International Journal for Multidisciplinary Research
International Conference on Multidisciplinary Research & Studies 2023
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Comparative Assessment of Effects of Contaminants on the Pollen Physiology of Some Crop Plants from Amravati Region with Respect to Spatial Variation

Ingle V.U.[1*] ,Thorat S.B.[2]

Department of Botany, RDIK and NKD College, Badnera, Amravati, Maharashtra – 444701.

Abstract

Metropolitan regions have substantially higher concentrations of widely dispersed pollutants, according to studies on environmental pollution. A gametophyte, a pollen grain, demonstrates a deviation from its regular physiological functioning and is very sensitive to its environment. According to our report, these characteristics of pollen grains can be used as a method to track the status of environmental pollution. In this investigation, two site, such as treatment (near highway) and control (far away from highway) were selected for the sampling of five crop plants that were common at both sides. In the evaluation it was found that *Glycine max* was the most susceptible plant to the contaminants when compared with the control. It showed drastic negative effects in the pollen viability (in both stain) and in vitro pollen germination. While, pollen-ovule ration was decreased in *Cajanus cajan* from treatment site in comparison to control site.

Keywords: Pollen, Environment, Contaminants, Pollutants, Pollen physiology.

1. Introduction

Environmental pollutants like nitrogen oxides, ozone, sulphur dioxide, and particulate matter (PM) are increasing in the atmosphere during the Anthropocene as a result of human activity such as burning or driving. These environmental pollutants may intensify oxidative stress and metabolic changes of allergens in organisms [1]. Pollutants in the air can affect pollen in a number of ways, including by changing its surface's physical and chemical properties, damaging its wall, and releasing allergens into the environment. They can also have an impact on pollen's reproductive and biological processes by reducing pollen fertility or changing its allergenic potential, which raises health risks [2, 3].

Pollutants in the atmosphere may have an immediate impact on sexual function and reduce pollen grain viability and germination. It demonstrates a change in the physicochemical properties of the pollen surface [4]. After exposure to SO2 and NO2, Sousa et al. [5] discovered that pollen germination was negatively impacted; this also had an impact on plant reproduction. The viability and germination experiments revealed that the freshly gathered pollen material lost its biological and reproductive function in an industrial and high-traffic road zone [2].

In this investigation, it was hypothesized that the differential pollution status at the sampling site may result in the alteration in magnitude of pollen physiological parameters under the study.

2. Materials and Methods

2.1 Sampling Site

The study area i.e. Amravati taluka was surveyed and observed based on the exposure of the agricultural land to the highways. In this context, National Highway (NH) 53 passing through the study area was selected. Two different sampling sites were selected. The location of the study area is provided in Fig. 1 (treatment site) and Fig. 2 (control site). The site nearer to the highway was treated as treatment site and a site far form highway was treated as control site.

2.2 Plant Material

Those crop plants that are commonly available in selected sites of the agriculture field were considered for the study. These plants along with their common and scientific name are given in Table 1.

2.3 Effect of Environmental Contaminants on Pollen Physiology

2.3.1 Pollen Viability

For testing and comparing the pollen viability, samples were collected from both the sampling sites. The Acetocarmine and TTC (Triphenyl Tetrazolium Chloride) staining techniques were utilized [6, 7] with required modified protocols.

2.3.2 In vitro Pollen Germination

The collected pollen samples from both the sites were assessed for in vitro percentages of pollen germination. Pollen germination was achieved by sitting drop culture [8].

2.3.3 Pollen–Ovule Ratio

The pollen-ovule ratio of the selected crop plants form both sampling sites was evaluated [8, 9, 10]. The experiments were repeated three times and the means values thus obtained are reported. Appropriate statistical methods are used to present the replication data.

3. Results and Discussion

The comparative assessment of the pollen viability in the plants collected from both sides showed that pollen viability was much reduced in the plants collected from treatment site as compared to the plants collected from the control site. The overall trend of decreasing viability was common in all plants without any exception. In this study, the maximum pollen viability was observed in the *Cajanus cajan* (89.41 ± 2.37) from control site in acetocarmine stain. While, the minimum pollen viability was observed in the *Gossypium herbaceum* (51.26 ± 9.43) from treatment site in TTC stain (Figure 3 and Figure 4).

The pollen germination percentage was affected negatively in the plants collected from treatment site as compared to the plants collected from the control site. The overall trend of decrease in pollen germination was common in all plants without any exception. In this study, the maximum pollen germination was observed in the *Glycine max* (97.35 ± 3.86) from control site. While, the minimum pollen germination was observed in the *Triticum aestivum* (54.53 ± 4.36) from the treatment site (Table 2 and Table 3).

In this investigation, while comparing the pollen-ovule ratio of the plants from both sites a considerable difference was observed. The results obtained for the comparative assessment made on pollen-ovule ratio selected plants showed reduction in the mean values of pollen-ovule ratio in treatment site as compared to the control site. The reduced values from treatment site are outcome of reduced number of pollen production while comparatively less reduction in the ovule number. The overall trend of decrease in pollen-ovule ratio was common in all plants without any exception. In this study, the maximum pollen-ovule ratio was observed in the *Triticum aestivum* (8346.57 ± 832.41) from control site. While, minimum ratio was obtained in the *Cicer arietinum* (948.52 ± 92.46) from treatment site (Figure 5).

Similarly, Talukdar et al. [4] investigated into the impact of air pollution on plants. In polluted and non-polluted sites, the pollen germination of every tested species differed noticeably. Similarly, in *Ambrosia artemisiifolia* Pasqualini et al. [11] found lower pollen viability following O_3 fumigation, which suggests harm to the pollen membrane system. The pollen of *Betula pendula*, *Ostrya carpinifolia*, and *Carpinus betulus* were treated to two amounts of NO_2 in vitro for the study by Cuinica et al. [12]. When compared to pollen samples that were not exposed to NO_2, all of the exposed pollen samples dramatically decreased in viability, germination, and total soluble proteins. According to Sousa et al. [5], it was confirmed that pollen exposed to pollution had a lower germination rate than pollen not exposed to pollution. This effect was particularly noticeable for samples exposed to NO2. Viability, germination, and tube length were examined in pollen grains from field-grown 'Summerred' apple trees by Bellani et al. [13]. With lower pH values and more treatments, it was shown that pollen viability and germination significantly declined.

Figure 1 Location of the Experimental or Treatment Sampling Site (White Circle) within the Study Area.

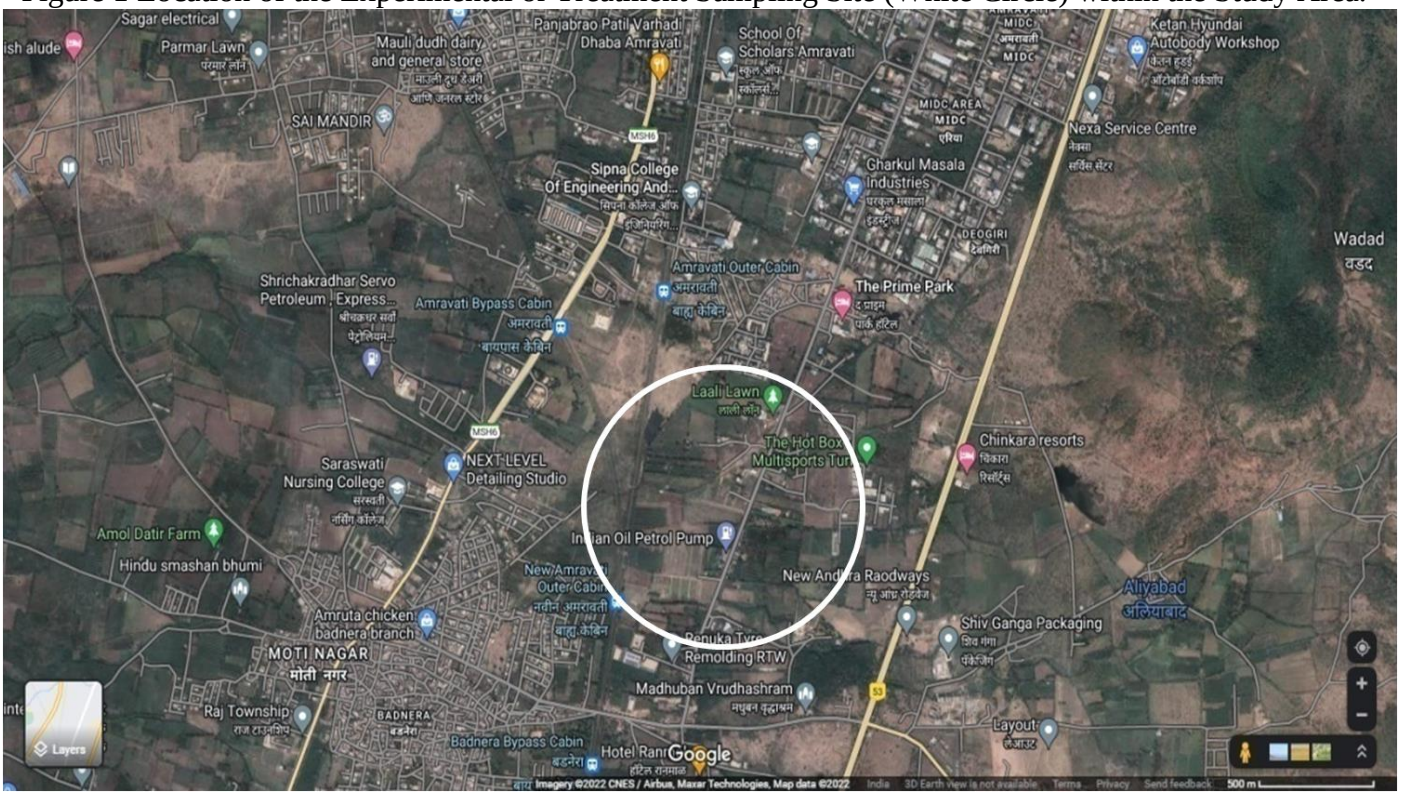


Figure 2 Location of the Control (Without Treatment) Sampling Site (Yellow Circle) Within the Study Area.

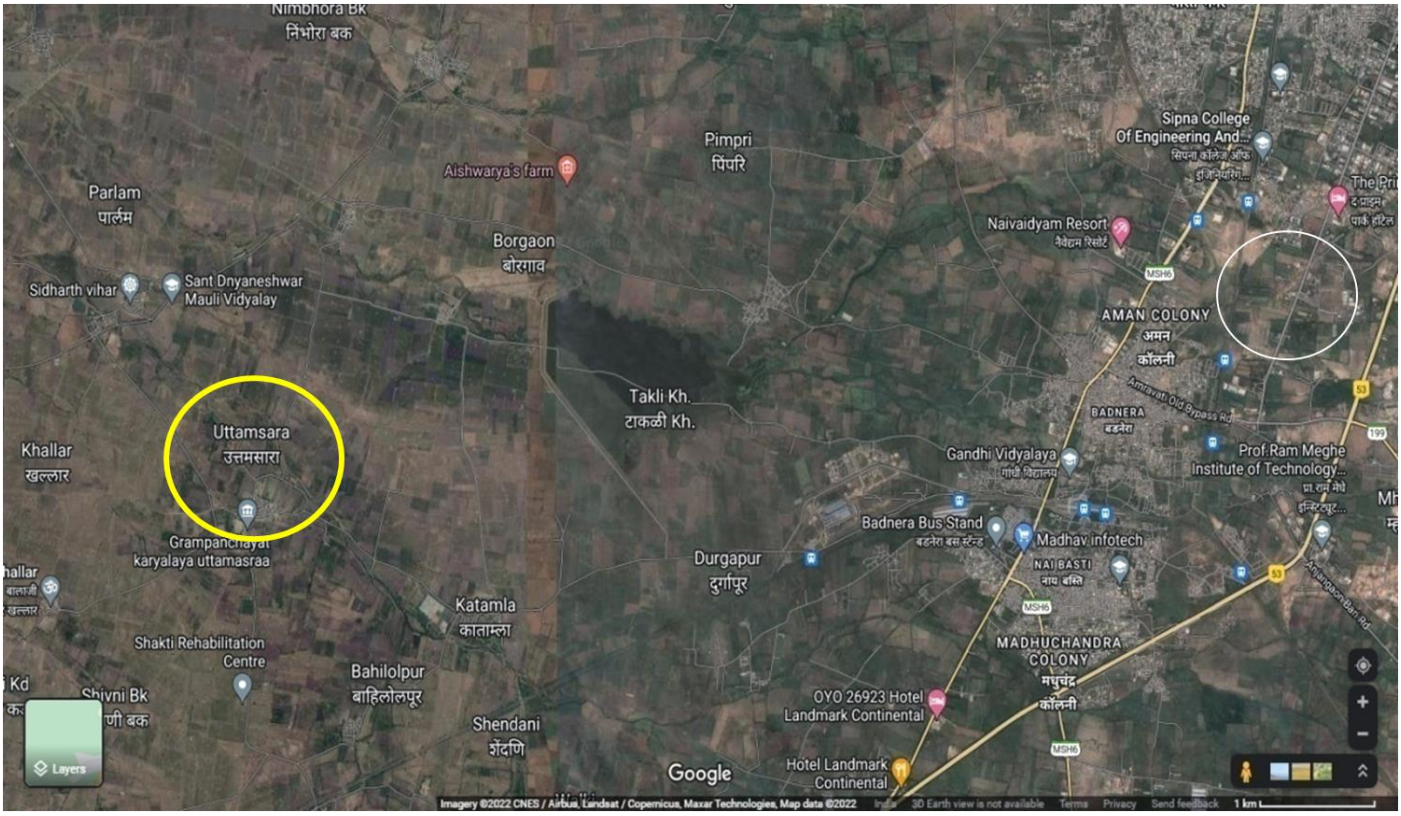


Table 1 The Selected Crop Plants Common at Both Sampling Sites.

Sr. No.	Common name	Scientific name	Family
1	Toor / Arhar	*Cajanus cajan* (L.) Millsp.	Fabaceae
2	Chana	*Cicer arietinum* L.	Fabaceae
3	Cotton	*Gossypium herbaceum* L.	Malvaceae
4	Soyabean	*Glycine max* (L.) Merr.	Fabaceae
5	Wheat	*Triticum aestivum* L.	Poaceae

Figure 3 Comparison Between Mean Percent of Pollen Viability in Selected Plants from Both Site (Treatment and Control) in Acetocarmine Stain.

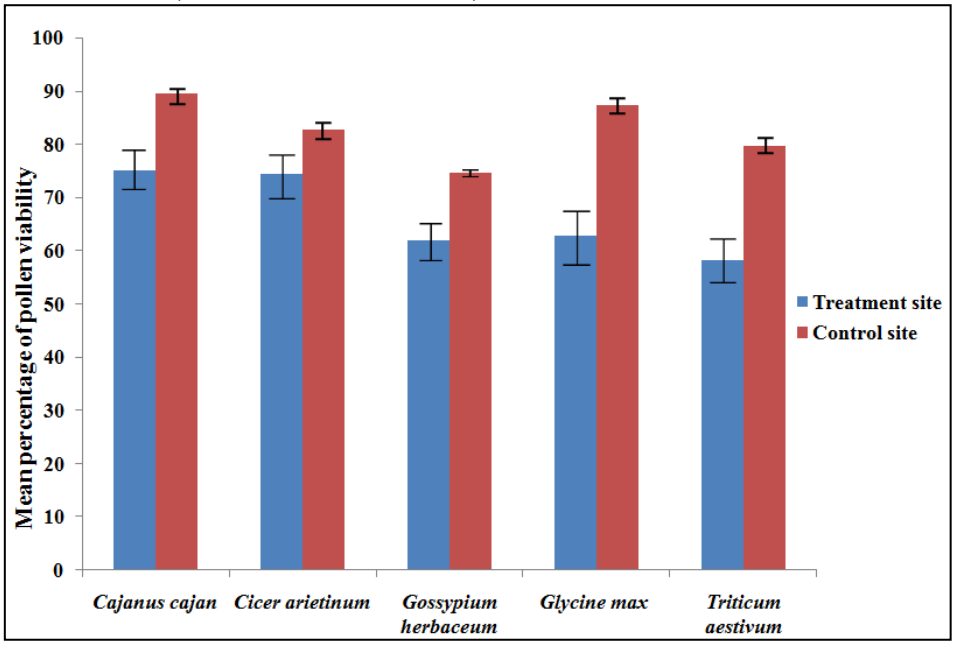


Figure 4 Comparison Between Mean Percent of Pollen Viability in Selected Plants from Both Site (Treatment and Control) in TTC Stain.

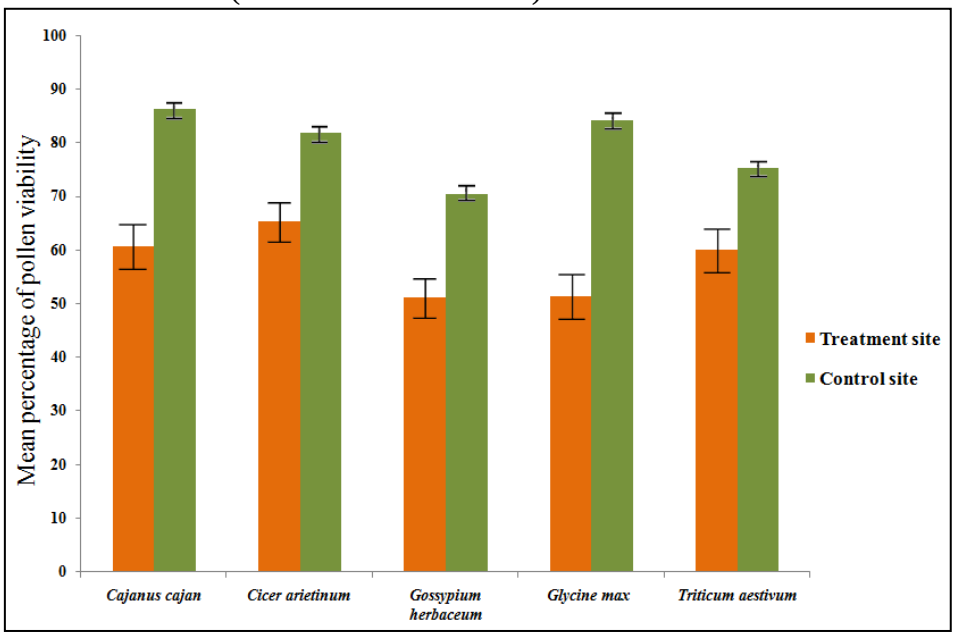


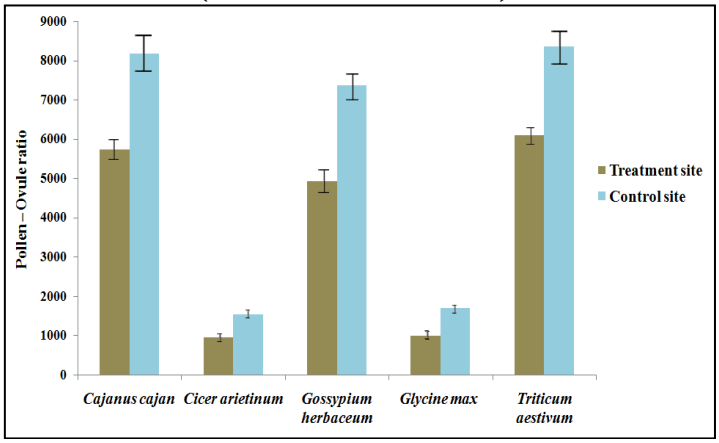
Table 2 Estimation of In Vitro Pollen Germination in Selected Plants from Treatment Site.

Sr. No.	Name of the plant	Germination media	Time of Observation	Mean % of pollen germination (Mean±SD)*
1	*Cajanus cajan*	12.5% Sucrose + 100 mg/l Boric acid + 150 mg/l $CaNO_3$ + 8% PEG 4000	10 min	59.43 ± 5.19
2	*Cicer arietinum*	10% Sucrose + 100 mg/l Boric acid + 200 mg/l $CaNO_3$ + 10% PEG 4000 + 100 mg/l $MgSO_4$	15 min	69.39 ± 6.01
3	*Gossypium herbaceum*	30% Sucrose + 150 mg/l Boric Acid + 50 mg/l KNO_3 + 150 $CaNO_3$ + 15% PEG 4000	25 min	80.07 ± 7.78
4	*Glycine max*	7.5% Sucrose + 50 mg/l Boric Acid + 50 mg/l $CaNO_3$ + 0.5% Agar	10 min	63.87 ± 6.51
5	*Triticum aestivum*	25% Maltose + 100 mg/l Boric Acid + 100 mg/l $CaNO_3$ + 15% PEG 4000 + 50 mg/l $MgSO_4$	20 min	54.53 ± 4.36

Table 3 Estimation of In Vitro Pollen Germination in Selected Plants from Control Site.

Sr. No.	Name of the plant	Germination media	Time of Observation	Mean % of pollen germination (Mean±SD)*
1	*Cajanus cajan*	12.5% Sucrose + 100 mg/l Boric acid + 150 mg/l $CaNO_3$ + 8% PEG 4000	10 min	88.17 ± 3.29
2	*Cicer arietinum*	10% Sucrose + 100 mg/l Boric acid + 200 mg/l $CaNO_3$ + 10% PEG 4000 + 100 mg/l $MgSO_4$	15 min	96.81 ± 4.11
3	*Gossypium herbaceum*	30% Sucrose + 150 mg/l Boric Acid + 50 mg/l KNO_3 + 150 $CaNO_3$ + 15% PEG 4000	25 min	92.56 ± 4.73
4	*Glycine max*	7.5% Sucrose + 50 mg/l Boric Acid + 50 mg/l $CaNO_3$ + 0.5% Agar	10 min	97.35 ± 3.86
5	*Triticum aestivum*	25% Maltose + 100 mg/l Boric Acid + 100 mg/l $CaNO_3$ + 15% PEG 4000 + 50 mg/l $MgSO_4$	20 min	85.72 ± 2.64

Figure 5 Comparison between Mean Values of Pollen – Ovule Ratio in Selected Plants from Both Site (Treatment and Control).



4. Conclusion

In light of the above observations and results it was concluded that the pollution status of both sampling sites have strong influence on the pollen physiological properties. The pollution level at the treatment site was more harmful and had lead to the decreased vigor of the pollen. The pollen grains of all studied plants were vulnerable to present level of pollution at treatment site than that present at control site. Further, more research is required to utilize this behavior of the pollen grains to act as pollution bioindicator.

Author's Biography

Ingle V. U. is currently working as Research Scholar at Department of Botany, Bar. R.D.I.K. and N.K.D. College, Badnera, Amravati. She is M.Phil. in Botany from Government of Vidarbha Institute of Science and Humanities, Amravati. She has 4 years of research and 7 years of teaching experience.

Thorat S. B. is currently working as Assistant Professor and Head, Department of Botany, Bar. R.D.I.K. and N.K.D. College, Badnera, Amravati. He is Ph.D. in Botany from Department of Botany, Sant Gadge Baba Amravati University, Amravati. He has 17 years of research and 13 years of teaching experience.

References

1. Narkhedkar V.R., "An Optimistic Utilization of Pollen as a Pollution Bioindicator", Agricultural Science: Research and Reviews Volume II, Bhumi Publishing, 2021, 110-117.
2. Senechal H., Visez N., Charpin D., Shahali Y., Peltre G., Biolley J.P., Lhuissier F., Couderc R., Yamada O., Malrat-Domenge A., Pham-Thi N., "A Review of the Effects of Major Atmospheric Pollutants on Pollen Grains, Pollen Content, and Allergenicity", Scientific World Journal, 2015, 1–29. doi: 10.1155/2015/940243
3. Oduber F., Calvo A.I., Blanco-alegre C., Castro A., Vega-maray A.M., Valencia-barrera R.M., "Agricultural and Forest Meteorology Links between recent trends in airborne pollen concentration, meteorological parameters and air pollutants", Agricultural and Forest Meteorology, 2019, 264,16-26.
4. Talukdar P., Ghosh N., Malik S., Rahaman C.H., "Effect of air pollution on plant growth and pollen viability", World Scientific News, 2018, 109, 131-142.
5. Sousa R., Duque L., Duarte A.J., Gomes C.R., Ribeiro H., Cruz A., Esteves da Silva J.C., Abreu I., "In vitro exposure of Acer negundo pollen to atmospheric levels of SO_2 and NO_2: effects on allergenicity and germination", Environmental science & technology, 2012, 46 (4), 2406-2412.
6. Brown W.V., "A preliminary study of the staining of plant cells by tetrazolium chloride", Bul. Torrey Bot. Cl., 1954, 81, 127-136.
7. Bhattacharya K., Majumdar M. R., Bhattacharya S. G., "A Text Book of Palynology", New central book Agency (P) Ltd. Kolkata, 2006, India.
8. Shivanna K.R., Rangaswamy N.S., "Pollen Biology. A Laboratory Manual". Springer Verlag, Berlin, 1992.
9. Cruden R.W., "Pollen Ovule ratios a conservative indicator of breeding system in flowering plants Evolution", 1977, 31, 32-46.
10. Mione T., Anderson G.J., "Pollen-ovule ratios and breeding system evolution in *Solanum* section Basarthrum (Solanaceae), American Journal of Botany, 1992, 79 (3), 279-287.
11. Pasqualini S., Tedeschini E., Frenguelli G., Wopfner N., Ferreira F., Amato G.D., Ederli L., "Ozone affects pollen viability and NAD(P)H oxidase release from Ambrosia artemisiifolia pollen", Environmental Pollution, 2011, 159 (10), 2823-2830.

12. Cuinica L.G., Abreu I., Da Silva J.E., "Effect of air pollutant NO_2 on *Betula pendula*, *Ostrya carpinifolia* and *Carpinus betulus* pollen fertility and human allergenicity", Environmental Pollution, 2014, 186, 50-55.
13. Bellani L.M., Rinallo C., Muccifora S., Gori P., "Effects of simulated acid rain on pollen physiology and ultrastructure in the apple", Environmental Pollution, 1997, 95 (3), 357-362.