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Elucidating Different Ways of Fungi Response in Stress Environment

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Abstract:- There is a very immediate and very current requirement for increasing the security of food on global level for reversing back the uplifting trends of cancer rates, protecting the environmental health and other climatic changes. The review focuses on the fungi that helps for providing remedies to such problems. We discussed the major aspect of stress biology of fungus on the special and current affairs of genetics involved. The area of biology has a very close significance in pure and advanced researched on fungal stress systems, biological control of insect pests, role of saprotrophic fungi in field of forestry and agriculture. Stress is an unfavored condition for an organism which includes fungus too. For overcoming the stress organisms shows the heat shock proteins also called chaperons for performing its basic biological purpose. Thus, it became very important for understanding the basic purpose of heat shock proteins which express themselves in response to the stress conditions of fungi. Osmotic stress, pH , temperature changes caused by stresses of these heat shock proteins is also briefly discussed.

Keywords:- *Fungi, Stress Responses, Heat Shock Proteins.*

I. INTRODUCTION

The Kingdom fungi broadly focuses on the versatile taxonomy which involves many filamentous fungi which are mainly grouped in the basis of their size, shape, characteristics, morphogenetic structure, reproducibility and toxigenicity of these fungus . The versatile mode of reproduction among fungi has been seen since ages in the environment. The diverse mode of absorption inside the fungi which are feeding by which they show adhesion with their substrate for the formation of the hyphae. Generally, in nature fungi needs an environment in which they can maintain their humid and moist condition helpful for them for the growth and development [1]. If there is a decrease in the temperature conditions of fungi this will ultimately leads to the death and degradation of such fungi which also sometimes leads to their dormancy in which their spores become resistant due to stress conditions. The main factor in the initiation of stress is the temperature fluctuation. These factors of stress can be both heat shock stresses or they can also be cold shock stresses which mainly affects the life cycle and other cellular processes involved in fungi [2].

The optimum temperature levels can be slightly different but are in range of about 37∘C to 41∘C. In the dimorphic fungi the morphological structure and temperature are closely interrelated to each other which converts the filamentous fungi to that of the yeast which occurs at an elevated stage of temperature and so on. Stress is a very critical factor which has its major role in the functional features of fungi. Protein denaturation has been successfully seen in stress and during the modulation of the temperature which plays a major role causing similar misfolding of the proteins and its aggregates which leads to the major loss of cellular functionality which causes apoptosis [3].

The stress related changes are responded by the major asset of proteins involved in such type of responses which provides facilities for their survival. The family of such type of proteinases known as Hsps which are basically found inside the cell. The major role of these Hsps is the proliferation inside the cell. It is also involved in the transcription, reproducibility, post transcriptional controlling factors inside the cell signaling pathways directing towards

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the genetic expression. Hsps are majorly conserved biomolecules which are being expressed and upregulates in response to various stress conditions. Hsps of fungi also reported to have shown its role in homeostatic stress responses. In the disorders which are majorly protein related it act as a suppressor by performing its catalytic unfolding activity and then refolding it properly by generation of stress responses and are majorly classified based on their molecular weight. They perform their function in many metabolic pathways and act as molecular chaperons for the proteins which are cellular in nature. They have range of their molecular weight from 15 to 110 kDa which separated and differentiates them based on size and performance. Small heat shock proteins have low monocular weight, and they have a conserved area of amino acids at the C terminus and at the crystalline domain [4].

There are two mechanisms inside the fungi based on which these heat shock proteins are been differentiated among which one is the specific mechanism and the other one is the general mechanism. Specific mechanism of heat shock proteins is based on the temperature induction and stresses whereas the other response is based on the pH, starvation conditions, osmotic stresses, or any type of typical oxidative stress responses. These stress responses also involve morphogenetic orientations of fungi.

The review also involves different fungal stress responses which is dedicated to the understanding on how the fungal stress responses are primarily important in many industrial setups which includes many fields from simple agricultural to highly advanced atrabiliar responses which can sense and helps in absorbing the fungal stress responses [5].

Insect pathogenic fungi are specially being used as a model system and has amazing importance in its biological control mechanism and is also persistent for other dimensions of fungus stress biology. Ortiz- Urquiza and Keyhani [2014] was a scientist who explained the perception of stress on basis of differentiation on optimum level. He further explained that every type of change can be implied as stress response generated based on a stable state of flux which is continuously exposed to stress. It was reviewed that both the fungi Beauveria bassiana along with Metarhizium robertsii have similar biochemical pathways during the time of stress induction which includes reactive species of oxygen, water stress and UV radiation. For both the species the responses to such type of stresses includes the clumps of solutes which are compatible in nature which can be enzymatic or non-enzymatic responses involved in the induction of the DNA damage repair pathways [6].

An article published in 2019 on the stress biology named “Light sensing and responses in fungi” in which it was discussed that the Light controls many significant physiological and morphological stress induced responses in fungi through light [7].

Another review was done on the research done by Lovett and St. Leger in 2014 in which the genus Micorhizium was being studied as transfer of nitrogen precursor from insects to the plants. Metarhiziumis a very diverse fungi which exist as a saprotrophs, in symbiotic relation with the plants. These are individually as organisms are contagious towards insects. In their article it named “Stress is rule rather than the exception for Metarhizium” the author described the infection causing process and discussed the role of large number of molecular factors which are primarily very important. It was described as adhesion of MADI and other hydrophobics showing adherence to the parillin for the regulation of the turgor pressure and its structure causing infection was briefly discussed. In the article it was reviewed that the stress was encountered during the host infection. Different types of stresses were involved which includes the stress mechanism exhibiting responses on the cuticle, oxidative stresses, and other osmotic stresses inside the hemocoel [8].

Another article was reviewed which was given by scientists Eleutherio et al. in 2014 in which there was an authentic review about the synthesis and the degradation of trehalose in S. cerevisiae and its further applications were also discussed describing its metabolic pathway inside the east and other organisms. They further explained the needs and wants which are very important aspect by the help of current discovery and by having the current knowledge about scientific developments being progressively made throughout the history of this field. The article mainly focused on the behavior of disaccharides and its major function in protection against different types of various stresses. Various types of stress protection mechanisms were also discussed in this article which also included the water replacement during the process of desiccation of membrane, formation of glass etc.

In another review which was mainly focused on the fermentation of biofuel by scientist Cray et al. in 2015 in which he and his collaborators were exploring the role of activity of kosmotropy which is a main activity related to the mode of action of similarly compatible solutes. The regulation pathways of this kosmotropy activity were also being discussed in detail which mainly focused on the TPP pathways inside the S. cerevisiae. The author also explained the transport of trehalose across the plasma membrane which is a key for effective protection against stress because trehalose must have to be located on both side of the bilayer and still the reassimilation of the extracellular trehalose are needed to be discussed in detail. The hydrolysis of trehalose provides the cell with main energy required for recovery for the fungal stresses [9].

Fungi also used the light as a major signal from the environment for the regulation of pigment synthesis, proliferation and involves the circadian clock. Another fungal specie known as ascomycete Neurospora crassa has also been used as model system for the fungal photo biology which is directly related to circadian rhythms. The main component of N. crassa reception of light involves the white collar complex also known as WCC which is a light responsive transcription factor complex, but its genome contains different types of photoreceptors. Red and blue light photoreceptors were also included in such studies.

Another review was done in which the fungal photobiology was summarized in 2014 by Fuller et al. The article was named as "Fungal photobiology: visible light as a signal for the stress, space and time". This article mainly focused that the pathogenic fungi uses light as a source of signal during the spread of disease which opened new avenues of research for understanding the mechanism of environmental sensing by the pathogenic fungi and also lead to approaches of treatment of diseases using the photoreceptors as the targets which are antifungal in nature.

II. ROLE OF HEAT-SHOCK PROTEINS IN CELLULAR STRESS RESPONSES OF FUNGI

A. Role of Hsp90 and Hsp70 in Fungal Morphogenesis

Generally, the asexual reproduction of fungi involves various diverse types of stages with dormant conidia which then indirectly later on converts into a vegetative hyphae called as mycelia which then further leads to its production of aerial hyphae which helps in formation of conidia. The heat shock proteins help in the morphogenesis of the fungal species which plays a very significant role in replication , reproducibility, post transcriptional changes and guides the activation of cell signaling pathways [11]. In C. albicans heat shock protein 104 in combination with Hsp 40 and Hsp70 plays an important role in the reactivation of the clumps accumulated of many different denatured proteins.

In resemblance to these vital roles , Hsp104 also plays an important role in the replication of yeast which are having prions such as P1N1 and URE3. Expression of these two proteins is regulated by the heat shock factor which interacts with the heat stress induction in yeast. Another important protein involved in the induction of fungal stress inside the fungal species is Hsp90 which an integral component of cytoplasmic Hsp90-Hsp70 network which is mainly considered responsible for the folding of protein which repairs the mismatched protein folding [10].

B. Conidiation

Conidia are the spores of fungi which are formed by the asexual type of reproduction in filamentous fungi. These spores are naturally produced after the mycelium stage occurs in the vegetative growth. In aspergillus species like the Aspergillus nidulans and Aspergillus fumigatus, the conidia formation is being specifically controlled by the heat shock proteins Hsp90 having a regulatory calcineurin pathway. If calcineurin is being removed, then the resulting hyphae will be with impaired growth and also defective sporulation will occur. If the Hsp90 is being inhibited than the down regulation of transcriptional factor in both the strains of fungi were being observed and reported in the reviewed article [9].

Hence Hsp90 is widely regulated inside the cytosol under a standard normal growth and moves inside the organs according to the type of stress induced like in the nucleus under the heat stress condition and inside the cell wall or the hyphal tips under the cell wall stresses. Induction of Hsp90 helps in the treatment of the caspofungin in A. fumigatus. The transcriptional factor is being repressed by the Hsp90 and Hsf1 is activated in C. albicans which is induced under specific type of thermal stress induction [7].

C. Dimorphism

Dimorphism is specifically the characteristic of fungus in which it induces an ability of conversion from to one form to another. This ability of fungus occurs when there is a stress generated inside the fungus and it plays an important role in the fungal virulence such as C. albicans, P. lutzi. In normal growth conditions, Paracoccidioides exhibit in the mycelia stage and then converts in the hyphal stage but the temperature increases at this conversion which leads to the further conversion into a yeast form which is basically pathogenic in nature. Due to these conversions a disease is generated known as Para coccidioidomycosis [5].

This disease is prevalent in the South America as an endemic. This infection was dominant inside the males and females were less infected in comparison. A precursor named 17β-estradiol was reported for the inhibition of transition of mycelia from to the yeast form. This was being inhibited by the heat shock protein Hsp70 which exhibited high transcripts. Thus, Heat shock proteins are very essential in dimorphism and the viability of the cell of Paracoccidioides specie filamentous fungi [8].

III. ROLE OF HSP IN STRESS TOLERANCE

A. TEMPERATURE:

There are many issues which are occurred by the changes in the temperature which are basically associated with the morphological changes which are associated with dependence on temperature and protein folding are also co related. Heat shock responses are generally being reported in the cells which are mainly affected by the thermal stresses. It has also been reported that several studies on formation of reactive oxygen species enhanced inside the cell under the thermal stress which activated Heat shock proteins [Hsps]. As the temperature increases there is a sudden increase in the dimorphic form of *N. crassa* but it occursat different stages of life cycle, so it is phase specific [4]. At temperatures 25-37∘C the mycelia formations of this fungal specie convert into hyphal form which is non-pathogenic. As the temperature increases to a higher level of 45 degree centigrade the mycelial form converts to a yeast form which is highly pathogenic in nature and causes widespread disease in South America as endemic [2].

B.pH:

pH plays a very significant role in Hsp gene expression which involves Pac pathway. This protein is member of signaling cascade of protein which is involved in the pH guided regulation of genetic expression in A. nidulans. Pac is mainly a regulator which is involved in the activation or the repression of the genes associated in filamentous fungi. In the mycelia culture of the A. nidulans at pH 5.0 is preferentially high. At an alkaline pH, the presence of the PalA environment there is a decrease in heat shock protein 30 being reported in research. Another Hsp70 was observed to be high at pH 8 in the PalA environment [9].

IV. CONCLUSION

This review was based on different studies of stress responses of fungi in which different heat shock proteins are regulated inside. There are different types of factors effecting the fungal expression of stress which is being discussed in this article. These can be pH, osmotic stresses, temperature, and different morphogenetic factors based on which fungal stresses are being induced. These studies help in the drug delivery treatment induced by the stress responses by many heat shock factors.

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