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RESEARCH ARTICLE

EFFECT OF DIFFERENT FLUORIDE ION CONCENTRATIONS ON GERMINATION, VIGOUR INDEX, AND FRESH LEAF YIELD OF SPINACH (SPINACIA OLERACEA) VARIETIES

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Abstract

This research investigates the effects of fluoride ion concentrations on germination percentage, vigour index, and leaf yield of three spinach (Spinacia oleracea) varieties under pot culture conditions. Fluoride stress was imposed using sodium fluoride at 0, 25, 50, and 100 ppm. A clear dose-dependent reduction was observed across all parameters. Variety I demonstrated the highest tolerance, while Variety III was most sensitive.These findings emphasize the adverse impacts of fluorid e stress on spinach growth and productivity, particularly in fluoride-contaminated soils of Fatehabad, Haryana.

Introduction:-

A basic human right is the availability of clean drinking water, but groundwater contamination—especially from fluoride—poses a serious threat to the environment and public health worldwide. Around 200 million people worldwide are impacted by fluoride pollution that exceeds the WHO's acceptable limit of 1.5 mg/L, which has been found in over 100 nations within the last ten years (Saxena et al.,2025).

Fluoride contamination in groundwater and soils represents a growing environmental concern. It is transferred from the fluoridated water used for irrigation to the crops, vegetables, and fruits that are being grown(Kumari et al., 2023).Plants are vulnerable to fluoride accumulation in soil, and their growth and development can be negatively affected, even with low fluoride content in the soil (Kumar et al.,2021).

The damages caused by Fluoride in plants may be chronic or acute and their rigidity is dependent on the duration of the fluoride exposure and concentration. Concentrations of fluoride demonstrated a substantial negative impact on the Spider plants, leading to a decline in overall health(Kumari et al., 2024). Fluoride toxicity in plants results into the continuous accumulation of fluoride into their subcellular structures which then changes towards biochemical activity. Fluoride toxicity negatively influences growth, germination, photosynthesis, mineral nutrition, respiration, reproduction and activity of cellular enzymes (Sahariya et al.,2021).

Spinach (Spinacia oleracea), a major leafy vegetable, is known to accumulate fluoride efficiently, making it an ideal candidate for fluoride stress evaluation. The objective of this study was to evaluate the effect of varying fluoride ion concentrations on the germination, growth vigour, and yield of spinach varieties under controlled conditions.

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Materials and Methods:-

Sampling and Pot Experiment Design

Soil and water samples were collected from different agricultural fields of Fatehabad district, Haryana. Three spinach varieties were grown in pots containing 10 kg soil treated with NaF to achieve concentrations of 0, 25, 50, and 100 ppm fluoride. Each treatment was replicated three times, following a completely randomized design. Observations were recorded for germination percentage, vigour index, and fresh leaf yield.

Fluoride Determination by Potentiometric Method

Fluoride concentration in water and soil samples was measured using a Cole-Parmer Fluoride Ion Selective Electrode (ISE) coupled with a pH/mV meter. A Total Ionic Strength Adjustment Buffer (TISAB-II) was added in a 1:1 ratio to maintain ionic balance and pH stability. Calibration was performed using NaF standard solutions ranging from 0.1 to 10 ppm. The potential difference (E) was measured and converted to fluoride concentration using the Nernst equation:

$$E = E_0 - (2.303RT / nF) \times \log_{10}[Fluoride^-]$$

where: E = measured potential (mV), E_0 = standard potential, R = gas constant, T = temperature (K), F = Faraday constant, n = charge number.

Fluoride concentration was then calculated from the calibration curve correlating potential (mV) with $\log_{10}$[Fluoride concentration].

Calculation Formulas

Germination Percentage (G%) = (Number of Germinated Seeds / Total Seeds) × 100

Vigour Index (VI) = (Mean Root Length + Mean Shoot Length) × Germination Percentage

Yield (g/plant)= Fresh weight of harvested spinach leaves per plant

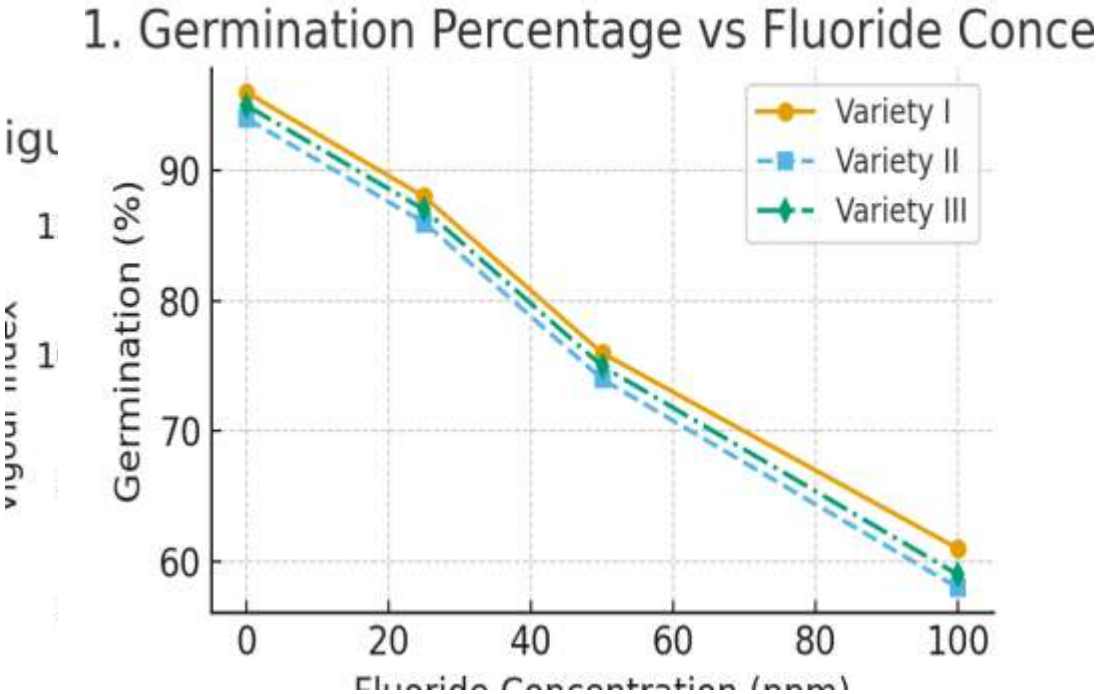
Results and Discussion:-

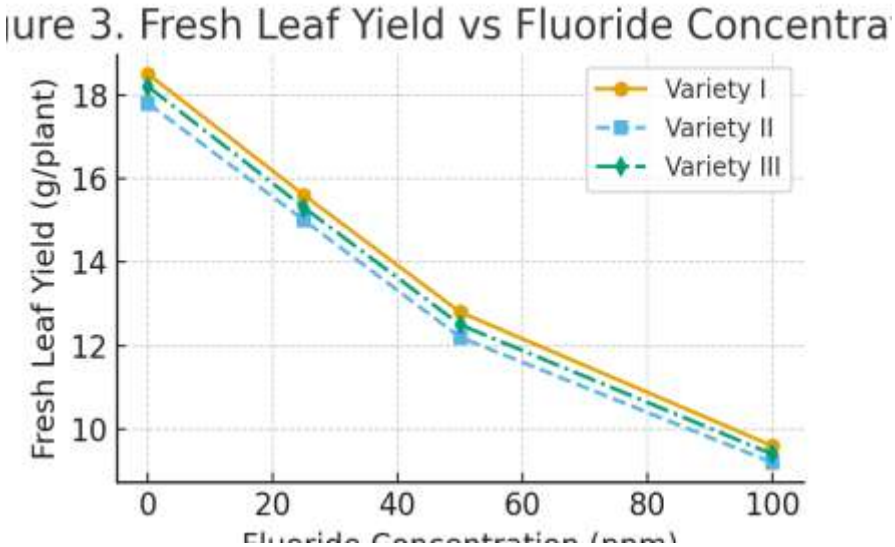
The results showed a gradual decline in germination, vigour index, and leaf yield as fluoride concentration increased from 0 to 100 ppm.

Table 1. Effect of Fluoride Stress on Spinach Parameters

Fluoride (ppm)	Variety I G%	Variety II G%	Variety III G%	Variety I VI	Variety II VI	Variety III VI	Variety I Yield	Variety II Yield	Variety III Yield
0	96	94	95	1250	1180	1225	18.5	17.8	18.2
25	88	86	87	1020	990	1015	15.6	15.0	15.3

50	76	74	75	850	820	835	12.8	12.2	12.5
100	61	58	59	620	590	605	9.6	9.2	9.4





Figures 4–7. Experimental Setup and Determination Process

The following figures show the actual potentiometric determination of fluoride and the spinach growth experiment under varying fluoride stress conditions.

Conclusion:-

Increasing fluoride concentrations significantly reduced germination percentage, vigour index, and leaf yield of spinach varieties. Among the tested varieties, Variety I demonstrated greater tolerance, suggesting its potential suitability for cultivation in fluoride-affected regions. Fluoride contamination poses a serious threat to crop productivity and human health; thus, management of irrigation water and soil fluoride is essential.

References:-

1. Kumar, R., Sinha, R., Sharma, P. K., Ivy, N., Kumar, P., Kant, N., Jha, A., Jha, P. K., Gupta, P. K., Sharma, P., Singh, R. K., Singh, R. P., Ghosh, A., & Prasad, P. V. V. (2021). Bioaccumulation of Fluoride in Plants and Its Microbially Assisted Remediation: A Review of Biological Processes and Technological Performance. Processes, 9(12), 2154. https://doi.org/10.3390/pr9122154
2. Kumari, S., Dhankhar, H., Abrol, V., & Yadav, A. K. (2023). Bioaccumulation of fluoride toxicity in plants and its effects on plants and techniques for its removal. In Water science and technology library (pp. 271–290). https://doi.org/10.1007/978-3-031-38845-3_15
3. Kumari, S., Dhankhar, H., Abrol, V., Saini, A., & Gulia, K. (2024). Fluoride toxicity and impact on Spider Plant leaves. Ecology Environment and Conservation, 30(02), 936–939. https://doi.org/10.53550/eec.2024.v30i02.085
4. Sahariya Aditi, Ahariya, Bhardwaj Chellapilla, Iwualaand Alam Afroz. (2021). Fluoride toxicity in soil and: An Overview. Asian Journal of Advances in Research, 4(1), 573–581.
5. Saxena Gaurav, Singhal Priyanka and Kumar Anil. (2025). An assessment of worldwide scenarios with special reference to India on Fluoride contamination in Groundwater. Tianjin DaxueXuebao (Ziran KexueyuGongcheng Jishu Ban)/ Journal of Tianjin University Science and Technology (58,4,1–22). Zenodo. https://doi.org/10.5281/zenodo.15173267