Chapter I

Introduction

1. INTRODUCTION

Seed Deterioration (Physiology and Biochemistry)

Storing of seeds is a major issue in tropical and subtropical nations like India, where seed ageing, degradation, and non-viability are significantly accelerated, mainly by high temperatures and high humidity (Dey *et al.*, 2012). In rice cultivation, high relative moisture and high temperatures, which cause rapid seed degradation, are depicted. A natural phase of seed deterioration is the uniformity loss, viability, and vitality as a result of age or exposure to severe environmental circumstances. The degenerative process is irreversible and occurs during storage. The degradation of seeds in agriculture and horticultural production is an important concern. This is a typical catabolism that terminates the seed life, leading to total viability loss. The pathogenic attack also enhanced the process as an adverse environmental condition. Special consideration is given to the seed technologies, crop growers, and seed men related to the seed sector. This inevitable natural detrimental process, in particular to pathogens and environmentally harmful accelerated ageing, leads to rapid seed deterioration.

Economically, seed deterioration is a major problem for agricultural production. Therefore, agriculturists and horticulturists are regularly crippled when it comes to maintaining standard seed vigour under environmental storage conditions. It is also reported that certain manipulative approaches such as X-ray radiation, hydration, dehydration, etc. can increase the lifespan of seeds or pre-treat seeds using a variety of chemicals such as phenols, salts, organic acids, hormones, and vitamins before storage (Coolbear, *et al.*, 1984; Bhattacharjee, *et al.*, 1993; Pati, 2020). Previous perceptions of some sodium-dikegulac (Na-DK) growth retardants, in particular, had a significant retroactive effect on seed senescence in storage. As a result, an antioxidant, ascorbic acid, a phytohormone, IAA, and a volatile oil, basil oil, were used as chemical manipulative agents to delay seed senescence, along with a growth retardant (Na-DK) (Bhattacharjee, *et al.*, 1984 & 1993; Rai, 2000; Ojha, 2014; Lama, *et al.*, 2016; Bhattacharjee, *et al.*, 2018; Kanp, *et al.*, 2021). The physiological and biochemical characterization of seed degradation continues to be the most ignored field of seed research. This lack of experience is primarily due to the many occasions leading to loss of seed viability, which leads to adversity in determining the cause and effect of a particular seed deterioration response (Copeland and McDonald, 1995).

Artificial Seed Deterioration Technology

Seed attributes are one of the pivotal factors that influence the quality and quantity of yield. Seed vigour is a vital component of seed quality. Seed deteriorative response typically initiates at physiological maturity and persists throughout harvest, processing, and storage, which are greatly influenced by genetic, production, and environmental aspects. The process of deterioration is predominantly a gradual and consecutive process where oxidation of fatty acid chains within the phospholipids of the membrane is the earliest change that is observed during cell membrane deterioration (McDonald, 1999). Deterioration of cell membranes prompts a reduction in the amount of ATP produced as an energy source as well as decelerates the synthesis of specific enzymes fundamental for growth and development, decreasing respiration, which provides energy molecules required for seed growth. The accumulation of all these deleterious changes contributes to a gradual decrease in seed vigour a decline in germination rate, a loss in storage capacity and the ability to resist diseases. In the long term, this perceptual manifestation of seed quality loss is manifested by an increasing incidence of anomalous seedlings, reduced speed and consistency of field emergence, and ultimately reduced crop yield (AOSA, 1983; Chhetri, 2009).

Numerous measures have already been developed to quantify vigour decline on the basis of physiological ageing impact, and the commonly acknowledged criterion of degradation of seeds is reduced germination (Malik & Shamet, 2009; Khan, *et al.*, 2007; Jatoi, *et al.*, 2004; Woltz & Tekrony, 2001; ISTA, 1993). Accelerated ageing, an easy and effective approach to assessing the degradation sequencing and relationships over a short time span by exposing seeds to high temperatures and high humidity levels, is a key approach. For some crop varieties, accelerated ageing research protocols have been standardized, as in soybean seeds (Krishnan, *et al.*, 200; Sung, 1996; Tekrony, 1993), pea seeds (Jatoi, *et al.*, 2004), chickpea seeds (Maeda & Wutke, 1996; Kapoor, *et al.*, 2010), corn seeds (Tekrony & Woltz, 2001), pigeon pea seeds (Rao & Kalpana, 1995), radish seeds (Jain, *et al.*, 2006), rice seeds (Millati, 2019; Bhattacharya, *et al.*, 2013; Bam, *et al.*, 2006; Zhou *et al.*, 2002; Ellis *et al.*, 1992; Ray *et al.*, 1990; Sheshu & Krishnaswamy, 1990).

The Tamil Nadu Rice Research Institute conducted an investigation.The results of the experiment showed that chemically treated seeds with the anti-oxidant tocopherol (Vitamin-E) at 1% for 18 hours and kept in a gunny bag showed higher germination (95%) and seedling vigour compared to control, but after six months, germination and vigour significantly decreased regardless of the treatments (Sasikala *et al*., 2018). The *Seleta* seeds needed for commercialization maintained their germination above the minimum regardless of the environment (Yogalakshmi *et al*., 1996; Marques *et al*., 2014). The effect of ageing is attributed to a decrease in viability percentage, which leads to the depletion of food reserves and a decrease in the unnatural activity of embryos. The ageing of seeds results in the production of free radicals, which can be controlled by antioxidant treatments such as ascorbic acid, tocopherol, and glutathione (Draganic and Lekic, 2012).

Aromatic Rice of Darjeeling Hill – Details and Importance

Characteristic Features of Aromatic Rice

Every state in the country has its own rice variety and quality/specialty. Farmers mainly cultivate fine, short, aromatic, highly scented grain varieties of rice for their own consumption and ceremonial purposes in their areas in West Bengal, Orissa, Chhattisgarh, Bihar, and the North East states. These varieties have a weak stem, a long growth period, a low grain weight, and a low yield, and their market is underdeveloped. There is a different class of aromatic rice, which is long-grained with a special blend of grain, cooking and eating consistency. In the north-west part of the Indian subcontinent, these rice varieties are best represented in the quality traits. Basmati rice is traditionally produced and exported by India and Pakistan, and it sells for three times as much as high-quality non-Basmati rice on the international market.

The Sanskrit words vas (aroma) and mayup (ingrained or present from the start) were combined to form the word "Basmati," which means "ingrained aroma." There is a common misconception that any aromatic rice is Basmati, but this is not the case since the fragrance/aroma is unique to Basmati, as is the silky texture of the long Basmati grain, which is unmatched by any other rice grain. There is no particular standard that can differentiate Basmati rice from other aromatic rice grown anywhere else in the world. Since time immemorial, several scented rice varieties have been grown in the Indian subcontinent. View texture and aroma intensity with minimal kernel dimensions, linear kernel elongation with minimal swelling, fluffiness, appetizing, fast digestibility, and longer shelf-life of cooked rice are the consistency combinations that make Basmati rice more appealing to consumers and traders (Shamimagrimet, 2013).

Rice has been exceptionally valued in Indian culture for many years because of its outstanding consistency and is considered auspicious (Bhattacharjee *et al.*, 2001). These highly regarded rice varieties are known across Asia, as well as Europe and the United States, as "Basmati" (bas=aroma). Aromatic rice was traditionally cultivated in India's Himalayan foothills, and its name is therefore historically connected to its topographical origin (Bligh, 2000). Superfine, long, slender grains with a calcareous endosperm and a pattern similar to something like a Turkish blade define high-quality aromatic rice. cooked rice with a pleasant and unusual aroma, sweet flavor, dry, soft, and delicate texture, fine curvature, less amylose, medium to low gelatinization temperature, delicacy, and 1.5 to 2 times length-wise elongation with the least breadth-wise swelling (Siddiq *et al.*, 1997).As a consequence, the global economy exorbitantly prices all of these Basmati rice properties. However, after cooking, flavor, and rice grain elongation, the scent is considered the most desired attribute by Indian farmers and customers.

Climatic Requirements

The quality of Basmati rice production is dependent on consistent irrigation, drainage, and regular soil. High humidity (70-80%) and a temperature range of 25–35 °C are ideal during the vegetative growth season. Bright and clear days with temperature ranges of 25–32°C, relatively moderate humidity, low wind intensity, and cooler nights (20–25°C) are considered important for proper grain and aroma production during flowering and maturity. The 1st worldwide final fine-grain "Aromatic Rice Observational Nursery Trial," IRRI-coordinated and including 26 sites, recently elevated the standard of aromatic rice to an international level. This preliminary included thirty Indian and Pakistani cultivars, including Basmati (Singh *et al.*, 1997). Regardless of the variety or size of the kernels, scent or natural aroma is assigned a premium price and is valued almost uniformly in both foreign and domestic market sectors. Basmati rice is the most commonly desired and commands the highest premium pricing in the finest preparations such as Biryani and Pulao almost anywhere in the world.

Geographic Description

Darjeeling district is located in West Bengal, with a portion of the district falling within the northern zone (approximately 2.43 lakh ha) and a portion falling within the terai-

Teesta alluvial zone (approximately 12.15 lakh ha) (Anon., 2009a; Adhikari *et al*., 2011). Rice grain is an important staple food grown in West Bengal and has long been associated with a variety of social festivities and ceremonies in Bengal life since time immemorial. West Bengal has the most diverse rice biodiversity and is hence known as the country's rice bowl. The rice ecospecies are so diverse and distinct that they have developed impulsively into a state whereby scientists instantly name them *Oryza sativa* var. benghalensis (Chatterjee *et al*., 2008). Since then, rice has been farmed all throughout the state since then, and the grain has now become an integral part of Bengal‟s life. It is not just the basic cuisine; it has also been mixed with rice in various cultural ceremonies and celebrations.

Darjeeling town is located at an average elevation of 6,710 feet in the Lesser Himalaya (2,045.2 m). Darjeeling is a triangular shaped district in Western Bengal ranging from north latitude to 26°31', north latitude to 87°59', and eastern longitude to 88°53'. Rice cultivation in the Darjeeling Hills, which is naturally organic, has a yield of just 9 q/ha. The poor yield of rice in this area is due to the erosion of the soil. Little is added to it and it continues to grow plants annually. There is no effort to recover and boost the soil's nutritional state (Rai, 2008). In the region, the subtropical humidity with rainfall varies between 2500 and 3500 mm. The maximum is 19.5^0 C and the minimum is 4.8^0 C (yearly average). Rainfall in this location is distributed between March and May at a rate of 398.5 mm, from June through October at 2637.5 mm, and 68.5 mm between November and February (Adhikari, *et al*., 2011).

In this area, the aromatic rice varieties are extremely short, thin-grained, and profoundly fragrant. Each variety is expensive in the area where it is produced, and it lacks a well-established market. These varieties are distinguished by their weak stems, very long growth time, low grain weight, and poor yield. Farmers consider rice as auspicious and basically cultivate rice for personal domestic consumption and utilisation for festivity and auspicious ceremonial purposes like pujas, weddings, and so forth.

The people of Darjeeling Hill have a wealth of knowledge useful to the neighbourhood in cultivating the local environment because of their familiarity with natural farming. Darjeeling Hill is home to a wide range of languages, as well as a long history of social and cultural identity characterised by differences in customs, cultures, and practises. The villagers engage in traditional hill cultivation, where fields are rain-fed and cultivating frames are constructed using various indigenous techniques. Maize, corn, and vegetables such as cabbages, potatoes, squash, coriander, and chillies are among the crops planted. In the hills, cultivation systems are inseparably linked to usability in terms of the comparison of usability and use of assets (Mukherjee, 2012).

Rice has been grown in Darjeeling for many years in a very small field. Indigenous methods of agriculture and innate scientific competence are part of a particular community's culture and history. Farmers rely on biodegradable waste in indigenous agricultural systems, which are effective in helping to maintain soil quality. Wet rice terrace agriculture, finger millets/black lentils, and forest area management by eco-friendly ecosystems and bioregional farm activities such as bio-waste recycling are all part of the rice-based farming scheme, which requires upgrading the advancement process to benefit from these populations (Mukherjee, 2010).

Panikheti

"Panikheti" is an indigenous rice cultivation technique that is practised by people at lower altitudes in the Darjeeling Hills. The terrace is filled with water in this farming scheme, which is redirected from the hilltops to make tiny shrubs like lemongrass and citronella flourish on the terrace that regulates the erosion of water. As soon as stream water rises from the hill forest, it is caught and canalised at the valley's rim, and diverted into primary, secondary, and tertiary network channels. Soil nutrients in hilly regions are controlled by weeds and other biomass that is generated on the soil, and people usually use cow dung and urine for treatment of soil-born insects and plant pathogens. These mechanical steps are an environmentally sustainable system for preventing water erosion in the landscape.

Present Study

Aromatic Rice

Rice, "one of the major developments in the history of mankind," is a cereal food that constitutes an essential part of a diet that produces cereals or grains, the second most consumed in the world. It is consumed as a basic food by over 60% of the population and is successfully grown in many parts of the world, including dry land mountain slopes, wetland valley bottoms, and terraced fields in hills. In the international market, Indian flavours and the appropriateness of rice are highly valued. Rice provides good protein and carbohydrate sources, as well as fibre, vitamins, and minerals. It is also a good source of energy and gives humans 15% of the world's protein and 21% of the world's calories per capita (FAO, 2003). India, the world's second largest rice producer (116.58 mt.), has a total rice area of 42.17 million hectares, or 33.3 percent of the total rice production area (Venkataramani, 2002).

Screening

Due to its extremely high relative humidity, which promotes the growth of microorganisms, the question of maintaining seed vigour in Darjeeling and the territories surrounding it is far more serious. As most crop seeds probably need storage for either one or a few planting seasons, farmers and horticulture professionals from this area are often impeded from maintaining standard seed vigour in an environmentally friendly storage environment. The moisture content of seeds and the storage temperature deeply affected the deterioration rate (Rai, *et al.*, 2000 &1993; Ellis, *et al.*, 1992). Seed degradation has been shown to have several physiological and biochemical indicators (Saraswathy *et al.*, 2017; Kapoor *et al.*, 2010; Jatoi *et al.*, 2004; McDonald, 1999; Kruse, 1999; Kalpana and Rao, 1995).

Scientific Study

The storability of rice seeds is a key feature of the programme for the storing of healthy seeds when the crop is well preserved in the processing process. According to preliminary findings (Akter *et al.*, 2015), rice yields may be increased by 10–15% simply by using good and stable seed. If processed under adverse climatic conditions, high quality seeds can even severely deteriorate. Long-term storage of rice seeds entails a significant amount of effort to protect the seeds from distinct climatic disasters such as extreme summer, winter, monsoon, and so on, all of which are incompatible with producing stable and well-developed rice plants. There have been many studies on rice seed storage in different parts of the world under various storage conditions (Khalid *et al.*, 2001; Kapoor *et al.*, 2011; Baek *et al.*, 2018; Henge, *et al.*, 2019). During storage, however, the vigour and viability of the seeds depend mainly on the genotypes and conditions of processing and post-harvesting, such as the seed quality, conservation packaging, air and storage temperature, relative moisture content, exchange of gas and skin characteristics of the seed.

Causes of Viability Lost

When processed in a natural environment, rice seeds display low physiological consistency. Tropical weather conditions with high relative humidity and temperature, along with unfavourable storage conditions, inevitably contribute to complete seed quality loss by affecting the storability of cereals, oilseeds, etc. (Marques, *et al*., 2014; Begum, *et al*., 2013;). Rice seeds stored for a half year in earthen, tin, and plastic holders without controlling temperature and relative humidity showed zero germination and minimum germination in the case of seeds stored in a gunny bag (Sultana *et al*., 2016). There is no doubt that proper seed treatment and storage techniques will greatly enhance seed quality and significantly increase the yield. Similarly, seed treatment with antioxidants such as ascorbic acid, tocopherol, and glutathione, as well as the use of bio-fungicide, has been found to have a beneficial effect on seedling vigour and is superior in increasing germination and vigour in rice seeds (Hossain and Akter, 2015; Lekic and Draganic, 2012; Basra, *et al*., 2006).

Adverse Climatic Condition

In 1965, in order to determine the storage capacity of seeds and to determine the vigour, vitality, and durability of storage seeds, Delouche first developed an accelerated ageing test (Khan, *et al*., 2017). The technology includes resistance to unfavourable temperatures of the seeds and 100% R.H. After a period of time, a normal germination test is performed. Owing to the high temperature, the seeds quickly aged and absorbed moisture from the humid environment. The precondition for the test is that high temperatures and high humidity in the most robust seeds maintain their capacity for natural germination in test seedlings. Later experiments confirmed the correctness of this test in order to determine the shelf life of different seed species under different conditions of storage (Delouche and Baskin, 1973). Accelerated ageing tests were proposed for stand establishment and indicated that this test may have added benefits, other than storage capacity, to predict seed yields (Baskin, 1970). Several analyses of the impact of the accelerated ageing test on crop seed field emergence have shown that the accelerated ageing test will predict field emergence. Further research has shown that the accelerated ageing test is also effective in forecasting the establishment of different crops' seeds.

Manipulator to Overcome the Adverse Condition- Phytohormones

Seed treatment and priming are two important quality aspects of seeds that can improve stand seed quality, increase yields, and protect against pests (Powell, 2006; Khan, *et al*., 2017). Rice seeds pretreated with sodium dikegulac (NaDK) at 1,000 and 2,000 µg/ml slowed germination, stopped electrolyte leakage, decreased soluble carbohydrate leaching, and slowed the rate of RNA loss from seeds (Tamang *et al*., 2020; Pati *et al*., 2019 & 2018; Bhattacharjee *et al*., 1994 and Bhattacharyya, 1989).

Probable Outcome of the Present Study

Since 2000, it has been estimated that 10 billion people depend on rice as their primary food source. As a result, rice consumption and usage have risen faster than global rice supply, and demand is expected to hit about 880 Mt. More than 3/4 of the population lives primarily in rural areas, and approximately 1 billion families rely primarily on rice farming and agricultural jobs for a living. If the population's consumption of rice continues to rise, we will face a future problem as the amount of land and water required to grow rice decreases, and the excessive use of fertilizers, pesticides, and insecticides has a negative impact on the environment. Rice research science and technology advancements are becoming increasingly important in order to improve rice production and sustainably agricultural growth.and cooperation in the scientific community as well as determination and accountability among all parties involved would be needed to ensure a steep increase in sustainable rice production. By 2030, Asia's paddy rice yield is expected to increase by 11.7 to 23.4 percent, reaching 4.59 to 5.08 mt/ha 1. As a result of technical advancements and more productive use of knowledge sources combined with increased cultivation area, productivity may increase over time. Rice production could change as a result of global warming due to changes in CO_2, temperature, and precipitation. Consequently, policymakers require accurate provincial production effect forecasts to take account of procedures of alleviation and adaptation. A wide range of Asian nations and organisations have agreed to strengthen national strategic initiatives and budgetary assistance for science, seed development, food safety, and hybrid rice growth (FAO, 2001). FAO has improved the method for determining the effects of changes in productivity on postharvest strategies for many crops, including rice (Mejia, 2015).