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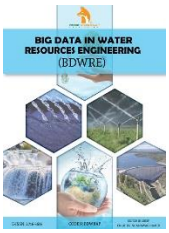

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RESEARCH ARTICLE

IMPORTANCE OF PSEUDOMONAS SYRINGAE AS BIOLOGICAL AEROSOL IN CLOUDS AND ITS ENVIRONMENTAL EFFECT

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ABSTRACT

Earth temperature ascend because of modern disturbance caused by petroleum products which produce heat entangling gases and cause an unnatural weather change. Rising temperature is disturbing condition for whole globe. Rainfall is the principal source for water and soil moisture within the semi-arid and dry places in the world. Due to temperature shift less rainfall affect agriculture turns into vulnerable and plants faces severe water shortages. So drought is a prime concern in many countries like UAE. Many countries using cloud seeding is a ultimate solution for drought. All around the world generally salts are utilized as cloud seeder. Silver iodide, dry ice, and potassium iodide are the most widely recognized as cloud nuclei. These chemical aerosols in cloud seeding might possibly harm the climate, particularly the plants as well as also adversely effect on human health. Biological ice nuclei are different from these chemicals for the reason that bacteria are more effective ice nuclei than salt particles, because of their sizes and there working temperatures. This study's goal is to concentrate on the impact of biological aerosol on cloud seeding and the environment. The findings of this study demonstrate that certain P.syringae strains are more suited to survive in conditions that arise at high altitudes and in clouds. P.syringea have own advantages and drawbacks. Bacterial ice nuclei activity cause frost in plants and damage them. Using of pesticides to control the damage of plants by P.syringea adversely affect the climate. Involving genetic adjustment in P.syringea host plants the plants effectively guarded off the bacterial disease with practically no harm to the actual plants or the general climate.

KEYWORDS

P.syringea, Bacterial Ice Nuclei, Weather Change

1. INTRODUCTION

It is an alarming situation for the planet as the temperature is rising. Global warming is one of the main reason for this. When the rays from sun reaches the earth's surface it causes global warming. Most of these rays are absorbed by the earth's surface whereas 30% is reflected back due to the clouds, particles present in the atmosphere, reflective surfaces and oceans. The heat from these rays increases the temperature of earth's surface and atmosphere and is a driving factor in keeping the life on the surface of earth. Due to increase in the earth's temperature the solar energy starts radiating by infrared rays and thermal radiations to keep the feasible temperature for life, hence conserving the ground's surface. A small amount of heat is re-absorbed by carbon dioxide, water vapor, methane, and other gases in our atmosphere during the radiation process. The gases that trap the heat are commonly known as greenhouse gases. To some extent, the re-absorption of the heat is very good as the earth temperature would be very cold if all the radiations are reflected back to space. The main problem started about two centuries ago when the greenhouse gases were produced artificially at an alarming rate. This increase in greenhouse gases in our environment is the major cause of global warming. The most common greenhouse gases are CO_2, CH_4, and N_2O. The total emission of these three gases naturally make up to 96%, 46% and 64% respectively (Hussain et al., 2020; Iqbal et al., 2022; Salam et al., 2020)(Waqas et al., 2021)(Mander et al., 2016). More than 8 billion tons of carbon dioxide was generated as of 2004. This man made increase phenomenon is known as human enhanced global warming effect. This increase in greenhouse gases resulting in temperature rise of the earth's surface. Between 1906 to 2006, the average augmented temperature of the earth was around 0.6 to 0.9 degree Celsius and this was the highest increase in earth's temperature in last 100 years. Moreover methane gas production is also increasing heavily due to the agricultural decomposition and waste landfills. The CH_4 hydrates are also increasing in oceans shelfs and is one of the main concern in long-term global warming threat. Moreover, the increasing wildfire has also resulted in increasing the earth's temperature. The agriculture sector is also playing a huge role in the increase of nitrous oxide gases as most of the fertilizers contain nitrogen specially urea and diammonium phosphate. These greenhouse gases once produced, can stay in our atmosphere for decades or even more (Shahzad, 2015). Due to the revolution in industry from 1750, the CO_2 and methane gas levels have increased by 35% and 148% according to the Intergovernmental Panel on Climate Change. There has been an uncertainty in rainfall as our climate is changing and this will lead us into disaster. The temperature of different countries in Australia and Asia region will be affected due to El Nino and La Nina. It is also predicted that there will be more floods and dry events all around the globe due the temperature rise (Ahmad Tarmizi et al., 2019).

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Scientists believe that there will be noticeable increase in temperature in some regions along with extreme droughts that will affect our agriculture and ecosystem according to August 2021 report by International Panel on Climate Change. This analysis also suggests that there is a 1.7 times greater risk of droughts occurring now than there was a decade ago.

Water is also one of the major issues all around the world and UAE is playing an important role to tackle the issue by precipitation and this project is led by state of the art technologies. Increase in rain will help to reduce the global warming as well as droughts. For the sustainability and water scarcity, cloud seeding is playing an important role to enhance water resources and UAE has carried out this operation successfully for the last two decades. Cloud seeding techniques has a diverse effect in increasing micro physical process within the clouds. It also helps in getting more water from the clouds and has capacity to increase precipitation by 18%. The main effects of climate change are drought and storms in different regions. To overcome the climate change issue and to keep our environment as sustainable as possible for our future generations, UAE has adopted the technique of cloud seeding so that rainfall can be increased despite the lack of natural resources of water. They have also fought the drought in Arabian Peninsula and other arid regions by using cloud seeding technique (Hussain et al., 2020; Iqbal et al., 2022; Waqas et al., 2021).

Cloud seeding also have some adverse effects and the chemicals used can damage the environment specially the plants. Although there is no solid study on the implication of silver iodine on the environment. Iodism is a form of poison, and it can be caused by silver iodine. In this the patient experiences headache, skin rashes, running nose and diarrhea. This is highly poisonous for human, livestock and fishes (Malik, 2018).

One of the most common nucleating salts used, especially in cloud seeding, is silver iodide. According to earlier research of cloud seeding, AgI is not readily available in the environment since it remains in soil, therefore the amount of free Ag is very small to have a toxic effect.Significant amounts of seeding materials accumulate in the atmosphere as a result of perfuming cloud seeding repeatedly in the same place. If so, AgI in cloud seeding might have less of an effect on plants and animals in aquatic as well as earthly environments. (Fajardo et al., 2016) Bioprecipitation is a type of precipitation caused by microbes. David Sands first introduced the idea of rain-making microbes in the 1970s. A bacteria can cause ice formation around -1°C depending on the nucleating substance, although pure water generally freezes at around -36°C1. The Bacteria might be seen as altering agents of climate, with clouds playing very vital role in the weather system's operation. Although it is estimated by (Hoose et al., 2010) that aerosol bacteria has an influence of 0.6% on the scale of 2. Numerous diversities of creatures are supposed being tangled, mostly those that can float in air easily. Pantoea agglomerans, Exserohilum turcicum, Pseudomonas fluorescens, Pseudomonas viridiflava, Xanthomonas campestris, and Pseudomonas syringae, are some of the organisms that could be engaged in bioprecipitation. According to David Sands, P.syringea is the same bacterium that cause loss in crop yield (frost damage the plants) that was discovered in samples of clouds, leading him to conclude that P.syringea is the reason of Bioprecipitation because of its ice nucleation ability. According to Leroy Maki in 1970's, Pseudomonas syringae is the most well explained organism that exhibits ice nucleation and can also supply a source of ice nucleates.

2. Rainfed Areas

Rainfed are those areas which are not irrigated by artificial water resources like canals and tube wells but where irrigation totally depend upon rain water. Dry lands rainfed areas arid areas these are same terms. But drylands terms use differently these term use for arid sub arid and subhumid where annually rain fall record less than 500mm. In Pakistan all provinces have areas where rain fall occur less than 250mm annually. Rainfall is the principal source for water and soil moisture within the semi-arid and dry places of Pakistan. During summer monsoon season due to less rainfall agriculture turns into vulnerable and plants faces severe water shortages in Thal desert in which sand dunes, wind cyclones, abundant sunshine and common drought frequent. The temperature of Thal area in summer reach to 50°C (Asghar et al., 2019) and in winter its fluctuate 20°C to 33°C. Underground water is usually brackish, not suitable for consuming and irrigation functions. so, cloud seeding is a ultimate solution for drought. According to Khaleej times UAE increase rainfall 10 to 25% through cloud seeding.

3. Pseudomonas Syringae

Dr.Lindow in 1970's discovered Pseudomonas syringae. He took a dried leaf powder which is damaged by frost where he observed this leaf totally powerless against frost. The protein present in P.syringea strain act as a ice nuclei and make ice crystals at temperature (-2°C to -14°C) (Prasanth. et al., 2015). This strain is called "Ice Plus" which have Ina (Ice nucleating active) protein while those strain which this protein is not present called "Ice negative strain". According to (Robbins, Jim 2010) this Ice plus strain are the responsible to damage crops by frost. Not all strains cause plants to develop ice crystals. Erwinia herbicola, Pseudomonas fluorescens, Pseudomonas viridiflava, and Xanthomonas are a few frequent strains that serve as ice nuclei.In homogenous ice nuclei at -40°C the pure water can be super cooled. The optimum temperature for growth of P.syringea is 28°C and range vary 23-33°C (Hockett, Burch, & Lindow, 2013).

3.1 Role of P.syringae in environment

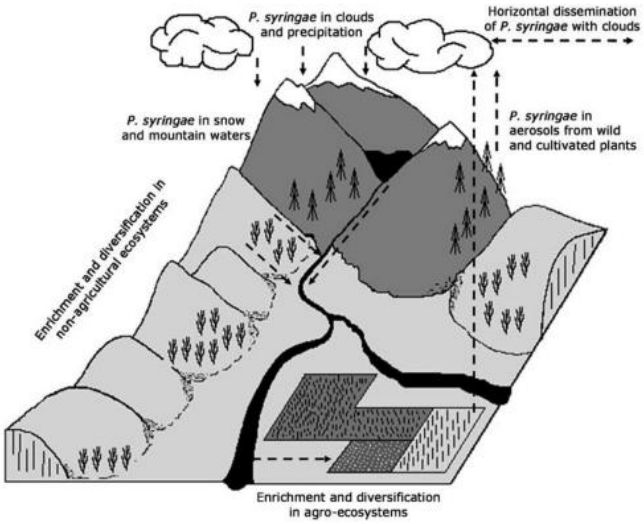

Figure 1: Water cycle and P. syringae (Morris et al., 2008).

Figure 1 shows that role of P. syringae in hydrological cycle. P.syringea either present in to clouds and atmosphere they come back to earth through snow and rain (Amato et al., 2007). The chances of this bacterium surviving in the atmosphere and in clouds depends on environmental factors and its own subspecies. P. syringea is transported through lakes and streams by runoff from snow and rain. According to Morris et al. (2007), runoff water can become a source of production in epilithic biofilms. Furthermore, streams are a source of P. syringea dissemination. P.syringea introduced in plants by Snow water, rain water, lakes and streams which is used for irrigation purpose after they disperse in atmosphere and around places by air and wash of plants. The holding ability of different crops, epilithic biofilms snow and water each factor deal different pressure that affect the population of P.syringea. All these factors either cause growth in biotypes of P.syringea or other may cause reduction (Morris et al., 2007).

When water is percolate underground and move from upside catchment of mountains to downside catchment these cause pressure on P.syringea. Bactria experiences pressure because of possible variations in chemical concentrations, oxygen tension, and other physical-chemical constraints relating to surface water. Recently, researchers have focused on the interaction between this bacterium and the agricultural environment. P. syringea spreads to crops via river water that is used for irrigation (Riffaud and Morris, 2002). Some P. syringae strains may adapt to the agricultural environment, while others may come under pressure. P. syringae in the epiphytic stage on plants (wild or developed) are carried by the air towards clouds and return to the soil as rain or snow. But in last few years those countries which faced crop damage due to frost cause by P.syringea they use pesticides to save the crops from P.syringea. The population P.syringea decreased which impact the rain water cycle.

4. Pseudomonas Syringae as Cloud Seeder

4.1 Ice Nucleation Potential

In Ice nucleating three factors are more important contact angle, concentration and diameter of bacteria. The classical heterogeneous nucleation theory is a phenomenological concept that sees the nucleating droplet as a collection of molecules with strong interactions amongst them but weak interactions with the rest of the system. In accordance with conventional theory, the nucleating cluster is viewed as a macroscopic droplet with equilibrium thermodynamics, whose free energy of formation is greatly influenced by the bulk surface tension. The nucleating

cluster is regarded by classical theory as a macroscopic droplet with equilibrium thermodynamics, whose free energy of formation is greatly influenced by the bulk surface tension. The nucleation rate is proportional to the reversible work of cluster formation since nucleation is an active process. The origin of the contact angle based on this theory. The macroscopic description of an embryo in contact with a substrate is the definition of contact angle (Seinfeld et al., 2016).According to different ice nucleation researches the contact angle of P.syringea is 20°.

The activation of P. syringae bacteria (mean bacterium radius, rp = 0.3 m) was investigated by at the surface level (sulfuric acid= 3.58108 molecules/cm3) and (water = 7.11016 molecules/cm3) for two different temperatures 25°C and 0°C. For both temperatures, low contact angles are beneficial for P. syringae activation. At temperature 0°C activation occurring at contact angles close to 90°. The activation happens at ambient temperature 25°C for contact angles less than 50°. In all situations, the model demonstrated that P. syringae bacteria have a high activation potential. The results with P. syringae's strong ice nucleation potential suggest that there is a nucleation probability of one at contact angles of 20 in the troposphere. Bacteria with varying contact angles have extremely diverse activation properties, and P. syringea has a high chance of activation at altitudes of 4–15 kilometers (Lazaridis, 2019).

4.2 Survival in clouds

Bactria presents in clouds for example, Pseudomonas syringae function as ice nuclei that cause precipitation and are likely to be connected to arising lightning., drove (Blanchard et al., 2017) capability of P.syringea. Here, they evaluate the chances of living of this bacterium in water and ice crystals in clouds. In cloud chamber they create electric shocks to check the ability of P.syringea and their DNA. P. syringae CC0094 as compared with two different types of bacteria which is (Pseudomonas sp. N3 and Escherichia coli TOP10), gives off an impression of being best adjusted stamina and for heritable electrotransformation under these conditions.P. syringae showed their survival chances are more contrasted with two other bacteria. This whole research support the previous hypothesis related to plant pathogen like P. syringae have a high ability to survive as compared to others microbe in a clouds.

4.3 Survival at High Altitude

It was detected in experiments on precipitation, snow, and cloud water, this bacterium may be suitable for dispersion through the environment. (de Araujo et al., 2019) conducted experiments to check the surviving ability and support of INA under focusing conditions which are in clouds and at higher altitudes. P. syringea strains are more UV-A and UV-B resistant than other bacterial strains in this study's solar simulator experiment. P.syringae and Garcae strains were compared to Escherichia coli strains. Pseudomonas were far more susceptible to UV-B. The P. syringae strains are more able to thrive in clouds and at high altitudes than E. coli.

4.4 P.syringea as Cloud Seeder

The above results shows that P.syringea have play important role in hydrological cycle, this bacteria have high nucleating efficiency tolerant to UV-B rays and also they survive in high altitudes and clouds. Cloud seeding are done by two methods one is arial cloud seeding and second is ground base cloud seeding (Almansoori & Badran, 2020) In Thal area the summer temperature remain between 40°C to 50°C so arial seeding is best option in summer monsoon while ground base seeding done by naturally in winter season because winter temperature is suitable for P.syringea growth for the purpose of this pick a particular area on the windward side of dry area for growth purpose pick the host crop of this biological aerosol and check the impact on rain fall near the host crop.

4.5 Different properties of P.syringea impact on ice nucleation

4.5.1 Chemical transformations

Ice-nucleating macromolecules (INMs) are specialized proteins or other molecules produced by some organisms that can induce the establishment of ice crystals at or near the freezing point of water. These INMs can undergo chemical transformations when exposed to various environmental conditions, which can alter their properties and functions. Here are some examples of chemical transformations that INMs may undergo.

Oxidation: INMs may undergo oxidation, a chemical reaction in which electrons are transferred to or from the INM, changing its chemical composition. This may happen, for instance, when INMs are exposed to reactive oxygen species (ROS) brought on by environmental stressors like UV radiation or pollution.

Functionalization: INMs may undergo functionalization, a process in which chemical groups are added to or removed from the INM, changing its chemical properties. For example, nitration or sulfatisation may occur when INMs are exposed to environmental pollutants, altering their ability to induce ice nucleation.

These chemical transformations can affect the activity and stability of INMs, which can have important ecological implications. For example, changes in the properties of INMs may affect the ability of organisms to survive in cold environments or to colonize new habitats. Additionally, chemical transformations of INMs may alter their interaction with other organisms, such as plants or fungi, affecting the broader ecosystem.

4.5.1.1 Effects of nitration and oxidation exposure

Gas exposure significantly reduced the viable cells of all strains. At the beginning of experiment ice nucleation activity was counted by dividing the number of ice nuclei by the number of viable cells keeping in mind that dead cells have efficient nucleation protein. Flow cytometry method was used to calculate the total number of cells to check the number of degraded cells after gas exposure.

To check the effect of exposure system, Comparisons of ice nucleation activity were conducted between bacteria exposed to synthetic air containing NO_2/O_3 and bacteria not exposed to synthetic air. Ice nucleation activity of strains 32b-74 and 13b-2 having same concentration which were not introduced into the exposure system and the one introduced were nearly same. The initial freezing temperature decreased by 1C and 2C respectively when strains CC0242 and CGina-01 were exposed to synthetic without NO_2 and O_3.

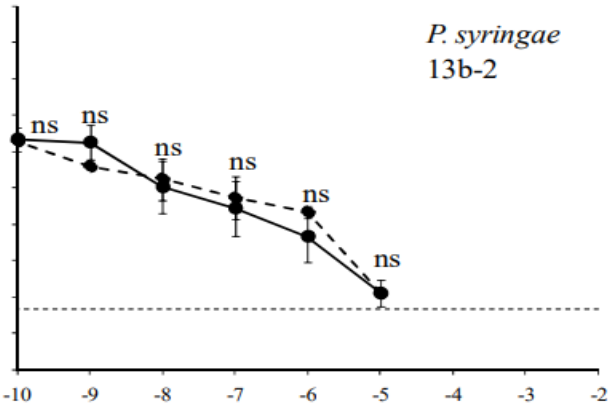

Figure 1: shows that ice nucleation activity of 13b-2 was not significantly affected by NO_2 and O_3 exposure.

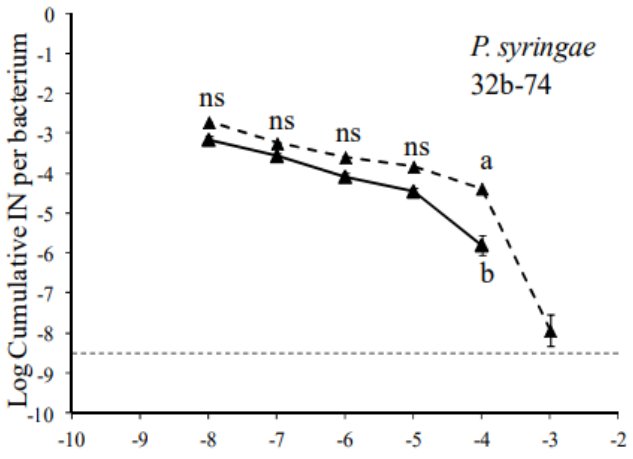

Figure 2: for strain 32b-74 temperature at which freezing was occur initially decrease by 1C and at -4C there was a slight difference in ice nuclei.

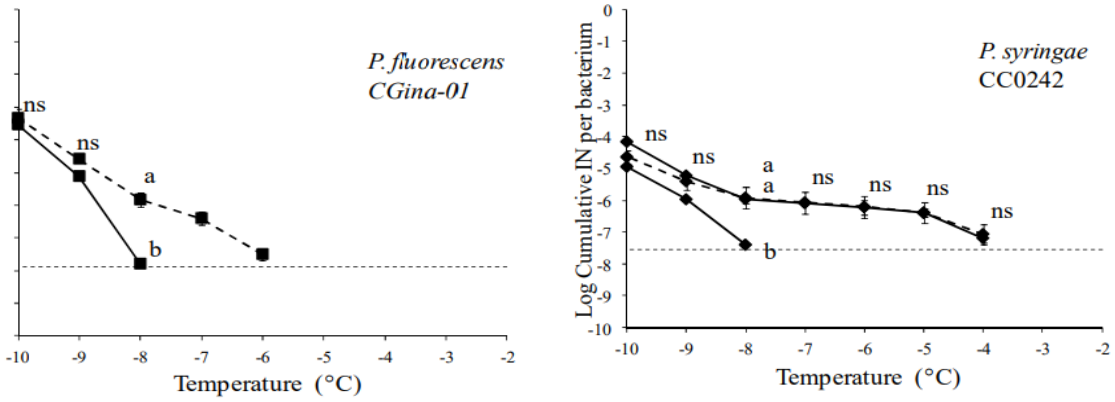

Figure 3: The ice nucleation activity of strain CGina-01 affected significantly when exposed to NO_2/O_3 as there was 2C decrease in temperature at which freezing was occurred initially.

Between four replicate trials Strain CC0242 two different type of response were recorded. 2 replicates show significant change in temperature at which freezing occurred initially, while other two replicates show 4C decrease in temperature when exposed to NO_2/O_3

4.5.2 Biological Transformation

Changes in ambient conditions (changes in temperature, humidity, or nutrient availability) can cause cellular reactions that alter the production of INAs, leading to biological changes in p.syringea. This can have important ecological implications, as it can affect the ability of p.syringea to interact with their environment and other organisms.

The following are specific terms to help clarify the content of the biological aging process.

4.5.2.1 Agglomeration

A method of particle production utilized in several sectors, in which at least two primary particles are mixed to create a new one**.** Pseudomonas syringae's ice nucleation activity was measured using a Twin-plate Ice Nucleation Assay (TINA), according to the research by (Kunert et al., 2018) describes the use of a Twin-plate Ice Nucleation Assay (TINA) to measure ice nucleation activity of Pseudomonas syringae, a common ice nucleating bacterium. One of the factors studied was the effect of agglomerates, which are clusters of bacterial cells, on ice nucleation activity.

The research discovered that P. syringae aggregates had a stronger ice nucleation capability than individual bacterial cells. This implies that the development of agglomerates may increase P. syringae's environmental ice nucleation activity. The authors also noted that the influence of agglomerates on ice nucleation action varied depending on the size and composition of the agglomerates. For instance, agglomerates with fewer cells showed lower ice nucleation activity than agglomerates with more cells.

Overall, the study suggests that the formation of agglomerates could be an important factor in the ice nucleation activity of P. syringae and other ice nucleating bacteria. Understanding the function of these microorganisms in cloud formation and atmospheric precipitation processes may be aided by this information

4.5.2.2 Biosurfactants

The materials that reduces the attraction between liquid molecules and are produced by microbes. Fluorescent pseudomonads that were isolated from clouds and precipitation in the Hebrides are said to create biosurfactants but not ice nucleation, according to the article by (Ahern et al., 2007).

The study's findings suggest that these fluorescent pseudomonads have the potential to be used in the production of biosurfactants but are unlikely to contribute to ice nucleation in the environment. This information also relevant to industries interested in using these microorganisms for biosurfactant production or for researchers studying cloud formation and precipitation.

4.5.2.3 Biofilms

A layer developed on the surface of ice that cannot be removed. Antimicrobial drugs no longer act after biofilm formation. According to (Morris et al., 2008). P. syringae's life history is significantly impacted by biofilms because they offer the bacterium more protection against environmental stresses such desiccation, UV radiation, and antimicrobial chemicals.

Biofilm formation by Pseudomonas syringae can have an impact on its ice nucleation ability. P. syringae is known to produce a protein called ice nucleation protein (INP) that can start ice crystal formation at relatively high temperatures (-2°C to -10°C), which can lead to frost damage in plants.

Studies have shown that P. syringae cells within a biofilm matrix can exhibit enhanced ice nucleation activity compared to planktonic cells (cells that are not part of a biofilm). This is thought to be due to the fact that the biofilm matrix can provide a scaffold for the assembly of INP molecules on the surface of the bacterial cells, leading to a higher density of INP and more efficient ice nucleation.

4.5.2.4 Endospore formation

Simply the formation of a thin wall around the whole bacteria. Due to external pressure of ice, bacteria didn't replicate and converted into spores. They are not actively metabolizing, and therefore are unlikely to contribute to ice nucleation activity. However, endospores can serve as a reservoir of bacterial genetic material and potentially contribute to the spread of ice-nucleating activity among bacterial populations.

4.5.2.5 Cell Generation

The amount of time required by bacteria to divide through binary fission. According to (Möhler et al., 2008), P. syringae's cell production and physiology may have an impact on its capacity to act as ice nucleation nuclei (INN).

According to the author, changes in the cell surface characteristics or increased expression of ice nucleation proteins may make P. syringae cells more effective at inducing ice nucleation as they develop and proliferate. In addition, the author speculates that the presence of specific nutrients or environmental factors may potentially have an impact on P. syringae's capacity to form ice.

Overall, P. syringae's ability to encourage ice nucleation in the atmosphere is affected by cell growth, which emphasizes the bacterium's potential significance in cloud formation.

4.5.2.6 Protein Expression

The inaQ protein produced in Escherichia coli demonstrated ice nucleation ability at temperatures above -5°C, according to the researchers (Li et al., 2012). This suggests that the inaQ protein may be involved in P. syringae's capacity to start ice formation in host plants.

The study also discovered that the inaQ protein is localized to the bacterial outer membrane and has a transmembrane domain. This shows that the protein may be involved in P. syringae transport pathways or nutrient intake.

Overall, the effect of inaQ expression on ice nucleation raises the possibility that it contributes to P. syringae's environmental adaptation and its capacity to harm crops through frost. To completely comprehend the role of inaQ and its consequences for bacterial physiology and agricultural practices, more research is required.

4.5.2.7 Pigment formation

Refers to the process by which microorganisms produce pigments, which are colored compounds that can be used for various purposes, such as absorbing light energy, protecting against UV radiation or toxins, or signaling to other microorganisms.

According to (Morris et al., 2004) the impact of pigment formation on ice nucleation depends on the type of pigment produced by the bacteria.

Some bacterial pigments, such as melanin, have been found to enhance ice nucleation by providing nucleation sites for ice crystal formation. This ability may allow bacteria to survive freezing temperatures by promoting the formation of ice crystals outside of their cells, preventing intracellular ice formation that could damage the cells.

Other pigments, such as carotenoids, have been found to inhibit ice nucleation. This may be due to the ability of carotenoids to scavenge free radicals, which can interfere with ice crystal formation. The inhibition of ice nucleation by carotenoids may allow bacteria to survive in supercooled water without triggering the formation of ice crystals, which could also damage their cells. As a result, the type of pigment that bacteria create can greatly change their capacity for ice nucleation, which in turn might affect their potential contribution to precipitation processes.

5. P.SYRINGAE AS PLANT PATHOGEN

P.syringae as pathogen that affects a broad range of different plants , and the symptoms of the diseases are often similar. Within the species, there is a large level of specialisation in terms of plants with which individual strains are likely to interact. The most fundamental and effective strategy for germs to cause disease is colony growth on the host. If the plant is a pathovar host, it will produce more colonies. P.syringae pathovars can cause disease in a variety of plants such as tomato, kiwifruit, pepper, olive, and soybean but only a few.

5.1 Use different strategies to save the Crop from P.syringea

Pseudomonas syringae (Ps), the plant pathogen and associated Ps classes invade and harm a huge variety of agriculturally vital crops, such as olive, tomato, soybean, kiwifruit and pepper resulting in commercial deficits. At this time, induced resistance genes and chemicals are being utilized to defend plants from these pathogens, although they have partial effectiveness and may have negative ecological consequences. As a corollary, different ways for combating bacterial infection in crops are urgently needed. However, one strategy includes the use of narrow-spectrum protein antibiotics (known as bacteriocins), which are used by various bacteria to fight against closely associated species. At this point, we illustrate that putidacin L1 (PL1), a bacteriocin, may be transcribed at high levels in active form in Arabidopsis and Nicotiana benthamiana planta to offer an efficient resistance to a variety of Ps pathovars. Moreover, (Rooney et al., 2020) discovered that Ps strains that mutation to attain tolerance to PL1 lose their O-antigen, display limited motility, and are still unable to cause illness symptoms in PL1-transgenic Arabidopsis. Our findings demonstrate that transgene-mediated bacteriocin expression in plants can give effective resistance to disease against bacterial pathogens. Therefore, whilst genetic alteration of crops to express insecticidal proteins has shown to be an enormously efficacious technique for pest management. For controlling bacterial disease the development of bacteriocins in crops may also be useful technique. Momentously, bacteriocins are produced by practically all bacterium genera, including many plant pathogenic species, offering a plentiful supply of antimicrobial agents.

Introducing I minus strain of P.syringea in plants is very helpful this mutant strain have not ice nucleating protein which not damage the plant if this Ice minus bacteria is succeeded against Ice plus strain than crops are save from frost damage but if not succeed in competition against Ice plus strain still the decrease the population of Ice plus strain and have less frost damage occur in plants.

6. DISCUSSIONS

Man would no longer be at rely at the climate instead it can be able to forecast at what time and wherever precipitation will fall. Rainfall is the principal source for water and soil moisture within the semi-arid and dry places in the world. Due to temperature shift less rainfall affect agriculture turns into vulnerable and plants faces severe water shortages. So, drought is a prime concern in rainfed areas of Pakistan. Cloud seeding is the solution in such areas but high cost requires for cloud seeding so it is necessary to focus on ultimate solution like Bioprecipitation. Humankind has labelled Pseudomonas syringae as a pest, yet it actually has a positive side in the rain-making bacterium's constructive nature. As previously said, microbes “Ice minus” may perhaps compete with wild strains that can lessen the crop damage risk. It is also not beneficial when considering its potential cause in changing rainfall. Plants can still be protected by genetic modification that allows mutant strain of P. syringea to play its role in the production of anti- freezing proteins which are essential to make them competitive toward ice plus bacteria. P.syringae will continue to play a part in rain production. As a result, it is always vital to make use of nature's gift of rain in order to assist farmers. Because Pakistan is an agricultural country, its not easy to work on this issue that can enhance the likelihood of rain and water shortage. Crops are destroyed by frosts and bacterial ice, yet they cannot survive without rainfall that is produced by ice nucleating microorganisms. Investigation will be necessary in understanding P. syringae's and its contribution in the hydrologic cycle. So new research figure out how to use it, instead of destroying, its quality to cater rainfall where it is required. To overcome this challenge, plant biologists, agronomists, and metrological researchers should collaborate and to locate the missing information.

REFERENCES

Ahern, H. E., Walsh, K. A., Hill, T. C. J., & Moffett, B. F. 2007. Fluorescent pseudomonads isolated from Hebridean cloud and rain water produce biosurfactants but do not cause ice nucleation. Biogeosciences, 4(1), 115-124.

Ahmad Tarmizi, A. H., Rahmat, S. N., Abd Karim, A. T., & Tukimat, N. N. A. 2019. Climate Change and Its Impact on Rainfall. International Journal of Integrated Engineering, 11(1).

Amato, P., Parazols, M., Sancelme, M., Laj, P., Mailhot, G., & Delort, A.-M. 2007. Microorganisms isolated from the water phase of tropospheric clouds at the Puy de DÃ´me: major groups and growth abilities at low temperatures. FEMS Microbiology Ecology, 59(2), 242-254.

Asghar, A., Iqbal, J., Amin, A., & Ribbe, L. 2019. Integrated hydrological modeling for assessment of water demand and supply under socio-economic and IPCC climate change scenarios using WEAP in Central Indus Basin. Journal of Water Supply: Research and Technology-Aqua, 68(2), 136-148.

Baig, M. B., Shahid, S. A., & Straquadine, G. S. 2013. Making rainfed agriculture sustainable through environmental friendly technologies in Pakistan: A review. International Soil and Water Conservation Research, 1(2), 36-52.

Blanchard, L. S., Monin, A., Ouertani, H., Touaibia, L., Michel, E., Buret, F., . . . Demaneche, S. 2017. Survival and electrotransformation of Pseudomonas syringae strains under simulated cloud-like conditions. FEMS Microbiol Ecol, 93(5).

Cochet, N., & Widehem, P. 2000. Ice crystallization by Pseudomonas syringae. Appl Microbiol Biotechnol, 54(2), 153-161.

De Araujo, G. G., Rodrigues, F., Goncalves, F. L. T., & Galante, D. 2019. Survival and ice nucleation activity of Pseudomonas syringae strains exposed to simulated high-altitude atmospheric conditions. Sci Rep, 9(1), 7768.

Després, V., Huffman, J. A., Burrows, S. M., Hoose, C., Safatov, A., Buryak, G., ... & Jaenicke, R. 2012. Primary biological aerosol particles in the atmosphere: a review. Tellus B: Chemical and Physical Meteorology, 64(1), 15598

Ervens, B., & Amato, P. 2020. The global impact of bacterial processes on carbon mass. Atmospheric Chemistry and Physics, 20(3), 1777-1794.

Hussain, S., Malik, S., Masud Cheema, M. J., Ashraf, M. U., Waqas, M. S., Iqbal, M. M., Ali, S., Anjum, L., Aslam, M., & Afzal, H. 2020. An Overview On Emerging Water Scarcity Challange In Pakistan, Its Consumption, Causes, Impacts And Remedial Measures. Big Data In Water Resources Engineering (BDWRE), 1(1). https://doi.org/10.26480/bdwre.01.2020.22.31

Fajardo, C., Costa, G., Ortiz, L. T., Nande, M., Rodriguez-Membibre, M. L., Martin, M., & Sanchez-Fortun, S. 2016. Potential risk of acute toxicity induced by AgI cloud seeding on soil and freshwater biota. Ecotoxicol Environ Saf, 133, 433-441.

Hartmann, S., Augustin, S., Clauss, T., Wex, H., Šantl-Temkiv, T., Voigtländer, J., . . . Stratmann, F. 2013. Immersion freezing of ice nucleation active protein complexes. Atmospheric Chemistry and Physics, 13(11), 5751-5766.

Iqbal, M. M., Li, L., Hussain, S., Lee, J. L., Mumtaz, F., Elbeltagi, A., Waqas, M. S., & Dilawar, A. 2022. Analysis of Seasonal Variations in Surface Water Quality over Wet and Dry Regions. Water (Switzerland), 14(7). https://doi.org/10.3390/w14071058

Hockett, K. L., Burch, A. Y., & Lindow, S. E. 2013. Thermo-regulation of genes mediating motility and plant interactions in Pseudomonas syringae. PLoS One, 8(3), e59850.

Hoose, C., Kristjánsson, J. E., & Burrows, S. M. 2010. How important is biological ice nucleation in clouds on a global scale? Environmental Research Letters, 5(2).

Huffman, J. A., Perring, A. E., Savage, N. J., Clot, B., Crouzy, B., Tummon, F., ... & Pan, Y. 2020. Real-time sensing of bioaerosols: Review and current perspectives. Aerosol Science and Technology, 54(5), 465-495.

Kunert, A. T., Lamneck, M., Helleis, F., Pöschl, U., Pöhlker, M. L., & Fröhlich-Nowoisky, J. 2018. Twin-plate Ice Nucleation Assay (TINA) with infrared detection for high-throughput droplet freezing experiments with biological ice nuclei in laboratory and field samples. Atmospheric Measurement Techniques, 11(11), 6327-6337.

Kristjánsson, J. E., Hoose, C., Chen, J.-P., & Hazra, A. 2010. A Classical-Theory-Based Parameterization of Heterogeneous Ice Nucleation by Mineral Dust, Soot, and Biological Particles in a Global Climate Model. Journal of the Atmospheric Sciences, 67(8), 2483-2503.

Lazaridis, M. 2019. Bacteria as Cloud Condensation Nuclei (CCN) in the Atmosphere. Atmosphere, 10(12).

Li, Q., Yan, Q., Chen, J., He, Y., Wang, J., Zhang, H., & Li, L. 2012. Molecular characterization of an ice nucleation protein variant (inaQ) from Pseudomonas syringae and the analysis of its transmembrane transport activity in Escherichia coli. International journal of biological sciences, 8(8), 1097.

Liu, X., Easter, R. C., Ghan, S. J., Zaveri, R., Rasch, P., Shi, X., Mitchell, D. 2012. Toward a minimal representation of aerosols in climate models: description and evaluation in the Community Atmosphere Model CAM5. Geoscientific Model Development, 5(3), 709-739.

Malik, S. 2018. Cloud Seeding; Its Prospects and Concerns in the Modern World -A Review. International Journal of Pure & Applied Bioscience, 6(5), 791-796.

Mander, Ü., Sohar, K., Tournebize, J., & Pärn, J. 2016. Risk analysis of global warming-induced greenhouse GAS emissions from natural sources. International Journal of Safety and Security Engineering, 6(2), 181-192.

Morris, C. E., Georgakopoulos, D. G., & Sands, D. C. 2004. Ice nucleation active bacteria and their potential role in precipitation. In Journal de Physique IV (Proceedings) (Vol. 121, pp. 87-103). EDP sciences.

Morris, C. E., Conen, F., Alex Huffman, J., Phillips, V., Poschl, U., & Sands, D. C. 2014. Bioprecipitation: a feedback cycle linking earth history, ecosystem dynamics and land use through biological ice nucleators in the atmosphere. Glob Chang Biol, 20(2), 341-351.

Morris, C. E., Sands, D. C., Vinatzer, B. A., Glaux, C., Guilbaud, C., Buffiere, A., Thompson, B. M. 2008. The life history of the plant pathogen Pseudomonas syringae is linked to the water cycle. ISME J, 2(3), 321-334.

Möhler, O., Georgakopoulos, D. G., Morris, C. E., Benz, S., Ebert, V., Hunsmann, S., ... & Wagner, R. 2008. Heterogeneous ice nucleation activity of bacteria: new laboratory experiments at simulated cloud conditions. Biogeosciences, 5(5), 1425-1435.

Pummer, B. G., Budke, C., Augustin-Bauditz, S., Niedermeier, D., Felgitsch, L., Kampf, C. J., . . . Fröhlich-Nowoisky, J. 2015. Ice nucleation by water-soluble macromolecules. Atmospheric Chemistry and Physics, 15(8), 4077-4091.

Robbins Jim, From Trees and Grass, Bacteria That Cause Snow and Rain. The New York Times 2010

Rooney, W. M., Grinter, R. W., Correia, A., Parkhill, J., Walker, D. C., & Milner, J. J. 2020. Engineering bacteriocin-mediated resistance against the plant pathogen Pseudomonas syringae. Plant Biotechnol J, 18(5), 1296-1306.

Salam, M., Cheema, M. J. M., Zhang, W., Hussain, S., Khan, A., Bilal, M., Arshad, A., Ali, S., & Zaman, M. A. 2020. Groundwater Storage Change Estimation Using Grace Satellite Data In Indus Basin. Big Data In Water Resources Engineering (BDWRE), 1(1). https://doi.org/10.26480/bdwre.01.2020.13.18

Seinfeld, J. H., Bretherton, C., Carslaw, K. S., Coe, H., DeMott, P. J., Dunlea, E. J., . . . Wood, R. 2016. Improving our fundamental understanding of the role of aerosol-cloud interactions in the climate system. Proc Natl Acad Sci U S A, 113(21), 5781-5790.

Stopelli, E., Conen, F., Guilbaud, C., Zopfi, J., Alewell, C., & Morris, C. E. 2017. Ice nucleators, bacterial cells and <i>Pseudomonas syringae</i> in precipitation at Jungfraujoch. Biogeosciences, 14(5), 1189-1196.

Waqas, M. S., Cheema, M. J. M., Hussain, S., Ullah, M. K., & Iqbal, M. M. 2021. Delayed irrigation: An approach to enhance crop water productivity and to investigate its effects on potato yield and growth parameters. Agricultural Water Management, 245. https://doi.org/10.1016/j.agwat.2020.106576

Zhang, M., Khaled, A., Amato, P., Delort, A.-M., & Ervens, B. 2021. Sensitivities to biological aerosol particle properties and ageing processes: potential implications for aerosol–cloud interactions and optical properties. Atmospheric Chemistry and Physics, 21(5), 3699-3724.