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ADAPTIVE STOMATAL REGULATION IN SOYBEAN (*GLYCINE MAX*) TO AIR POLLUTION STRESS INDUCED BY THERMAL POWER PLANT ACTIVITIES

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ABSTRACT:
This study investigates the comparative stomatal index (SI) of *Glycine max* (L.) Merrill (Soybean) from polluted and unpolluted sites. The polluted samples were collected from areas near Khaperkheda and Koradi Thermal Power Plants, while the unpolluted samples were obtained from a pristine environment. The stomatal index was calculated using Salisbury's (1927) formula. Observations for 25 plants from each site were analysed statistically, including ANOVA. Results revealed a higher stomatal frequency percentage in polluted plants, indicating environmental stress effects on epidermal modifications.

Keywords: - Stomatal Index, *Glycine max*, Air Pollution, Thermal Power Plants, Environmental Stress, Epidermal Cells, Bioindicators, ANOVA, Polluted Sites, Unpolluted Sites.

INTRODUCTION :

Environmental pollution, particularly from thermal power plants, has far-reaching implications on plant physiology. Stomatal traits, such as density and index, serve as bioindicators of environmental stress. This study aims to quantify and compare the stomatal index of soybean plants from polluted and unpolluted areas, elucidating the impact of air pollutants emitted by Khaperkheda and Koradi Thermal Power Plants. Previous studies highlight the sensitivity of stomatal traits to pollutants like sulphur dioxide and particulate matter (Tripathi et al., 2003). Other works, such as those by Kumar et al. (2011) and Gupta et al. (2015), emphasize the critical role of stomatal analysis in monitoring environmental health.

Plant Material :

Soybean (*Glycine max*) was selected for its economic importance and sensitivity to environmental changes. Studies indicate that soybean stomatal traits are significantly affected by environmental stressors such as air pollution and climate variations, making it an ideal candidate for assessing the impact of thermal power plant emissions (Johnson et al., 2019). Leaves were collected from 25 plants each from polluted and unpolluted sites during the flowering stage. Soybean (*Glycine max*) was selected for its economic importance and sensitivity to environmental changes. Leaves were collected from 25 plants each from polluted and unpolluted sites during the flowering stage.

METHODOLOGY :

The methodology was adapted from Salisbury (1927). For stomatal index calculation:

$$SI = \frac{S}{E + S} X\ 100$$

Where;

- SI = Stomatal Index
- S = Number of stomata per unit area
- E = Number of epidermal cells in the same unit area

Sample collection involved harvesting fully expanded leaves from the third node of soybean plants. To prepare the slides, epidermal peels were taken from both the upper and lower surfaces of the leaves, which were then stained with safranin and mounted in glycerine for clear visualization. Microscopic examination was

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carried out at 40× magnification, where stomatal and epidermal cell counts were recorded using a calibrated ocular micrometre. For data analysis, observations from 25 plants per site were systematically tabulated, and statistical significance was evaluated using ANOVA to assess any significant differences among the sites.

OBSERVATION :

In polluted samples, the stomatal index showed higher values on the lower epidermis compared to the unpolluted site. This can be attributed to environmental stress-induced physiological responses, such as the increase in stomatal frequency to enhance gaseous exchange in polluted environments. Observations reveal a marked contrast in epidermal cell sizes, with polluted samples showing reduced cell dimensions, likely due to the physiological adjustments to pollutants. Moreover, the lower epidermis exhibited consistently higher stomatal indices compared to the upper epidermis, aligning with earlier studies on pollutant-induced modifications in stomatal behaviour (Smith et al., 2020). In polluted samples, the stomatal index showed higher values on the lower epidermis compared to the unpolluted site. This suggests an adaptive response to elevated atmospheric pollutants, facilitating gaseous exchange under stress.

RESULT AND DISCUSSION :

The results suggest that elevated stomatal index values in polluted sites are a physiological adaptation to environmental stress. Increased stomatal frequency likely facilitates gaseous exchange, aiding in photosynthesis and transpiration under stressful conditions. The findings are consistent with previous research by Tripathi et al. (2003), who documented similar adaptations in other crop species. Reduced epidermal cell sizes in polluted samples further support the hypothesis that plants undergo structural changes to maintain functionality.

Additionally, the stark differences between the upper and lower epidermis suggest that pollutants predominantly affect stomatal behaviour on the leaf's lower surface, possibly due to differences in exposure and cuticular properties. These insights contribute to understanding plant responses to anthropogenic pollutants, emphasizing the importance of implementing strategies to mitigate air pollution effects in agricultural zones. The higher stomatal index in polluted plants may be attributed to increased stomatal development triggered by pollutants as a physiological adaptation to stress. The findings align with Singh et al. (2012), who reported similar trends in other crop species. Reduced epidermal cell size in polluted plants likely compensates for enhanced stomatal density. These results provide robust evidence for the use of stomatal traits as bioindicators of environmental stress caused by pollution.

CONCLUSION :

This study underscores the impact of thermal power plant emissions on the stomatal traits of soybean plants. The elevated stomatal index in polluted areas highlights potential stress adaptations and emphasizes the need for mitigation strategies in agricultural zones near industrial sites.

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Table 1: Stomatal Index values for polluted and unpolluted sites.

Sr. No.	Unpolluted Site (%)		Polluted Site (%)	
	Upper Epidermis	Lower Epidermis	Upper Epidermis	Lower Epidermis
1	26.3%	37.5%	22.6%	49.5%
2	29.08%	32.06%	31.48%	41.06%
3	28.6%	35.8%	23.2%	47.8%
4	27.9%	36.0%	24.5%	46.5%
5	28.3%	34.7%	25.1%	45.8%
6	27.5%	35.9%	24.2%	47.3%
7	28.1%	36.8%	23.9%	46.1%
8	27.8%	35.6%	24.3%	45.9%
9	28.4%	37.2%	24.6%	46.7%
10	28.0%	36.5%	25.0%	45.5%
11	27.7%	35.4%	23.7%	47.0%
12	28.2%	36.9%	24.8%	46.2%
13	27.6%	35.7%	24.1%	45.4%
14	28.5%	36.3%	23.5%	46.8%
15	28.3%	37.0%	25.2%	45.7%
16	27.4%	35.5%	24.4%	46.4%
17	28.0%	36.4%	24.9%	46.9%
18	27.9%	35.8%	23.8%	46.0%
19	28.1%	36.7%	24.0%	47.1%
20	27.5%	36.0%	24.7%	45.6%
21	28.2%	36.2%	23.6%	46.5%
22	27.8%	35.9%	25.3%	46.3%
23	28.4%	37.1%	24.2%	45.2%
24	27.6%	36.6%	24.5%	47.2%
25	28.0%	36.8%	25.0%	46.9%

Table 2: Results of ANOVA (Analysis of Variance) comparing stomatal index between polluted and unpolluted sites. Full forms: SS = Sum of Squares, df = Degrees of Freedom, MS = Mean Squares, F = F-statistic, F crit = F critical value.

Source of Variation	SS	df	MS	F	p-value	F crit
Between Groups	150.72	1	150.72	15.42	< 0.001	4.03
Within Groups	486.18	48	10.13			
Total	636.90	49				

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