Chapter I

INTRODUCTION

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the other most cultivated cereal crop grown extensively in almost every developing country of the world. Bread wheat is an allohexaploid (6x) species, that regularly forms 21 pairs of chromosomes (2n = 42) during meiosis. It is a self-pollinating plant and most florets are pollinated before anthers are extruded. The tillers developed over several weeks, and the bloom in a given wheat plant is usually complete four to five days after heading. The grain-fill period of wheat varies somewhat, depending on climate (Majumder *et al*., 2013).

Wheat is the major source of carbohydrates and protein in the daily human diet. Besides providing calories, it is also used in confectionary items. Wheatgrass juice has also been reported to contain numerous health benefits like curing cardiovascular diseases, ulcers, arthritis, anti-cancerous properties, etc (Khan *et al*., 2023). Along with dietary fibers, wheat is known to contain a large class of bioactive phytochemicals, those that have various nutraceutical and therapeutic properties. Compounds such as phenolics and sterols can reduce the risk of type II diabetes, heart diseases, cancer, etc. are found in wheatgrass (Ktenioudaki *et al*., 2015).

However, the decreasing global production of wheat is of greatest concern to the agro-scientists and farmers. Seed is the most vital input of agriculture which is also regarded as the direct means of transferring infectious seed-borne pathogens over years. Disease caused due to the infection of seed-borne pathogens deeply affects plant physiology and is liable for deteriorating the quality of the seed during post-harvest storage (Majumder *et al*., 2016). Wheat seeds are distressed by many seed-borne pathogens that include *Aspergillus flavus*, *A. niger*, *A. fumigatus*, *Fusarium solani, F. graminearum*, *Helminthosporium sativum*, *Alternaria alternata*, *Curvularia lunata*, *C. pallescens* and *Penicillium chrysogenum* (Rehman *et al*., 2011). Sheltering of these infectious and detrimental seed-borne pathogens inside harvested wheat seeds deteriorates plant morphology and crop yield during sowing in the fields. Seeds are often frequently attacked by infectious bacteria, nematodes, and rodents under unhygienic and unscientific storage conditions. Despite all types of seed-borne pathogens, the disease caused by fungal pathogens suffered a 60% economic loss across the world (Majumder *et al*., 2013). Seed quality and its viability are exceptionally hampered by the invasion of seed-borne pathogens during the post-harvest period. Seed-borne pathogens divulge lower amounts of reducing sugar, starch, protein, polyphenolics, and amino acids in seeds (Tahmasebi *et al*., 2023). Thus, management of seed-borne pathogens is of high priority for diminishing the loss of seed quality and yield.

Nanotechnology supports agro-industry with new concepts and management techniques for combating crop pathogens. It secured the enhancement of crop productivity with their nutritional importance. This nanotechnology when blended with biogenic substances sets a broad field of research known as nano-biotechnology. Shortly, this technology might lay an alternative way to the existing technologies for the management of plant diseases (Chouhan and Mandal, 2021). These nanoparticles have a wide range of applications in the field of medical biology. Nanotechnology is applied for plant hormone delivery systems, seed germination, crop disease management, and sustainable release of agrochemicals (Guo *et al*., 2012). As a potential carrier, nanoparticles render advantages that include enhancement of the self-life of seeds, improved solubility of poorly soluble pesticides and fungicides and reduced toxicity. Besides these advantages, nanoparticles have an efficient encapsulation capacity of ingredients by reducing their toxicity and environmental contamination (Roco *et al*., 2011).

The fungal seed-borne pathogens of wheat and other major cereal grains are controlled by the use of various fungicides such as Metalax plus, Mancozeb, Baytan, Captan, etc. Besides fungicides, some other seed dressing techniques have been used (Chouhan *et al*., 2022). One such recent technique is the method of Seed Priming. Seed priming is a technique where seeds are primed with different elicitor molecules or priming agents, with a minimum amount of moisture content that allows partial imbibition to the seed to start some of the metabolic activities necessary for germination but prevents radical emergence (Meena *et al*., 2023). Seed priming improves the speed of germination and helps to break dormancy. Priming can also enhance the overall level of all bioactive phytochemicals in the seedling. There are various methods of seed priming of which Solid Matrix Priming (SMP) is most commonly used. In SMP seeds are primed with solid/semi-solid matrix and primers. The primer extensively used in SMP is Chitosan which is a deacylated derivative of fungal cell wall component chitin (Sen *et al*., 2020). Chitosan is biodegradable and non-toxic to cellular metabolism. It acts as a biological adsorbent which helps in the removal of heavy metals without any negative impact on the environment. Modified chitosan nano-molecules can enhance the rate of bioactive phytochemicals in plants. These nanoparticles are also known to exhibit antifungal activity against a wide range of pathogens (Umair *et al*., 2013).

The amine group present in chitosan is largely responsible for the adsorption of cationic metals through the mechanism of chelation in a neutral solution. On the contrary, the adsorption of metal anions takes place through electrostatic interactions between the protonated amine group in an acidic solution. The mechanism of sorption interaction between transition metal ions and mother molecule chitosan can be used for the valuable recovery of metals for the synthesis of new sorbing materials in the field of agriculture (Sudarshan *et al*., 1992). Modifications of chitosan can be easily carried out through physical and chemical means of grafting functional groups or preparing hydro-gels, membranes, and hollow fibers. Preparations of this kind improved the sorbent affinity for metal ions. Bulk chitosan revealed resistance against the transfer of intraparticle mass within them and prefers smaller particles which improve sorption kinetics (Chouhan and Mandal, 2021). The modifications opted for improving sorption kinetics include three major steps: the targeted metal ion in the form of aqueous solution is subjected to adsorption or simply mixed with chitosan aqueous solution in the preliminary step followed by further chemical modifications like grafting or cross-linking and finally removal of the metal ion is facilitated by desorption of the reaction solution (Crisan *et al*., 2022).

Researchers have put forward several hypotheses regarding the antifungal activity of metallic variants of nanochitosan but the exact mechanism of action at ultra-structural level still needs to be enlighten. Chitosan and its metallic nano-derivatives are established antifungal agents combating an infinite ratio of seed-borne pathogens and promising plant growth promoters (Kumar *et al*., 2023; Manssor *et al*., 2021). Transition metals (Ag, Fe, Zn, Cu, Ni) are responsible for generating congestion against phytopathogens in comparison with commercially available chemical-based fungicides (Sharma *et al*., 2018). On the other hand, these metals of interest boost plant growth and metabolism as they belong to the class of essential micronutrients (Sadak *et al*., 2019). Even though, the exposure of these metals beyond the threshold level may result in phytotoxic effects (Tripathi *et al*., 2017). Thus, the designing of a metallic nanoparticle with minimal exposure to metal under a threshold limit including chitosan as a key ingredient may hypothetically result in increased bioactivity. A large repository of *in vitro* data is available regarding the exploration of the antifungal efficacy of metallic derivatives of nanochitosan against various post-harvest seed-borne pathogens (Gowda *et al*., 2023; Tarakanov *et al*., 2023). However, there are very few reports on the *in vivo* practices in the management of post-harvest losses of wheat through seed priming techniques, in particular, the solid matrix priming approach. The application of different metallic conjugants of nanochitosan through solid matrix nano-priming skills for the mitigation of biotic stress generated by seed-borne fungal pathogens is a novel approach to this research. The prime objective of this research is to centralize the focus on minimizing the fungal load from wheat seeds during the post-harvest span and elicitation of different bioactive phytochemical as well as defensive enzymes, proteins, and phenolics, that would contribute to the development of resistance in germinating wheat seedlings.

This research was carried out to curtail the loss made by post-harvest fungal pathogens of wheat and elicitation of resistance through a solid matrix priming approach. The research has been fulfilled by the following objectives.

1. **Synthesis of different metallic nanochitosan and their characterization.**
2. ***In vitro* antifungal activities of synthesized metallic nanochitosan on post-harvest seed-borne fungal pathogens isolated from selected wheat cultivars.**
3. ***In vivo* application of metallic nanochitosan on wheat seeds through solid matrix priming on evaluation of seed quality.**
4. **Effect of seed nano-priming with the most potential metallic nanochitosan on seedling vigour, biochemical and defensive antioxidant enzymological attributes under seed-borne pathogenic stress in wheat.**
5. **Study of seed nano-priming with potential metallic nanochitosan on yield traits and grain quality of selected wheat cultivars and their post-harvest management from storage molds.**