INTERNATIONAL JOURNAL OF
TECHNO-ENGINEERING
IJTE
ISSN: 2057-5688

POLLINATORS OF MANGROVES FROM AN INDIAN SUNDERBANS POINT OF VIEW

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Abstract: Despite being an important ecological and economic resource, mangrove habitats are seriously endangered. The rehabilitation of mangroves has been the subject of several national and international programs, which entail raising the seedlings in a nursery before replanting them in ruined or uninhabited places. However, there are varying degrees of nursery-bred seedling survival in the field. According to a number of findings from across the globe, seedlings may develop more quickly on the field if they are injected with plant growth-promoting bacteria (PGPB) that has been isolated from the rhizosphere of mangrove plants. In agriculture, using such PGPB is a popular technique. However, relatively few research have been conducted on PGPB, a species native to Navi Mumbai's mangroves, a fast growing coastal metropolis that has seen significant mangrove degradation. The goal of this work was to separate and analyze PGPB from Navi Mumbai mangroves in order to assess its potential to encourage the establishment of Avicennia marina seedlings, the area's most common mangrove species. 42 bacterial isolates were collected from different mangrove habitats in Navi Mumbai and Mumbai, and three of these isolates, designated N5, N13, and N14, were chosen for further study after undergoing a series of screening procedures intended to identify their potential for boosting plant development and biocontrol. These isolates were examined for their capacity to encourage the development of mangrove seedlings both as pure cultures and in different combinations. When compared to the uninoculated control plants, the dual culture of N13+N14 was shown to be very successful since it raised the values of

practically all of the physical and chemical growth parameters of the infected plants. The shoot weight and protein content saw the most notable growth, with a 200% rise. The values of all the physical parameters evaluated rose as a result of the pure culture N14; the weight of the shoots increased by 200% and the protein content by >125%. HPLC, GC, and spectrophotometric tests were used to measure the isolates' capacity to promote plant growth and operate as biocontrol agents.

1 Introduction

The relationship between a plant and its pollinator is a stunning natural occurrence. This cooperative relationship helps both the plant and the pollinator simultaneously. Additionally, this relationship is a reciprocal interaction in which both the plant and the ollinator gain, however benefits aren't necessarily shared equally. Charles Darwin acknowledged that an animal's mutualistic relationship with another animal may not be one of altruism in his essay On the origin of species (1859). "Although I do not believe which any animal in the world does an action for the exclusive good of another of its kinds, yet each species attempts to take advantage of the instincts of others," Darwin wrote. As a result, from an evolutionary standpoint, the relationship between plants and pollinators is only concerned with maintaining the balance of nature. Pollination is a crucial component of nature that has an impact on plant reproduction. According to Barrows (2011), pollination is the transfer of pollen from a plant's male reproductive section to its female receptive portion in order to initiate the fertilization process. The female portion of gymnosperm flowers is referred to as the microphyle, while pollen grains in angiosperm flowers go from the anther (male part) to the stigma (female part) (Abrol, 2012).

1.1. Pollination and pollinators

The interaction between plants and their pollinators is one of the important events in the field of plant reproduction. The majority of these plants have a pollination mechanism that interacts with animals, and cross-pollinated angiosperm blooms exhibit a range of morphological traits, including size, color, scent, nectar, and pollen (Dupont & Olesen, 2009). Studying pollination

ISSN: 2057-5688

ecology is one of the best methods to understand how a natural plant community is structured.The definition of the adaptational traits of floral structure, which are essential for illuminating the pollination process and visitor adaptation to the flower, is aided by pollination ecology. The relationship between a plant and a pollinator, according to SilberbauerGottsberger and Gottsberger (1988; Gottsberger, 2012), contributes to the organization of the plant community and has an effect on the distribution of plants depending on the species richness and quantity of pollinators.

Typically, there are two types of pollination:
Pollen is transmitted from the anthers to the stigmas of the same flower or blooms of the same genetically identical plant during the process of self-pollination (Abrol, 2012; Barrows, 2011). In cleistogamy, pollination occurs before the bloom opens. This kind of self-pollination takes place. Inevitably self-compatible and self-fertile, cleistogamous flowers are (Abrol, 2012). The transport of pollen from the anther to stigma of the flowers of genetically diverse plants is known as cross pollination (Abrol, 2012). Ovule and pollen gametes have different genetic makeups.

The practice of fertilizing the same flower again is known as autogamy. Geitonogamy, the act of pollination the two flowers of the same plant, takes place between them (Eckert, 2000). Xenogamy is the term used to describe the occurrence of flowers from genetically diverse plants pollinating one another (Faegri and Pijl, 1966). When abiotic variables play a role in the pollen transport process, the process of pollination is referred to as abiotic pollination. Wind and water, two abiotic variables, are very important in this pollination process. The pollen is dispersed by the water in water pollination, also known as hydrophily; the wind helps spread the pollen in anemophily. the process of pollination that uses biotic agents, also known as biotic pollination. Pollination is carried out by both invertebrates and vertebrates and is referred to by a number of words, including: For invertebrates, see Cantharophily in beetles, Myophily in flies, Sphecophily in wasps, Melittophily in bees, Myrmecophily in ants, Psychophily in butterflies, and Phalaenophily in moths. The terminology used for vertebrates include: (Abrol, 2012) Ornithophily is the study of birds, while therophily is the study of mammals, metatherophily is the study of marsupials, eutherophily is the study of placentals, chiropterophily is the study of rodents.

West Bengal is said to contain the highest number of mangroves of all Indian states which have mangroves. The most extensive mangrove forest in the state is Sundarban Mangrove Forest, which is located within the South and North 24 Paraganas districts of West Bengal. The Midnapore zone also includes recently developed mangrove forests. The biggest mangrove forest on the planet is Sundarban area, with the size of 10200 sq km. The border between Bangladesh and India cuts the forest in half (http://www.sundarbanbiosphere.org). Bangladesh as well as India each own a part of the Sundarban area, which is Bangladesh comprising around 60 percent of region and India with 40 percent (Neogi and co. (2016)). The Indian portion of the Sundarban that is situated in West Bengal's southern regions located between 21deg 32' to 22deg 40' north latitude, and between 90deg and 88deg 04'E longitude. According to Mitra et al.

2 Litreature Survey

In subtropical and tropical regions around the world Mangroves can be described as a wide range of halophytic communities found wherever the sea and land meet (Tomlinson 1986). They are able to withstand huge waves, extreme temperatures, powerful winds, high salinity as well as muddy, anaerobic soils. The mangrove forest community also known as mangal, is composed by mangrove vegetation and the fungi, bacteria along with animals, plants and other species. The mangrove ecosystem is comprised from mangal and the abiotic components associated with the mangal (Kathiresan and Bingham, 2001).To survive in areas with high salt levels as well as saturated soils and regular tidal flooding Mangrove plants are extremely evolved physical and morphological adaptations. The breathing roots exposed above ground, stem-support structures, viviparous water dispersed leaflets, salt-excreting propagules lower water potency, and the high levels of intracellular salt to keep water relationships in salinity environments. There are some of the morphological characteristics which render them structurally as well as functionally distinct. (Duke and Norman, 2011).

The mangrove's standing crop tends to be higher than that of the other ecosystems that are aquatic and equatorial mangrove forest generally reaching a dry biomass that is in the range of 300 to 500 metric tons per ha (Alongi 2009.). Mangrove forests may rise to huge levels and volumes of biomass that rival the amount of tropical forests. If viewed from one's generic or species scale it is evident that the variety of mangrove trees within the region of interest is small relative with the other forests of tropical origin (Saenger 2002). The tropical rainforests could contain hundreds of different species of trees, however the mangrove ecosystems with the highest diversity contain only about 50 distinct types of trees. It is the persistence of warm temperatures that are essential to the longevity of mangroves. They currently have around 70 species, and comprise an estimated 150,000 sq km at low latitudes across the globe (down from 198,000 km2 in the year 1980) (Alongi 2009).

Mangroves provide distinctive ecological settings that support diverse assemblages of organisms. An array of epibenthic meiofaunal, and infaunal insects are found in the muddy and sandy substrates. This ecosystem is place for the communities of zooplankton, fish and phytoplankton. They may be used for a particular purpose, such as a nursery habitat for juvenile fish that are found in various ecosystems (such coral reefs or seagrass beds). The roots, trunks, and branches of submerged mangroves may draw diverse epifaunal species, including bacteria, fungus, macroalgae, and invertebrates, since they are surrounded by loose sediments. The other kinds of animals reside in the branches, aerial roots branches, leaves and roots. A variety of crab species are discovered in the canopy on the trunks or even among the roots. The environment is thriving and has a distinctive character thanks to the presence of insects, reptiles, amphibians, birds, and mammals (Kathiresan and Bingham, 2001).

ISSN: 2057-5688

3 Methodology

On the androphore wall facing the perianth, there was initially a faint shape visible. With passing time, the hand lens began to see these outlines as cracks. After one hour of anthesis, the little fissure on the androphore wall transformed into a longitudinal line, and the anthers started to dehisce. It takes between 1 and 5 hours for an androphore's anthers to completely dehisce. Pollen grains were turgescent in mature anther before they shed. After six hours of anthesis, the anther walls entirely parted from one another, and the anther locules had no visible pollen grains. Pollen grains were shown to be ejected from the longitudinally split anthers when they were seen to split lengthwise. The androphores wither away after the anther dehiscence.

Fresh pollen grains were stained with acetocarmine in the field to assess pollen fertility. Additionally, fluorescein-diacetate (FDA) was applied in the lab. Every eight hours, the viability of the male flowers was checked in a humidity room after they had been gathered and kept. In a fluorescent microscope, viable pollen grains thrive in bright green. At the moment of an anther dehiscence, 86% of pollen grains were found to be viable. As the number of days following anthesis increased, pollen viability decreased. The highest viability of pollen occurred at the time of another dehiscence and lasted for five days. After dehiscence for six days, pollen viability was entirely gone.

Both male and bisexual blooms had nectarines. At the base of the androphore covering the base of the flower in male flowers, nectariferous trichomes were seen. However, these trichomes were found at the base of each carpel, directly below the staminode, in female flowers. Each ovary's base is surrounded by trichomes that are elliptical in form and have a convex surface. Multicellular nectariferous trichomes developed into one or more basal cells, a neck cell, and head and neck cells. The multiseriate head and the globular head were separated by a substantial wall. The nectariferous trichome's cells have prominent nuclei and thick cytoplasm.

Table 3.1. Heritiera fomes: Developmental stages of anther and ovule.

Days after emergence from sheath	Anther	Ovule
2	Four anther lobes visible in all the anthers, but cells not differentiated	Initiation of integuments and differentiation of megasporocyte
4	Archesporial cell differentiated below epidermis	Archesporial cell divided to form outer parietal cell and inner sporogenous cell
6	Sporogenous tissue surrounded by epidermis and undifferentiated parietal layers	Megaspore mother cell formed
8	Microspore mother cells (MMC) formed surrounded by parietal layers	Four megaspores formed, arranged in a linear tetrad
12	Tetrahedral tetrads formed	Non-functional micropylar tetrads start degeneration
15	Division of microspore nucleus	Nucleus of functional megaspore divides
18	Mature pollen grains formed	Mature embryo sac formed

When the perianth teeth were entirely shut, without any slits, male and bisexual flowers were identified. When the anther dehisces in male flowers, the androphore grows in size, which forces the perianth teeth apart. When a flower is bisexual, the basal portion of the carpel grows together with the style and stigma, which causes the perianth teeth to push open. Anthesis occurs in a 14–16 day old floral bud. As the temperature rises subsequently, anthesis in the male flower has been seen starting about 6:00 in the morning. For male flowers, the peak anthesis took place between 9:00 and 11:00 a.m. The anthesis in bisexual flowers was seen between 06:00 and 17:00 hours. Maximum anthesis was seen in the female flowers between the hours of 11:00 and 13:00, continuing until 17:00.

4 Discussion

Pollen grains were inoculated with water and allowed to germinate at room temperature in Brewbaker & Kwack's medium with 2%, 5%, 10%, and 15% sucrose concentrations. After two hours in a humidity room, pollen grains start to germinate. A percentage was estimated after observing the pollen tube's expansion. In 5% sucrose, the highest pollen germination was seen. Pollen grains rupture due to an increase in sugar content.

Each of the free carpels in the pistil has a capitate stigma, a conspicuous ovary, and a short style. The base of the four to five carpels was only partly connected, leaving the majority of the remaining space open. One ovule was present in each superior ovary, while two ovules were seldom seen. There were several nonglandular trichomes on the ovary surface. Floral nectaries and a tiny, solid staminode were also found at the base of the ovary. Every carpel has an own style.

Dry stigma has little papillae. By using ocular observation and fruit set trials, stigma receptivity was investigated. Every year, 50 flowers were tagged for each experiment at the following times:

ISSN: 2057-5688

the day before anthesis (IDBA), the day of anthesis (DOA), the day after anthesis (1DAA), the day after anthesis (2DAA), and the day after anthesis (3DAA). Flowers marked with tags were manually pollinated for each experiment by applying pollen grains to the stigmatic surface and covering the flowers with muslin pollination bags. For each experiment set, the percentage of fruit set was noted. The largest amount of fruit was seen to set on the day of anthesis and the next day. Maximum stigma receptivity was discovered to occur on the day of anthesis based on fruit set data. The proportion of stigma sensitivity continues to decline as the days after anthesis rise.

Table 4.1. Heritiera fomes: Different parameters recorded for studying Decomia sp. and plant interaction

Parameters accorded	Sample size (N=78)
Average no insects per flower	3.34±1.74
Average time spent by insects in flower	7.33±4.58
Average no of pollen load on insect body	10.38 ± 8.15

Away from the canopy region and all around the tree canopy, glycerine-coated slides were suspended. On the slides, however, there were no pollen grains to be detected. Thus, the results showed that there was no pollen load in the atmosphere. As a consequence, it was discovered that there was no likelihood of fruit setting due to wind pollination.

By using hand pollination and bagging, breeding systems were explored. Two days prior to anthesis (2 DBA), tags and pollination bags were applied to the flowers. For self-pollination, some of the bagged flowers were left covered. In other cases, the bags were removed to allow for cross-pollination during the time of stigma receptivity after the buds had been emasculated before anthesis. Additionally, tagged flowers were let out for open pollination, and in each instance, the rate of fruit set was noted. Following cross-pollination, there was a high fruit set. It was also noted that fruit was placed in manually self-pollinated blooms. Flowers that were manually unpollinated and bagged did not produce any fruit. Fruit set results from self pollination showed that the species was compatible with itself. Cross pollination resulted to a high proportion of fruit set, indicating that the species liked it.

Prior to anthesis, flowers were marked, and the same tree's pollen dust was used

ISSN: 2057-5688

to manually pollinate the flowers. When the stigma was most receptive, manual pollination was done using pollen grains from the same tree, and fruit set was seen after a month.

Table 4.2. Heritiera fomes: Fruit set in three consecutive years

of Pollination	Number of flowers	Fruit set	% Fruit set	Number of flowers	Fruit set	% Fruit set	Number of flowers	Fruit set	% Fruit set
Open Pollination	50	22	44	50	18	36	103	24	23
Self Pollination	40	19	47	50	27	54	55	19	34
Cross pollination	50	29	58	61	36	59	55	37	67
Apomixis	50	0	0	50	0	0	55	0	0

After the seed fell from the parent tree, it took 15 to 25 days for it to germinate. The seed coat stayed on the ground's surface throughout germination, and radicals migrated into the soil, resulting in hypogeal germination. Due to strong seas or a flood, the young seedling that had sprouted on the riverside was farther removed. The rate of seedling establishment was very low, and over the years of monitoring, not a single seedling was seen in the research locations.

5 Conclusion

Large fruits with a firm, smooth pericarp were produced (Figure 39 F). The location and growth of the embryo were visible in the longitudinal slice of the seeds. A zygote was seen at the micropylar end after 6 days after pollination. Endosperm was created when a male gamete fused with the polar nuclei of the central cell. Early in the zygote's development, the endosperm was nuclearly unbound. The endosperm developed into cells when the embryo reached the globular stage. The endosperm was replaced by integument ingrowths and gained rumination as the embryo developed.

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