Chapter II

Review of Literature

2. REVIEW OF LITERATURE

This survey was conducted as part of a comprehensive project on aromatic rice, with the aim of improving the vigour, viability, and post-harvest loss of selected plants grown in the Darjeeling Hills, as well as preventing seed deterioration and improving germinating efficiency and productivity. This analysis contains a brief introduction to aromatic rice, with a focus on the global scenario and the topics covered in this study.

Seed Science and Technology

The study was conducted on the degradation, storage, and viability of chemical manipulation of the rice grains, as well as post-harvest analyses of aromatic rice. The emphasis was on chemically induced improvements in the consistency and productivity of aromatic rice seeds, as well as the investigation of specific phytochemical pretreatment. According to the literature, certain chemical manipulative agents are used to improve the efficiency and productivity of seed plant production in productive ways (Bhattacharjee, 1984; Rai, 2000; Kanp, 2007; Dolui, 2008; Sultana, *et al*., 2016; Saraswathy, *et al*., 2017, Pati, 2018; Zhou, *et al*., 2020).On various aspects of aromatic rice research, the current review focuses, including postharvest system, seed viability, growth modulation, metabolism, efficiency, and phytochemical analysis.

Three methods of hydration-dehydration treatment in mid-storage, such as soaking, drying, moisture equilibrium-drying, and moist sand cooling-drying, each with different durations, have been used to assess the vigour and viability of stored pea seed (*Pisum sativum* L.). Maintaining membrane integrity and preventing lipid peroxidation, despite the proven harm of soaking-drying, and all durations of moisture equilibration treatment except 120 h outperformed the regulation, while 48 h proved to be the best, could be plausible explanations for such beneficial results (Ramamoorthy *et al*., 2008). Pretreating pea seeds with chemical substances decreases the germinability loss greatly. In chemical pretreatment, pea seed performance was also shown to be significantly improved, and thus the yield of healthier plants increased (Pati *et al*., 2017).

Naturally, seeds of *Allium cepa* L. are less feasible and hydrophilic than many other seed plants. Today, Tamil Nadu is boosting the production of seed onions in India. Inadequate stockpiling of onion seed or disadvantageous circumstances results in degradation of seeds marked by a lack of viability, vigour loss and seed uniformity loss. Onion seeds can be kept germinating and growing for more than a year, lowering to 6 ± 1 percent the seed moisture content and conserving it between 4 to 15°C and relative humidity 40 to 60 percent in damp sealed receptacles. Seed invigoration treatments such as hydration-dehydration, different pretreatments were discovered to be effective in delaying seed deterioration and, as a result, the viability and survivability of seeds during storage is increased (Saraswathy, *et al*., 2017; Jangjoo, *et al*., 2020).

The impact of soaking on seed vigour and viability in artificial ageing conditions and the effects of hydrate dehydration on viability and storage were examined for tomatoes and radish seeds. During mid-storage, hydration-dehydration of seeds was successful in increasing seed retention. Presoaking of seeds with water followed by drying was subjected to rapid ageing (40Q C, 90 percent RH for 48 hours) and storability demonstrated greater seed germinability and vigour than unsoaked seeds in both the tomato and the radish mainly affected by moisture content and environmental factors such as temperature and relative humidity during storage. Certain toxic compounds accumulate in seeds, shortening the storage time, though it has been discovered that storing seeds with water or chemicals improves seed germination and activity (Pan and Basu, 1985; Doijode and Raturi, 1990; Kim *et al*., 2006; Kar *et al*., 2011; Dominic, *et al.,* 2016).

Aromatic/Basmati Rice

Basmati rice, also known as the scented pearl, is a blessing from nature that is exclusive to the Indian subcontinent (Bhattacharjee *et al*., 2001) and is well-known for its abundance of basmati and aromatic non-basmati rice grown on its own land. Aromatic short grain varieties are inexplicably exclusive for scent, excellent cooking, and consistency characteristics, which have a significant impact on worldwide customer choice and a high price command both domestically and internationally (Rani, *et al*., 1998, Khan, *et al*., 2003; Singh, *et al*., 2012). The export restriction for basmati and short-grain aromatic rice was put in place by India in 2011-2012, exporting 4000 thousand tonnes of basmati rice and earning Rs 10582 crores ($2.17 billion) in foreign exchange (FAO, 2012; Anonymous, 2012; DRR, 2014).

Rice, which has been called "one of the most significant developments in human history," is a cereal product that is an important part of the diet and the world's second-most eaten cereal/grain. It is consumed as a staple meal by about 60% of the global population. It is grown successfully on mountain slopes (or upland) and in wetlands in valley grounds and terraced terrain in different world regions. Rice of Indian flavour and suitability is highly regarded in the international market. Rice is a good source of starch and proteins, and it also has the best energy, vitamins, minerals, and fibres (FAO, 2003). There are 42.17 million hectares of total rice area (116.58 mt.) in India, accounting for 33.3 percent of the world's food crop area (Venkataramani, 2002).

International Scenario

The world's longest continuously cultivated cereal, rice, is "one of the most significant products in history," according to the International Institute for Rice Research (IRRI). The United Nations' Food and Agriculture Organization (FAO) proclaimed 1966 to be the rice year. The UN General Assembly designated 2004 as the "International Year of Rice" in significance recognition of this crop (IYR). IYR's theme "Life is rice" represents the value of rice in 2002 as the principal source of food.

The UN honoured rice as the only food crop twice, and the UN paid such a special homage to rice for the second time. Their enormous impact on social, economic, and political stability makes them considered a political good. Not only is rice a vital crop, it is also a key source of jobs and income for the rural poor and a key enriching element in society, lifestyles and ecosystem functions, a sign of cultural pride, global solidarity and existence (Shamimagrimet, 2013).

Phytogeographical and archaeological data indicate that rice from its wild ancestor, *O. rufipogon,* was domesticated more than 10,000 years ago. The Himalayan Mountain Ranges, which currently extend from East to South China, Nepal, Thailand, and Myanmar, contain *O. rufipogon* (Chang, 1976; Kush, 1997; Londo, *et al*., 2006).Rice has grown tremendously, but is essentially limited to Asia's monsoon. That is not the case for the worldwide distribution of wheat and maize. Rice is the most suitable lowland crop, where the drift of water naturally flows like runoff and rivers. As a result, a rare mixture of climate and landforms has aided in the development of Asia's paddy rice system.

Asian Scenario

Rice has nurtured more people than any other grain and has influenced billions of people in Asia's heritage, society, lifestyle, and economy. Whether it is to encourage social or community growth and promote war or pursue peace, generate prosperity or endure suffering, enjoy good health or live deficiently, or provide a basis for worshipping God, rice has been central to all facets of human life (Ahuja *et al*., 2001, O"Toole, 2004). This crop links India, China, Bangladesh, the Philippines, Burma, Thailand, Vietnam and all common rice nation countries and has since time immemorial been interwoven with Asian culture (Mitu De, 2014 & 2019).

Rice and its derivatives provide 60 to 70% of the calories consumed by over 2,000 million people in Asia alone.Its growth is crucial for food security and poverty reduction. Rice is grown on 159.40 million hectares around the world, with Asia accounting for 88.95 percent of global rice production and consumption (90.4 percent) (FAO, 2012; Singh *et al*., 2014).Rice cultivation employs approximately 300 million people in Asia and the Pacific alone, and it consists of two subspecies: *Oryza sativa* L. subsp. India, which originated in India, and *Oryza sativa* L. subsp. Japonica, which originated in Eastern Asia.

National Scenario

Rice is India's backbone, the second largest country to grow rice in an area of over 44.6 million hectares, yielding 104.32 million tones, averaging nearly 2.34 tonnes/hectare productivity, of which 85-90% is internally consumed by the Indian economy. Our national food safety is central to the development and prosperity of its supply for over 65 percent of the population (Anonymous, 2013, DRR, 2014, Rajasekar and Jeyakumar, 2014). India is the most produced region in Asian countries and has the largest proportion, accounting for almost 20 percent of the rice produced worldwide (Babu, *et al*., 2014). India is also one of the world's rice diversity hotspots, with significant inter-and intra-specific variation recorded (Roy *et al*., 2016). India has a plethora of specialty rice varieties, including basmati and short indigenous varieties that have become ingrained in Indian culture and are considered treasures (Talukdar *et al*., 2017). In addition, hundreds of indigenous short-grain aromatic and non-aromatic cultivars and landraces are cultivated in pockets throughout the states. Each state has its own aromatic rice stock in indigenous regions, which works well (Shobha Rani and Krishnaiah, 2001). In addition to conventional varieties, India has many landraces and several lesser-known varieties that have been grown for years by both farmers and local entrepreneurs. The selection of such crops was based on desired characteristics, which led to the development of large agro-ecologically suited rice varieties and, therefore, nearly all Indian rice farming provinces have their own regionally accepted cultivars suited to distinct agro-climate factors and local outcomes (Singh, *et al*., 2003).

Aromatic (scented) Rice varieties in India and their distribution

TABLE: 1

States	Varieties (district)
Assam (65)	Rangafoha I, Joha 947 types), Bongali, Bhabeli, Kanjoha, Kanku, Khorikakala, Kopausali, Manki, Ranga, Rampal, Bagribhog, Tulsibhog, Govidbhog, Badshabhog, Prasad bhog, Malbhog, Kalajira.
Bihar (42)	Basmati3 (Patna); Katarani (Bhagalpur, Champaran) Kari bank (Patna, Bhojpur, Munger, northern Bihar) Mohindhan, Sagarbhog, Hansraj (Patna, northern Bihar); Sonachur (Bhojpur, Rohtas, northern Bihar); Badshahbhog (Bhojpur,Bhagalpur); Kanakjira (Bhojpur,northern Bihar); Shamjira (Rohtas, Aurangabaf, northern Bihar); Shapasand (Rohtas, northern Bihar); Tulsiphul (Rohtas,northern Bihar); Kanehonehur (Gaya); Mahijawain (Aurangabad, northern Bihar Tulsimanjari (Bhagalpur, Munger, northern Bihar); BR 9, BR10 (Bhagalpur, northern Bihar); Badshahpasan, Bahraini, BhuriC.basmati, Chenaur, Devtabhog, Kamod, Kalichamparan basmati, Kesarbani, LalC.basmati, Malbhog, Ramjawain, Sonalari, Tulsipas and (northern Bihar); Mircha, Malida, Satar (Muzzafarnagar); Amad, Abdul, Ramjain (western Champaran); Bramabhusi (Semara, Ramgarh, western (***Champaran); Deobhog(Darbangha); Kamini(Bhagalpur)***
Gujarat (5)	Pankhali, Kamod (Kheda); Krishnakamod (Ahmadabad); Kolhapur scented (Saurashtra); Zeersal
Haryana (2)	Basmati 370 (Rohtak, kaithal); Karnal local (Karnal,Kurukshetra, Panipat)
Himachal Pradesh (9)	Muskan, Ramhjawain, Achhoo ,Seond basmati, Baldhar basmati, Madhumalati, Chitru basmati (Kangra valley); Pansara local (Kullu); Hathkoti basmati (Shimla)
Jammu and Kashmir (7)	High hills: Gulzag,, Zagir, Muskkanti, Tumlazag; Mid-hills: Musk budji, Qadirbaig, Ranbir basmati (R.S. Pura, Katua, Jammu)
Karnataka (19)	Ambemohor (Belagoan, Dharwar); Devamallig (north Kanara), Gumsali (Haveri); Gandhsali, Gulvadi, Gamanasanna (south Kanara); Huggibatta

States	Varieties (district)
	(Belagoan, Dharwar); Jeerigesanna (Mysore, Bangalore, Kodagu, Chikmanglur); Kagisali (Balagoan, Dharwar, Haveri); Kumudh (Haveri); Karigajavile (Belagoan, Dharwar, Haveri); Krishnapasangi (Raichur, Gulbarga, Bellary0; KunsumKesari (north Kanara); Kalabatta (Tumkur, Banglore); Kavali (Bidar); Rattansagar (Bidar);Sindhagi local (Bijapur); VasaneSannaBatta (north Kanara); Yalakkisali (Haveri)
Kerala (7)	Gandhakasala, Jeerakasala, Velumbala, Chomala, Kayama (Wyanand); Kothampalari (Kannur); Pookkilathari (Palakkad); Amarjyoti (Mandalla); Adamchini, Antraved (Damoh, Panna); Badshahbhog (Bastara); Batanphul (Sidhi); Chakarbhatta (Chattarpur); Chhatri (Jabalpuur); Chindikapur (Raigarh); Chinoor (Balaghat); Chirnakhai (Bastar) Dilbaxa (Tikamgarh, Satna, Reva); Dubraj (Raipur, Durga, Rajnandgaon, Bilaspur,Mahasamund, Dhamtari, Janjgir, Korba, Kanker); Gangaprasad (Rajnandgaon); Kapursar (Rajpur, Durg, Rajnandgaon); Kubrimohr (Raipur, Durg); Loktimanchi (Bastar); Mekhrabhundha (Durg); Samodchini (Bilaspur, Surgujar); Kalimoonch, Ganju (Gwalior); Shakarchini (Surguja, Shahdol); Sri kamal (Shahdol); Tulsiamrit (Raigarh, Seoni); Laloo (east Madhya Pradesh); Vishnuparag, Tedai, Chinigauri, Chiranki, Kali kamod, Kaktimanchi, Mekrabidu, Vishnubhog, Banaspatri (pockets)
Maharashtra (6)	Ambemohor, Krishna sal (Pune, Satara, Ahmednagar); Banaspatri, Chinoor (Vidharbha); Gham (Raigad); Ghansal (Kolhapur)
Manipur (5)	Chakaoangouba, Chakaoamubi, Phorenmubi, Langgphouanganba, Chakaopoireiton
Mizoram (6)	Tai, Pharte, Bawangbuh, Mawangbuh, Zongam, Phanrai
Orissa (33)	Thakurbhog, Ratnasidol, Prabhatjeera, Nalidhan, Manasi, Jhinghasali, Sitakesari, Barangamali, Basnaphali, Jala, Jhilipanjiri, Lekhtimahi (Orissa); Kalajira (Cuttack, Puri, Ganjam, Koraput); Dubraj (Keonjhar, Deogarh, Sambalpur, Bolangir, Jharsuguda); Badshahbhog (Bolangir, Balasore, Koraput, Bhadrak); Durgabhog (Keonghar, Mayurbhanj, Phulbani); Pimpdibsa (Keonjhar); Mugajai (Phulbani, Koraput); Krishnbhog (Puri); Givindbhog (Cuttack); Chinikamini, Saragdhuli, Padamkesri (Konark, Puri); Karpurakali, Pusimakenda (Neyagarh); Kalikati (Kalahandi); Thakurbhog (Puri0; Karpurakanti, Suragaja, Laxmibias (Bolangir, Sambalpur, Deogarh); Tulsiphulla (Puri); Gangabali (Ganjam); Kanikakala
Punjab (2)	Basmati 370 (Amritsar, Gurdaspur, Jullundur); Quadian basmati (Amritsar, Gurdaspur)

States	Varieties (district)
Rajasthan (6)	Basmati, Danger, Sutar, Pathania, Ratipanne, Zed zeera
Tamil Nadu (1)	Jeerakasambha
Tripura (5)	Govindbhog (white); Govindbhog (black); Sadakhaja, Kalakhau, Kalijira
Uttar Pradesh (20)	Kalanamak (Basti, Sidharthnagar, Maharajganj, Gonda, Goroli); Adamchini (Balia); Bindli (Pauri); Badshahbhog (Bareilly, Rae Bareilly, Allahabad, Partapgarh); Batanphul (Basti, Sidharthnagar, Ajana, Mau, Sultanpur); Benibhog (Barabanki); Dhania (Basti, Gonda); Dulhania (Baraich); Hansraj (Dehradun, Rampur, Pilibhit); Jeerabati (Basti, Varanasi); Kamalijira (Basti, Sidharthnagar,Baraich); Lalmati (Baraich, Barabank); Laungchoor (Mirzapur, Varanasi); Phoolchameli (Varanasi, Mirazapur, Son Bhadra); Ramjawain (Basti, Sidharthnagar); Shakarchini (Varanasi, Mirzapur, Son Bhadra); Ramjawain (Basti, Sidharthnagar);Sakarchini (Varanasi, Mirzapur, Son Bhadra); Sonachur (Mirzapur, Varanasi); Tilakchandan (Rampur, Pilibhit, Nainital); Tulsimanjri (Balia); Vishnuparag (Barabanki)
West Bengal (15)	Radhunipagla (Birbhumi, Bankura, Burdwan); Badshabhog (Burdwan, Hooghly,Bankura); Kalonunia (Doars, Jalpaiguri); Kataribhog, Seetabhog (Dinajpur); Gandheswari (pocket); Chinisakar (Raiganj); Ramtulsi (Darjeeling); Tulsibhog (north Bengal); Tulaipanji (Dinajpur);Mahishadan (Bankura); Govindbhog (Hoogly, Howarh, Nadia); Patina, Basmati, Kalijira

North-East India Scenario

The Indian subcontinent features a wide range of common rice types, which may indicate a significant grain domestication role. The North East Indian territories are Assam, Arunachal Pradesh, Manipur, Mizoram, Meghalaya, Nagaland, Tripura, Sikkim, and Mizoram, which span over 255,000 square kilometers. In NE India, it is estimated that 10,000 indigenous rice cultivars of agronomic, ecological, and cultural significance remain (Hore *et al*., 2005). Such a large rice gene pool may contain a variety of agronomic and ecologically important traits. This area has a diverse variety of locally embraced non-basmati aromatic rice germplasm, in addition to other conventional cultivars, which have enormous cultural and economic significance. However, the rest of them have low productivity and are grown solely for their socio-cultural value (Roy *et al*., 2015).

Rice is grouped into various categories based on its features, with the grain shape and kernel type being the most common. Rice is often classified into long, medium, and short grain types, with long grain rice usually measuring more than 6.2 millimetres (mm), or about three times the width of the grain. Rice is between 2.1 and 2.9 times the width of the medium grain. Finally, the short-grain rice group is less than twice as large. Around the globe, fourteen distinct rice varieties are cultivated and eaten, which are classified into subcategories such as glutinous and glutinous free aromatic rice. Aromatic glutinous free rice comprises long seeds with intense flavors, including jasmine and basmati. Another kind of rice is glutinous rice, also known as sticky rice, which comes in both long and short grains and has a high starch content (Shamimagrimet, 2013).

Aromatic Rice Germplasm

Scented rice germplasm is divided into three categories: basmati rice, jasmine rice, and non-scented rice. They are distinguished by their medium-to-heavy fragrance. For the overall eating quality of rice, not only the level of fragrance in general, but also the presence or absence of certain other significant qualities, such as kernel lengths and widths, after-cooking kernel elongation, the concentration of amylose (AC), the temperature at which gelatinization occurs (GT), and the consistency of the gel and flavour are all determined. Basmati rice cultivars are of low to moderate GT, intermediate AC, and medium gel consistency (GC) and have their origins in India and Pakistan. On the other hand, Thai Jasmine rice has low AC and GT and a smooth gel consistency (Jualiano and Villareal, 1993). Jasmine rice kernel length is marginally longer than that of basmati rice, but the latter seems longer because it is more slender. In both varieties of rice, the L/B ratio is almost the same. The ability to lengthen the Basmati rice group almost doubles its original length after cooking, which is its most distinguishing feature. This aspect does not include other scented rice, and although some of them elongate, they are not as evident in length as Basmati.

Biochemistry of Aroma

The chemical 2-acetyl-1-pyrroline was discovered and found as a key contributor to the popcorn-like aromatic rice scent (Buttery *et al*., 1982 & 83). Researchers examined 114 volatile chemicals in cooked fragrant rice to determine the greatest contributor to scent was 2-Acetyl-1-Pyrroline. By using 13-hydrocarbons, 14-acids, 13-alcohol, 16-aldehydes, 14-ketones, 8-esters, and 5-phenols, the volatile chemicals were categorized. When the grain is cooked, the characteristics of the sweet fragrance of Basmati rice are shown to imitate the aroma of *Madhuca longifolia* flowers.

Recent investigations have nevertheless demonstrated the existence of four additional compounds: pyrrol, 2-acetyl pyrrole, 1-pyroliin and 6M5OTP, 2AP isomers (6-Methyl-5-Oxo-2, 3, 4, 5-Tetrahydropyridine) has a chemical and genetic significant link to 2AP, which distinguishes non-aromatic rices from aromatic rices (Daygon, *et al*., 2017). An effort was made to map three QTLs that regulate 2AP density. On chromosome 8 with a single major QTL (Lorieux, *et al*., 1996, Chen, *et al*., 2008) as well as two chromosomal minor QTLs on 2 and 12 (Lorieux, *et al*., 1996). Since then, map-based cloning has subsequently found the gene involved in grain flavour (Vanavichit *et al*., 2004, 2005). The gene was mapped to a 4.5 kb genomic tract with 15 exons of the 1512-bp coding region, each containing 15 exons of chromosome 8, which converted into 503 sequences of amino acids in non-aromatic rice varieties. This gene is found to be recessive in all aromatic rice due to two critical mutation events in positions 730 and 732, which result in the depletion of an 8-bp "GATTAGGC" commencing at position 734. Several transcriptional and whole genome expression studies have also shown that Os2AP is over expressed in non-aromatic rice varieties, and that in aromatic rice, the premature stop codon of 753 reduces the complete length of the peptide to 252 amino acids due to its suppressive expression (Bradbury *et al*., 2005; Vanavichit *et al*., 2005). According to the hypothesis, this short, unfinished peptide has been confirmed in some cases to induce nonsense-mediated decay, which is thought to be active in all aromatic rice varieties (Chang *et al*., 2007).

AOV is determined by the number of oxygen components by weight needed in typical circumstances to oxidise 105 parts in the sample, and has been linked to the rice flavour of Basmati. It is a measurement of how much flavour volatiles in rice have been reduced.This importance is greatly influenced by alcohol and carbonyl compounds. The AOV, after six months of storage tests with both ordinary as well as Basmati rice species, decreased from 14 to 8 on average for newly harvested rice. This decrease suggests the development of reducing flavour compounds in old rice (Buttery *et al*., 1982).

Markers of Aroma Genes

Any breeding programme requires a simple assay to monitor inheritance. They added KOH to the plant sample, which emitted the fragrance and produced an assay for measuring the aroma from plant content (Sood and Siddiq, 1978). The strong scent was diverse in 117 lines, whereas 28 lines had a mild scent (Jin *et al*., 1996). An aroma gene marker was discovered using the RAPD method (Ahn *et al*., 1992). The fragrance gene was tagged using RFLP methods. 2-acetyl-1-pyrroline plays an important part in adding a spice or flavouring to non-aromatic rice in order to impart the fragrant of scented rice (Buttery *et al*., 1985). Additional considerations of cooked rice include grain flavour, size, elongation, whiteness, texture, stickiness, and market acceptability, even though the scent is possibly due to a mixture of different compounds.

In the processing, storing, milling, cooking, and eating areas, aromatic rice emits specific aromas. The growth of the fragrance and aroma is enhanced when aromatic rice is grown in areas with cooler temperatures during maturity. Ricer breeders have employed a range of methods to research the heritage of rice scents to analyse and identify scents, involving chewing a couple of seeds and cooking a seed sample of each plant and noting the fragrance. The characteristic fragrance has also been recorded in the leaf tissue of scented plants (Nagaraju *et al*., 1975; Sood and Siddiq, 1978, 1980). In aromatic rice sampling, the concentration of 2-acetyl-1-pyrroline may be altered by cultural, harvester, and post-harvest activities (Goodwin *et al*., 1994). The disparity between non-aromatic rices and aromatic rices is because of differences in 2-Acetyl-1-Pyrroline contained in grains (Buttery *et al*., 1986 & 1983). As a result, transforming non-aromatic rices into aromatic rices must involve a change rather than a new biochemical pathway.

It was confirmed that a single dominant gene controls rice aroma (Jodon, 1944), while digenic and trigenic (Kadam and Patankar, 1938; Nagaraju, *et al*., 1975; Dhulappanavar, 1976; Reddy and Sathyanarayanaiah, 1998) recorded the presence of four complementary genes in scent regulation, one of which was linked to a complementary gene for apiculus red pigmentation. Two dominant complementary genes, SK 1 and SK 2, were found to regulate aroma (Tripathi and Rao, 1979). The trial verified that the fragrance gene is mapped to chromosome 8 of the rice genome using the RFLP technique. Furthermore, these genes have no control over the genes that regulate the colour of the leaf sheath, the maturing hull, etc. 36 of the 37 marker genes analysed were isolated independently of the scented gene (Ahn *et al*., 1992).

About the Experimental Plant

For more than half of mankind's life is rice (*O. sativa* L.). Every third human on the planet consumes rice in some way or another every day. The rice plant is a kind of grass that produces rice, an edible grain. The International Rice Research Institute has stored over 1,00,000 rice adhesions (IRRI). The genus Oryza has 2 cultivated and 22 wild species. There are about 1,20,000 different types of rice. The features of species divergence include biotic and non-biotic influences such as productivity, susceptibility to disease and insects, cold and drought tolerance, and many other variables. *O. sativa* (2n = 24 AA), usually known as Asian rice, has been grown globally among the two cultivated species, while in West Africa, *O. glaberrima* (2n = 24 AA), or "African rice," is grown in a small area (Shamimagrimet, 2013).

Agronomy

Common traditional aromatic cultivars are tall (160 cm or more), have low grain yields, and may get stuck in heavy nitrogenous fertiliser doses. Blast, stem borer, bacterial leaf blight, and white-backed hopper are all problems that can affect these rice cultivars (Siddiq *et al*., 1997). The seedlings are manually transplanted in the first week of June into waterlogged regions and surpassed when the height of the planting is around 8 inches. This is crucial in maintaining a high return and higher quality. In late October and November, rice is harvested. Large varieties are photosensitive and require a limited flowering induction time. When the day length decreases and a crucial phase for the flowering induction hits sensitive variations by shortening the day, this impact on the blooming affects the time of maturation. Conventional Basmati lines, like Pusa Basmati 1 and Haryana Basmati 1, have a greater photosensitive index/phase than upgraded or recently released Basmati kinds (Ahuja *et al*., 1995).

Aromatic cooked rice efficiency depends greatly on environmental aspects such as soil fertility, irrigation and spacing, transplanting time, harvesting time, and storage (Singh & Singh, 1997). Rice cultivated in alkaline, inadequate soil or with insufficient water supply has inordinate abdominal whiteness ingrains and poor cooking quality, especially during the grain development stage. Early transplantation deteriorates the quality of the cooking because the grains are excessively opaque or because of the inappropriate growth of the starch molecules due to the loss of packaging at high temperatures (Ali *et al*., 1991; Azeez and Shafi, 1996).

Plant Growth Substances

Plant hormones have a wide range of effects on plant development. In both plant morphology and physiology, the growth regulators are critical in their specific actions, depending on the material concentration and the organ sensitivity. The effect of the growth regulator depends on the variety, growth, chemical concentration, method, and frequency of plant species (Hilli *et al.*, 2010). Regulatory plant growth are chemicals that cause rapid changes in plant phenotypes as well as affect plant growth when used in limited quantities, whether by enhancement or stimulation of the regulatory mechanism for natural growth, from seed germination to senescence. Diverse chemical combinations have a substantial influence on rice agriculture, morphology, and biological features, and it has been revealed that Plant Growth Regulators (PGRs) produce rapid cell division at low concentrations, resulting in quicker vegetative and reproductive growth, and that they can improve physiological efficiency, including photosynthetic capacity, and enhance effective portioning of accumulation (Kim *et al.*, 2006; Amanullah, *et al.*, 2010; Kar *et al.*, 2011).

A plant growth inhibitor or retardant is another form of phytohormone based on its action. In plants, these chemicals hinder growth and foster dormancy and abscission. Plant growth retardants are most often involved in extending or elongating the cells, where Gibberellin synthesis inhibition quickly reduces stem elongation and leaf expansion (Tanomoto, 1987; Leclerc, *et al.*, 2006) and reduces cell division and cell elongation (Rademachar, 1991, 1993, & 2000; Boldt, 2008). The number of lateral shots increases with growth retardants, which leads to greater inflorescence (Whealy *et al.*, 1988; Keever and Foster, 1989). Various growth retardants decrease the internodal length and the plants are known to reduce their height. As a result, they are often used in the floricultural industry for height management (Bailey and Whipker, 1998; Pasian, 1999; Hayashi *et al.*, 2001; Karlovic *et al.*, 2004). As a result, the source-sink interaction is influenced, and photosynthesis is stimulated to move from the source to the sink. As a result, the source-sink interaction is influenced, and photosynthesis is stimulated to move from the source to the sink. Growth retardants can also increase the chlorophyll content of leaves, extending the source's functional life and improving portioning quality and productivity (Kanp *et al.*, 2021; Pati, 2019; Ojha, 2014; Kashid, *et al.*, 2010).

Accelerate aging

The accelerated test was performed to quantify the stored seed and assess the force involving the sensitivity of the seed to unfavourable temperatures and 100% R.H. for different times, followed by routine tests of germination (Delouche and Baskin, 1973). Because of the high temperature and humid atmosphere, the seeds absorbed moisture and aged quickly. The basis of this test is that high-vigor seeds can withstand the high-temperature, high-moisture treatment and to maintain their capacity in germination testing to generate average seedlings. Many crops have suggested and recommended accelerated ageing tests, and some trials have been conducted in **rice seeds** (Henge, *et al*., 2019; Baek, *et al*., 2018; Ali, *et al*., 2003; Krisnasamy and Seshu, 1990), **wheat seeds** (Bhattacharyya *et al*., 1985), **French bean seeds** (Pandey, 1989), **cotton seeds** (Basra *et al*., 2003), **carrot seeds** (Al-Maskri, *et al*., 2003), **aubergine, cucumber and melon seeds** (Demir, *et al*., 2004), **beet root** (Silva, *et al*., 2006), **kale seeds** (Komba, *et al.,* 2006), **soybean seeds** (Torres, *et al*., 2004), **sunflower seeds** (Pati, *et al*.,2012; Vijay Kumar, 2015; and Kanp, *et al*., 2021), **black gramme seeds** (Pati, *et al*.,2019), **Mungbean seeds** (Bhattacharjee, *et al*., 2006; Luciana, *et al*., 2019), **corn seeds** (Dutra, *et al*., 2004; Pati, *et al*., 2014) **Radish seeds** (Jain, *et al*., 2006) **Onion seeds (** Jangjoo, *et al*., 2020) have also proved to be effective for an accelerated ageing test as a seed vigour test.

In the warehouse store, accelerated ageing was originally utilised to evaluate the vitality of seeds (Delouche 1965, quoted in AOSA 1983). Seeds that are stored well after accelerated ageing have a high survival rate, while seeds that have a lower germination rate after accelerated ageing have a rapid storage decline. Under a lot of circumstances following accelerated ageing (Delouche and Baskin, 1973), germinating responses were strongly associated with storage responses under a lot of circumstances. The consistency of the mung beans and the maize seed in the bags of paper indicated that the best longevity assessment in the humid tropics was accelerated by 43ºC for 96 hours and 44ºC for 96 hours, respectively (Santipracha, *et al*., 1993). According to another study, the easiest way to distinguish mungbean seed lots is to use a combination of 42ºC temperature and 72 hours of seed exposure for the accelerated ageing test (Luciana *et al*., 2019). A combination of 45ºC/72 h conditioning of the seeds in only one layer for corn and 42ºC/48 h conditioning of the seeds in only one layer for soybean was the most effective process for separating the lots in terms of vigour (Dutra *et al*., 2004).

Principles of accelerate aging test

The accelerated ageing test significantly improved seed degradation by exposing it to elevated ambient temperatures between 40°C and 45°C and high relative humidity above 90% for short intervals of 48 hours or longer based on species (AOSA, 1983). The loss of physiological potential as a result of accelerated ageing is commensurate with the physiological potential of the seeds. High-vigor seeds showed moderate declines in germination after accelerated age treatment, but low-vigor seeds showed significant declines. Furthermore, after accelerated aging, the germination response of seed lots was compared to field performance under a wide range of conditions (Delouche and Baskin, 1973).

Accelerated aging as seed vigor test

Delouche invented accelerated ageing as a seed consistency test in 1965. The method for forecasting seed viability during storage was initially created in the warehouse (AOSA, 1983; Khan *et al*., 2017). The following investigations have proven the exactness of the test to determine the life cycle of various seed types under different storage circumstances (Delouche and Baskin, 1973). The accelerated ageing test was proposed by Baskin in 1970 and would have additional usefulness for the prediction of seed production beyond storability, with the aim of predicting the establishment of peanuts. Other investigations have now demonstrated the equivalent efficacy of the accelerated ageing test in the prediction of seed establishment from diverse crops.

Benefits of accelerating ageing test

According to surveys of seed test facilities in North America, the accelerated ageing test is among the most commonly used viability tests in laboratories for seed research. It is quick, easy, and economical; no sophisticated facilities are necessary and it can be done without training by anyone. Seed vigour tests may also be used for the assessment of future plant seed storage in the prediction of field outcomes (TeKrony, 1993; Ferguson, 1990; AOSA, 1995). Seed vigour testing has been recommended for accelerated ageing tests in different crops under common conditions. The accelerated ageing process was effectively connected and demonstrated as a signal of the seed viability in the emergence and stand establishment of a large variety of crop species (AOSA 1983 and ISTA 1995).

A number of studies of the findings from the accelerated ageing test in crop seeds showed that accelerated ageing tests would forecast the development of fields such as **wheat seeds by** (Tomer and Maguire, 1990), **sweet corn** seeds by (Singhabumrung and Juntakol, 2004), **soybean** seeds by (Egli and TeKrony, 1995; Torres, *et al*., 2004; Patil, *et al*., 2018), **cotton seeds by** (Bishnoi and Delouche, 1980), **watermelon** seeds by (Mavi and Demir, 2007), **pepper** seeds by (Sundstrom, *et al*., 1986), **pea** seeds by (Kanp, *et al*., 2009) and **rice** seeds by (Chea, 2006; Kapoor, *et al*., 2011; Baek, *et al*., 2018; Henga, *et al*., 2019).

Accelerated ageing is a physiological resistance test that allows regulated seed degradation since exposure is above 90% at high temperatures and high relative humidity (ISTA, 1995; Begnami and Cortelazzo, 1996). Relative humidity, temperature, and humidity and their effects are essential factors that affect the life cycle of seeds. Most crop seeds are less viable at 80 percent relative humidity and temperatures ranging from 25 to 30^{o} Celsius (Copeland and McDonald, 1995).Rice seed ageing is linked to the content of seed humidity and high temperatures, which affect the metabolism of the seeds. Higher temperatures improve the pace at which certain enzymatic and metabolic reactions occur, increasing the metabolic activities of hydrolyzed substrates and enzymes, resulting in a faster rate of degradation, whereas high relative humidity raises the moisture content of seeds, resulting in biochemical events such as increased hydrolytic enzyme activity and free fatty acids (Copeland and McDonald, 1995 & 2001).

Since seeds were exposed to an accelerated ageing test, some researchers looked at how they deteriorated. Many times, the deleterious modifications that occur throughout the process of ageing have been discussed in depth (Delouche and Baskin, 1973). The first symptom of seed decay was cell membrane depletion, which was caused by oxidation in the phospholipid membrane by chains of fatty acid (McDonald, 1999). Increasing solute leakage leads to a decrease in cell membrane integrity, which is the first direct expression of degradation (AOSA, 1983). Sub-cellular organisation was disrupted, enzyme activity was reduced, respiration rate and performance were reduced, and total macromolecule synthesis was reduced, according to electron microscope tests. Before the reduction in germination population was found in the root of aged seeds, degraded DNA and an increase in 32 chromosome abnormalities were suspected (Powell, 2006). Membrane degradation of soybean seeds was the first symptom of seed decay after increased ageing by lipid peroxidation (Panratsamee, 2008). Due to accelerated ageing, the decay of seed in the embryonic axis of a peanut has triggered changes in the integrity of the membrane, resulting in seed leaks of essential electrolytes (Arguello, 1995).

Protein synthesis rate reduction in radish under accelerated ageing conditions can be attributed to a decrease in protein synthesis, an increase in proteinase degradation activity, or a combination of the two (Jain *et al*., 2006).There have also been reductions in total protein content in pigeon peas due to decreased protein production as well as a steady depletion of seed viability (Madhava Roo and Kalpana, 1994), **sunflower** (Pati, *et al*., 2012), **and maize** (Bhattacharjee, *et al*., 2014). Under accelerated ageing conditions, seeds lose viability at a rapid rate. Even cotton has been observed with low viability, vigour, lipoxygenase activity, acid phosphatase activity, and lipid content (Freitas *et al*., 2006). Henga *et al*. (2019) have discovered that extended exposure to higher temperatures reduces rice seed viability. Instead of causing stress, higher temperatures will facilitate the denaturation of proteins and the death of seeds.

Chemicals used in this Investigation

Sodium dikegulac (NaDK)

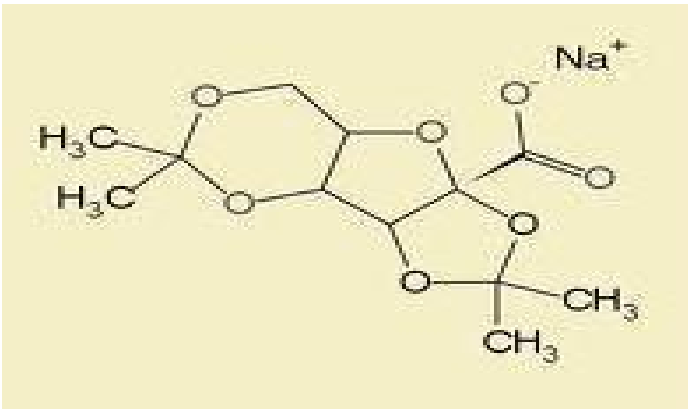
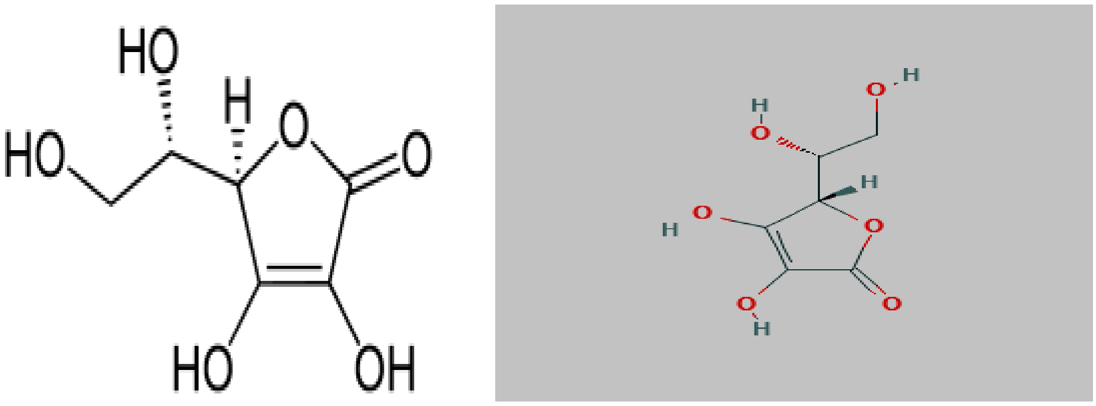


Fig.1. NaDK (Formula $C_{12}H_{17}NaO_7$ & Molecular weight 296.25)

Sodium dikegulac, commercially named as Atrinal, has been discovered as an influential growth retardant with a molecular formula of 2,3:4-6-Di-0-Isopropylidene-Lxylo-2-Hexalofuranosate. It is white, odourless, solid, and photosensitive. In water, methanol, and ethanol, Na-Dikegulac is very soluble but not so soluble with chloroform, acetone, cyclexane, and hexane. In liquid solutions, it is stable at pH 7 or above.

A large number of plant progressions, metabolic activity, production, usefulness, and other characteristics of a diverse range of plant species have been studied in various ways (Bocion, *et al.*, 1975; Arzee, *et al.*, 1977; Zilkah & Gresel, 1980; Purohit, 1980; Bhattacharjee, *et al.*, 1984, Chhetri, *et al.*, 1993; Bhar, 2011; Bhattacharjee, *et al.*, 2014; Lama, *et al.*, 2016; Pati, *et al.*, 2018; Kanp, *et al.*, 2021).NaDK is a monosaccharide-based sucrose hormone, with several salts used as intermediates in the commercial manufacture of L-ascorbic acid and sodium-connected to this hormone having been shown to be the most successful in showing hormonal activity. It inhibits gibberellins and auxins, although in the usual sense, it is not anti-gibbrellin or anti-auxin. The substance is relatively low in toxicity and does not irritate the eyes or skin. Agri-horticulturists are particularly interested in the chemical because of its chemical pinching property.

Ascorbic Acid (ASA)



L- ASA D-ASA

Fig.2. L and D -Ascorbic Acid ($C_6H_8O_6$) (Molecular weight 176.12 g/mol)

Hexuronic acid was the original name for ascorbic acid, which has the formula $C_6H_8O_6$. Since it is a white solid, impure samples may look yellow. It readily dissolves in water and produces a slightly acidic solution. It is a mild reducing agent that comes in two enantiomers (mirror-image isomers): "L" (for "levo") and "D" (for "dextro"). The L isomer is the most widely seen, appears naturally in many foods, and is one source ("vitamin a") of vitamin C, an important nutrient for humans and many animals. It is used for its antioxidant qualities as a food additive and a nutritional supplement. The "D" type is possible by chemical synthesis, but does not have an important biological function.

Succinic acid 2,2-dimethylhydrazide (SADH)

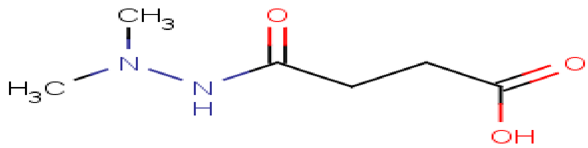


Fig.3. Succinic acid 2, 2-dimethylhydrazide (Formula $C_6H_{12}N_2O_3$ & Molecular weight 160.173).

Succinic acid is a heat-sensitive, scentless white crystal and powder of the molecular formula $C_6H_{12}N_2O_3$, 154-156ºC, melting point, water-soluble. It is also called aminocide and is used as a growth control for a wide range of plants and adornments. Inorganic fluorides, halogenated organics, isocyanates, ketones, metals, amides, carbohydrates, cyanides, or phenols can create hazardous gases, as well as combustible gases, epoxides, acyl halides, and other heavy oxidising and reduction agents. Powerful oxidising agents, metal salts, peroxides, and sulphides can also cause explosive reactions.

SADH, also known as alar, daminozide, kylar, B-995, daminozide, is known to retard plant growth and has been commonly used to monitor plant size and fruit maturation for agricultural and horticultural applications (Rademacher, 2000). Chemicals are sprinkled on fruits to control growth, facilitate harvesting and prevent apples from dropping out of the trees until they mature, storing them in a reddish and solid state. Alar was licenced for use in the United States for the first time in 1963. It was used on apples until 1989, when the company voluntarily stopped using it after the EPA recommended banning it due to fears about cancer threats to customers (USEPA, 2012).

This is a U.S. manufacturer of daminozide, which was registered for use on human fruit in 1963 by Uniroyal Chemical Company, Inc. (now Chemtura Corporation). It was also employed on cherries, peaches, pears, Concord grapes, transplants of tomatoes and peanut vines, in addition to apples or ornamental trees. Daminozide has an influence on the starting of fruit tree flowers, ripening, hardness, and colouring, decline of pre-harvest, and uniformity in harvesting and storage of fruits. Daminozide usage on U.S. food crops was deemed prohibited by the EPA in 1989, but allowed it on non-food crops such as ornamental plants (EPA 2006).

Maize is a common crop farmed all over the world. Pretreating maize seeds for 8 hours with sodium dikegulac (NaDK) or maleic hydrazide (MH) delayed the aging-induced rapid loss of germination. Furthermore, as compared to age-accelerated seeds that had not been treated, the treated seeds outperformed untreated seeds in terms of germination percentage, field emergence capability, fresh and dried weight of entire plants, and length of root and shoot. Unlike controlled plants, the seeds treated with NaDK and MH were grown with increased protein, chlorophyll, DNA and RNA levels, greater catalase and decreased amylase activity (Pati *et al.,* 2014; Kumar Nandi, *et al*., 2016).

During seed storage, an aqueous solution of ascorbic acid increased rice germination and seedling vigour. The study sought to determine whether priming plant seeds with hormones and vitamins such as growth regulators and ascorbate could aid in the energisation of coarse and fine rice seeds (Basra *et al*., 2006).In aerated ascorbate (vitamin priming) or salicylic acid (hormonal priming) solutions, rice seeds were soaked for 48 hours. Similar hormone and vitamin priming therapies had the same effect on both rice forms. Both priming treatments enhanced vigour when compared with the control, and ascorbic acid, on the other hand, showed the earliest and most consistent germination and emergence (Pati *et al*., 2011).

The dicotyledonous model plant Arabidopsis thaliana has been extensively studied, particularly plant hormones and their role in innate immunity. In monocotyledonous model rice, plant hormones, on the other hand, have just lately been shown to perform conserved and diverse roles in fine-tuning immune responses. Based on the rice pattern of receptor and resistance protein mediated immunity, evidence suggests that salicylic acid plays an essential part in rice basal protection, but that its activity is more likely to rely on the signalling route than on modifying endogenous levels. Jasmonate, which may be implicated in salicylic acid-mediated resistance, aids rice basal immunity against bacterial and fungal invasion. Ethylene can function as a positive or negative resistance modulator depending on the pathogen type and environmental conditions. Brassinosteroid signalling and abscisic acid promote or protect against pathogenic infection through several infection/colonization techniques. In rice, auxin and gibberellin are believed to be negative regulators of innate immunity. In addition, as a master regulator for the two hormone paths, gibberellin interacts with jasmonate signals through the DELLA protein for rice growth and immunity (Yang *et al*., 2013).

In three rice varieties, Shaheen Basmati, IR-6 and Super Basmati, a pot test has been carried out to investigate in a glass house the ASA (Abscisic acid), BA (Benzyleadenine) and CCC (cycocel) functions in proline formation, growth, ion accumulation and yield. All the treatments resulted in a significant improvement in shoot and root dry weight over salt alone. Under salt stress, both the CCC and the ABA chemically treated plant cultivars showed a considerable decline in the content of Na+ and a rise in flag leaf K+ content. ABA was found to be more successful than BA and CCC at increasing Ca_2+ content in flag leaves and roots of all cultivars. The stimulatory effect of salts on proline aggregation was further enhanced by the ABA and CCC treatments. IR-6 exhibits stronger proline aggregation and a greater leaf area under salt stress than Shaheen Basmati and Super Basmati (Gurmani *et al*., 2006).