, 1970). Fluorides taken up through the leaves are often in the gaseous forms of hydrofluoric acid or silicon tetra fluoride as they are taken up faster than particulate fluoride (Landis *et al.* 2011) and according to (Herman and Weinstein, 1982) hydrofluoric acid is the most phytotoxic of the more common air pollutants. When fluoride has entered the plants and is dissolved in the water, it is transported via the vascular tissue to the leaf edges where it is accumulated The translocation of fluoride is always upwards, which indicates no transportation from the leaves to the roots. The concentrations at the leaf tips can thus reach quite high the first signs of fluoride toxicity are often observed at the leaf edges (Threshow, 1970). Further, several studies with respect to indicate inhibition at concentrations around 1 mM sodium fluoride, some of the visible evidences of toxic effects of fluorides to plants are necrosis and chlorosis. Chlorosis is related to the plants partial failure to produce chlorophyll due to lack of nutrition or pathogenic attacks. High concentration of fluoride caused various changes in mineral content in plants which are important for physiologicaland biochemical reactions (Elloumi *et al.* 2005). Fluoride contaminated ground water is used for irrigation which adversely affects crop growth especially in early stage of seedling growth (Bhargava and Bhardwaj, 2010). With due consideration on all abovementioned and important effects of fluoride on plants the study associated to study effect of sodium fluoride on seed germination of *Triticum aestivum*, variety (UP-2382).

## MATERIALS AND METHODS

### 1. Sterilization of seed

Equal number (Ten) from sterilized seeds were placed in individual petri dishes labeled as control and NaF concentrations viz. $T_1$- 20 mg/L, $T_2$- 40 mg/L, $T_3$- 80 mg/L, $T_4$-120 mg/L and $T_5$-160 mg/L. The pre-sterilized petri-dishes were lined with filter paper, moistened from below with sterilized cotton pads. 10 replicates were taken for each respective concentration of fluoride and $T_0$-control. 5-10 ml of sodium fluoride solutions were added to each petri-plate on every day of treatment.

2. Determination of seed germination.

Germination was recorded on 3th and 5th days after germination was complete, the number of germinated seeds in each petri dish was counted, and the percentage (%) of germination was calculated. The mean values were calculated from the results of the ten replicates.

Germination percentage = $\frac{\text{Total number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$

3. Number of Roots. it was recorded from each treatment, the data was estimated and recorded at 5th and10th days interval.

4. Root and Shoot length. it was measured with the help of a scale in centimeters, data for root and shoot length was measured and recorded at 5th,10th and15th days interval.

5. The Vigour index of growth: it was calculated for each NaF concentration according to the equation (Abdul-Baki and Anderson, 1973) at 5th,10th and15th days interval.

Vigour index = (Root length + Shoot length) × Germination percentage

6. Fresh and Dry Weight. The fresh and dry weights was estimated by four plants was selected and weighed by electrical weighing blance in grams. After that, the seedlings were wrapped in labeled blotting paper, oven dried at 80ºC for 24 hr, and the dry weight was then recorded.

7. Photosynthetic pigments analysis: Chlorophyll a, b were determined by method given by ( D.I. Arnon,1949).

Calculations: Arnon's equation (below) was used to convert absorbance measurements to mg Chl g-1 leaf tissue

Chl a (mg g-1) = [(12.7 × A663) - (2.6 × A645)] × ml acetone / mg leaf tissue

Chl b (mg g-1) = [(22.9 × A645) - (4.68 × A663)] × ml acetone / mg leaf tissue

Total Chl = Chl a + Chl b.

8. Chlorophyll stability index (CSI): it was estimated by method given by (Koleyoreas, 1958).

CSI (%)= $\frac{\text{Total chlorophyll content (heated)}}{\text{Total chlorophyll content (control)}} \times 100$

**9. *Statistical Analysis:*** ANOVA Statistical analysis performed with the statistical software (SPSS) one-way analysis of variance (ANOVA) was performed to evaluate the significance of the main effect of the F treatment. Differences were considered significant at the $P<0.05$ level.

## RESULTS AND DISCUSSION

### 1. Effect of NaF on seed germination at 3 and 5 days.

The results of wheat seeds with NaF were decreased gradually with increasing NaF concentrations (Table1). The germination significantly by NaF concentrations at 5 days but not recorded significantly at 3 days. At 3 days the $T_0$ germination was 95%, which diminished to 85% at $T_5$. is due to higher concentration of F present in solution. At 5 days that the mean value of seed germination of wheat the maximum germination % of wheat seedlings were founded in treatments $T_0$ and $T_1$ which were 100% and minimum were recorded in treatment $T_4$ and $T_5$ 95%. The results observed that NaF had a negative effect on germination % of wheat. due to toxic effect of fluoride to earlier reports from germination experiments on cluster beans by (Sabal *et al.* 2006), and inhibition of germination may be due to reduction of amylase activity caused by fluoride. This is in agreement with (Bhargava and Bhardwaj, 2010) who said that the seed germination and seedling growth inhibition under fluoride stress in *Triticum aestivum* . fluoride can cause effect on the physiology and biochemistry of germinated seedlings (Gupta *et al*. 2009) The damage appears to result from a rapid reaction between the interhalogens and the plant or seed surfaces.

**Table 1. Effect of different concentrations of NaF on germination at 3 and 5 days.**

| Treatments | Germination (%) | |
|---|---|---|
| | At 3 DAYS | At 5 DAYS |
| $T_{0=}$ Control | 95 | 100 |
| $T_{1=}$ 20mg/L NaF | 94 | 100 |
| $T_{2=}$ 40mg/L NaF | 90 | 98 |
| $T_{3=}$ 80mg/L NaF | 87 | 97 |
| $T_{4=}$ 120mg/L NaF | 86 | 95 |
| $T_{5=}$ 160mg/L NaF | 85 | 95 |
| **F- test** | **NS** | **S** |
| **S. Ed. (±)** | 4.032 | 1.795 |
| **C. D. (P = 0.05)** | 8.387 | 3.734 |

## 2. Effect of NaF on number of roots at 5 and 10 days.

number of roots were depicted by Table 2 , number of roots of wheat was highest in $T_0$ and gradually decreased with the increase in concentration of NaF treatment from $T_0$ to $T_5$. The number of roots were not significantly influenced by NaF concentrations. Results showed that the mean value of number of roots of wheat seedlings were maximum in $T_0$ 3.8 and minimum was recorded in treatment $T_5$ 3.3 and was recoded 13.16% at 5 days, and the mean value of number of roots of wheat seedlings were maximum in $T_0$ 4.3 and minimum was recorded in treatment $T_5$ 3.5 and was recoded 18.60% at 10 days. The result observed that NaF had a negative effect on the number of roots of *Triticum aestivum*. is due to higher concentration of NaF present in solution.

**Table 2. Effect of different concentrations of NaF on number of roots at 5 and 10 days.**

| Treatments | Number of Roots at 5 DAYS | Inhibition(%) of No. of Roots at 5 DAYS | Number of Roots at10 DAYS | Inhibition(%) of No. of Roots at 10 DAYS |
|---|---|---|---|---|
| $T_{0=}$ Control | 3.8 | | 4.3 | |
| $T_{1=}$ 20mg/L NaF | 3.7 | 2.63 | 4.1 | 4.65 |
| $T_{2=}$ 40mg/L NaF | 3.6 | 5.26 | 3.9 | 9.30 |
| $T_{3=}$ 80mg/L NaF | 3.5 | 7.89 | 3.7 | 13.95 |
| $T_{4=}$ 120mg/L NaF | 3.4 | 10.52 | 3.6 | 16.28 |
| $T_{5=}$ 160mg/L NaF | 3.3 | 13.16 | 3.5 | 18.60 |
| **F- test** | **NS** | | **NS** | |
| **S. Ed. (±)** | 0.220 | | 0.316 | |
| **C. D. (P = 0.05)** | 0.458 | | 0.657 | |

## 3. Effect of NaF on root length at 5,10 and 15 days.

significant reductions in root length were presented by Table 3. Root length of *Triticum aestivum* was highest in $T_0$ and gradually decreased with the increase in concentration of NaF treatment . Result depicted that the mean value of root length of wheat seedlings were maximum in$T_0$ 4.04 and minimum was recorded in treatment $T_5$ 2.83 and inhibited was recoded 29.95% at 5 days. At 10 days the mean value of root length of wheat seedlings were maximum in $T_0$ 8.37 and minimum was recorded in treatment $T_5$ 3.71 and was recorded 55.68% At 15 days the result depicted that the mean value of root length of wheat seedlings were maximum in$T_0$ 10.33 and minimum was recorded in treatment $T_5$ 4.27 and was recorded 58.66% . The result observed that NaF had a negative effect on the root length of *T. aestivum* is due to higher concentration of NaF present in solution. NaF affects the root length of wheat seedlings. Such observation recoded by other worker by Bhargava and Bhardwaj **,**(2010).

## 4.Effect of NaF on shoot length at 5,10 and 15 days.

The results to shoot length were depicted highly significant by Table.4. shoot length of wheat was highest in $T_0$ and gradually decreased with the increase in concentration of NaF treatment from control to $T_5$. Results showed that the mean value of shoot length of wheat seedlings were maximum in $T_0$ 2.15 and minimum was recorded in treatment $T_5$ 1.44 and inhibited was recoded 33.02% at 5 days. At 10 days the mean value of shoot length of wheat seedlings were maximum in $T_0$ 11.02 and minimum was recorded in treatment $T_5$ 4.15 and inhibited was recoded 62.34%. the mean value of shoot length of wheat seedlings were maximum in $T_0$ 16.14 and minimum was recorded in treatment $T_5$ 8.41 and inhibited was recoded 47.89% at15 days. The result observed that NaF had a negative effect on the shoot length of *Triticum aestivum* was due to higher concentration of NaF present in solution. The results are in confirmation with the results reported by (Joshi and Bhardwaj, 2012) due to imbalanced nutrient uptake by seedlings.

## 5. Effect of NaF on vigour index at 5,10 and 15 days.

Result presented by Table 5. vigour index of wheat was highest in $T_0$ and gradually decreased whit the increase in concentration of NaF treatment from $T_0$ to $T_5$ solution. Results

showed that the mean value of vigour index of wheat seedlings were maximum in $T_0$ 619 and minimum was recorded in treatment $T_5$ 405.65 and inhibited was recoded 34.46% at 5 days. At 10 days the mean value of vigour index of wheat seedlings were maximum in $T_0$ 1939 and minimum was recorded in treatment $T_5$ 746.7 and inhibited was recoded 61.49%, the mean value of vigour index of wheat seedlings were maximum in $T_0$ 2647 and minimum was recorded in treatment $T_5$ 1204.6 and inhibited was recoded 54.49% at15 days. The result observed that NaF had a negative effect on the vigour index of *Triticum aestivum* was due to higher concentration of NaF present in solution. The results are in confirmation with the results reported by (Bhargava and Bhardwaj, 2010).

**6.Effect of NaF on fresh and dry weight at 15 days.**

The Table 6. highly significant reduction in the mean value of fresh and dry weight of wheat seedlings were maximum in$T_0$ 0.6533 and 0.1593 and minimum were recorded in treatment $T_5$ 0.3447 and 0.0589 and inhibited of fresh and dry weight were recoded 47.24% and 63.03%. Fresh and dry weight of *Triticum aestivum* were highest in $T_0$ and gradually decreased with the increase in concentration of NaF treatment from$T_0$ to $T_5$ . The result observed that NaF had a negative effect on the fresh and dry weight of *Triticum aestivum*, was due to higher concentration of NaF present in solution. The results are in confirmation with the results reported by (Chakrabarti *et al.* 2012) Fresh and dry weight of seedlings decreased monotonically with increasing fluoride concentration due to reduction of metabolic activity in presence of fluoride, because germination is a one kind of metabolism and fluoride acts as a metabolic inhibitor .

**Table 3. Effect of different concentrations of NaF on root length at 5,10 and 15 days.**

| Treatments | Root Length(cm) at 5 DAYS | Inhibition(%) of Root Length | Root Length(cm) at 10 DAYS | Inhibition(%) of Root Length | Root Length(cm) at 15 DAYS | Inhibition(%) of Root Length |
|---|---|---|---|---|---|---|
| $T_{0=}$ Control | 4.04 | | 8.37 | | 10.33 | |
| $T_{1=}$ 20mg/L NaF | 3.67 | 9.16 | 7.43 | 11.23 | 9.32 | 9.78 |
| $T_{2=}$ 40mg/L NaF | 3.39 | 16.09 | 6.29 | 24.85 | 8.37 | 18.97 |
| $T_{3=}$ 80mg/L NaF | 3.15 | 22.03 | 5.17 | 38.23 | 6.29 | 39.11 |
| $T_{4=}$120mg/L NaF | 3.06 | 24.26 | 4.16 | 50.29 | 5.08 | 50.82 |
| $T_{5=}$160mg/L NaF | 2.83 | 29.95 | 3.71 | 55.68 | 4.27 | 58.66 |
| **F- test** | **S** | | **S** | | **S** | |
| **S. Ed. (±)** | 0.171 | | 0.550 | | 0.272 | |
| **C. D. (P=0.05)** | 0.356 | | 1.144 | | 0.567 | |

**Table 4. Effect of different concentrations of NaF on shoot length at 5,10 and 15 days.**

| Treatments | Shoot Length(cm) at 5 DAYS | Inhibition(%) of Shoot Length | Shoot Length(cm) at 10 DAYS | Inhibition(%) of Shoot Length | Shoot Length(cm) at 15 DAYS | Inhibition(%) of Shoot Length |
|---|---|---|---|---|---|---|
| $T_{0=}$ Control | 2.15 | | 11.02 | | 16.14 | |
| $T_{1=}$ 20mg/L NaF | 2.07 | 3.72 | 9.23 | 16.24 | 14.33 | 11.21 |
| $T_{2=}$ 40mg/L NaF | 1.93 | 10.23 | 8.03 | 27.13 | 13.34 | 17.35 |
| $T_{3=}$ 80mg/L NaF | 1.71 | 20.47 | 7.20 | 34.66 | 10.49 | 35.01 |
| $T_{4=}$120mg/L NaF | 1.66 | 22.79 | 5.23 | 52.54 | 9.46 | 41.39 |
| $T_{5=}$160mg/L NaF | 1.44 | 33.02 | 4.15 | 62.34 | 8.41 | 47.89 |
| **F- test** | **S** | | **S** | | **S** | |
| **S. Ed. (±)** | 0.111 | | 0.815 | | 0.214 | |
| **C. D. (P = 0.05)** | 0.231 | | 1.696 | | 0.446 | |

**Table 5. Effect of different concentrations of NaF on vigour index at 5,10 and 15 days.**

| Treatments | Vigour Index at 5 DAYS | Inhibition(%) of Vigour Index at 5 DAYS | Vigour Index at 10 DAYS | Inhibition(%) of Vigour Index at 10 DAYS | Vigour Index at 15 DAYS | Inhibition(%) of Vigour Index at 15 DAYS |
|---|---|---|---|---|---|---|
| $T_{0=}$ Control | 619 | | 1939 | | 2647 | |
| $T_{1=}$ 20mg/L NaF | 574 | 7.27 | 1666 | 14.07 | 2365 | 10.65 |
| $T_{2=}$ 40mg/L NaF | 521.36 | 15.77 | 1403.36 | 27.62 | 2117.58 | 20.00 |
| $T_{3=}$ 80mg/L NaF | 471.42 | 23.84 | 1199.89 | 38.12 | 1627.66 | 38.51 |
| $T_{4=}$120mg/L NaF | 448.4 | 27.56 | 892.05 | 53.99 | 1384.15 | 47.71 |
| $T_{5=}$160mg/L NaF | 405.65 | 34.46 | 746.7 | 61.49 | 1204.6 | 54.49 |

**Table 6 Effect of different concentrations of NaF on fresh and dry weight at 15 days.**

| Treatments | Fresh weight (gm) | Inhibition(%) of Fresh weight | Dry weight (gm) | Inhibition(%) of Dry weight |
|---|---|---|---|---|
| $T_{0=}$ Control | 0.6533 | | 0.1593 | |
| $T_{1=}$ 20mg/L NaF | 0.5419 | 17.05 | 0.1402 | 11.99 |
| $T_{2=}$ 40mg/L NaF | 0.4821 | 26.21 | 0.1273 | 20.09 |
| $T_{3=}$ 80mg/L NaF | 0.4458 | 31.76 | 0.1168 | 26.67 |
| $T_{4=}$ 120mg/L NaF | 0.3733 | 42.86 | 0.1082 | 32.08 |
| $T_{5=}$ 160mg/L NaF | 0.3447 | 47.24 | 0.0589 | 63.03 |
| **F- test** | **S** | | **S** | |
| **S. Ed. (±)** | 0.017 | | 0.013 | |
| **C. D. (P = 0.05)** | 0.034 | | 0.026 | |

### 7. Effect of NaF on chlorophyll *a*, chlorophyll *b*. and total chlorophyll(*a*+*b*).

Highly significant reductions in chlorophyll *a* were presented by Table 7. chlorophyll *a* of *Triticum aestivum* were highest in $T_0$-control and gradually decreased with the increase in concentration of NaF treatment from $T_0$ to$T_5$ solution. Result repoted that the mean value of chlorophyll *a* of wheat seedlings were maximum in $T_{0-}$ control 3.539 and minimum was recorded in treatment $T_5$ 1.141 and inhibited was recoded 67.75% is due to higher concentration of F present in solution.The result observed that F had a negative effect on the chlorophyll *a* of *T. aestivum*. NaF treatment at $T_5$ showed highest percentage decreased in chlorophyll *a* of wheat seedlings as compared to $T_0$ . The results are in confirmation with the result reported by (Gadi *et al.* 2012).

The results to chlorophyll *b* were depicated highly significant by Table 7 chlorophyll *b* of wheat was highest in $T_0$ and gradually decreased with the increase in concentration of NaF treatement from$T_0$ to $T_5$ . Results showed that the mean value of chlorophyll *b* of wheat seedlings were maximum in $T_0$ 4.436 and minimum was recorded in treatment $T_5$ 0.667 and inhibited was recoded 84.96% is due to higher concentration of NaF present in solution.The result observed that NaF had a negative effect on the chlorophyll *b* of *Triticum aestivum*. The results are in confirmation with the result reported by (Joshi and Bhardwaj, 2012).

Result presented by Table.7. showed that total chlorophyll of wheat was highest in$T_0$ and gradually decreased with the increase in concentration of NaF treatment from $T_0$ to$T_5$ NaF solution. Results showed that the mean value of total chlorophyll of wheat seedlings were maximum in $T_0$ 7.975 and minimum was recorded in treatment $T_5$ 1.809 and inhibited was recoded 77.32% due to higher concentration of NaF present in solution.The result observed that NaF had a negative effect on the total chlorophyll of *Triticum aestivum*. The result are in confirmation with the result reported by (Bhargava and Bhardwaj, 2010) due to the breakdown of chlorophyll during stress or due to inhibition of chlorophyll**.**

**Table 7. Effect of different concentrations of NaF on chlorophyll *a* , Chlorophyll *b* and chlorophyll of plants.**

| **Chlorophyll *a* (mg/l)** | | | | | |
|---|---|---|---|---|---|
| **Treatments** | **$S_1$** | **$S_2$** | **$S_3$** | **Mean value** | **Inhibition of Chlorophyll *a* (%)** |
| $T_{0=}$ Control | 3.581 | 3.522 | 3.513 | 3.539 | |
| $T_{1=}$ 20mg/L NaF | 2.964 | 2.921 | 2.932 | 2.939 | 16.95 |
| $T_{2=}$40mg/L NaF | 2.869 | 2.812 | 2.873 | 2.851 | 19.44 |
| $T_{3=}$80mg/L NaF | 2.762 | 2.751 | 2.732 | 2.748 | 22.35 |
| $T_{4=}$120mg/L NaF | 2.534 | 2.521 | 2.512 | 2.522 | 28.74 |
| $T_{5=}$160mg/L NaF | 1.142 | 1.132 | 1.151 | 1.141 | 67.75 |
| **F- test** | | | **S** | | |
| **S. Ed. (±)** | | | 0.020 | | |
| **C. D. (P = 0.05)** | | | 0.041 | | |
| **Chlorophyll *b* *(mg/l)*** | | | | | |
| **Treatments** | **$S_1$** | **$S_2$** | **$S_3$** | **Mean value** | **Inhibition of Chlorophyll *b* (%)** |
| $T_{0=}$ Control | 4.433 | 4.425 | 4.451 | 4.436 | |
| $T_{1=}$ 20mg/L NaF | 4.251 | 4.268 | 4.233 | 4.250 | 4.19 |
| $T_{2=}$40mg/L NaF $T_{3=}$ | 4.063 | 4.051 | 4.022 | 4.045 | 8.81 |
| 80mg/L NaF | 4.021 | 4.034 | 4.013 | 4.023 | 9.31 |
| $T_{4=}$120mg/L NaF | 2.935 | 2.961 | 2.972 | 2.956 | 33.36 |
| $T_{5=}$160mg/L NaF | 0.684 | 0.642 | 0.676 | 0.667 | 84.96 |
| **F- test** | | | **S** | | |
| **S. Ed. (±)** | | | 0.015 | | |
| **C. D. (P = 0.05)** | | | 0.030 | | |
| **Total Chlorophyll *(mg/l)*** | | | | | |
| **Treatments** | **S1** | **S2** | **S3** | **Mean value** | **Inhibition of Total Chlorophyll (%)** |
| $T_{0=}$Control | 8.014 | 7.947 | 7.964 | 7.975 | |
| $T_{1=}$20mg/L NaF | 7.215 | 7.189 | 7.165 | 7.189 | 9.86 |
| $T_{2=}$40mg/L NaF | 6.932 | 6.863 | 6.895 | 6.896 | 13.53 |
| $T_{3=}$80mg/L NaF | 6.783 | 6.785 | 6.745 | 6.771 | 15.08 |
| $T_{4=}$ 120mg/L NaF | 5.469 | 5.482 | 5.484 | 5.478 | 31.31 |
| $T_{5=}$160mg/L NaF | 1.826 | 1.774 | 1.827 | 1.809 | 77.32 |

## 8. Effect of NaF on chlorophyll stability index (CSI).

Highly significant reductions in CSI were presented in Table 8. CSI of *Triticum aestivum* were highest in $T_0$ and gradually decreased with the increase in concentration of NaF treatment from$T_0$ to $T_5$ solution. Result reported that the mean value of CSI of wheat seedlings were maximum in $T_0$ 100 and minimum was recorded in treatment $T_5$ 23.54 due to higher concentration of F present in solution. CSI showed a positive correlation with photosynthetic pigments. Decrease in pigments content in plants may be due to reduction of membrane integrity of chloroplast lead to reduction in CSI. Our findings were in agreement to the earlier researchers who found decrease in CSI in legume plants under stress (Gadi *et al.* 2012). Higher CSI indicates the level of polyunsaturated lipids stabilizes chloroplast membrane and increases adaptive responses to tolerance under stress conditions by (Deivanai *et al*. 2010).

**Table 8 Effect of different concentrations of NaF on chlorophyll stability index (CSI) of plants.**

| Treatments | CSI (%) | | | |
|---|---|---|---|---|
| | $S_1$ | $S_2$ | $S_3$ | Mean value |
| $T_{0=}$ Control | 100 | 100 | 100 | 100 |
| $T_{1=}$20mg/L NaF | 99.72 | 99.64 | 99.69 | 99.68 |
| $T_{2=}$ 40mg/L NaF | 88.03 | 88.04 | 88.06 | 88.04 |
| $T_{3=}$ 80mg/L NaF | 81.18 | 81.13 | 81.14 | 81.15 |
| $T_{4=}$ 120mg/L NaF | 76.12 | 76.18 | 76.13 | 76.14 |
| $T_{5=}$ 160mg/L NaF | 23.53 | 23.58 | 23.51 | 23.54 |
| **F- test** | **S** | | | |
| **S. Ed. (±)** | 0.023 | | | |
| **C. D. (P = 0.05)** | 0.049 | | | |

## CONCLUSION

The germination and early seedlings growth are physiologically complex processes and affected by different environmental conditions. Therefore, aim of present study to examine the effect of F on wheat by analyzing seed germination, growth, pigments, photosynthesis. The increasing concentration of sodium fluoride shows phytotoxic effect on morphological. In the present study, NaF (all concentrations), disturbs the seed germination and early growth of seedlings. Further it was reported that CSI and vigour index also decreased by NaF. In addition to morphological features, photosynthetic pigments (chl a, b) were also adversely affected by increased NaF concentration. In this study we found positive correlation between photosynthetic pigments and CSI.

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