

**Training on  
"Seed Quality Management"**

Date: 22-24 February 2025  
Venue: Conference Room-2, BARC  
Funded by: APCU-PARTNER, BARC

Organized by  
  
Crops Division  
Bangladesh Agricultural Research Council




# Training Manual 2025 Seed Quality Management



**Crops Division**  
**Bangladesh Agricultural Research Council**  
Farmgate, Dhaka-1215, Bangladesh  
[www.barc.gov.bd](http://www.barc.gov.bd)



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Training Manual on Seed Quality Management

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# **Training**

## **on**

# **Seed Quality Management**

**Date:** 22-24 February 2025

## **Training Manual 2025**

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# Bangladesh Agricultural Research Council

New Airport Road, Farmgate, Dhala-1215

## Training on “Seed Quality Management”

### Training Schedule

Date: 22-24 February 2025

Venue: Conference Room # 2, BARC, Dhaka

Organized by: Crops Division, BARC

Funded by: PARTNER Program, APCU-BARC

### **Inaugural Session**

9:00-10:00	Registration Recitation from Holy Qur’an: Mawlana Abul Hasan, Pesh Imam, BARC Mosque, BARC Welcome Address: Dr. Md. Jamal Uddin, PSO (Crops), BARC Remarks from the Special Guests Remarks from Chief Guest: Dr. Nazmun Nahar Karim, Executive Chairman (RC), BARC Remarks from Chairperson: Dr. Md. Abdus Salam, MD (Crops), BARC
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### **Technical Session**

#### **Day-1: 22.02.2025 (Saturday)**

Time	Topic/Session	Resource Person/Speaker
10:00-11:00	Pre-Evaluation and Training Course Introduction (Seed Quality Management)	Dr. Md. Jamal Uddin PSO (Crops), BARC
11:00-11:30	<b>Tea Break</b>	
11:30-12:30	Seed Sector in Bangladesh: Challenges and Opportunities	Dr. Md. Abdus Salam Member Director (Crops), BARC
12:30-13:30	Status of Seed Industry in Bangladesh	Dr. M A Rashid Ex-CSO, BARI and General Manager, Lal Teer Seed Limited
13:30-14:30	<b>Lunch &amp; Prayer</b>	
14:30-15:30	Disease and Insect-Pest Management in Quality Seed Production	Prof. Dr. Ismail Hossain College of Agricultural Science (CAS) IUBAT, Uttara, Dhaka/ Dr. Md. Jamal Uddin, PSO (Crops), BARC
15:30-16:30	Seed Production Techniques for Quality Assurance and Raising Farmer Awareness on Quality Seed Use with Post Harvest Handling	Dr. Md. Nazmul Islam Chief Coordinator Research Cell BADC, Dhaka
16:30-17:30	Seed Processing and Storage for Quality Maintenance	

#### **Day-2: 23.02.2025 (Sunday)**

Time	Topic/Session	Resource Person/Speaker
09:00-10:00	Seed Regulatory Framework and Certification Systems in Bangladesh	Mr. Md. Shahjahan Ali Senior Vice President
10:00-11:00	Plant Quarantine Regulation for Quality Seed Import and Export	Bangladesh Society of Seed Technology (BSST)
11:00-11:30	<b>Tea Break</b>	
11:30-12:30	Seed Quality Management: Concepts and Importance in Agriculture	Dr. Md. Moshir Rahman Professor
12:30-13:30	Climate Change and Its Impact on Seed Quality	Department of Agronomy BAU, Mymensingh



# Seed Sector in Bangladesh: Challenges and Opportunities

**Dr. Md. Abdus Salam**

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## 1. Seed Sector in Bangladesh

Seed sector refers to the system encompassing seed production, processing, marketing, distribution and regulation. It plays a critical role in agricultural productivity by ensuring farmers have access to high quality seeds that enhance crop yield, resilience and nutritional value. In Bangladesh, where agriculture contributes significantly to economy (GDP-11.2%) and employs 45.40% of workforce (BBS, 2023), the seed sector is fundamental in ensuring food security and sustainable farming practices. In 2023, Bangladesh seed market was estimated at USD 321.83 million. It is projected to grow from USD 338.98 million in 2024 to USD 433.88 million by 2029, at a compound annual growth rate (CAGR) of 5.06%.

The seed sector in Bangladesh is a vital component of agricultural development, ensuring improved crop productivity, food security and environmental sustainability. Strengthening the seed supply chain through technological advancements, policy support and investment in research and development is essential for sustaining agricultural growth in Bangladesh.

## 2. Key Role of Seeds in Food Security, Crop Improvement and Sustainable Agriculture

*Food Security:* Quality seeds increase crop productivity and resilience, ensuring stable food production and reducing vulnerability to climate change, pests and diseases. Improved seed varieties contribute to higher yields, supporting national food self sufficiency.

*Crop Improvement:* The development and distribution of high yielding, disease resistant, and climate adaptive seed varieties enable farmers to maximize output while minimizing losses. This supports economic stability for farmers and enhances national agricultural competitiveness.

*Sustainable Agriculture:* Seeds of improved varieties, including hybrid and stress tolerant crops, promote resource efficient farming by requiring less water, fertilizers and pesticides. They also support crop diversification, which enhances soil health and biodiversity.

## 3. Seed Supply Chain in Bangladesh

The seed supply chain in Bangladesh consists of multiple stages, involving both public and private sector stakeholders:

### **3.1 Seed Production**

- Public sector, including BARI, BRRI, BINA, BJRI, BWMRI, BSRI and CDB, develops and releases the new varieties.
- Bangladesh Agricultural Development Corporation (BADC) plays a significant role in producing and distributing foundation and certified seeds.
- Private seed companies and non-government organizations (NGOs) are increasingly contributing to hybrid seed production, specially in rice, maize and vegetables.
- Farmers also engage in informal seed production and exchange systems, particularly for open pollinated varieties (OPVs).

### **3.2 Seed Processing**

- After production, seeds undergo cleaning, grading, drying and treatment to ensure quality.
- Processing facilities are primarily operated by BADC and private companies, ensuring that seeds meet germination and purity standards.

### **3.3 Seed Marketing and Distribution**

- Seeds are marketed through public and private sector channels. BADC supplies seeds through its network, while private companies and dealers operate in a competitive market.
- NGOs and cooperative groups also distribute seeds, particularly in rural areas where access may be limited.
- Informal seed exchange remains prevalent among smallholder farmers, playing a crucial role in preserving traditional crop varieties.

## **4. Seed Industry Structure in Bangladesh**

The seed industry in Bangladesh consists of a multi stakeholder system, involving government or public institutions, private sectors (seed industries/companies), cooperatives and farmer led seed systems. The government plays a key role in seed regulation, research and distribution, while the private sector has significantly expanded access to hybrid and high yielding seeds. At the same time, farmer led seed exchange systems remain crucial, particularly for resource poor farmers.

### **4.1 Government Institutions**

The public sector plays a crucial role in seed research, variety development, production, quality control and policy regulation. The key government institutions involved in the seed industry include:

#### **a) Bangladesh Agricultural Research Council (BARC)**

- The apex body of NARS responsible for coordinating agricultural research, including seed development.
- Supports collaboration between research institutions and policymakers to improve the seed sector.

#### b) National Agricultural Research System- NARS Institutes

- Bangladesh Rice Research Institute (BRRI)- Develops new high yielding and climate resilient rice varieties.
- Bangladesh Agricultural Research Institute (BARI)- Focuses on seed research for crops like wheat, maize, pulses, oilseeds and vegetables.
- Bangladesh Institute of Nuclear Agriculture (BINA)- Develops improved seed varieties using nuclear breeding techniques, particularly for stress resistant crops.

#### c) Bangladesh Agricultural Development Corporation (BADC)

- The primary public agency for seed production, processing and distribution.
- Produces and distributes foundation and certified seeds for rice, wheat, maize, and vegetables.
- Works with research institutions to multiply and commercialize new seed varieties.

#### d) Seed Certification Agency (SCA)

- Regulates seed quality control, certification and testing to ensure compliance with national seed standards.
- Conducts field inspections and laboratory testing for seed purity, germination rates and viability.

#### e) Ministry of Agriculture (MoA)

- Oversees seed policies, subsidies and regulations for sustainable seed sector development.
- Implements seed related programs and ensures coordination among stakeholders.

### 4.2. Private Sector Involvement (Seed Industry)

The private sector has played an increasing role in seed production, marketing and distribution, particularly in hybrid seeds and high value crops.

#### a) Seed Companies

- Several private companies actively produce, import and market hybrid and improved seed varieties.
- Leading private seed companies in Bangladesh include:
  - ACI Seed Ltd.- A major player in hybrid rice, maize, and vegetable seeds.
  - Lal Teer Seed Ltd.- Specializes in vegetable seeds and high yield crop varieties.
  - BRAC Seed and Agro Enterprise- Focuses on quality seed production for rice, maize, and pulses.
  - Supreme Seed Company Ltd.- Supplies a range of hybrid and OPV (open pollinated variety) seeds.

#### b) International Seed Companies

- Global seed companies such as Syngenta, Bayer Crop Science and East West Seed (now Lal Teer Seed Ltd.) are active in Bangladesh.
- These companies focus on hybrid seed research, technology transfer and farmer training programs.

### c) Seed Cooperatives and NGOs

- Farmer cooperatives and NGOs like PROSHIKA, RDRS and Practical Action play a significant role in seed distribution.
- They provide access to quality seeds for smallholder farmers and promote community-based seed banks.

## 4.3. Farmer-Led Seed Systems and Informal Seed Exchange

Despite the growth of the formal seed sector, informal seed exchange remains a dominant source of seeds, particularly among smallholder farmers.

### a) Traditional Seed Saving and Exchange

- Farmers save seeds from their own crops for the next planting season.
- Seeds are exchanged locally among farmers, ensuring access to preferred varieties.
- This system is particularly common for rice, pulses, oilseeds and indigenous vegetables.

### b) Community Based Seed Banks

- Some farmer groups, with the support of NGOs and research institutions, establish community seed banks.
- These banks preserve local seed diversity and improve access to climate resilient crop varieties.

### c) Challenges in Informal Seed Systems

- *Lack of quality control*: Seeds may have low germination rates or carry diseases.
- *Limited access to improved varieties*: Farmers relies on traditional varieties with lower yield potential.
- *Climate vulnerability*: Traditional seed saving practices may not be effective in dealing with erratic weather patterns.

## 5. Challenges in the Seed Sector

### *Quality Control Issues*

- Poor seed quality due to inadequate infrastructure and technology for seed testing.
- Contamination and adulteration of seeds in the informal sector.
- Limited access to high-quality seeds for smallholder farmers.

### *Seed Production Constraints*

- Limited investment in seed research and development.
- Inconsistent seed production and supply due to climate variability.
- Lack of appropriate infrastructure for seed storage and preservation.

### *Policy and Regulatory Challenges*

- Inadequate enforcement of seed laws and regulations.
- Limited government support for seed certification programs.

### *Access to Seed Technology*

- Farmers' limited access to new seed varieties with high yield potential.
- Lack of awareness and education about improved seed technologies.
- Low adoption rates of genetically modified (GM) seeds and hybrids.

### *Climate Change and Environmental Factors*

- Impact of climate change on seed production, quality and yield.
- Increasing frequency of natural disasters (e.g., floods, river bank erosion, cyclones, droughts, saline water intrusion etc.) affecting seed availability.
- Inability of seed varieties to cope with changing agroclimatic conditions.

## **6. Opportunities for Improvement**

### *Seed Research and Development (R&D)*

- Growing importance of developing drought tolerant, pest resistant and high yield varieties.
- Opportunities for improving indigenous seed varieties and conserving biodiversity.
- Role of research institutions (NARS, Universities) in breeding improved varieties.

### *Public-Private Partnerships (PPP)*

- Opportunities for collaboration between the government and private seed companies.
- Strengthening seed market linkages through public-private partnerships to improve seed access and availability.
- Promoting seed business models that incentivize farmers to grow seeds.

### *Digital and Technological Advancements*

- Role of digital technologies in improving seed supply chains, such as mobile apps for seed information.
- Use of artificial intelligence (AI) and big data for predicting seed demand, market trends and weather patterns.
- Promoting precision agriculture and digital platforms to enhance seed distribution.

### *Farmer Training and Education*

- Enhancing awareness about the benefits of improved seed varieties.
- Increasing the number of farmer training programs on seed handling, storage and selection.
- Encouraging the adoption of improved seed varieties through government-sponsored awareness campaigns.

### *Seed Policy and Governance*

- Opportunities for strengthening seed laws and policies to protect the interests of farmers and consumers.
- Promoting seed certification and quality control mechanisms.
- Improving the regulatory environment to support research, innovation, and commercialization of new seed varieties.

### *Climate Resilient Seed Varieties*

- Focus on breeding climate resilient seed varieties that can thrive in changing agroclimatic conditions.
- Research into seeds with tolerance to floods, drought, and salinity, which is critical for Bangladesh.

- Investment in long term strategies for developing seeds for high stress environments.

## 7. Case Studies and Success Stories

Hybrid rice seed adoption and integration of digital platforms in seed supply chain are two significant success stories in Bangladesh's seed sector.

- i) Hybrid rice seeds - Significantly enhanced Productivity
- ii) Digital platforms - Improving Seed Accessibility and Efficiency

Both advancements contribute to Bangladesh's long term agricultural sustainability and food security.

### 7.1 Example-1: Hybrid Rice Seeds

#### 7.1.1 *Successful Adoption of Hybrid Rice Varieties in Bangladesh and Their Impact on Rice Productivity*

Hybrid rice technology has been one of the most significant advancements in Bangladesh's seed sector. Introduced in the late 1990s, hybrid rice varieties have played a key role in increasing rice production and ensuring food security. Hybrid rice varieties yield 15-20% more than conventional high yielding varieties (HYVs), making them an attractive option for farmers facing limited land resources.

##### *Impact on Rice Productivity*

- Bangladesh has seen a steady increase in hybrid rice adoption, especially in the Boro (dry) season, when water availability allows for high-yield potential.
- The productivity of hybrid rice ranges from 7-8 t/ha compared to 4-5 t/ha for HYVs.
- Widespread adoption of hybrid rice has helped Bangladesh achieve self sufficiency in rice production, reducing dependence on imports.

#### 7.1.2 *Role of Research Institutions in Developing and Promoting Hybrid Varieties*

BARI, BRRI and BINA has played a crucial role in hybrid rice research and promotion.

##### *Development of Local Hybrid Varieties*

- Initially, Bangladesh depended on imported hybrid rice seeds from China and India. However, research institutions have successfully developed locally adapted hybrid varieties (BRRI Hybrid Dhan 1-8), reducing dependence on foreign seeds.
- These hybrids are better suited to local climatic conditions, offering improved disease resistance and higher grain quality.

##### *Promotion and Adoption*

- Government initiatives, including subsidies on hybrid seeds and farmer training programs, have accelerated adoption.
- The private sector, including seed companies such as BRAC Seed, Supreme Seed, and ACI Seed, has been instrumental in distributing hybrid seeds and providing extension services.

- NGOs have played a role in educating farmers about hybrid benefits, contributing to increased adoption rates.

## 7.2 Example-2: Digital Platforms for Seed Supply

### 7.2.1 Introduction of Digital Platforms in Rural Areas for Better Access to Quality Seeds

The integration of digital platforms in the seed sector has revolutionized access to quality seeds, especially for rural farmers. With increasing smartphone penetration, farmers now use mobile apps, e-commerce websites and SMS based platforms to order seeds, compare prices, and receive agronomic advice.

#### *Key Digital Initiatives*

- **Krishoker Janala (Farmer's Window):** A mobile application offering farmers information on seed selection, crop management, and weather updates.
- **AgroBazaar & iFarmer:** Online marketplaces that connect farmers directly with certified seed suppliers, reducing reliance on local intermediaries.
- **e-Krishok (ICT Division & FAO):** Provides SMS based seed advisory services, allowing smallholder farmers to access quality seeds without visiting distant markets.

### 7.2.2 Success Stories of Seed Companies Using E-Commerce to Increase Seed Availability

- **ACI Agribusiness:** ACI Seeds launched an online seed ordering system, allowing farmers to purchase seeds via mobile apps. During COVID-19 lockdowns, this initiative ensured uninterrupted seed supply, benefiting thousands of farmers.
- **Lal Teer Seed Ltd.:** One of Bangladesh's leading seed companies, Lal Teer partnered with digital payment platforms (bKash, Nagad) to enable farmers to order seeds online and pay digitally, reducing delays in the seed distribution process.
- **iFarmer:** A digital agritech platform that connects farmers with seed suppliers through an e-commerce system. It also provides microloans for seed purchases, helping small farmers invest in high-quality seeds.

## 8. Recommendations for the Future

### *Strengthening R&D Investment*

- Increased public and private sector funding for seed research.
- Encouraged joint research initiatives to develop improved varieties through investment.
- Focus on developing varieties suited to local environmental conditions and farmer needs.

### *Improving Seed Infrastructure*

- Upgrading seed processing, storage and transportation facilities.
- Strengthening seed certification processes to ensure quality control.

### *Enhanced Collaboration*

- Fostering collaboration between universities, research institutions, and private companies to scale innovation.
- Empowering farmers by promoting farmer-led seed systems and informal seed exchanges.

### *Policy and Legal Reforms*

- Formulating seed policies that ensure availability, accessibility, and affordability of seeds.
- Expanding seed support for smallholder farmers through subsidies and loan programs.

## **9. Conclusion**

- Importance of a strong seed sector is needed for ensuring food security and sustainable agricultural development in Bangladesh.
- Strengthening seed supply chain through technological advancements, policy support, and investment in R&D is essential for sustaining agricultural growth.
- Emphasize need for collaborative efforts between government, research institutions, universities, and private sector.
- Invite participants to contribute ideas and solutions for overcoming challenges and seizing opportunities within seed sector.

# Status of Seed Industry in Bangladesh

**Dr. M A Rashid**

Ex-Chief Scientific Officer, BARI;  
General Manager, Lal Teer Seed Limited  
abdur.rashid@multimodebd.com

## 1. Importance of Seed

It is a recognized fact that the seed is the most vital input for crop production. Use of quality seeds, OP and hybrids can increase crop yield from 20-200%. Most food crops have to be started from seed. The production of seed requires skill, knowledge and specialization. The crop production in Bangladesh is constrained by the inadequate supply of quality seed.

## 2. History of Seed Industry Development in Bangladesh

In the late nineties (1995) the scenario of seed production and supply in Bangladesh was extremely poor. BADC used to produce mainly the seeds of cereal crops, BRRI developed inbred rice varieties, hybrid rice was not introduced at that time and BARI developed wheat varieties. The scenario of vegetable seed was worse, there was no organized seed production, BADC used to produce only 10-15 tons of seeds of BARI developed OP vegetable varieties. There was no existence of seed industries (private sector seed companies). As a result, the vegetable production was far below than the requirement due to inadequate supply of quality seed. At that time per capita vegetable consumption was 35-40 gm against recommended 300g and there was widespread malnutrition in the country. It is worth mentioning here that the seed entrepreneurs were playing role in production of BARI developed OP varieties and in importing of some Cole vegetable seeds like cabbage, cauliflower, kholrabi and watermelon.

Realizing the importance of quality seed and the fact that, meeting the requirement of huge quantity of quality seed by BADC alone is not possible with its manpower and infrastructure, the Government of Bangladesh under its Privatization Policy declared a new Seed Rule in 1993 emphasizing promotion of efficient private sector participation for expanding production and supply of high quality seed. In the meantime, FAO came forward with a project named Strengthening of Vegetable Seed in Bangladesh in 1987. The project played great role in organizing public and private sector for organized seed production. Since the declaration of New Seed Rule, the private sector came forward and initiated seed companies with R&D, production, processing, promotion and sales network to supply seeds to farmers. The first seed company in the private sector, the then East West Seed (BD) Ltd was established in 1995 under the joint venture of Multimode Group of Mr. Abdul Awal Mintoo and East West Seed, Netherlands which is now Lal Teer Seed Ltd. By now there are hundreds of seed companies in Bangladesh but a very few (4-5 in no.) are with R&D commitments. However, companies with R&D background are doing very well in developing vegetable and rice hybrids using local germplasm and producing

seeds locally through contract growers. Hence the situation has been significantly improved in last 25 years, sustainable supply chain was established. By this time, the seed companies have been declared as Industry by the Ministry of Industries. Now Bangladesh is exporting tropical vegetable seeds to abroad. However, the seed industry in Bangladesh is still at infantile stage and are developing gradually.

### **3. The Present Seed Status of Major Crops**

#### **Rice**

Total seed requirement 3,55,308 MT; total supply 2,32,588 MT (65% of requirement); Public sector 1,30,212 MT (56% of the supply); Private sector 102376 MT (44% of the supply); farmers saved seed 35%.

Hybrid Rice: Area under cultivation 1.34 M ha (23.60%); Local hybrid seed production 16,693 MT; Hybrid seed import 7,963 MT (Source: MoA 2021; BBS, 2021-22).

#### **Wheat**

Total seed requirement 44,772 MT; Total supply 20,100 MT (45%); Public sector 19,200 MT; Private sector 900MT; Farmers saved seed 55% (Source: MoA, 2021).

#### **Maize**

Total seed requirement 11,588 MT; total Supply 8,539 MT (74%); Public sector 39 MT; Private sector 8,500 MT, mainly imported (Source: MOA, 2021).

#### **Jute**

Total seed requirement 6,206 MT; Total supply 5,423 MT (88%); Public sector 934 MT; Private sector 455 MT; farmers saved seed 12% (Source: MoA, 2021).

#### **Pulse**

Total seed requirement 26,271 MT; Total supply 3,370 MT (13%); Public sector 3,210 MT; Private sector 160 MT; farmers saved seed 87% (Source: MoA, 2021).

#### **Oilseed**

Total requirement 21,056 MT; Total Supply 3,656 MT (17%); Public Sector 3,077 MT; Private sector 580 MT; farmers saved seed 83% (Source: MoA, 2021).

#### **Vegetables**

Total seed requirement 4,445 MT; Total supply 2,756 MT (62% of requirement); Local organized production 1,468 MT (33%); Import 1,288 MT (29%); Farmers saved seed 1689 MT (38%); Seeds produced by public sector 467 MT (Source: BBS, 2021; BSA, 2021; BADC, 2021).

The demand of quality seed is huge in the country and is continuously expanding leaving a wide gap between demand and supply. It is therefore, necessary to strengthen the seed industry in the country to strengthen food and nutrition security. It is revealed that private sector is playing significant role in production and supplying of seeds of major crops like

rice, maize, wheat and vegetables crops. The use of hybrid seeds of rice is slowly increasing, now 23% of the land is covered by hybrid rice. More than 95% of the vegetable seed is supplied by the private sector (local production and import).

#### **4. Recommendations for Strategic Development**

##### *Strengthening of R&D at Public and Private sector*

The research and development activities should be strengthened for the regular supply of HYV and hybrid varieties for sustainable seed production. Hybrids of rice, maize, oilseeds, onions and vegetables should be developed to produce seeds locally to reduce import dependency.

##### *Biotechnological intervention*

For food and nutrition security, we have to go beyond the ability of conventional breeding. We have excellent achievement in HYV and hybrid development through conventional breeding but it has got some limitations to yield increase. New traits developed by molecular tools offer tremendous potential in raising crop productivity. Varieties with particular traits such as salinity, heat, drought and disease-pest resistance could be developed using molecular tools like Gene Editing. To expedite testing and product development in priority crops by combined effort should be taken by public and private sector research and seed industry partners.

##### *Resilience development to combat climate change*

Bangladesh is one of the vulnerable countries to climate change. Huge southern coastal area comprising 2.85 million ha which is the 30% of the cultivable area of the country, is saline contaminated while northern Barind area (more than 7000 sq km) is characterized by drought and high heat. Crop production in those areas is constrained due to salinity, drought and high heat. Public and private sector must take strong step to develop climate resilient varieties to bring those huge areas under cultivation.

##### *Strengthening BADC for seed production and market development of NARS developed seeds*

BADC is the public body for the seed production of NARS developed crop varieties and is doing good in production of cereals, oils, pulse and other crops. But vegetable seed production is constrained due to shortage of manpower and infrastructure. The NARS institutions have developed some good varieties, both OP and hybrids. Due to the lacking of sustainable seed production and supply those varieties are not reaching to growers. BADC should strengthen the manpower and infrastructure for increasing seed production in particular vegetables.

##### *Skill development of seed producers (Human resource development and capacity building)*

The demand of quality seed is huge in the country and continuously expanding leaving a wide gap between demand and supply. It is therefore, necessary to strengthen the seed

industry in the country. To achieve this, producing a large number of qualified, well trained seed technologist will be required.

#### *Development of modern seed processing facilities*

Modern seed processing facilities in both public and private sector are inadequate, for the sake of maintaining quality and good branding, the automation system should be adopted.

#### *Establishment of modern seed testing labs in public and private sector*

Seeds are living being. To maintain seed quality establishment and strengthening of modern seed laboratories with modern equipment are required. To expedite seed export and even domestic seed sales accredited seed testing labs are required for quality testing and issuing of yellow and blue certificates. In Bangladesh only one lab, MNT Seed Testing Lab of Lal Teer Seed Ltd is accredited by both ISTA and BAB.

#### *Bank loan*

Bank loan on easy terms and conditions should be allotted to private seed sector as huge investment is required in infrastructure development, equipment and R&D.

#### *Updating quarantine rules*

The seed rule in place developed by the government is seed friendly. However, the Quarantine Rule should be updated regularly to strengthen the export and import of seed. At present private sector is facing difficulties to import seeds of cole vegetable crops for imposition of restrictions on some diseases and pests.

#### *Easy and economic access of farmers to seed*

Easy and economic access of the farmers to the availability of good seeds is of immense importance to improve the nation's food and nutrition security.

# Seed Quality Management: Concepts and Importance in Agriculture

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## 1. Introduction

Seed quality management is a fundamental aspect of modern agriculture, ensuring the production of high-quality seeds that contribute to better crop yields and sustainability. It encompasses a range of activities including seed selection, genetic purity maintenance, seed testing, storage, and distribution. The quality of seeds directly impacts agricultural productivity, food security, and economic stability. This essay explores the key concepts of seed quality management and its significance in agriculture.

## 2. Concepts of Seed Quality Management

Seed quality management is a systematic approach that involves several interrelated components:

**Genetic Purity:** Genetic purity refers to the true to type characteristics of a seed variety. It ensures that the seeds possess the desired genetic traits, such as disease resistance, drought tolerance, and high yield potential. Maintaining genetic purity involves strict breeding programs, isolation techniques, and proper seed certification processes.

**Physical Purity:** Physical purity relates to the absence of unwanted materials such as inert matter, weed seeds, and other crop seeds. High physical purity enhances seed viability and prevents competition from unwanted species.

**Seed Viability and Germination:** Viability and germination percentage are crucial indicators of seed quality. High-quality seeds should exhibit high germination rates, ensuring uniform crop establishment. Proper drying, storage, and seed treatment techniques help maintain seed viability over time.

**Seed Health:** Seed health refers to the absence of pathogens, insects, and pests that can compromise seedling development. Seed treatment with fungicides, insecticides, and biological agents is an essential practice in managing seed health.

**Moisture Content and Storage:** Maintaining optimal moisture content is critical for prolonging seed longevity. Excess moisture can lead to fungal growth and seed deterioration, whereas extremely dry conditions may affect seed viability. Proper storage facilities, such as climate-controlled seed banks and hermetically sealed containers, help in preserving seed quality.

**Seed Certification and Labeling:** Certification programs ensure that seeds meet established quality standards before they reach farmers. Certified seeds undergo rigorous testing and are labeled with essential information regarding origin, purity, germination rate, and treatment status.

### 3. Importance of Seed Quality Management in Agriculture

**Enhancing Crop Productivity:** The use of high-quality seeds results in better crop establishment, higher yields, and improved resilience to environmental stressors. This directly contributes to increased agricultural productivity and profitability.

**Ensuring Food Security:** Quality seeds play a crucial role in achieving food security by enhancing the production of staple crops. Improved seed quality helps meet the growing global food demand while minimizing crop failures.

**Reducing Dependency on Chemical Inputs:** Genetically pure and healthy seeds require fewer pesticides and fertilizers, promoting sustainable agricultural practices. This reduces input costs for farmers and mitigates environmental degradation.

**Facilitating Sustainable Agriculture:** Seed quality management supports sustainable agriculture by ensuring that only high performing and resilient seed varieties are cultivated. It also promotes biodiversity conservation through the preservation of indigenous and improved seed varieties.

**Economic Benefits for Farmers:** Using highquality seeds leads to higher returns on investment due to better yields and reduced losses. This improves the economic stability of farming communities and enhances rural development.

**Compliance with Regulatory Standards:** Adhering to seed quality management practices ensures compliance with national and international agricultural standards. This facilitates seed trade, enhances market access, and fosters agricultural development globally.

### 4. Conclusion

Seed quality management is a critical component of modern agriculture that influences productivity, sustainability, and food security. By implementing stringent quality control measures, farmers and stakeholders can ensure the availability of superior seeds that drive agricultural growth. Investing in seed quality management not only benefits individual farmers but also contributes to the overall advancement of global food production systems. As the agricultural sector faces challenges such as climate change and increasing population demands, the role of high-quality seeds in ensuring resilient and efficient farming systems cannot be overstated.

# Climate Change and Its Impact on Seed Quality

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## 1. Introduction

Climate change is one of the most pressing global challenges, influencing ecosystems, biodiversity and agriculture. One of its lesser discussed but critical impacts is on seed quality, which is fundamental for food security and sustainable agriculture. Seeds determine the resilience, productivity and adaptability of crops, and any adverse changes in their quality can have long term consequences for global food production. This essay explores how climate change affects seed quality and the potential implications for agriculture and food security.

## 2. Effects of Climate Change on Seed Development

Climate change alters seed development by affecting the environmental conditions necessary for proper growth and maturation. Rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events disrupt the physiological processes of plants, leading to poor seed formation, lower viability, and reduced germination rates.

- **Temperature Extremes:** Higher temperatures can accelerate the seed maturation process, reducing the accumulation of essential nutrients and leading to lower seed quality. Heat stress during flowering and seed development phases can also lead to incomplete fertilization, malformed seeds, and decreased seed weight.
- **Water Stress:** Both drought and excessive rainfall have detrimental effects on seed quality. Drought stress reduces seed size, vigor, and storage ability, while excessive moisture increases the risk of fungal infections and reduces seed longevity.
- **CO<sub>2</sub> Concentrations:** Elevated carbon dioxide levels can influence seed composition by altering the balance of proteins, carbohydrates, and lipids. While some crops may exhibit increased seed yield under higher CO<sub>2</sub> concentrations, the nutritional quality of seeds may decline, impacting both human and animal nutrition.
- **Extreme Weather Events:** Increased frequency of storms, floods, and heatwaves disrupts seed development and dispersal. Such conditions may lead to seed dormancy issues, higher susceptibility to pests, and loss of genetic diversity.

## 3. Impact on Seed Storage and Longevity

Seed longevity is crucial for maintaining seed banks and ensuring food security. Climate change affects seed storage conditions, leading to increased deterioration over time.

Warmer temperatures and higher humidity levels can accelerate seed aging, reducing their viability. This presents challenges for seed conservation, particularly for traditional and heirloom varieties that play a crucial role in maintaining genetic diversity.

#### 4. Implications for Agriculture and Food Security

The deterioration of seed quality due to climate change has far-reaching consequences for agriculture:

- **Reduced Crop Yields:** Poor seed quality results in lower germination rates, weak seedlings, and reduced crop productivity.
- **Loss of Genetic Diversity:** Many traditional crop varieties, which are adapted to specific local conditions, may struggle to survive, leading to a decline in biodiversity.
- **Increased Dependence on Genetically Modified Seeds:** As climate change impacts natural seed viability, there may be a shift towards genetically modified (GM) seeds engineered for resilience, potentially limiting seed sovereignty for farmers.
- **Economic Strain on Farmers:** Reduced seed quality may force farmers to invest in high-cost, climate-resilient seeds, increasing production costs and reducing profits.

#### 5. Strategies for Mitigating Climate Change Effects on Seed Quality

To counteract the negative effects of climate change on seed quality, various strategies can be adopted:

- **Breeding Climate Resilient Crops:** Developing and promoting crop varieties that can withstand extreme temperatures, drought, and pests is essential for sustainable agriculture.
- **Improved Seed Storage Techniques:** Enhancing seed storage facilities with controlled temperature and humidity conditions can prolong seed viability.
- **Sustainable Agricultural Practices:** Agroecological farming, crop rotation, and soil conservation techniques can improve seed health and productivity.
- **Strengthening Seed Banks:** Investing in seed banks and community-based seed saving initiatives can preserve genetic diversity and safeguard against future climatic uncertainties.

#### 6. Conclusion

Climate change poses a significant threat to seed quality, directly affecting agricultural sustainability and food security. Addressing these challenges requires a multi-faceted approach, including scientific research, sustainable farming practices, and robust seed conservation efforts. By mitigating the impacts of climate change on seeds, we can ensure the resilience of future agricultural systems and the well being of global populations.

## Seed Regulatory Framework and Certification Systems in Bangladesh

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The Seed Regulatory Framework (SRF) and Seed Certification Systems Governing Body is National Seed Board (NSB) of the Ministry of Agriculture (MoA), Government of the People's Republic of Bangladesh (GoB). The NSB was established in 1973. The NSB, MoA is headed by the Secretary, MoA. The Secretariat of the NSB, MoA is the Seed Wing, established in 1992. The Seed Wing is headed by the Director General, MoA.

The NSB, MoA is assisted by two (2) committees namely (i) Technical Committee (TC) of the NSB, headed by the Executive Chairman, Bangladesh Agricultural Research Council (BARC) established in 1979, and (ii) Seed Promotion Committee (SPC) of the NSB, headed by the Secretary, MoA established in 1995.

The Functions of the TC of NSB are mainly Field Evaluation through Multilocational Field Trials (MLFT)/Regional Field Trials (RFT) of different Agro-Ecological Zones (AEZ) for Notified Crop Varieties through Seed Certification Agency (SCA) of MoA. On the basis MLFT/RFT Reports of SCA, the TC-NSB Technically Evaluate the Performances of the locally developed and introduced from abroad promising Notified Crop Variety (Varieties) and Recommend to the NSB, MoA for finally Releasing the best performing promising Notified Crop Variety (Varieties). The notified crop varieties includes Inbreds and Hybrids of seven (7) crops (Rice, Wheat, Potato, Sugarcane, Jute, Kenaf and Mesta).

The Functions of the SPC of NSB are mainly to Planning and Programing of the National Seed Requirement, Seed Production and Seed Supply Chain Management System through public sector Agricultural Research Institutes (ARIs) under National Agricultural Research System (NARS) mainly production and supply of Breeder Seed (BS), public sector Bangladesh Agricultural Development Corporation (BADC), Department of Agricultural Extension (DAE) of the MoA and Private sector Seed Industries/Seed Companies/Seed Enterprises (officially registered with the MoA) for the purposes of multiplication of BS to produce Foundation Seed (FS), and supply of Certified Seed (CS), and Truthfully Labelled Seeds (TLS) to the farmers.

### The SRF of NSB, MoA are as follows:

1. [National Seed Policy, 1993](#) (the updated and modified National Seed Policy was prepared in 2018(Draft National Seed Policy, 2018), but has not yet been finalized and officially published). Noteworthy to mention here that, in pursuance to the updated [Seed Act, 2018](#), [Seed Rules, 2020](#) and [Seed Rules, 2023](#), the [National Seed Policy, 1993](#) and [Draft National Seed Policy-2018](#) is needed to be modified, updated and published.

2. The Seeds Ordinance, 1977
3. The Seeds (Amendment) Act, 1997
4. The Seeds (Amendment) Act, 2005
5. The Seed Act, 2018 (updated Seed Act)
6. The Seed Rules, 1980
7. The Seed Rules, 1998
8. The Seed Rules, 2020
9. The Seed Rules, 2023 (modified and updated)
10. The Plant Variety Protection Act, 2019 (Intellectual Property Right-IPR)
11. The Plant Variety Protection Rules (Intellectual Property Right-IPR), drafted in 2024, but has not yet been finalized and officially published.
12. The Guidelines on Hybrid Rice, Inbred Rice, Hybrid Wheat, Inbred Wheat, Jute, Kenaf, Mesta, and Potato Notified Crop Variety Development and Release Guidelines, and Seed Potato Laboratory Establishment Guidelines.
13. **Seed Certification Regulation in Bangladesh**
  - 13.1 The Seed Certification Ordinance, 1974 for establishment of **Seed Certification Agency (SCA)** under the Ministry of Agriculture (MoA).
  - 13.2 Seed Quality Declaration and Certification Guidelines through publishing the **Seed Standard** and **Field Standard in 2010** for a total of **80**(eighty) Crops comprising of (a) **Seven** (7) Notified Crops (**Rice, Wheat, Potato, Sugarcane, Jute, Kenaf and Mesta**), and (b) **73** (Seventy-three) Non-Notified Crops; There are two Standards published in 2010:
    - (i) The **Seed Standard**, 2010 following the International Guidelines of International Seed Testing Association ISTA (ISTA), and
    - (ii) The **Field Standard**, 2010 following International Guidelines of Organization for Economic Cooperation and Development (OECD).
  - 13.3 **Quality Declared Seed** (QDS) of Food and Agriculture Organization (FAO) of the United Nations for ensuring the following criteria and indicators:
    - (i) **Genetic Purity** of Seed in the Field to be ensured through Testing by following the Field Standard of OECD;
    - (ii) **Physical Purity** of Seed in the Seed Testing Laboratory by following the Seed Standard of ISTA;
    - (iii) **Physiological Purity** of Seed in the Seed Testing Laboratory by following the Seed Standard of ISTA;
    - (iv) **Seed Health** of Seed in the Seed Testing Laboratory by following the Seed Standard of ISTA.
14. **Plant Quarantine Regulation**
  - 14.1 **Destructive Insects and Pests Act, 1914**
  14. 2 **Destructive Insects and Pests Rules, 1966** (Plant Quarantine)
  14. 3 **Destructive Insects and Pests Rules, 1989**
  14. 4 **Plant Quarantine Act, 2011**
  - 14.5 **Plant Quarantine Rules, 2018** (Updated and modified rules drafted in 2023 but has not yet been finalized)

## **The different Seed Regulatory Framework (SRF) of the Ministry of Agriculture (MoA), Government of the People's Republic of Bangladesh (GoB)**

### **The National Seed Policy, 1993**

Quality seed is considered to be the basic input for increasing agricultural output and thereby achieving self-sufficiency in food production. Effectiveness of other inputs like fertilizer and irrigation depends largely on good seed.

National Seed Policy, 1993 provides for policy directives to increase production of improved seed both in the public and private sectors and for making best quality seeds available to the farmers on timely basis, and at competitive price. The seed policy has also provisions, among other things, for liberalization of import of seed and seed processing machineries, strengthening of quality control and research system and maintaining a seed security arrangement. A major thrust of the seed policy has been on the institutional arrangement of the seed sector.

#### **1. Objectives of the seed policy**

##### **Overall objectives**

The overall purpose of this policy is to make the best quality seeds of improved varieties of crops conveniently and efficiently available to farmers with a view to increasing crop production, farmer's productivity, per capita farm income and export earnings.

##### **Specific objectives**

- 1) To breed, develop and maintain improved crop varieties with special emphasis on those suitable for high-input and high-output agriculture.
- 2) To multiply and distribute, on a timely basis, to all farmers sufficient quantities of quality seed of improved high yielding varieties that are Resistant to Biotic Stresses (Diseases and Insect-Pests) and Tolerant to Abiotic Stresses (Salinity, Drought, Flood, Submergence, Heat and other Environmental Stresses).
- 3) To promote farmers' acceptance and use of quality seeds of improved varieties.
- 4) To promote, through education, training and financial supports, balanced development of public and private sector seed Industries/Seed Companies/Seed Enterprises (**level playing fields of public and private sector**).
- 5) To simplify the importation for research and commercial purposes of high quality seeds and planting materials of improved varieties.
- 6) To promote seed technology by providing training and technical supports to agricultural seed specialists and professionals, general farmers, contract growers, and human resources/professionals of public and private sector in seed value chain management for seed production, processing, storage and seed supply chain management of high-quality seed.
- 7) To monitor, control and regulate the quality and quantity of seeds produced as well as development and commercialization of the seed industry.

## 2. Strategy for Seed Development

To achieve the above objectives, the following strategies among others, are to be followed:

- 2.1. To strengthen the institutional capability of the public and private sector entities engaged in the seed industry.
- 2.2. To evolve and/or adapt seed technology to meet the needs of high input and high output agriculture.
- 2.3. To promote balanced development of the seed sector by providing equitable opportunities to the public and private sector at all stages of the seed industry from breeding of improved varieties and hybrids to marketing of high quality seeds.
- 2.4. To simplify procedures for import of high-quality seeds and planting materials, both by the public and private sectors to enable farmers to have access to the best quality planting materials available in the world.
- 2.5. To strengthen seed certification, quality control and testing facilities to ensure availability of quality seeds to farmers.
- 2.6. To simplify procedures for effective implementation of plant quarantine regulation for seed import and export.

### **The Seed Act, 2018**

The Bangladesh Gazette, January 28, 2018  
Government of the People's Republic of Bangladesh  
Ministry of Agriculture  
NOTIFICATION  
Dated: January 28, 2018  
The Seeds Act, 2018  
Act No. VI of 2018

An Act to repeal and re-enact the Seeds Ordinance, 1977 by updating the provisions with modifications thereof.

The most important regulation of the Seed Act, 2018 is the duly approval of the Seed Bill, 2017 in the National Parliament on January 22, 2018 and the approved Seed Act, 2018 was promulgation of the Seed Act, 2018 through officially published in the Bangladesh Gazette on Sunday, 28 January 2018.

**In the Seed Act, 2018 the following specifications have been approved as:**

- (i) **“Seed Dealer”** means any person involved in production of seeds or carrying on business of selling, storing, importing, exporting, bartering or otherwise supplying any seed of any crop or variety for agricultural purpose, but does not include the farmer producing or stocking seeds for his own use and for sale in the local hat-bazar by himself or through any other person;
- (ii) **“Seed Inspector”** means any person appointed under section 18;
- (iii) **“Seed Laboratory”** means any official Seed Testing Laboratory established or, as the case may be, declared as such under section 12;

- (iv) **“Seed Certification Agency”** means the Seed Certification Agency established under section 13;
- (v) **“Seed Analyst”** means any person appointed under section 21; and
- (vi) **“Secretary”** means the Secretary to the Board.

### **National Seed Board (NSB)**

**In the Seed Act, 2018 the Governing Body of Seed Regulation has been created through formation of the National Seed Board (NSB).**

(1) The Government shall constitute a Board (NSB) to be called the National Seed Board (NSB) consisting of Members specified in subsection-

(2) to advise the Government on matters of proper implementation and proper application of this Act and to carry out other functions assigned to it under this Act.

**(3) The Seed Wing**, Ministry of Agriculture, shall perform the secretarial duties of the Board (NSB).

#### **(4) Constitution of the Committee.**

(1) The Board (NSB) may, subject to the prior approval of the Government, appoint one or more committees consisting wholly of the Members of the Board (NSB), or partly of the Members of the Board and partly of other expert persons or wholly of expert persons, as it thinks fit, for assisting it in discharging its functions. The numbers of Members, duties and the terms of reference of the committees of the Board (NSB) constituted under sub-section (1), shall be determined by the Board (NSB).

**(5) Power to Regulate the Crop Varieties and Seed quality.** The Government shall regulate the standard quality of seed of any kind or variety to be used and sold for the purpose of agriculture.

**(6) Registration of Seed Dealer.** No Seed Dealer shall carry on a business as Seed Dealer without having a Registration Certificate of the Seed Wing, MoA.

**(7) Classification of Seeds.** The Government may, in consultation with the Board (NSB), classify Seeds on the basis of its source, in such manner as may be prescribed.

**(8) Specification of necessary Standard of the Seed Quality.** The Government may, after consultation with the Board, by notification in the official Gazette, specify the seed quality standards for the purpose of ensuring the quality of seeds, namely.

**(9) Control of sale of Seeds of Notified Crops.** No Seed Dealer shall, himself or by any representative on behalf of him, sell, keep or offer to sell, barter, import, export or carry on any business of otherwise supplying any seed of a Notified crop or variety, unless the variety is officially Release by the Board (NSB) through technical evaluation by the Technical Committee (TC) of the NSB.

(10) **Control of sale of Seeds of Non-Notified Crops.** No Seed Dealer shall, himself or by any representative on behalf of him, sell, keep or offer to sell, barter, import, export or carry on any business of otherwise supplying any seed of a Non-Notified crop or variety, unless the variety is officially Registered by the Seed Wing of the Board (NSB).

### **(11) Import and Export of Seeds.**

(1) No person shall export or import or cause to be exported or imported any seed of any crop or variety unless it conforms to the standard of seeds quality, and the container of such seed bears, in the prescribed manner, the mark or label containing the correct particulars thereof specified for that seed under section 10.

In respect of Seed Import and Export- the Plant Quarantine Regulation- **Plant Quarantine Act, 2011 and Plant Quarantine Rules, 2018** shall be strictly followed. The Plant Quarantine Regulation shall be monitored and implemented by the Plant Quarantine Wing of the DAE of the Ministry of Agriculture.

### **12. Power to Regulate the Crop Varieties and Seed Quality**

- (1) The Government shall regulate the standard quality of seed of any kind or variety to be used and sold for the purpose of agriculture.
- (2) If the Government, after consultation with the Board (NSB), is of opinion that it is necessary or expedient to regulate the sale, distribution, barter, import and export or otherwise supplying seed of any crop or variety, it may, by notification, in the official Gazette, determine such crop or variety to be notified crop or variety and different crops or varieties may be Notified for different areas.
- (3) Any new variety of Notified crops developed by any Government institution or individual shall be released with the approval of the Board (NSB) upon recommendation of the committee constituted thereby and be Released by the Board (NSB).

**NOTE:** The most important modification and amendment of the Seed Act, 2018 is that in the Seeds (Amendment) Act, 2005, it was only allowed the public sector to develop and release Notified Crop Varieties by restricting the private sector, but in the Seed Act, 2018 both public and private sector have been equally allowed to develop and release Notified Crop Varieties.

- 4) New varieties of Non-Notified crops imported or locally developed by any Government institution or individual shall be Registered in the prescribed manner with its characteristics.
- (5) If any seed of a crop or variety is found harmful or likely to be harmful to agriculture, the Board (NSB) may, by order, prohibit the sale, distribution, barter, import or otherwise supplying of that crop or variety and may take any other action.

**Explanation:** “Non-Notified crop” includes the seeds of a crop or variety not included in the Notified crops or varieties.

### **13. Registration of Seed Dealer**

- (1) No Seed Dealer shall carry on a business as Seed Dealer without having a Registration Certificate.
- (2) If any person desires to carry on business as a Seed Dealer, he shall make an application on payment of fees for registration to the Board (NSB) in such manner as may be prescribed.

(3) On receipt of the application under sub-section (2), the Board shall verify the information mentioned in the application and issue a Certificate of Registration as a Seed Dealer.

**14. Control of sale of Seeds of Notified crops.**

No Seed Dealer shall, himself or by any representative on behalf of him, sell, keep or offer to sell, barter, import, export or carry on any business of otherwise supplying any seed of a Notified crop or variety, unless-

- (a) such crop or variety is Released by the Board (NSB);
- (b) such seed is identifiable as to its crop or variety;
- (c) it conforms to the standard mentioned in clause (a) of section 10;
- (d) the seed container is sealed, and the standard label or mark specified under clause (b) of section 10 is attached thereon; or
- (e) it complies with the terms and conditions of the Seed Dealership Registration Certificate.

**15. Classification of Seeds.**

The Government may, in consultation with the Board (NSB), classify seeds on the basis of its source, in such manner as may be prescribed.

**16. Specification of necessary Standard of the Seed quality.**

The Government may, after consultation with the Board (NSB), by Notification in the Official Gazette, specify the Seed Standard and Field Standard of the Quality Declared Seed for marketing.

## **The Seed Rules, 2020**

Bangladesh Gazette

June 9, 2020

In exercise of the powers conferred by Section 31 of the Seed Act 2018 (Act No. VI of 2018), the Government is pleased to make the following Rules viz.:

**This Rules will be called to as the Seed Rules, 2020.**

### **1. Functions of the Board (National Seed Board hereinafter NSB).**

The functions of the Board (National Seed Board) shall be as follows, viz.: -

- (A) To advise the Government on all matters regarding the promotion and development of Seed Industry;
- (B) To advise the Government on suitability and functions of the Seed Testing Laboratory;
- (C) To advise the Government about determining the crops or varieties to be declared as Notified Kind or Varieties of Crops;
- (D) To advise the Government to Releasing of any Kind or Variety of Notified Crop or Registration of Any Kind or Variety of Non-Notified Crop, and De-Notify or Withdraw or Extinction of any Kind or Variety of Crops;
- (E) To advise the Government on procedures or standards for certification (Field Standard following the International Guidelines of OECD), test or analysis of seeds (Seed Standard following the International Guidelines of ISTA);
- (F) To advise the Government on Seed security system;
- (G) Made arrangements for Releasing of any Kind or Variety of Notified Crops and Registration of any Kind or Variety of Non-Notified Crops being developed locally in Bangladesh or imported/introduced from abroad;

**NOTEWORTHY:** The Government shall regulate the quality of any Seed of any **Kind or Variety (Notified or Non-Notified)** to be sold and used for the purposes of Agricultural Seed Multiplication/Crop Production.

- (H) To Authorize the Director General, Seed Wing/Secretary (Member Secretary of the National Seed Board) to Provide Seed Dealership Registration and Renewal of Registration of Seed Dealers; and
- (I) To advise the Government about Seed Dealer Registration and Renewal Fee, Late Fee, Seed Certification Fee, Appeal settlement Fee, sample Seed testing Fee, and Seed DUS (Distinctness, Uniformity and Stability) Testing Fee.

### **2. Registration of Seed Dealers and Renewal.**

(1) To become a registered Seed Dealer, the applicant has to, in accordance to Form- 8, will have to apply to the Director General, Seed Wing/Secretary (Member Secretary) of the National Seed Board (NSB), Ministry of Agriculture after paying the necessary fee prescribed by the Government.

Note: Private Organizations are required to submit a copy of the Certificate of Membership of Bangladesh Seed Association (BSA) should be attached with the application form.

### 3. Releasing or Registration of Crop Varieties.

- (1) In order to Releasing of any Notified Kind or Variety, or Registration of any Non-Notified Kind or Variety of Crop, necessary capacities, capabilities, facilities needed to be available under the Seed Dealer are as follows-
  - (A) There must have a Plant Breeder and the said Plant Breeder must have a Bachelor's Degree in Agriculture from a recognized University; and
  - (B) There must have necessary Infrastructure, Research Field, and Seed Testing Laboratory for Plant Breeding Research and Development(R&D) for Crop Varieties.
- (2) For Releasing of Notified Crop Varieties, the Seed Dealer has to submit an application to the Director, Seed Certification Agency (SCA) as per **Form- 10** of this Seed Rules and the said application has to be settled in the manner described below, viz.: -
  - (A) The Director, Seed Certification Agency (SCA) will present the results of the evaluation of the crop variety in the meeting of the Technical Committee of the National Seed Board (NSB) as per the evaluation guidelines prepared by the National Seed Board for the purpose of Releasing of Notified Crop Varieties;
  - (B) The Technical Committee of the National Seed Board (NSB) will technically evaluate the results of the field evaluation performed by the Seed Certification Agency (SCA) on Mean Yield, Crop Growth Duration, Source of Seed and other necessary Characteristics; the Technical Committee will accordingly recommend the technically qualified crop varieties of Notified Crops to the National Seed Board (NSB) for Releasing of Crop Varieties; and
  - (C) If the proposed variety will be approved at the Meeting of the National Seed Board (NSB), a certificate of Certificate Releasing of the technically qualified varieties of Notified Crops will have to be issued by the Seed Wing of the National Seed Board (NSB) to the Seed Dealer who has been applied for Releasing of Notified Crop Variety.
- (3) For Registration of Non-Notified Crop Varieties, the Seed Dealer has to submit an application to the Director General, Seed Wing / Secretary (Member Secretary of the National Seed Board) of the National Seed Board as per **Form- 11** of this Seed Rules by paying the necessary fee prescribed by the Government and the said application has to be settled through following the necessary Official procedures as described below, viz.: -
  - (A) The Director General, Seed Wing/Secretary (Member Secretary of the National Seed Board) of the National Seed Board, on behalf of the National Seed Board, will approve the registration of the crop variety if the information mentioned in the application **Form 11** of this Seed Rules is deemed of appropriate after verification; and

- (B) The applicant Seed Dealer shall be provided a Certificate of Registration signed by the Director General, Seed Wing/Secretary (Member Secretary of the National Seed Board) of the National Seed Board (NSB).
- (4) Any Registered Seed Dealer shall not be allowed to Transfer the Releasing of any Notified Kind or Variety of Crop or Registration of any Non-Notified Kind or Variety of Crop to any other Registered Seed Dealer and shall not be allowed to Change the Name of the Releasing of any Notified Kind or Variety of Crop or Registration any Non-Notified Kind or Variety of Crop.
- (5) A private Registered Seed Dealer will be eligible to Apply for the Releasing of any Notified Kind or Variety of Crop or Registration of any Non-Notified Kind or Variety of Crop after 5 (five) years of the receipt of Dealership Registration as a Seed Dealer.
- (6) In case of any complain raised regarding the Registration of any Non-Notified Kind or Variety of Crop, the Director General, Seed Wing/Secretary ((Member Secretary of the National Seed Board) of the National Seed Board may revoke or maintain the registration of the variety subject to proper consideration and to investigation by the Inquiry Committee constituted by the Authority for this purpose.

#### 4. Classes of Seeds

There shall be the following 4(four) Classes of Seeds of any Kind or Variety of Crop (Notified Kind or Variety/ Non-Notified Kind or Variety) viz.: -

- (1) **Breeder Seed (BS):** Source of Breeder Seed (BS) shall be Nucleus Seed (NS). The Certification Tag of Breeder Seed (BS) shall be Green Color.
- (2) **Foundation Seed (FS):** Source of Foundation Seed (FS) shall be Breeder Seed (BS). The Foundation Seed (FS) shall only be used for the purpose of Multiplication of Seed (the FS shall not be allowed to directly distribute to the Farmers); Provided, however, for national need and subject to the decision of the Seed Promotion Committee (SPC) of the National Seed Board (NSB), Foundation Seed (FS) to Foundation Seed (FS) can only be produced once. The Certification Tag of Foundation Seed (FS) shall of White Color.
- (3) **Certified Seed (CS):** The source of Certified Seed (CS) shall be Foundation Seed (FS); the Certified Seed (CS) shall be the progeny of Foundation Seed (FS). The Certification Tag of Certified Seed (CS) shall be Blue Color.
- (4) **Truthfully Labelled Seed (TLS):** The source of Truthfully Labelled Seed (TLS) shall be Foundation Seed (FS) /Certified Seed (CS); Truthfully Labelled Seed (TLS) shall be the progeny of Foundation Seed (FS)/ Certified Seed (CS). The Certification Tag of Truthfully Labelled Seed (TLS) shall be of Yellow Color.

## **5. Import and Export of Seeds.**

- (1) For purpose of Seed import and export, the Seed container should have a label or mark containing the name of the crop and variety, seed quantity, date of expiry, seed moisture content, germination capacity, percentage of purity and other seed quality attributes.
- (2) Registered Seed Dealers will have to obtain prior approval of the Government for import of more than 20 (twenty) kg of Notified Kind of Variety of Crop Seeds and more than 5 (five) metric tons of Non-Notified Kind of Variety of Crop Seeds.
- (3) Registered Seed Dealers will have to obtain prior approval of the Government for export of any quantity of any Kind or Variety of Crop Seed (Notified or Non-Notified Kind of Crop Variety of Seeds).
- (4) Any quantity of any Kind or Variety of Crop Seed shall be allowed to imported with the prior approval of the Government for Research or Experimental /Adaptation purposes.

## Variety Release and Registration System in Bangladesh

In pursuance to the Seed Act, 2018 and Seed Rules-2020 the total 80(eighty) Crop Varieties have been Classified into Notified Crops (7 Notified Crops) and Non-Notified Crops (73 Non-Notified Crops). The Varieties under Notified Crops have been specified to be Released by following the “FORM-10” of the Seed Rules, 2020 and Varieties under Non-Notified Crops have been specified to be Registered by following the “FORM-11” of the Seed Rules, 2020.

The TC of the NSB of the MoA, is mandated to conduct Field Evaluation through Multilocation Trials of Notified Crop Varieties applied by following “FORM-10” of the Seed Rules, 2020. The field evaluation of Notified Crop Varieties is being performed by the SCA for two consecutive years at the selected Agricultural Regions (there are officially approved 14 Agricultural Regions) of different 30 Agro-ecological Zones (AEZs) of the country. In the two years field evaluation the most important evaluations are being conducted to *Distinctness, Uniformity and Stability* (DUS) testing as well as *Value for Cultivation and Use* (VCU) testing have been performed by the SCA in accordance to the Guidelines of UPOV. At present, NSB has approved the DUS and VCU testing procedures for two consecutive Seasons for rice, wheat, potato, sugarcane, jute, kenaf and mesta.

The DUS and VCU Tests (Field evaluation trial) results of proposed Notified Crop Variety/Varieties are compiled by the Variety Testing Officers of SCA. Compiled results of DUS and VCU tests results are discussed at the TC of NSB. Satisfactory results of proposed variety/varieties are then recommended by TC of the NSB to the NSB for final approval and releasing by the NSB.

In case of Non-Notified Crops, after developing a variety, respective public and private sector organizations (officially registered Seed Dealers) duly apply through “FORM-11” of the Seed Rules, 2020 with the Seed Wing, MoA. The Seed Wing, MoA after completing formal procedures the qualified Non-Notified Crop Variety/Varieties are officially Registered.

**The Seed Rules, 2023**  
(Amendment of The Seed Rules, 2020)

Under the authority prescribed in section 31 of the Seed Act, 2018 (Act No. VI of 2018), the following Amendment of the Seed Rules, 2020 have been prescribed by the Government.

1. The Heading of the Rule 9 as mentioned “Duties of Seed Inspector” should be replaced with “Duties of Seed Analyst”
2. Rule 11-Sub-Rule (4) should be replaced with the following Sub-Rule (4):  
No Registered Seed Dealer shall be allowed to change the Name of Released Variety of Notified Crop or Registered Variety of Non-Notified Crop;  
However, it is Noteworthy to specifically mentioned here that, the Released Variety of Notified Crop or Registered Variety of Non-Notified Crop shall be allowed to transferred by the Seed Dealer to other Seed Dealer provided the Director General, Seed Wing/Secretary (Member-Secretary of the National Seed Board) is pleased to approve the issue of Variety Transfer with conditions thereof;
3. Rule 11-Sub-Rule (5): Amendment shall be as follows-  
The Registered Seed Dealer shall be allowed to apply for Releasing of Notified Crop Variety or Registration of Non-Notified Crop Variety with the amendment of the Rule as after 1(one) Year instead of 5(five) years of Seed Dealership Registration.
4. Tafshil 4, Form 9, Rule 10, Section 6, of Seed Rule 2020: the following languages should be modified-

In case of Bangladesh Agricultural Development Corporation’s appointed Seed Dealers- the Private sector Seed Dealers should be mentioned as appointed Seed Dealers of Bangladesh Agricultural Development Corporation will have to submit Membership Certificate of Bangladesh Seed Association (BSA); this language should be replaced with the original language as mentioned in Rule (4) in the Form 9 in terms of documents needed to be attached.

**Clarification:** It may specifically be mentioned here that; the private sector Seed Dealers being appointed by the public sector Bangladesh Agricultural Development Corporation (BADC) of the Ministry of Agriculture (MoA) shall not be needed to submit the Membership Certificate of the private sector Bangladesh Seed Association (BSA).

## **Seed Certification Systems in Bangladesh**

The Bangladesh Gazette, January 31, 1974

Section-XV

Establishment of Seed Certification Agency

No. Agri/XV/3-2/74/-. Dacca, the 22nd January, 1974

The Government is pleased to establish with immediate effect, an Agency with the name of **“Seed Certification Agency”** to perform the following functions:

- i) To organize and effectively use a well-trained team of Seed Certifying Personnel.
- ii) Establish Seed Certification Standards.
- iii) Fix Seed Testing Rules.
- iv) Establish Laboratory/Seed Testing Centers for Testing of Seed.
- v) Formulate Seed Laws for the country.
- vi) Certify Seeds of varieties of crops as specified by the National Seed Board (NSB), Ministry of Agriculture (MoA).
- vii) Field demonstration of improved Seeds.

1. The Seed Certification Agency (SCA) shall be under the direct administrative control of the Ministry of Agriculture (MoA), Government of Bangladesh (GoB).
2. The Seed Certification Agency (SCA) will be headed by an Officer of the Government of Bangladesh designated as Director, Seed Certification Agency (SCA).
3. The Director, SCA will be assisted in performance of his duties by such other Officers as may be placed under him by the Ministry of Agriculture (MoA).
4. The Head Quarters of the Seed Certification Agency (SCA) shall be located at BARI-Farm, Joydebpur, Gazipur.

### **Production of Quality Seed and Seed Quality Control**

Seed is a living thing; it must be sown/grown, harvested, processed and preserved correctly to maximize its viability, vigor and subsequent crop productivity. Quality seed is produced in the field; the seed quality is controlled and maintained in the seed storage. For the yield potential of any crop variety to be realized, good quality seed must be sown/planted. Globally it is scientifically proved that, good quality seed can increase yield to the extent of 10-15 percent in case of high-yielding variety (HYV)/modern variety (MV) crop varieties, but 15-20 percent standard heterosis (yield increase) can be achieved in case of hybrid crop varieties. The extent of this potential yield increases is directly proportional to the varietal potentiality and quality of seed that is being sown/planted. Seed quality can be considered as the summation of all technical factors that contribute to seed performances.

## Principles in Quality Seed Production and Quality Control

### (A) Production and Certification of Quality Seed in the Field

1. Selection genetically pure and officially notified and registered variety for quality seed multiplication/quality seed production;
2. Inspection and approval of field for seed planting;
3. Maintaining adequate isolation to avoid contamination;
4. Roguing of undesirable plants and admixtures and weeding of noxious weeds;
5. Maintaining “Seed Health Standard” by controlling seed-borne diseases as per ‘Field Standard’.
6. Grow-out-Test (GOT) for ensuring genetic purity;
7. Certification of Seed Field according to “Field Standard”.

### (B) Seed Quality Control, Seed Testing and Seed Certification

1. Quality Seed produced in the Fields is processed (drying, grading) in the Seed Processing Centers;
2. Seed Quality is controlled in the Seed Processing Centers by maintaining seed purity, seed moisture content, seed germination capacity, seed health and seed packaging;
3. Quality Seed is stored in the ideal Seed Storage (Normal Seed Storage/Conditioned Seed Storage) by maintaining seed moisture content, seed germination capacity, seed health through controlling stored insect-pest and micro-organisms/seed-borne pathogens;
4. Declaring Seed Lot to Seed Certification Agency (SCA) for collection of seed samples for Seed Testing in the Seed Testing Laboratories of SCA;
5. The SCA collect seed samples from seed processing centers, tested seed samples in SCA Seed Testing Laboratories;
6. Issue Seed Certification and Tag for Quality Seed after testing seeds as per the “Seed Standard”.

### (C) Market Monitoring of Seed by SCA

1. The SCA is authorized to certify Breeder Seed, Foundation Seed and Certified Seed of Notified Crops;
2. The SCA is authorized to market monitoring the quality of Truthfully Labelled Seed (TLS) of Notified Crops and Non-Notified Crops;
3. SCA will assure the farmers to use high quality seeds through regular field inspection of Notified Crops and seed testing and certification of Notified Crops; market monitoring through inspection of seeds in the seed stores of Seed Distributors/Seed Dealers (The Registered Seed Dealers must be Registered Seed Dealers of the MoA);

The SCA will help farmers to assure the availability of high-quality seed which must have NSB approved seed packaging, seed labeling, and use of approved Tags for different classes of seeds so that farmers are not exploited.

**(D) Production of Quality Seed by Farmers**

1. The farmers should replace their own saved seed by high quality seeds of improved varieties;
2. Farmers need to be trained up by public sector-DAE, BADC and private sector seed industries/ seed companies/seed enterprises on using quality declared seeds, production of quality seed, maintaining seed quality in the indigenous seed storage of farmers;
3. General Farmers and Contract Growers should be trained up on maintaining their seed fields as per approved **“Field Standard”** and maintaining their produced seed quality through proper drying, cleaning, grading through indigenous methods and store of seeds in proper storage.

## Seed and Seed Quality: Technical Information for SCA Officials

**Seed Quality** means different things to different people depending on their interpretation of “Quality”. It is critical to understand the “**Seed Quality, Crop Variety and Quality Seed.**” For new varieties to reach their optimum potential in the field, it is essential to follow recommended farming practices, including the timely use of quality seed.

The adoption and spread of improved varieties depend on the quality of seed made available to farmers. High yield cannot be obtained by planting low quality seed of poor-quality variety; it is the quality of the seed that ultimately determines the plant density in the field and the number of plants established per hectare.

### Parameters of Seed Quality Attributes

**There are 4(four) parameters of seed quality attributes. These attributes of the “Field Standard” of OECD and “Seed Standard” of ISTA duly officially approved by the Ministry of Agriculture (MoA), GoB as follows:**

- (i) **Genetic Quality** - relating to the specific genetic characteristics of the crop variety (genetic purity). true-to-type nature of the seeds and whether they come from a distinct variety. Genetic purity has a direct effect on final yield. Trueness-to-type is usually determined by checking the seed source records to verify the origin and history of the seed. Alternatively, direct inspections may be carried out in the field with the guidance of control plots (Genetic Quality is verified in the field by following the Field Standard of OECD).
- (ii) **Physical Quality** - relating to the condition of the seed in the specific seed lot (physical purity, presence of other seeds and moisture content). The Physical Quality is tested in the Seed Testing Laboratory by following Seed Standard of ISTA.
- (iii) **Physiological Quality** - referring to seed performance (germination, viability and vigor). The Physiological Quality is tested in the Seed Testing Laboratory by following Seed Standard of ISTA.
- (iv) **Seed Health** - referring to the presence of diseases and insect-pests in the seed. The Seed Health is tested in the Seed Testing Laboratory by following Seed Standard of ISTA.

Seed Standard and Field Standard of 80 (eighty) different crops have been approved and officially published by the Ministry of Agriculture (MoA) in the year 2010. Out of 80 (eighty) crops, it has been categorized into two classifications:

- (i) Notified Crop (seven crops - Rice, Wheat, Potato, Sugarcane, Jute, Kenaf and Mest);
- (ii) Non-Notified Crop (73 crops).

Note: The Notified crop “Potato” has been temporarily declared “Non-Notified” in the 100<sup>th</sup> NSB Meeting of the MoA in 2019 for a period of 3(three) years. This decision of Potato Non-Notified crop is under review by a “Committee” formed by the NSB, MoA

with Terms of Reference (TOR) of the Committee through evaluation of field performances as well as laboratory testing of a total 94 Potato Varieties Registered as Non-Notified crop. Up-Dated decision will be taken by the NSB on the basis of field evaluation Report of the Committee. As per TOR-the Committee has classified the total registered Non-Notified Potato Varieties as Follows-

- (i) Yield Performance,
- (ii) Dry Matter,
- (iii) Reducing Sugar,
- (iv) Industrial Processing Qualities, and
- (v) Export Qualities.

## The Brief on Seed Standard and Field Standard as a Reference in this Respect

### The Seed and Field Standard of Paddy (Rice) as an Example

<b>Seed Standard of Paddy (Rice)</b>			
Factor	Seed Standard		
	Breeder Seed (BS)	Foundation Seed (FS)	Certified Seed (CS)
1. Pure seed (Min. % by wt.)	99.0	97.0	96.0
2. Inert matter (Max. % by wt.)	1.0	2.0	3.0
3. Other seed (Max. % by wt.)	Trace	1.0	1.0
a) Other crop seed (Max. No. in total; whole sample will be tested)	2/kg	5/kg	10/kg
b) Total weed seed (Max. No. in total; whole sample will be tested)	2/kg	8/kg	10/kg
4. Germination (Min. %)	80.0	80.0	80.0
5. Moisture content (Max. %)	12.0	12.0	12.0
<b>Note:</b> The Seed Standard for Truthfully Labelled Seed (TLS) shall be equivalent to Certified Seed (CS)			

<b>Field Standard of Paddy (Rice)</b>			
Factor	Field Standard		
	Breeder Seed (BS)	Foundation Seed (FS)	Certified Seed (CS)
1. Isolation distance (in meter)	3.0	3.0	3.0
2. Other crop plants (Max. % by No.)	0.0	0.1	0.2
3. Other varieties (Max. % by No.)	0.0	0.1	0.5
4. Weed plants (Noxious Max. % by No.)	0.0	0.01	0.02
a. Wild rice/Red rice			
b. Burnyard grass			
5. Plants infected by seed borne diseases (Max. % of infected plants)	5.0	10.0	20.0
6. General condition of crop: If the field crops severely damaged or lodged and irregularly flowered that makes crop assessment difficult to judge the trueness of variety and varietal purity will be rejected.			
<b>Note:</b> The Field Standard for Truthfully Labelled Seed (TLS) shall be equivalent to Certified Seed (CS)			

## Naming of Crop Varieties

In pursuance to the NSB Meetings of the MoA, the writing of name of crop varieties developed by different public sector Agricultural Research Institutes (ARIs) under NARS, public Agricultural Universities, public sector BADC and private sector Seed Industries, Seed Companies, Seed Enterprises (Officially Registered with the Ministry of Agriculture) the Crop Varieties Naming Guidelines have been approved.

The NSB Meetings of MoA on 30<sup>th</sup> NSB (held on October 26, 1993), 32<sup>nd</sup> NSB (held on July 25, 1994) 103<sup>rd</sup> NSB (held on September 8, 2020) and latest 104<sup>th</sup> NSB (held on February 9, 2021) the naming of agricultural crop varieties has been approved for all public and private organizations. The officially approved naming of agricultural crop varieties for **Notified and Non-Notified Crop Varieties (it includes HYV/HYMV /Hybrids)** are as follows:

Appropriate Naming Guidelines				Remarks
Name of Organization in Abbreviation	Name of Crop in small letter	Serial No. of Variety	Example of correctly naming of Variety	Incorrect/Inappropriate naming of Variety
BRRRI	dhan	27	BRRRI dhan 28	
BINA	dhan	25	BINA dhan 25	Binadhan-25
BARI	alu	91	BARI alu 91	BARI Alu-91
BWMRI	gom	1	BWMRI gom 1	BWMRI Gom-1
<p><b>Note:</b> In case of BRRRI-the initial naming of Rice varieties was BR 1 to BR 26 (BR-means Bangladesh Rice). Since at that time only BRRRI (Bangladesh Rice Research Institute) was the only public sector Agricultural Research Institute developed Rice variety as such the naming was BR (Bangladesh Rice). After initiation of Rice Varietal Development by other public sector Research Institutes under NARS and public Agricultural Universities the naming of Rice Varieties of BRRRI (Bangladesh Rice Research Institute) has been started from BRRRI dhan 27 to onwards as well as initiation of naming of Rice Varieties were followed by respective public and private sectors using their organizational name (example BINA dhan).</p>				

## International Seed Testing Association (ISTA) Membership Seed Testing Laboratory in Bangladesh

In Bangladesh the following Seed Testing Laboratories of public and private sector organizations have duly accorded Membership and Accreditation by the ISTA

Name of the Seed Testing Laboratory Organization	Status of the Organization (Public/Private)	Status of Membership of ISTA
1. Seed Certification Agency (SCA)	Public sector Organization of the Ministry of Agriculture (MoA)	Laboratory Member of ISTA; Personal Member of ISTA
2. Bangladesh Agricultural Development Corporation (BADC)	Public sector Organization of the Ministry of Agriculture (MoA)	Laboratory Member of ISTA; Personal Member of ISTA
3. Lal Teer Seed Limited	Private sector Seed Industry/Seed Company of the MoA	Personal Member of ISTA; ISTA Accreditation to MNT Seed Testing Laboratory of Lal Teer Seed Limited in Bangladesh dated May 11, 2023;
4. Supreme Seed Company Limited	Private sector Seed Industry/Seed Company of the MoA	Associate Member of ISTA
5. ACI Limited	Private sector Seed Industry/Seed Company of the MoA	Laboratory Member of ISTA; Personal Member of ISTA;

## Plant Quarantine Regulation for Quality Seed Import and Export

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### History of Plant Quarantine Regulation

The first plant quarantine Act was promulgated in Rollen, France in 1860 to suppress and prevent the spread of common barberry, the alternate host for wheat stem rust. Among other countries, the first few to establish plant quarantine services were Germany, France, Australia and the U.S.A.

Sl. No.	Plant Quarantine Regulation
1	In British-India, Legislative measures against crop pests (Diseases and Insect-Pests) were initiated under the “Destructive Insects and Pests Act, 1914 (DIP Act).” This “DIP Act, 1914” was passed by the Hon’ble Governor General of India on February 3, 1914.
2	Bangladesh (the then East Pakistan of Pakistan)), in 1966 promulgated “Destructive Insects and Pests Rules, 1966 (Plant Quarantine)” in accordance to the “Destructive Insects and Pests Act, 1914 (DIP Act).”
3	In 1989 Bangladesh promulgated the “Destructive Insects and Pests Rules, 1989” in accordance to the “Destructive Insects and Pests Act, 1914” and “Destructive Insects and Pests Rules, 1966.”
4	In 2011 Bangladesh promulgated “Plant Quarantine Act, 2011”
5	In 2018 Bangladesh promulgated “Plant Quarantine Rules, 2018”

### Important Regulatory and Technical Information on the Plant Quarantine Regulation

Bangladesh though an agricultural country has to import a huge quantity of seeds and other plant and plant products. Plant Quarantine" means the effort to prevent entry, establishment or spread of a foreign pest in the country through legal restriction on the movement of plant and plant products.

The term “**Regulation/Legislation**” refers broadly to all legal texts that are promulgated by the legislative arm of the state exercising its legislative powers under the constitution. Regulations / Laws establish the general principles of plant protection legislation and the inherent phytosanitary policy, and designate and empower appropriate authorities, among other things.

**PLANT QUARANTINE, 2011**  
BANGLADESH GAZETTE  
PUBLISHED BY THE AUTHORITY  
GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH  
MINISTRY OF AGRICULTURE  
PLANT QUARANTINE ACT, 2011  
ACT NO, V OF 2011  
APRIL 5, 2011

An Act to make provisions, in the context of international traffic in plants and plant products, for preventing the introduction of insects or pests into, and spread thereof within Bangladesh and for the matters relating to phytosanitary and other measures incidental and ancillary thereto.

**National Plant Quarantine Authority and its Functions**

National Plant Quarantine Authority.

- (1) For the purposes of this Act, the Government shall establish an authority to be called the National plant Quarantine Authority.
- (2) The Director, Plant protection wing, Department of Agricultural Extension, shall be deemed to be the National plant Quarantine Authority and shall exercise all the powers of the Authority under this Act until an independent National Plant Quarantine Authority is established under subsection (1).

**Powers and functions of the Authority:** The powers and functions of the Authority shall be as follows: -

- (a) to regulate the import of plants or plant products (issuing Import Permit-IP), beneficial organisms and packing materials for preventing the introduction of quarantine pests into Bangladesh from other country;
- (b) to regulate the export of plants or plant products, pests, beneficial organisms and packing material according to the phytosanitary requirements of the importing country in consistence with international agreements;
- (c) to make arrangement for issuing phytosanitary certificates (PC) in accordance with the phytosanitary requirements of the importing countries;
- (d) to comply with the international agreements, protocols, conventions, etc. on phytosanitary measures, of which Bangladesh is a party or a signatory country, and to conduct implementation activities thereof, and to follow, conduct and coordinate the activities regarding conservation of plant biodiversity;

**Prohibition or restriction on import and export of plants or plant products, etc.**

- (1) The import or export of any plants or plant products which have the potential threat to introduce any pest into plants and plant products may be prohibited, restricted or otherwise controlled subject to the conditions mentioned in the import or export policy

order issued by the Government, from time to time, under the Imports and Exports (Control) Act, 1950 (Act No. XXXIX of 1950)

### Regulations of plants or plant products for Quarantine

All the plants or plant products confined or confiscated for quarantine shall remain under the custody of the plant quarantine officer and he shall take necessary measures in the manner prescribed by rules for the purposes of quarantine of such plants or plant products.

### Import and Export

Prohibition against import. (1) No importer shall, without an import permit (IP), import any plant or plant product, beneficial organism, soil or packing materials into Bangladesh.

(2) The Authority may, with prior sanction of the Government, from time to time, prescribe the procedure for importing plants or plant products.

(3) The Authority may, with approval of the Government, by notification in the official Gazette, from time to time, exempt plants and plant products from the conditions of import.

(4) Permit and certificate. Plants or plant products, beneficial organisms or packing materials shall not be imported into Bangladesh without an import permit (IP) and certificate issued by the Authority.

(5) Any plant or plant product, beneficial organism or packing material shall be imported into Bangladesh only through a designated point of entry, and upon notification for importation, the import permit issued against the consignment and the phytosanitary certificate (PC) issued by the National Plant Protection Authority of the exporting country shall have to be submitted to the concerned plant quarantine officer for examination.

(6) on the import permit (IP), there shall have a description regarding the type of treatment to be applied on the plants or plant products, if imported, or other measures, including post-entry quarantine for ascertaining phytosanitary before or after importation of plants or plant products.

### Phytosanitary

Phyto means 'Plant' and 'Sanitary' means 'health' so, Phytosanitary indicates concerning the health of plants; especially the free from pest which require quarantine. 'Phytosanitary' Measures means any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests. Phytosanitary procedure: Any official method for implementing phytosanitary measures including the performance of inspections, tests, surveillance or treatments in connection with regulated pests. Phytosanitary certification: Use of phytosanitary procedures leading to the issue of a phytosanitary certificate (PC).

Plant Quarantine Regulatory measures are taken at the national level (Domestic Quarantine) as well as international level (Foreign Quarantine). The enforcement of the quarantine measures is supported by legal enactments, called quarantine Acts/Rules. It acts as an important tool in excluding pests from the crop. Effective implementation of quarantine is highly emphasized for manage of quarantine pests, which in turn helps in maintaining the productivity of crops

Globally it is recognized (WTO, FAO, IPPC, ISPM) that the principal objectives of Plant Quarantine Regulations are to prevent introduction of any quarantine pests (diseases and insect-pests, or other pests), which may be destructive to plant or plant products (Seeds/Planting Materials/ Germplasms) while importing from abroad.

### **Principles of Plant Quarantine as related to International Trade**

The Principle of Plant Quarantine Regulation with the aim of preventing the introduction of quarantine pests into their territories, it is recognized that countries may exercise the sovereign right to utilize phytosanitary measures to regulate the entry of plants and plant products and other materials capable of harboring plant pests.

The primary aim in formulating the principles of Plant Quarantine Regulation is to facilitate the process of developing international standards for plant quarantine. It is envisaged that implementation of these principles by the relevant phytosanitary authorities will result in the reduction or elimination of the use of unjustifiable phytosanitary measures as barriers to trade. Furthermore, in addition to general principles there are others specific to particular areas of quarantine activity. The general principles indicate the process of development of phytosanitary measures as applicable to international commerce. These general principles should be read as a single entity and not interpreted individually. The specific principles either directly support the International Plant Protection Convention (IPPC) or are related to particular procedures within the plant quarantine system.

It is expected that the principles will be subject to continuing review and should reflect changing quarantine concepts and technologies. The interpretation and implementation of these principles shall be coherent with the relevant provisions to be established in the context of the World Trade Organization (WTO), and International Plant Protection Convention (IPPC).

**PLANT QUARANTINE RULES, 2018**  
BANGLADESH GAZETTE  
**PUBLISHED BY THE AUTHORITY**  
GOVERNMENT OF THE PEOPLE’S REPUBLIC OF BANGLADESH  
**MINISTRY OF AGRICULTURE**  
THURSDAY, MAY 10, 2018  
**NOTIFICATION**  
Date: April 24, 2018 AD

**S.R.O. No. 119-Law/2018.** In exercise of the powers conferred under section 39 of the Plant Quarantine Act, 2011 (Act V of 2011), the Government enacted the following Rules, namely: **Title:** This Rules shall be called the Plant Quarantine Rules, 2018.

In the Plant Quarantine Rules, 2018-the Ministry of Agriculture (MoA), Government of Bangladesh (GoB) has issued different Rules to protect domestic plants and plant products from foreign invasive Quarantine Pests (Diseases, Insects and other harmful Pests). The Rules includes “**PROFORMA**” for Import Permit (IP) for importing Plants and Plant Products (Seeds, Planting Materials, Germplasms), Phytosanitary Certificate (PC) for export of Plants and Plant Products. The Rules also specify additional conditions for complying of the exporting country Plant Quarantine Authorities.

Plant quarantine means activities, which aim at preventing and controlling the harmful organisms subject to quarantine, and exotic harmful organisms from entry or being spread. The Plant Quarantine Rules followed different Global Guidelines in respect of Plant Quarantine Regulations of WTO, FAO, **CPM**, IPPC and ISPM.

#### **Standard Setting Process**

The International Plant Protection Convention (IPPC) is the standard setting organization. responsible for preventing the spread and introduction of invasive alien species (quarantine pests) affecting plants and plant products.

International Standards for Phytosanitary Measures (ISPMs) are standards adopted by the Commission on Phytosanitary Measures (CPM), which is the governing body of the International Plant Protection Convention (IPPC). The IPPC is the only standard setting organization for plant health. In addition, these standards are recognized as the basis for phytosanitary measures applied in international trade by the Members of the World Trade Organization (WTO) under the Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement).

The development and adoption of standards, recommendations, diagnostic protocols and phytosanitary treatments is currently the major role of the Commission on Phytosanitary Measures (CPM) and the IPPC Secretariat. The FAO provides a neutral forum for members to negotiate such international instruments as the International Plant Protection Convention (IPPC). The IPPC standards are recognized by the World Trade Organization (WTO) as international benchmarks for trade in plant commodities. The WTO Agreement

on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) recognizes standards developed under the auspices of the IPPC as the only international standards for plant health. **International Standards for Phytosanitary Measures (ISPMs)** are adopted by the Commission on Phytosanitary Measures (CPM) and come into force once countries establish aligned requirements within their national legislation. The standards of the IPPC are recognized as the basis for phytosanitary measures applied in trade by the Members of the WTO.

The standard setting work of the IPPC is led by the Commission's Standards Committee. The Standards Committee (SC) is supported by various technical panels, expert working groups, and the IPPC Secretariat. The **Standard Setting Unit** is committed to efficiently facilitate the development of harmonized international standards through a transparent and inclusive process meeting the needs of contracting parties.

### **Import Permit (IP)**

Subject to the provisions of the Section 10 of this Rule, in case of import of the following plant or plants products, importer should apply to the authority for an import permit (IP): Seeds for sowing and other breeding materials for research and educational purposes, the importer shall have to apply to the Plant Quarantine Authority for an Import Permit (IP).

**Note:** In case of importing more than 20 (twenty) kg Seed of Notified Crop and more than 5 (five) metric tons Seeds of Non-Notified Crop, the import permit (IP) shall be issued subject to prior approval from the Government.

**Explanation – “Notified Crop”** means any Crop or Variety as defined in the section 2(7) of the Seed Act, 2018 (Act VI of 2018).

### **Phytosanitary Certificate (PC)**

In case of export or re-export of plants and plant products, exporter should apply to the Plant Quarantine Authority for phytosanitary certificate (PC)

The Plants and Plant Products for import and export have been categorized.

In case of Seeds/Planting Materials it has been mentioned in the IP “**Seeds for Sowing or Grains for Consumption (example Rice).**”

### **Conditions of Import**

Hot water treatment at 52-55°C for 15 minutes or/and seed dressing with appropriate fungicide (Carbendazim group fungicide) @ 3 g/1kg of seeds.

# Quality Testing of Seeds: Procedures and Standards

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## Quality Seed

Quality seed is defined as varietal pure with high germination percentage, free from disease and disease organisms, and with proper moisture content. Quality seed ensures good germination, rapid emergence and vigorous growth contributing better yield performance

## Seed Testing

Seed testing is the science of evaluating seed quality of seed lot, which is to be proceed in market for sale. It is done for determining planting value of seed along with following objectives:

- i). to identify seed quality problems and their probable cause
- ii). to determine the need for further processing or any other specific procedures
- iii). to determine if seed meets established quality standards or labeling specifications
- iv). to establish quality and provide a basis of price among the lots in the market.

## Quality Attributes

*Genetical purity* - trueness and pure

*Physical quality* - pure seed (free from other crop seed, weed seed, inert matter, low moisture)

*Physiological quality* - high germination capacity with seedling vigour

*Pathological quality* - free from seed borne diseases

## Genetical Purity Test

Each aspect of seed quality may be the result of different testing procedure. For determination of genetical purity control plot test or grow out test is done. Control plot tests are used to monitor the identity and purity at various stages in seed multiplication program. The control plot tests confirm to the description of the variety, thereby confirming its identity. The identification of off-type plants within the control plot measures the uniformity of the seed lot. Is also determines whether or not the characteristics of the variety have remained unchanged during seed multiplication. Control plot tests may be pre or post control depending upon the time of test.

Genetic purity may also be determined in the laboratory with the following techniques:

- (i). Visual observation - shape, colour or other physical features
- (ii). Seed germination - while determining germination percentage, certain cultivar of cereals can be classified by the color of their coleoptiles. The color of the coleoptiles may change from green to violet. Some cultivar of *Beta sp.* can be identified by seedling color, some *Brassica sp.* can be identified by color of cotyledons etc.
- (iii). Use of ultraviolet light - color differences which are not normally visible may appear under ultra-violet light e.g. in the roots of beet seedlings
- (iv). Other tests like, Fluorescent test for verification of oats varieties; Phenol colour test; Sodium Hydroxide test for verification of wheat varieties; Verification of sorghum varieties by KOH bleach test of seed; Identification of red rice by KOH test; Peroxidase activity test in Leguminaceae; Verification of *Melilotus sp.* By copper sulphate ammonium test and Amonium Fluorescent test for *Festuca sp*
- (v). DNA finger printing

The responsibility of maintaining genetic purity of breeder seed lies with the plant breeder who has evolved the variety, while the genetic purity of foundation and certified seed classes is ensured through seed certification.

### Moisture Test

The life process of seed revolves around the seed moisture content. The moisture content of seed should not be too high or too low. Seed moisture content should be brought to the desirable level through drying enabling to preserve their viability in storage and avoiding the spoilage by insects and pathogens.

The moisture content of seed is the loss in weight when it is dried. Moisture content (MC) of seed may be expressed both as fresh weight and dry weight basis.

$$\text{MC (\%)} = \text{Weight of water} / \text{weight of fresh seed} \times 100 \text{ (wet basis)}$$

$$\text{MC (\%)} = \text{Weight of water} / \text{weight of dry seed} \times 100 \text{ (dry basis)}$$

There are several methods may be used for determination of seed moisture but constant temperature oven method is the most appropriate as per ISTA rules.

*Methods of moisture determination:*

- i). Moisture meter: quick method
- ii). Oven dry method

Low constant temperature oven method (103°C for 17 hours)

High constant temperature oven method (130°C for 4 hours)

Apparatus:

- i). An adjustable grinding mill
- ii). Constant temperature oven

- iii). Metallic containers
- iv). Desiccators
- v). Analytical balance
- vi). Sieve

*Procedure:* The submitted sample shall be accepted for moisture determination only if it is in an intact, moisture proof container from which as much air possible has been excluded. Weighing of the sample shall be in grams to three decimal places. Weighing of the working sample shall be carried in duplicate in two independently drawn working sample each of the following weight, depending on the diameter of the containers used:

Less than 8 cm diameter - 4 to 5 g

8 cm diameter or larger - 10 g

Before the working sample is drawn, the submitted sample shall be thoroughly mixed by one of the following methods:

- i). Stir the sample in its container with a spoon, or
- ii). Place the opening of the original container against the opening of a similar container and pour the seed back and forth between the two containers.

*Calculation of results:*

The moisture content as a percentage by weight shall be calculated to one decimal place by means of the following formula:

$$(M_2 - M_3) / (M_2 - M_1) \times 100$$

Where,

M<sub>1</sub> - is the weight in grams of the container and its cover,

M<sub>2</sub> - is the weight in grams of the container, its cover and its contents before drying,

M<sub>3</sub> - is the weight in grams of the containers, cover and contents after drying.

*Tolerance:*

The result of the arithmetic mean of the duplicate determination carried out on a sample is to considered if the difference between the two determinations does not exceed 0.2%. Otherwise, the determination in duplicate have to be repeated

## Purity Test

The actual planting of seed can be determined only when the purity analysis and germination are considered together. The components examined in purity analysis are pure seed, inert matter and seeds of other species. The objectives of purity test are to determine percentage of components by weight of the sample being tested and to identify of the various species of seeds and inert particles constituting the sample.

### *Methodology*

For purity analysis working sample is taken from the submitted sample by mixing and reducing

The weight of the working sample for is calculated on the basis of a population of 2500 seeds.

The identification of seed is usually by comparison with a mental image, a reference collection or with illustrations. In most cases, the useful clues for the identification of seeds comes from size, shape, color surface markings, texture and the shape and position of the attachment of the scar. Wings, scales, spines, awns or presence of hairs may also be useful.

*Pure seed:* Pure seed is classified after the pure seed definition (PSD) of the appropriate species. In general, the following structures (even immature, under sized, shriveled, diseased or germinated, providing they can be definitely identified as of that or species) indicate the pure seed. As for example, in case seeds of Poaceae (i) Florets with an obvious caryopsis containing endosperm, (ii) Free caryopsis and (iii) Pieces of seed unit larger than one half of their original size.

*Other seed:* Other seeds include seed unit of any plant species other than that of pure seeds; for species and genera without pure definition in 3.2.1.A the definition in 3.2.1 shall apply; multiple structure, capsules, pods are opened and the seeds are removed and the non-seed materials placed in the inert mater, except in certain species or genera as indicated in the pure definition.

*Inert mater:* Inert mater shall include seed units and all other structures not defined as pure seed or other seed as follows:

- i). Seed units in which it is readily apparent that no true seed is present.
- ii). Florets of those species listed in 3.5.2A.2 of ISTA rules with a caryopsis less than the minimum size described. Sterile florets attached to fertile florets are to be removed, except in certain genera listed in 3.5.2.A.2
- iii). Pieces of broken or damaged seed units half or less than the original size.
- iv). Those appendages not classed as being part of the pure seeds in the pure seed definitions for the species. Appendages not mentioned in the pure seed definitions must be removed and included in the inert mater.

- v). Seeds of *Fabaceae*, *Brassicaceae*, *Copressaceae*, *Pinaceae*, *Texaceae* and *Taxodiaceae* with the seed coat entirely removed.
- vi). Unattached sterile florets, empty glumes, lemmas, paleas, chaffs, stems, leaves, cone scales, wings, bark, flowers, nematode galls, fungal bodies such as ergot, sclerotia and smut balls, soil, sand, stones and all other non-seed matters.
- vii). All materials left in the light fraction when the separation is made by the uniform blowing method (3.5.2.A.5) except other seeds. In the heavy fraction, broken florets and caryopsis, half or less than half the original size and all other matters except pure seed and other seeds.

### *Calculation of results*

This sum must be compared with the original weight as a check against gain or loss. If there is a discrepancy of more than 5% or the initial weight, retest must be made (tolerance). The percentage by weight of each component parts to be reported on the analysis certificate shall be given to the one decimal place. The percentage must be based on the sum of the weight of the components, not on the original weight of the working sample.

### **Germination Test**

The essential quality of the seed is the viability. If all other qualities of the seeds are hundred percent perfect and seed is non-viable, there is no use of other excellent qualities as seed. The objective of the germination test is to determine the maximum germination potential of a seed lot, which can in turn be used to compare the quality of different lots and also estimate the field planting value. The germination test is carried out under the best possible optimal conditions with regard to the temperature, moisture, substrate, and light, as to give the most complete, rapid and regular germination for the majority of the sample of a particular species.

### *Counting equipments*

- i). Counting board - used for large seed such as *Zea*, *Phaseous* and *Pisum*
- ii). Vacuum counter - mostly used for species with regular shaped and relatively smooth seeds such as cereals, *Brassica* and *Trifolium* species.

### *Germination apparatus*

- i). Bell jar or Jacobsen apparatus (Copenhagen tank) - this apparatus usually consists of a germination plate upon which filter papers substrate with seeds are placed. The substrate is kept continuously moist by means of a wick, which extends down through the slits or holes in the germination plate in to the underline water bath.
- ii). Germination cabinet - This type apparatus is the closed cabinet for germinating seeds in darkness or light. Modern cabinets are well insulated and have both heating and cooling systems. Suitable models are available for constant and alternating

temperatures covering the full range required. The temperature may be maintained by circulating water or air or both through the cabinet.

- iii). Room germinator - it is modification of the germination cabinet. It is constructed on the same principles, in large enough to permit workers to enter and place the test along either side of a central passageway. Alternatively, tests can be placed on trolleys which are then wheeled in to the room for the test period. Unless tests are enclosed in moisture proof containers, room humidifiers should be installed to maintain a high level of humidity.

### *Procedure*

**Working sample:** A number of 400 seeds are counted at random from the well mixed pure seeds. Care should be taken that there is no selection of seeds thus causing biased results. Replicates of 100 seeds are normally used. To ensure adequate spacing, split replicates of 50 or 25 seeds may be necessary particularly where there is seed borne disease present.

**Paper substrate:** Paper substrate is used for the top of the paper (TP), between paper (BP) and pleated Paper (PP). In TP, seeds are germinated on top of one or more layers of paper. In BP method, seeds are germinated between two layers of papers and in PP, the seeds are placed in a pleated, accordion like paper strip with 50 pleats, usually two seeds to a pleat.

**Sand substrate:** Sand substrate is used as Top of Sand (TS), and in Sand (S). For TS, the seeds are pressed in to the surface of the sand. In S method the seeds are planted on a level layer of moist sand and covered with 10 to 20 mm of uncompressed sand depending of the size of the seeds.

**Moisture and aeration:** The substrate must all the times contain sufficient moisture to meet the requirements for germination. However, moisture content must not be excessive, as aeration may be limited. The initial quantity of water to be added will depend on the nature and dimensions of the substrate and also on the size and species of the seed to be tested.

**Temperature:** Temperatures prescribed in Table 5A of ISTA rules are those the seed is exposed to on, or inside the substrate. They should be as uniform as possible through out the germination apparatus, cabinet or room germinator. Where alternating temperatures are indicated, the lower temperature should usually be maintained for 16 hours at the higher for 8 hours.

**Light:** Seeds of most of the species in Table 5A will germinate either in light or in darkness. However, illumination of the substrate from an artificial source or by indirect day light is generally recommended, as better developed seedlings, which are more easily evaluated are produced.

**Evaluation**

Seedlings are evaluated in the form of normal seedling, abnormal seedlings, hard seeds, fresh seeds and dead seeds. Generally, two types of seedlings are found from the test - normal and abnormal. Normal seedlings are those which show the potential for continued development in to satisfactory plant when grow in good quality soil and under favorable condition of moisture, temperature and light. Abnormal seedlings do not show the potential to develop in to a normal plant when grown in good quality soil and under favorable condition of moisture, temperature and light.

#### *Category of normal seedlings*

Intact seedling - seedlings with all their essential structures well developed, complete, in proportion and healthy.

Seedling with slight defects - seedling showing certain slight defects of their essential structures, provided they show another wise satisfactory and balanced development comparable to that of intact seedling of the same test.

Seedling with secondary infection - seedling which it is evident would have confirmed with above mentioned, but which have affected by fungi or bacteria from sources other than the parent seed.

#### *Category of abnormal seedlings*

Damaged seedling - seedling with any of the essential structures missing or so badly and irreparably damaged that balanced development can not be expected.

Deformed or unbalanced seedling - seedling with weak development or physiological disturbances or in which essential structures are formed or out of proportion.

#### *Ungerminated seeds*

Hard seed - at the end of a germination test hard seeds are counted and reported as such on the certificate.

Fresh seed - measures as described in 5.6.3A must be taken in induced to germination, specially if large numbers are found. If fresh seeds are to be reported as rate of 5% or more, it must be verified that these seeds have the potential to produce normal seedling. This may be tested by tetrazolium test or other appropriate test.

Dead seed - obviously dead seeds are counted and reported as such on the certificate. If can be seen that a seed has produced any part of a seedling even though decayed at the time of assessment, it is counted as abnormal seedling and not as a dead seed.

#### **Retest**

The result of a test shall be considered unsatisfactory and shall not be reported and second test may be made by the same or alternative method under the following circumstances.

- i). When dormancy is suspected
- ii). When the result may not be reliable because of phytotoxicity or spread of diseases.
- iii). When there is difficulty in deciding the correct evaluation of a number of seedling.

- iv). When there is evidence of errors in test conditions, seedling evaluation or counting.
- v). When the range for the 100 seeds replicates exceed the maximum tolerated range.

### *Calculation of results*

Results are expressed as percentage by number. When four 100 - seed replicates of a test are within the maximum tolerated range (Table 5.1 - ISTA). The average percentage is calculated to nearest whole number.

### Tolerance

The result of a germination test can be relied upon on the difference between the highest and lowest replicates with in accepted tolerances. To check the reliability of a test result, the average percentage of the replicates is calculated and compare with Table 5.1 of ISTA rules. The result is reliable, if the difference between the highest and lowest replicates does not exceed the tolerance indicated.

## **Seed Health Test**

Seed health is also an important seed quality attribute and quality seed should be free from pathogens. Infection of seed by pathogen may affect germination and seedling vigour and thereby reduces the crop yield. Seed health refers primarily to presence or absence of diseases causing organisms, such as fungi, bacteria and viruses, and animal pests, such as eelworms and insects, but physiological conditions such as trace elements may be involved. The objective of seed health test is to determine the health status of a seed sample, and by inference that of the seed lot.

### *Health testing of seed is important for four reasons -*

- i). Seed borne inoculum may give rise to progressive disease development in the field and reduce the commercial value of the crop.
- ii). Imported seed lots may introduce diseases into new regions. Tests to meet quarantine requirements may therefore be necessary.
- iii). Seed health testing may elucidate seedling evaluation and causes poor germination or field establishment and supplement germination testing.
- iv). Seed health test results may indicate the necessity to carry out seed lot treatment in order to eradicate seed borne pathogen or reduce the risk of disease transmission.

### *Methods of seed health testing -*

#### A. Examination of dry seed

- Direct examination
- Examination of imbibed seeds
- Examination of organisms removed by washing

#### B. Examination after incubation

- Blotting paper
- Sand, compost or similar substrate
- Agar plates

C. Examination of growing plants

D. Bioassay

Pathogen specific test:

Fungal Pathogen - visual inspection; NAOH test; microscopic examination; incubation test; serology test; developing seedling examination and controlled environment test.

Virus Pathogen - visual inspection; microscopic examination; infectivity test; ELISA; serology test; electron microscopy test and developing seedling examination under insect proof chamber.

Bacterial Pathogen - visual inspection; microscopic examination; biochemical test and physiological test.

### Seed standards

Seed quality control measures stipulated to provide the standards for labelling and for seed certification. The standard should be realistic and achievable. The standard should be based on the analytical data generated by the seed testing laboratories. It would be desirable that before obtaining the final approval of the standard by the competent authority, the standards should be discussed thoroughly by a committee which is represented by the seed producers, certification and seed law enforcement officials.

#### Seed Standard of Rice

Quality attributes	Standard		
	Breeder	Foundation	Certified
1. Pure Seed (Min. % by wt.)	99	97	96
2. Inert matter (Min. % by wt.)	1	2	3
3. Other Seed (Max. % by wt.)	Trace	1	1
a. Other crop seed (Max. no. / kg)	2	5	10
b. Total weed seed (Max. no. / kg)	2	8	10
4. Germination (Min. %)	80	80	80
5. Moisture Content (Max. %)	12	12	12

### Field Standard of Rice

Field standard	Standard		
	Breeder	Foundation	Certified
1. Isolation distance (m)	3	3	3
2. Other crop plants (max. % by no.)	0	0.1	0.2
3. Other varieties (max. % by no.)	0	0.1	0.5
4. Weed plants (obnoxious max. % by no.)	0	0.01	0.02
5. Seed borne disease (max. % by no.)	5	10	20

### Seed Testing Results

Lab. No. / Reg. No.:	Date of seed test		
Date of sample received	From:	To:	
Reference:	Crop:	Lot No.:	
Source:	Variety:	Lot size:	
	Seed class:		
<b>A. Purity test</b>			
Pure seed (%):	Other crop seed (%):	Weed seed (%)	Inert matter (%)
<b>B. Germination test</b>			
Normal seedling (%):	Abnormal seedling (%):	Hard seed (%)	Dead seed (%)
<b>C. Moisture test</b>			
Seed moisture content (%):			
Test results:			
Pure seed (%) :			
Germination (%) :			
Moisture (%) :			
Remarks:			
Purity:			
Germination:			
Moisture:			
Others:			
Test by		Counter signed by	

Seed certification standards may refer to the field condition or may refer to the procedures in inspection of the harvested produce as well as the manner of harvesting transporting, processing and packing. In addition, field and seed standards, such as isolation distances, inseparable other crop seeds, weeds, plants affected by seed-borne disease, genetic purity, percentage of pure seeds, other crop and weed seeds, inert matter, moisture content, germination and insect damage should be prescribed for successful accomplishment of the certification. For the purpose of labeling the seed under the seed law enforcement programme, the standard for pure seed and germination is usually required. These standards will vary according to the kind of seed. The standards should be reviewed at timely intervals in order to make them realistic.

# Factors Influencing Seed Germination and Viability

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## 1. Seed germination

Seed germination is the process by which a seed develops into a new plant under favorable conditions. It begins with water absorption (imbibition) and ends with the emergence of the embryonic root (radicle) and shoot (plumule).

### Phases of Seed Germination

Seed germination occurs in *three* main phases:

#### *Imbibition* (Water Uptake Phase)

- The seed absorbs water, causing it to swell and soften.
- This activates metabolic processes, such as enzyme activation and respiration.
- It is the initial step that breaks seed dormancy and prepares it for growth.

#### *Lag Phase* (Enzyme Activation and Metabolism)

- The seed does not absorb more water but undergoes internal biochemical changes.
- Stored food (starch, fats, and proteins) is broken down into energy and nutrients.
- Enzymes like amylase, protease, and lipase become active.
- Cellular respiration increases, providing energy for growth.

#### *Radicle Emergence* (Growth Phase)

- The embryonic root (radicle) breaks through the seed coat and starts growing downward.
- The shoot (plumule) starts growing upward toward light.
- The seedling develops into a young plant with functional roots and leaves.

## 2. Factors Affecting Seed Germination

### A. Environmental Factors

Seed germination is a crucial stage in the plant life cycle, influenced by various environmental factors. Understanding these factors can help in improving germination rates and ensuring successful plant growth. Below are the primary environmental factors affecting seed germination, along with examples:

#### 1. Water Availability

Water is essential for seed germination as it activates metabolic processes. It facilitates the breakdown of stored food, initiates enzyme activity, and softens the seed coat for embryo expansion. Insufficient water prevents germination, while excessive water can lead to oxygen deficiency and seed decay.

Example: Desert plants like cacti have seeds that remain dormant until significant rainfall occurs, triggering germination.

## 2. *Temperature*

Temperature plays a key role in enzymatic activity and cellular metabolism. Each plant species has an optimal temperature range for germination. Generally:

- Cool-season crops germinate well between 5°C to 15°C (41°F to 59°F).
- Warm-season crops require temperatures between 20°C to 30°C (68°F to 86°F).

Extreme temperatures can either slow down or completely inhibit germination.

Example: Lettuce seeds require cooler temperatures (below 25°C) to germinate effectively, while tomatoes germinate best at warmer temperatures (25-30°C).

## 3. *Oxygen Availability*

Oxygen is vital for cellular respiration, which provides the necessary energy for seedling growth. Seeds buried too deeply or in waterlogged soils may suffer from oxygen deficiency, leading to poor germination.

Example: Rice seeds can germinate in flooded conditions due to their ability to tolerate low oxygen, unlike most other crop seeds.

## 4. *Light (Photoperiodism)*

Light requirements vary among plant species:

- Some seeds, such as lettuce and many small-seeded plants, require light for germination (positive photoblastic seeds).
- Others, like beans and peas, do not require light and may even germinate better in darkness.

Example: Tobacco seeds require light for germination, whereas onion seeds can germinate in darkness.

## 5. *Soil Composition and pH*

The physical and chemical properties of soil significantly impact germination. Well-drained, aerated soil promotes healthy seedling growth, while compacted soil can hinder root penetration. Additionally, soil pH influences nutrient availability:

- Most seeds prefer a pH range of 5.5 to 7.5.
- Highly acidic or alkaline soils may inhibit germination.

Example: Blueberries require acidic soil (pH around 4.5-5.5) for optimal germination, while alfalfa thrives in neutral to slightly alkaline soil.

## 6. *Seed Dormancy and Pre-Treatment*

Some seeds have natural dormancy mechanisms that require specific environmental conditions to break. Pre-treatments such as stratification (cold treatment), scarification (mechanical or chemical treatment to weaken the seed coat), or soaking can enhance germination.

Example: Apple seeds require stratification (exposure to cold temperatures) for several weeks before they can germinate.

## B. Internal Factors

Seed germination is influenced not only by environmental conditions but also by internal factors specific to the seed itself. These internal factors play a crucial role in determining the ability of a seed to germinate successfully. Below are the key internal factors affecting seed germination, with relevant examples:

### 1. *Seed Viability*

Seed viability refers to the ability of a seed to germinate and develop into a healthy seedling. Over time, seeds lose their viability due to aging, improper storage, or environmental stress.

Example (Bangladesh): Rice seeds stored in humid conditions lose viability quickly, whereas seeds stored in cool, dry conditions maintain viability longer.

### 2. *Seed Dormancy*

Dormancy is a natural mechanism that prevents seeds from germinating under unfavorable conditions. It ensures seed survival until conditions become optimal.

Example (Bangladesh): Jute seeds often require pre-treatment like soaking in warm water to break dormancy before sowing.

### 3. *Seed Coat Impermeability*

Some seeds have a hard seed coat that prevents water and oxygen from entering, delaying germination until the coat is weakened.

Example (Bangladesh): The black gram (mashkalai dal) has a tough seed coat, which requires scarification (mechanical scratching or soaking in warm water) to enhance germination.

### 4. *Embryo Abnormalities*

A healthy embryo is essential for germination. Some seeds may have undeveloped or damaged embryos, leading to failed germination.

Example (Bangladesh): Mustard seeds affected by fungal infections during storage may have damaged embryos, reducing their germination rate.

### 5. *Hormonal Balance*

Plant hormones like gibberellins and abscisic acid regulate germination. High levels of abscisic acid (ABA) can inhibit germination, while gibberellins promote it.

Example (Bangladesh): Wheat seeds treated with gibberellic acid (GA) can overcome dormancy and germinate faster, especially in winter sowing conditions.

### 3. Factors Influencing Seed Viability

Seed viability refers to a seed's ability to germinate and develop into a healthy seedling. Several factors influence seed viability, affecting agricultural productivity and sustainability. Below are the key factors influencing seed viability, with relevant examples:

#### *Seed Storage Conditions*

Proper storage conditions, including temperature, humidity, and ventilation, are crucial for maintaining seed viability over time.

Example (Bangladesh): Rice and wheat seeds stored in traditional earthen pots or plastic containers in humid conditions often lose viability quickly due to fungal infections. Using airtight containers and controlled humidity can enhance seed longevity.

#### *Seed Age*

As seeds age, their viability decreases due to biochemical and physiological changes.

Example (Bangladesh): Jute seeds have a short viability period; they need to be used within one year for optimal germination, whereas mustard seeds remain viable for multiple seasons if stored properly.

#### *Moisture Content*

High moisture levels in stored seeds can lead to fungal growth and loss of viability, while extremely low moisture levels can cause seed desiccation.

Example (Bangladesh): Lentil seeds stored in open sacks in high-humidity areas experience reduced germination rates due to increased moisture absorption.

#### *Genetic Factors*

Some seeds have inherently higher viability based on their genetic traits.

Example (Bangladesh): Hybrid rice seeds tend to lose viability faster than traditional rice varieties, requiring precise storage methods.

#### *Pest and Disease Infestation*

Insect pests and fungal infections can significantly reduce seed viability.

Example (Bangladesh): Stored pulses like chickpeas and mung beans are often attacked by weevils, reducing their viability if not treated with pest control measures.

### Key Differences between Seed Germination and Seed Viability

Factor	Seed Germination	Seed Viability
Definition	Process of seed developing into a seedling	Potential of a seed to germinate
Requirement	Requires optimal environmental conditions	Seed must be alive
Testing method	Germination tests (e.g., observing sprouting percentage)	Viability tests (e.g., float test, tetrazolium test)
Influence on crops	Determines seedling establishment	Ensures seed longevity
Impact of storage	Does not directly affect germination but influences outcomes	Poor storage reduces viability

## Seed Production Techniques for Quality Assurance

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Seed is the basic and live input of agriculture. The effectiveness of the other inputs like fertilizer, irrigation etc. depends on seed quality. If the seed does not maintain quality standards, the use of other inputs become less effective and sometimes wasteful. Seed production is a crucial process that requires careful attention to detail and strict adherence to quality assurance protocols.

To ensure high-quality seeds and maintain the integrity of the seed production process, several best practices should be followed. Here are key areas of focus for quality assurance in seed production.

### Principles of Seed Production

During quality seed production, continuous care is needed for ensuring genetic purity, physical purity, physiological quality and seed health. This may be attained by implementing a defined set of interventions and corrective measures, which are broadly classified under varietal deterioration, genetic, agronomic and seed technology principles as discussed in the following sections:

#### A. Genetic Deterioration in Crop Varieties

Several factors are responsible for the deterioration of a variety over a period of repeated use which is summarized here with some modifications.

##### i) Genotypic Constitution and Pollination Behaviour

Cross-pollinated and often-cross-pollinated species are more prone to outcrossing and genetic contamination than the self-pollinated species. Similarly, maintenance of the genetic constitution of the synthetic and composite varieties needs more care than pure-line varieties. Residual heterozygosity and occurrence of aneuploidy (as in bread wheat, an allohexaploid species) can cause occurrence of off-types and genetic deterioration even in highly self-pollinated species.

##### ii) Developmental Variation

Modern crop varieties are mostly bred to perform in a specific environmental condition. In such a scenario, if seed production is undertaken in the changed environmental backdrop (different soil fertility conditions, altered photo and thermo periods, relative humidity and elevations), developmental variations in the form of dissimilar plant phenotype may arise sometimes due to differential growth responses. To minimize the chance for such shifts to occur in the varieties, it is advisable to grow the seed crops in their areas of adaptation for the variety and in recommended growing seasons.

### **iii) Mechanical Mixtures**

It is a physical process by which the seeds of other varieties may get mixed inadvertently and deteriorate the genetic purity of the given variety. This may happen through the seed drill during sowing, through wind carrying the harvested crop from one field to another, in the threshing yard where many varieties are kept together, during processing operations, etc., and also through rodents or other interferences. Hence, care is needed during production (rogueing), harvesting, threshing and further handling to avoid mechanical admixtures. Proper hygiene needs to be maintained at every step of production and processing operations.

### **iv) Natural Out-Crossing**

This is the major source of contamination in sexually propagated plant species through the flow of genes from dissimilar genotypes (which are cross-compatible). The extent of contamination depends upon the extent of the natural crossfertilization with off-types, and diseased plants. To overcome the natural crossing, seed crop should be sufficiently isolated from the contaminants. The extent of contamination also depends on the intensity and direction of the wind and activity of the pollinators. Highly cross-pollinated species belonging to genus brassica, cucurbits, etc., need to be sufficiently isolated from fields of dissimilar varieties to avoid natural outcrossing.

### **v) Influence of Pests and Diseases**

In case of foliar diseases, the size of the seed gets affected due to the poor supply of photosynthates from the infected plant parts. In case of seed and soil-borne diseases, use of infected seeds can cause widespread disease occurrence in the commercial crop. Control of diseases through the use of healthy seed, and in some cases pesticide-treated seeds provide an effective means minimizing the pesticide use. Similarly, vegetative propagules deteriorate fast, if infected by viral, fungus or bacterial diseases. Hence, during seed production, plant protection measures need to be deployed at the right stages to check the incidence of pest and diseases.

### **vi) Minor Genetic Variations and Pre-mature Release of Varieties**

Often, some small proportions of genetic heterogeneity may exist in the variety appearing phenotypically uniform and homogenous at the time of release. This may result in different plant types arising during repeated multiplications. Thus, pre-mature release of a variety may lead to quicker varietal deterioration. For instance, if a variety is bred for disease resistance and the gene(s) conferring this trait is not sufficiently fixed at the time of release, it may segregate producing susceptible and resistant plants during subsequent reproduction cycles. This not only impacts yields and other agronomic traits, but also poses serious problems in the process of certification with respect to the occurrence of off-types in the seed plots. Post-control grow out testing of the breeder seed, and production of the nucleus seed after every few years following stringent measures are recommended to avoid such genetic variations. This type of genetic inconsistency is more

common in cross-pollinated and often cross-pollinated species needing more care during variety maintenance.

## **B. Principles of Quality Seed Production**

Principles of Quality Seed Production during seed production; utmost care is needed for ensuring genetic purity, physical and physiological quality and seed health. This may be attained by implementing a defined set of interventions and corrective measures, which are broadly classified under genetic, agronomic and seed technology principles as discussed in the following sections.

### **Genetic Principles of Seed Production**

Producing genetically pure seed is a challenging task that requires significant technical expertise, skill, and a relatively high financial investment. During seed production, it is crucial to maintain varietal purity, which necessitates a thorough understanding of the underlying genetic principles. Various interventions must be applied based on factors such as flowering patterns (determinate or indeterminate), floral structure, pollination behavior (self-pollinating or cross-pollinating), and the genetic constitution of the variety (pure line, multi-line, composite, or hybrid). Additionally, considerations like photo- and thermo-sensitivity, as well as the need for specific stimuli for floral initiation, play a role in preventing genetic deterioration of a crop variety. Below are some safeguards to help maintain genetic purity during seed production

- Maintenance Breeding
- Confirmation of the Seed Source
- Previous Cropping History
- Isolation
- Compact Area Approach
- Discarding the Peripheral Strip

#### **a. Maintenance Breeding**

Maintenance breeding is the backbone of a quality seed production program. Varietal maintenance is a simple, but key technique for purification and stabilization of released genotypes. Though based on the basic principles of genetic constitution, it has a profound role in varietal spread, popularization and life of a variety. Maintenance procedures are the extension of normal breeding process, but selection is mild and aims not to improve the variety, but only to keep the genetic constitution unchanged. Based upon the original characteristics of a variety, off types are discarded and seeds only from the uniform 'true-to-type' plants are pooled to get nucleus seed, which is the basis for generation system of seed multiplication under OECD seed schemes and other established systems of seed quality assurance.

## **b. Confirmation of the Seed Source**

For raising a certified seed crop, the initial seed should be of appropriate class and from the approved source. In a generation scheme of seed multiplication, specific class of seed is used for multiplication of the ensuing seed class. For instance, under the OECD seed scheme, pre-basic seed is used for the production of basic seed, which in turn is employed for the production of certified seed class. Under the AOSCA seed scheme, generations (classes of seeds) are nucleus seed, breeder seed, foundation seed and certified seed.

The source of the seed can be ascertained through the labels attached to the containers or bags used for seed production purpose.

## **c. Previous Cropping History**

The primary objective of this step is to avoid any genetic contamination through volunteer plants (grown from self-sown seeds of the previous crop). Seed production in related or similar crops in rotation may be followed to address other issues such as plant nutrition, maintenance of soil physical condition and minimizing the risk of soil-borne pathogens and weeds common to a particular group of crops (George 2011). Similarly, the dormant seeds from previous crop may lead to genetic contamination in planned seed crop. Under OECD seed schemes, previous crop requirement for crucifer species, grass species and legume species are five, two and three years, respectively, for production of basic and certified seeds.

## **d. Isolation**

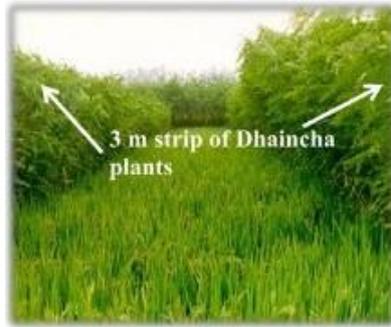
Isolation is required to avoid natural crossing with cross-compatible species and undesirable types from nearby fields, mechanical mixtures and contamination due to seed-borne diseases from adjoining fields. Protection from these sources of contamination is necessary for maintaining desired genetic purity. Three types of isolation can be achieved during seed production-

**Isolation by Distance:** This type of isolation is based on the concept that if a seed crop is sufficiently distant from any other cross-compatible crop then the adverse pollen contamination will be negligible. The distance isolation is efficient and practical type to achieve in most of the crops. The isolation distance recommended in regulations for specific crop take into account the method of pollination (self or cross-pollinated) and mode of pollination (insect or wind).

**Isolation in Time:** The planting time of two varieties of the same crop or two cross-compatible varieties of related crops can be staggered over time. The time isolation should be a minimum of 15 to 20 days or more depending on the flowering habit of the crop. As the plants will not blossom at the same time, cross-pollination becomes impossible. Time isolation is only applicable to crops having determinate flowering habit. Time isolation in the case of paddy can be achieved by providing a time of over 25 days.



Time Isolation



Isolation with barrier



**Isolation with barrier:** Isolation strips are areas between seed crops that are planted with tall or flowering plants that catch windblown pollen and distract insects from crossing and moving pollen from one side to the other. Cages and artificial barriers, made of PVC and fabric row covers, physically prevent cross-pollination. Caged plants must be hand-pollinated or pollinators must be introduced into the caged or covered environment

#### e. Compact Area Approach

Under this approach, seed production of single variety is allowed in a wide stretch of area. By allowing only one variety to be grown in a specified area or zone, the chances of undesirable cross-pollination are minimized. In the USA, compact area approach is followed for seed production of sweet corn in Idaho State. This approach is also advantageous in seed production of hybrid seed by making available sufficient pollen mass in a compact area.

#### f. Discarding the Peripheral Strip

In wind-pollinated crops, the pollen concentration in the air over a field is higher at the windward end and tends to decline towards the leeward end (Dark 1971). The marginal strip is important in the production of genetically pure seeds. When a cloud of contaminant pollen passes over the field, it is possible that some quantity of pollen grains drop out at random. Those falling over the center of the plot will compete with the relatively high concentration of the crop's own pollen source and have a negligible chance of fertilizing, whereas those falling on the marginal areas will not have so much competition and will therefore have a higher chance of fertilization. The seeds from a five-meter-wide strip around the perimeter of the plot are harvested separately and these can either be destroyed or placed in a lower seed category. The bulk of the seed harvest will come from the inner area of the plot

## **Agronomic Principles of Seed Production**

Agronomic interventions in a seed crop vary from that of commercial crop production. The basic principles are aimed at economically viable seed production practices.

### **i) Selection of the Agro-Climatic Region**

For successful seed production, a crop variety must be well-suited to the local photoperiod and temperature conditions. Regions with moderate rainfall and humidity are generally better for seed production compared to areas with high rainfall and humidity. Most crops need a dry, sunny period and moderate temperatures to promote flowering and pollination. Excessive rainfall during the flowering stage can reduce seed set and increase the likelihood of diseases, particularly in onions and other crops. Additionally, extremely high temperatures during flowering can lead to pollen abortion. Therefore, regions with extreme temperatures should generally be avoided for seed production, unless a specific crop is particularly adapted to thrive and produce seeds under such conditions.

A crop variety employed for seed production in a given area must be adapted to the photoperiod and temperature conditions prevailing in that area. Regions of moderate rainfall and humidity are more suited for seed production than the regions with high rainfall and humidity. Most crops require a dry sunny period and moderate temperature for induction of flowering and pollination. Excessive rainfall during flowering will reduce the seed set and may lead to incidence of diseases in onion and other crops. Too high temperatures during flowering may result in pollen abortion. In general, regions with extreme temperatures should be avoided for seed production, unless particular crop is especially adapted to grow and produce seed under these conditions.

### **ii) Field Preparation**

Field preparation consists of eliminating any weeds and volunteer plants and making flat or raised seed beds, as required. Well-tilled seed bed help in improved germination, good stand establishment and removal of potential weeds during tillage operations. To avoid contamination of site with other crop or weed seed, equipment employed during field operations need to be cleaned of soil, residual weed or crop seeds before entering into the site. Stale seedbed technique, in which the seed beds are formed about a week before it is to be sown, can be adopted. This allows the weed seeds to germinate first, so these can be removed to minimize the weed competition in the seedbed before the seed crop is sown.

### **iii) Selection of a Variety**

For certified seed production, the variety must be authentic, duly released/registered and must be clearly identifiable by a set of stable characteristics, which can be employed for field inspection by the certification agency. However, for quality declared seed (QDS) class or truthfully labelled seed (TLS) class, production of a non-registered variety is also taken by seed production agencies. A good market demand for the variety is desirable for successful seed business. Generally, the improved varieties having resistance against

major pests and diseases and tolerance against extreme weather conditions are more in demand.

#### **iv) Seeding and Stand Establishment**

Though the seeding method and seed rate vary from crop to crop, a desired plant stand is achieved by adopting good agricultural practices. However, the row-to-row distances are generally kept wider in a seed crop than in a commercial crop, to facilitate field inspection. The sowing of seed crops in wide-spaced rows also helps in conducting effective plant protection measures and roguing operations. In case of Factors hybrid seed production, suitable planting ratio needs to be followed for obtaining optimum seed yield. Besides, to allow synchrony in the flowering of the parental lines, staggered sowing may be followed (see chapter 'Hybrid Seed Production Technology' for details). The seed crops should be sown during the most favourable season, though, depending upon the incidence of diseases and pests, some adjustments could be made, if necessary.

#### **v) Roguing of the Seed Crop**

Roguing is the selective removal of undesirable plants from a seed crop on the basis of distinct morphological characteristics in order to improve one or more parameters (genetic purity, free from diseases and noxious weeds) of seed quality (Laverack and Turner 1995). Rogues include off-types, diseased plants, objectionable weeds and other crop plants (Parimala et al. 2013). Adequate and timely roguing is important in seed production. Roguing of off-types at flowering stage is more important than at vegetative stages.

Different **Stages** of Rouging –

- (a) **Pre-flowering:** Plants having different morphological characteristics like plant height, foliage morphology, colour, etc. should be removed from seed production fields before flowering.
- (b) **Flowering:** To prevent mixing of varieties of the same crop, rouging is done based on curd maturity in cauliflower, sex expression in cucurbits and flower initiation time in solanaceous crops.
- (c) **At fruit development:** Based on true-to-type characteristics of developing fruits like fruit shape, ripening colour, size, etc., the off-types are removed.
- (d) **At maturity:** Late maturing plants in case of early maturing varieties (specially in fruit vegetables) and vice versa are to be discarded.

#### **vi) Weed Control**

Presence of weeds in seed crop not only reduces the yield by competing for space, nutrients, moisture and sunlight, but also lowers the quality standard. Weed plants in the seed field or nearby areas may also serve as the host to a number of diseases. Presence of prohibited weed (objectionable/obnoxious weed) seed may result in the rejection of an entire seed plot/lot.

## **vii) Disease and Insect Control**

Successful disease and pest control is another important aspect of raising a healthy seed crop. Apart from the reduction of yield, the quality of seed from diseased and insect-damaged plants is invariably poor. There are number of diseases which are systemic and seed-borne in nature. If not checked, the seed thus produced will carry the spores of the pathogens (inoculum) and produce diseased plants in the next generation. Production of disease-free seed can be achieved by using disease-free planting material, producing seed in isolated and disease-free zones, and using recommended plant protection measures. Insects can be managed in the field by the use of insecticides and in storage by proper sanitation, fumigation and seed treatment. Insecticide-impregnated seed packaging material is also effective in managing cross-infestation during storage. Some diseases are identified by the national authorities, as in India, as designated diseases. As per the IMSCS, loose smut in wheat, ashy stem blight in cowpea, halo blight in green gram and downy mildew in sunflower are designated as objectionable diseases during field inspection.

## **Seed Technology Principles**

Quality seed production is a function of not only genetic and agronomic principles but also seed technology principles. Aspects such as selection of field free from volunteer plants, strategies for enhancing the seed set, time and method of harvest, seed extraction, drying and other post-harvest operations constitute seed technology principles crucial for obtaining seeds of highest quality.

### **a. Selection of Field**

The plot selected for seed production must be leveled and should have an assured source for irrigation. The field must be free from volunteer plants, weed plants, soilborne diseases and have good soil texture and fertility. It should be feasible to isolate the plot as per the requirements of seed certification. In case space isolation is not possible for some reason, time and barrier isolation may be deployed. For instance, in case of maize, time isolation could be provided and barrier isolation may be achieved by planting rows of a tall barrier crop or additional border rows. Fields that have produced seed crops of small-seeded forage legume (e.g., red clover) in the preceding season should not be used to produce seed of another inseparable legume seed crop (e.g., alfalfa). Seed of such crops tends to remain viable in the soil and continue to germinate and contaminate subsequent crops.

### **b. Supplementary Pollination**

Pollination occurs naturally without human interference either through the wind or pollinators. Pollen availability on the stigma determines the seed set and ultimately the seed yield. This can be augmented through human intervention or by supplementing the pollinator activity. Various kinds of bees (honey bee, leaf-cutting bee and alkali bee) are

common and effective. Seed set and quality in berseem can be enhanced significantly by maintaining three to five honey bee hives in close proximity to seed fields. However, safe isolation distance needs to be ensured in such cases to avoid genetic contamination by pollinators. Hand pollination is a commonly used strategy in hybrid seed production of sunflower where pollen is collected from the heads of male plant and applied gently over receptive stigma of female plants. In hybrid seed production (please see chapter ‘Hybrid Seed Production Technology’ for details) of rice, rope pulling or beating the male parent with stick is generally practised to release the pollen grains from the male parent.

### **c. Harvesting**

The development of seed is characterized by two distinct stages of maturity viz. physiological (or mass) maturity and harvest maturity. Physiological maturity is the end of seed filling period whereas; harvest maturity is the point of time that coincides with the maturation drying when it is harvested. The germination and vigour of the seed are at peak when the seed attains physiological maturity. However, as the seed moisture is quite high at this stage, seed is harvested only once it attains a safe moisture level that allows safe processing and storage. In plants with determinate flowering habit, seed maturity is uniform, whereas in crops with indeterminate flowering habit (carrot, sugarbeet, etc.), harvesting needs to be timed to obtain maximum seed yield and quality. Method of harvesting also influences seed quality, hence selecting the right method of crop-appropriate harvesting is important. Harvesting and threshing equipment must be thoroughly cleaned before harvesting each variety to avoid mechanical mixtures.

### **d. Drying and Storage of Raw Seed**

Drying seeds to a safe level is critical to maintain the seed viability and vigour during the storage, and to keep seeds free from pests and disease incidence. Drying should be done using an optimum combination of temperature and airflow maintaining a temperature that does not adversely impact seed quality. In warmer environments, and natural drying by spreading the seeds in thin layer under the sun, or forced air drying at ambient air temperature can be performed. In case of mechanical drying, care should be taken to avoid any mechanical admixture. Pre-processing sheds and bags containing pre-processed seed also need to be well-cleaned.

### **e. Seed Conditioning and Up gradation**

After seed has been harvested and before it is dried and stored, it must be cleaned. Seed as it comes from the field, contains varying quantities of physical impurities such as trash, dried leaves, weed seeds, other crop seeds, etc. The purpose of conditioning is to remove these physical impurities, as well as to upgrade the seed quality and appearance. Satisfactory conditioning requires a specific sequence through several operations. Raw seed is initially conditioned by pre-cleaner to remove impurities such as crop debris and soil particles. It also removes bigger and smaller sized seeds to large extent. Later, pre-cleaned seed is conditioned through air-screen machine (seed grader) and quality

upgradation is done through machines viz. indented cylinder separator, gravity separator, fractioning aspirator, roll mill, spiral separator, buckhorn machine and inclined belt separator. Specialized machineries such as huller-scarifiers (to scarify hard seeds) and deboarders (to remove seed appendages like awns, beards or glumes) are also employed. The choice of operation and machinery depends on the kind of seed, the nature and type of contaminants in seed lot and quality standard need to be achieved after seed conditioning and upgradation.

#### **f. Seed Certification**

Seed certification is a legally sanctioned system for quality assurance of seed multiplication and production. Certification programme is necessary (or sometimes obligatory) for the seed trade. OECD seed schemes are globally accepted seed certification system, whereas AOCSA system is widely followed in North America. In India, the state seed certification agency is the legally authorized body to manage and monitor the seed quality during multiplication. Seeds which are certified under the certification schemes have to meet both general and crop-specific field and seed standards. Producing high-quality seeds of the crop varieties and making them available to the farmers are the prime aim of any seed certification system (see chapter 'Role of Seed Certification in Seed Quality Assurance' for more).

#### 5.3.9 Seed Certification Procedures

**Application** Seed producer needs to submit an application along with the requisite fee to the designated seed certification authority, requesting for certification. The fee is for one season for a single variety and for an area as specified for one seed plot, which is mostly up to ten hectares. The official tag of the source seed should also be submitted (e.g., breeder seed tag in case of foundation seed production; and foundation seed tag in case of certified seed production) along with the application.

**Field Inspection** The field inspections are performed by the concerned certification agency on all fields for which applications are received. The objective of the field inspection is to verify that proper care is taken to check the factors that may affect genetic purity and physical health of seeds during multiplication. A number of field inspections differ from crop to crop and certification schemes. Generally, field inspections would be carried out for a minimum of two or more times during pre-flowering, flowering, pre-harvest and harvest stages. During field inspection, isolations are verified; presence of off types, other crops, weed contaminations and diseased plants are checked and seed growers are guided to undertake necessary corrective measures, if required. The fields, which do not conform to the prescribed standards, and if there is enough evidence to prove that contamination has already occurred, shall be rejected for certification.

**Seed Sampling, Testing and Tagging** The purpose of sampling is to draw a representative sample from a seed lot (of 10 t or more) of a size suitable for conducting quality testing, in which the probability of a constituent being present is same as its proportion present in the seed lot. Seed sample thus drawn by the authorized persons is sealed, labeled and submitted to the certification agency, and tested for quality parameters in an official seed testing laboratory. Seed lots which meet the prescribed

seed standards (pure seed, germination, weed seeds, other crop seeds, and diseased seeds) alone will be eligible for allotment of seed certification tag. Under the OECD seed schemes, the results of seed testing should, whenever possible, be given on the orange international seed lot certificate issued under the rules of the International Seed Testing Association (ISTA). Most of the agencies have adopted a two-tag system, in which seed analysis tag and certification tag are different. Certification tag is issued by the seed certification authority and seed analysis information is printed on seed label and affixed on seed containers separately.

## **Seed Production Techniques of Wheat and Maize**

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Wheat and maize are Bangladesh's two most important cereals after rice, playing a crucial role in food and nutritional security. In 2021-22, wheat production reached 1.17 million tons from 0.32 million hectares, meeting only 20% of national demand. Wheat consumption has been rising by 13% annually due to dietary shifts, socio-economic growth, and increased demand from bakeries and fast-food industries. Productivity improved to 3.65 t/ha, driven by high yielding, disease resistant and stress tolerant varieties, along with better management practices.

Although maize is not a staple in Bangladesh, it is the third most important cereal. In 2021-22, maize production totaled 5.63 million tons from 0.55 million hectares, while national demand stood at 7 million tons. The average yield of 10.2 t/ha is attributed to hybrid seeds and improved management. Maize demand is rising due to its use in poultry, fish and livestock feed, processed foods and exports.

In 2024, wheat production was estimated at 1.2 million tons, covering only 20% of national needs. Wheat imports, covering 80% of consumption, are projected at 6.1 million tons in 2024-25, with total cereal imports forecast at 8.3 million tons.

The 2024 maize harvest, completed in July, reached a record 5.2 million tons due to expanded sowing, high domestic demand, and favorable weather. Maize imports are expected to rise to 2.1 million tons to meet livestock and fisheries feed demand.

In 2022-23 and 2023-24, cereal imports fell below average due to foreign currency shortages and currency depreciation. These challenges persist in 2024-25, potentially limiting the country's ability to meet its full import requirements.

## বাংলাদেশ গম ও ভুট্টা গবেষণা ইনস্টিটিউট কর্তৃক উদ্ভাবিত গমের জাতসমূহ

ক্র. নং	জাতের নাম	অবমুক্তি	হেক্টর প্রতি ফলন (টন)
১	সনোরা ৬৪	১৯৬৮	২.৬-৩.২
২	কল্যানসোনা	১৯৬৮	১.৬-২.২
৩	ইনিয়া ৬৬	১৯৭২	২.৫-৩.০
৪	নরটেনো ৬৭	১৯৭২	২.৮-৩.২
৫	সোনালিকা	১৯৭৩	৩.০-৩.৫
৬	টানোরী ৭১	১৯৭৪	২.৮-৩.২
৭	নুরী ১০	১৯৭৪	৩.০-৩.২
৮	জুপাটেকো ৭৩	১৯৭৪	২.৫-৩.০
৯	বলাকা	১৯৭৯	৩.০-৩.৬
১০	দোয়েল	১৯৭৯	২.৫-৩.০
১১	পাভন ৭৬	১৯৭৯	২.৬-৩.০
১২	আনন্দ	১৯৮৩	২.৪-৩.৪
১৩	কাঞ্চন	১৯৮৩	৩.৩-৪.০
১৪	আকবর	১৯৮৩	৩.৪-৪.০
১৫	বরকত	১৯৮৩	৩.৫-৪.০
১৬	অম্মানী	১৯৮৭	২.৫-৩.৬
১৭	প্রতিভা	১৯৯৩	২.৭-৩.৭
১৮	সওগাত	১৯৯৩	২.৮-৩.৮
১৯	বারি গম ১৯ (সৌরভ)	১৯৯৮	৩.৫-৪.৫
২০	বারি গম ২০ (গৌরব)	১৯৯৮	৩.৬-৪.৮
২১	বারি গম ২১ (শতাব্দী)	২০০০	৩.৬-৫.০
২২	বারি গম ২২ (সুফি)	২০০৫	৩.৬-৪.৮
২৩	বারি গম ২৩ (বিজয়)	২০০৫	৪.৩-৫.০
২৪	বারি গম ২৪ (প্রদীপ)	২০০৫	৩.৫-৫.১
২৫	বারি গম ২৫	২০১০	৩.৮-৫.০
২৬	বারি গম ২৬	২০১০	৪.০-৫.০
২৭	বারি গম ২৭	২০১২	৩.৫-৫.৪
২৮	বারি গম ২৮	২০১২	৪.০-৫.৫
২৯	বারি গম ২৯	২০১৪	৪.০-৫.০
৩০	বারি গম ৩০	২০১৪	৪.০-৫.৫
৩১	বারি গম ৩১	২০১৭	৪.৫-৫.০
৩২	বারি গম ৩২	২০১৭	৪.৬-৫.০
৩৩	বারি গম ৩৩	২০১৭	৪.০-৫.০
৩৪	বিডার্লিউএমআরআই গম ১	২০১৯	৪.৬-৫.০
৩৫	বিডার্লিউএমআরআই গম ২	২০২০	৪.৫-৫.৫
৩৬	বিডার্লিউএমআরআই গম ৩	২০২০	৪.০-৪.৫
৩৭	বিডার্লিউএমআরআই গম ৪	২০২২	৪.০-৫.৫
৩৮	বিডার্লিউএমআরআই গম ৫	২০২৪	৪.৬-৫.৫

## বাংলাদেশ গম ও ভুট্টা গবেষণা ইনস্টিটিউট কর্তৃক উদ্ভাবিত ভুট্টার জাতসমূহ

### কম্পোজিট জাতের ভুট্টার তালিকা ও অবমুক্তির বছর

ক্র. নং	জাতের নাম	অবমুক্তি	হেক্টর প্রতি ফলন (টন)
১	বর্ণালি	১৯৮৬	৪.৫-৫.৫
২	শুভ্রা	১৯৮৬	৫.৫-৬.০
৩	খই ভুট্টা	১৯৮৬	৩.৫-৪.০
৪	মোহর	১৯৯১	৫.০-৫.৫
৫	বারি ভুট্টা ৫	১৯৯৮	৫.০-৫.৫
৬	বারি ভুট্টা ৬	১৯৯৮	৬.৫-৭.০
৭	বারি ভুট্টা ৭	২০০২	৬.৫-৭.৫
৮	বারি মিষ্টি ভুট্টা ১	২০০২	১০.০-১০.৫
৯	বারি বেবি কর্ণ ১	২০১৩	১.২৭-১.৩০

### হাইব্রিড জাতের ভুট্টার তালিকা ও অবমুক্তির বছর

ক্র. নং	জাতের নাম	অবমুক্তি	হেক্টর প্রতি ফলন (টন)
১	বারি হাইব্রিড ভুট্টা ১	২০০২	৮.৫ - ৯.৫
২	বারি হাইব্রিড ভুট্টা ২	২০০২	৮.০ - ৯.০
৩	বারি হাইব্রিড ভুট্টা ৩	২০০২	৯.৫ - ১০.০
৪	বারি হাইব্রিড ভুট্টা ৪	২০০২	৭.৫ - ৮.৫
৫	বারি হাইব্রিড ভুট্টা ৫ (কিউপিএম)	২০০৪	৯.৫ - ১০.০
৬	বারি হাইব্রিড ভুট্টা ৬	২০০৬	৯.৫ - ১০.০
৭	বারি হাইব্রিড ভুট্টা ৭	২০০৬	১০.৫ - ১১.৫
৮	বারি হাইব্রিড ভুট্টা ৮	২০০৭	১০.৫ - ১১.৫
৯	বারি হাইব্রিড ভুট্টা ৯	২০০৭	১১.৫ - ১২.৫
১০	বারি হাইব্রিড ভুট্টা ১০	২০০৯	১০.০ - ১১.৫
১১	বারি হাইব্রিড ভুট্টা ১১	২০০৯	১০.৫ - ১১.৫
১২	বারি হাইব্রিড ভুট্টা ১২ (খরা সহনশীল)	২০১৬	৮.১ - ৮.৫ (খরা অবস্থায়)
১৩	বারি হাইব্রিড ভুট্টা ১৩ (খরা সহনশীল)	২০১৬	৮.২ - ৮.৯ (খরা অবস্থায়)
১৪	বারি হাইব্রিড ভুট্টা ১৪ (তাপ সহিষ্ণু)	২০১৭	৯.০ - ১০.০
১৫	বারি হাইব্রিড ভুট্টা ১৫ (তাপ সহিষ্ণু)	২০১৭	১১.০ - ১২.০
১৬	বারি হাইব্রিড ভুট্টা ১৬	২০১৮	১০.০ - ১১.০
১৭	বারি হাইব্রিড ভুট্টা ১৭ (তাপ সহিষ্ণু)	২০১৯	১১.০ - ১২.০ (রবি) এবং ৮.০ - ৯.০ (খরিফ)
১৮	বিডার্লিউএমআরআই হাইব্রিড ভুট্টা ১	২০২০	১১.০ - ১২.০
১৯	বিডার্লিউএমআরআই হাইব্রিড বেবি কর্ণ ১	২০২০	২.৩০ - ২.৬৫
২০	বিডার্লিউএমআরআই হাইব্রিড ভুট্টা ২	২০২২	১২.০ - ১৪.০

## Seed Processing and Storage for Quality Maintenance

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In narrow sense, seed processing includes only the operations of pre-cleaning, cleaning and grading of the seed stock. But in broader sense, it includes all the operations required to meet certain quality standards from harvesting of the seed, via cleaning, drying and chemical treatment to packaging.

Seed Processing is the several sequences of operations included cleaning & grading for desirable size, drying to optimum moisture level for storage, testing for purity & germination, treating for storage pest & seed borne diseases and bagging & labeling for marketing with standard quality.

**Seed processing** is the normal sequence of operations included in the processing of seed after its harvest include threshing, drying to optimum moisture level for storage, cleaning and grading, testing for purity and germination, treating for storage pests and seed borne diseases, bagging, labeling and distributing. This because of Seed is almost never pure as it comes from the field and is mixed with weed seeds, trash, chaffs, leaves, other crop seeds, insects and small seeds etc. Seeds are also often harvested at higher moisture content than that recommended for storage. Seed processing is the normal sequence of operations included in the processing of seed after its harvest include threshing, drying to optimum moisture level for storage, cleaning and grading, testing for purity and germination, treating for storage pests and seed borne diseases, bagging, labeling and distributing. This because of Seed is almost never pure as it comes from the field and is mixed with weed seeds, trash, chaffs, leaves, other crop seeds, insects and small seeds etc. Seeds are also often harvested at higher moisture content than that recommended for storage.



## Seed cleaning and grading

When a farmer has harvested his seed, it is not yet ready for sale. First it has to be taken some treatment for removal of undesirable materials. It is impossible to grow and harvest seed crops without getting undesirable intermixture. These intermixtures may comprise weed seeds, other crop seeds and various inert matter as well as undeveloped seeds of the species.

Seed cleaning involves a number of processes with the handling of seed after harvest. In fact, it is impossible to have quality seeds without intermixture. The intermixtures are weed seeds, other crop seeds and various inert matter as well as undeveloped seeds of the species. Seed cleaning is a mechanical process to separate undesirable seeds and other components from the harvested lot with the least possible loss of pure seeds.

### Objectives

- Removal of plant debris like chaff, straw, flower parts, stem, leaf etc.
- Separation of non-seed materials like soil sand or stones.
- Removal of other crop seeds and weed seeds.
- Removal of poor quality seeds such as damaged, diseased, insect affected, partly germinated, discolored, lighter, larger or smaller than the optimum.

### Methods

#### Pre-cleaning

Particles usually larger in size and lighter in weight than the desirable crop seed are removed from the threshed seed lot. The main objectives of pre-cleaning is to ready the seed lot for basic cleaning. Blower, Air separators, Pre-cleaner, brasher etc are used for this purpose.

#### Basic cleaning

The second stage of cleaning operation carried out with air blasts and vibrating screens and is applicable for to all kinds of seeds. The aim in basic cleaning is to remove from the seed lot those adulterants that are larger and smaller in width and thickness than the desirable crop seed and those which are lighter in weight. It is performed by one machine usually known as “air screen cleaner”.

#### Upgrading

The basic cleaning removes all the adulterants that can be separated by a simple combination of air blast and screens, and for many lots this is sufficient. In some cases, for better quality it needs some special methods to separate those seeds which are same in size and thickness. Grading is the removal of seeds which are cracked, damaged, diseased, off size, off weight, off color. These separations are performed on the basis of physical characteristics of seeds.

#### Principles

The separation is based on physical or morphological characteristics of the seed and that of the contaminants such as:

- Thickness
- Width
- Length
- Size and shape
- Mass and specific gravity
- Surface structure and texture
- Colour, affinity for liquids
- Electrical conductivity etc.

### **Commonly used Equipments**

- i). Brusher/Scarifiers
- ii). De-awner
- iii). Screen and air cleaner
- iv). Indented cylinder
- v). Gravity separators
- vi). Destoner
- vii). Table separators
- viii). Belt grader
- ix). Spiral separators
- x). Air separators
- xi). Color separator
- xii). Magnetic separators

#### **Brusher/Scarifiers**

Sometimes raw seed material is in such a condition that it is impossible to handle it directly on the air screen machines. The raw materials can contain seeds not completely separated from pods or flowers, hairy seeds, twin seeds, seeds with unwanted shells etc. To make such seeds suitable for the screen, brusher or scarifier is needed.

#### **De -awner**

The de-awner has in principle the same purpose as a scarifier. The rotor, however, has no brushes, but consists of a shaft with a number of pins. The mantle is replaced by a trough made in sheet.

#### **Screen and Air Cleaner**

The cleaning machine with screen and air cleaning is the most important part of almost any cleaning process of seeds and grain. On this machine, seeds can be cleaned in two ways: according to weight by means of air system, according to width and thickness of the seeds on the screens.

If the machine has both head and tail aspiration system, then it is used head aspiration only for the removal of dust and very light wastes and the tail aspiration system for the removal of the lightest grain, awns, and some heavy wastes. The screen can be fitted with different types of perforations as needed for different types of seeds.

### **Indented Cylinder**

As the air screen machines clean seeds according to weight and width of the seeds, a grading process considering the length of the grain is still needed. For this purpose, the indented cylinder is used.

### **Gravity Separators**

Gravity separators are used for product, grade and impurity separation by difference in specific gravity of materials which are other of the same shape or size. The gravity separator is being used where traditional cleaning methods by air, screen or indented cylinder proved to be insufficiently effective.

### **De-stoner**

A de-stoner acts with the same principles as a gravity separator, but it only makes a two-way grading. In its commercial design, it is mainly intended for the removal of stones from the edible crops like beans and peas, cereals for milling use and malt for brewery purposes.

### **Table Separators**

A table separator separates by specific gravity materials of similar size, shape and nearly equal specific gravity. Infinitely variable adjustment during operation assists removal of unshelled grains, foreign seeds, ergots and wild oats from prime grains. Separate grain mixture such as wheat from barley, oats from wheat. Remove light and barren grains, sprouted grains, and weeds from high class seed grain.

### **Belt Grader**

A belt grader is intended for the removal of stems and flat parts from the round seeds, specially *Beta vulgaris*, but is useful for all kind of seeds being ball-shaped or nearly ball shaped, like *Pisum sativum*, *Vicia sativa*, *Brassica napus* etc. It consists of a feeder and rising belt with the grading part running upwards.

### **Spiral Separators**

The spiral separator is like the belt grader intended for separation of stems, flat parts and deformed grains from round shaped seed like *Sinapis alba*, *Pisum sativum*, *Vicia sativa*, *Brassica* spp, *Glycine* spp. etc, but also very good for handling *Raphanus sativum* and many other species not having the perfect ball shaped as the previously mentioned seeds.

### **Air Separators**

Air separators are used for separation by means of specific gravity into three or more grading, viz. clean materials and two grading of reject.

### **Color Separator**

If all the physical properties of the seed are the same except for color, this machine is suitable. The material to be handled must be well cleaned in order to get it as uniform as possible. A color separator has its highest efficiency and capacity in separating heavy materials like cereals, peas and beans, but is also excellent in lighter seeds. Common applications are removal of discolor seeds, ergots and *sclerotia*.

## **Magnetic Separator**

During seed conditioning, some seed lots are separated magnetically if the contaminants are different from the crop seed in texture. Seed lots are pretreated by the addition of iron powder, and moisture. The rough, porous, or sticky contaminants, but not the smooth crop seeds, pick up the iron powder.

A separation can then be made by passing the treated lot over a magnetic drum that attracts the iron coated items away from the uncoated crop seeds. This magnetic separator method is used when the previous cleaning on the more traditional equipment has proved not to be sufficient.

## **Drying Process and Methods**

At the stage of maturity, the seed has reached maximum germination capacity. At this stage the moisture content of the seed can be as high as 45% and including leafy material it can reach 60%. Seed that dries on the plant can be allowed to dry in the field. However, losses can be considerable because of lodging, shattering, disease and bird or insect damage.

It is often possible to harvest the seed during a dry period. Such a practice is recommendable, particularly for small seed, because it dries out relatively quickly on the plant. Seed of fleshy fruits will always be obtained at high moisture content after washing out. For this seed, quick drying to a moisture content, at which the seed will keep its germination capacity is almost always required, particularly in a humid environment. However, drying to extremely low moisture content (3-5%) should be avoided to prevent bad germination due to seed dormancy and hard seeded seed.

The moisture content of seed has to be reduced to a safe level, whether it is to be stored for a short or a long time. For short term storage (9 months) seed should be dried to a moisture content of 8-10%. For storage up to 3 years a moisture content of 6-8% is recommended.

## **Importance of seed drying**

Improper drying and storage conditions in handling seeds can have an adverse effect on the life of the seeds. High moisture content during storage is undesirable, since moisture will:

- Reduce storage life and viability of seed due to increased respiration
- Allow the activity of storage moulds.
- Create a medium for storage pests as mites and weevils.
- Cause the seed to “during storage as a result of bacteria.

## **Grain moisture content and grain quality**

Moisture content (MC) is the amount of water in the rice grain. In post-harvest handling, grain moisture content is generally stated on a wet weight basis ( $MC_{wb}$ ), meaning that it is expressed as percentage of water contained in the wet grain. Rice is usually harvested at

20-25% MC while 14% or less is considered safe for storing grains, 12% or less for storing seeds. Paddy should be dried to safe moisture content within 24 hours after harvesting to avoid damage and deterioration. Improper drying and storage practices lead to low grain or seed quality.

Some problems related to incomplete or untimely drying or storage of paddy with high MC are:

### **Heat buildup in the grain**

Natural respiration of stored, wet grain will generate heat, in particular when it is stored in sacks in bulk. Heat will provide excellent growth conditions for molds, insects and deteriorate quality.

### **Mold development**

Molding of grain propagates diseases in the grain and may release toxins into the grain. Although some fungi causing the molds may be present in the grain at harvest time, safe moisture content can reduce further development of these molds. If the fungi are of the mycotoxin-producing family, rice is unsafe for nourishment and might be totally unusable for food or livestock feed purposes.

### **Insect infestation**

Insect infestation is always a problem in stored grain in tropical climates, even if the grain is completely dried. However, the less moisture in the grain, the fewer the expected insect problems. A combination of proper drying procedures and storage practices, including storage hygiene, will keep insect infestation at acceptable levels.

### **Discoloration/Yellowing**

A general yellowing of the rice grain is a result of heat build up in the paddy grain before drying. Discolored grain drastically reduces the market value of rice since whiteness is an important quality characteristic for rice consumers. Although discoloration is a complex biochemical process, it can be easily avoided by timely drying of paddy after harvest.

### **Loss of germination and vigor**

Moisture in grain will gradually reduce germination ability of the seed during storage. Active respiration of the grain during storage will deplete the nutrition reserves that the seed uses to germinate or sprout. Molds and diseases can also reduce the ability of the seed to germinate. The lower the moisture content of seed at the beginning of storage, the longer the seed remains viable.

### **Loss of freshness/odor development**

Deterioration of quality or aging of stored rice results from a combination of a change in the chemical components (increase in fatty acids and decrease in sugars) and changes of rice kernel characteristics (such as kernel hardness). Heat build up in the grain (above 55°C) due to insects, molds or high humidity will often lead to a musty odor in rice. Therefore, rice stored for longer periods under adverse conditions (high grain moisture content and/or high temperatures) can develop odors which reduce the market value of rice considerably. In particular, molds (fungi) that grow on rice can produce offensive

odors due to deterioration of chemical components in the rice. If the fungi are of the mycotoxin-producing family, rice is unsafe for nourishment and might be totally unusable for food or livestock feed purposes.

### Reduced head rice yield

A major cause for fissuring of rice kernels is the moisture adsorption of individual dry grains with moisture contents below 16%. This can happen either when wet grain is mixed with dry grain (in storage, in the dryer or after drying in a batch dryer with a resulting moisture gradient) or when dry grain is exposed to humid ambient air with a relative humidity higher than the equilibrium relative humidity at the corresponding grain moisture content. Fissures in rice kernels usually lead to cracking of the grain during the milling process and thus reduce the head rice recovery.

### Drying Basics

Drying of grain involves exposing grain to ambient air with low relative humidity or to heated air. This will evaporate the moisture from the grain and then the drying air will remove the moisture from the seed bulk. Since drying practices can have a big impact on grain quality or seed quality, it is important to understand some fundamentals of grain drying.

### Drying Process

Seed is a hygroscopic material that loses moisture when placed in a dry environment and takes up moisture in a humid environment. Drying of seed can be explained by following the transport of water from a single seed into atmosphere (figure-1).

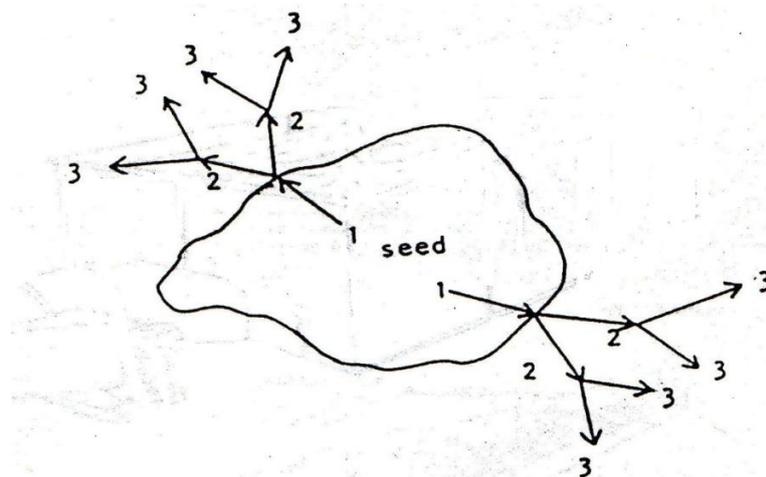


Fig.1: Basic mechanisms involved in the drying process

The *three* phases are:

- Transport of water from the interior of the seed to the surface.
- Evaporation from the seed surface into the surrounding air.
- Removal of the saturated air film around the seed.

The rate of moisture migration from the centre to the surface of a seed is influenced by -

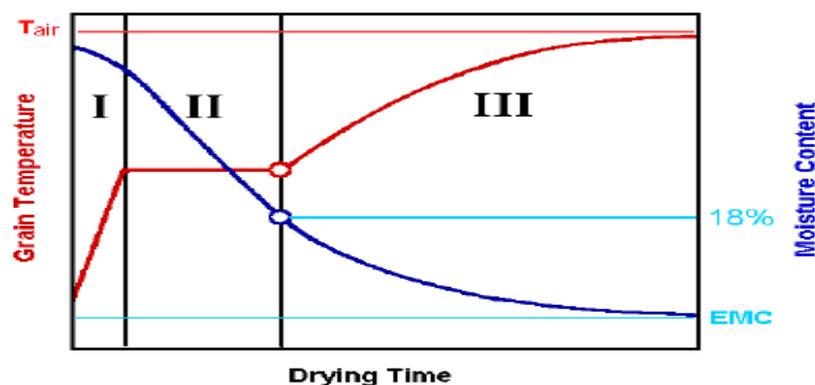
- the temperature of the seed
- physical structure of the seed
- chemical composition of the seed and
- seed coat permeability.

Drying of grain involves exposing grain to air with low relative humidity (RH) which will lead to evaporation of the moisture in the grain and then the moisture's removal away from the grain

### Moisture removal

In paddy grain, moisture is present at two places: at the surface of the grain, 'surface moisture', and inside the kernel, 'internal moisture'. Surface moisture will readily evaporate when grain is exposed to hot air. Internal moisture evaporates much slower because it first has to move from the kernel to the outside surface. As a result, surface moisture and internal moisture evaporate at a different rate. This difference results in a different 'drying rates' for different period of drying. The drying rate is defined as the rate at which grain moisture content declines during the drying process. It is normally expressed in percent moisture removed per hour [%/hr]. Typical drying rates of rice dryers are in the 0.5%/hr to 1%/hr range.

A drying curve, as illustrated in the figure below, shows how the grain moisture content (MC) and grain temperature change over time. As can be seen in the chart, the drying rate is not constant but changes over time. The temperature of the grain equally changes over time.



*Theoretical drying curves with different drying periods.*

### Drying periods and implications optimal drying

There are three different drying periods which will occur consecutively in time:

#### I. Preheating period (drying rate is almost 0)

When wet grain is exposed to hot air, initially only a very slight change in MC is observed. This happens because all the heat provided in the drying air is used to heat up the grain to the drying temperature.

## **II. Constant-rate period** (drying rate is constant in time)

Once the grain is at the drying temperature, water starts to evaporate from the surface of the grain. During this period, all the heat from the drying air is used to evaporate surface moisture and the amount of moisture removed from the grain is constant in time. It is therefore called the constant-rate period. During this period, grain temperature is constant as well.

## **III. Falling-rate period** (drying rate declines over time)

As time passes, it takes more time for internal moisture to appear at the surface, and evaporation of water is no longer constant in time. As a result, drying rate will decline, and some of the heat from the drying air will heat up the grain. For paddy grain, the falling-rate period typically occurs at around 18% grain moisture content.

By using the 18% MC and the drying curve characteristics as a guideline, a few recommendations can be made in regard to grain drying procedures. These guidelines can be used regardless whether grain is dried in the sun or by using artificial grain dryers.

## **Drying Rate and Temperature**

Above 18% MC the grain drying rate can be increased (that is, drying will occur faster) by providing a higher temperature or more drying air without major changes in grain temperature. Below 18%MC increase in drying air temperature will not increase the drying rate but will increase grain temperatures and potentially damage the grain. Therefore, higher drying air temperatures can be used to dry grain quickly down to 18% MC (to remove “surface moisture”) but lower temperatures should be used to remove internal moisture from the grain.

For seed purposes, drying air temperatures should never exceed 43°C, regardless of the MC, to avoid overheating of the grain which kills the germ. Exposing paddy to 60°C for one hour can reduce the seed germination rate from 95% to 30%. Two hours at 60°C will reduce the germination rate to 5%.

## **Uniform Drying**

During the drying process there is always variability in MC of individual grains. Especially in fixed-bed dryers the grains at the air inlet dry faster than at the air outlet resulting in a moisture gradient in the grain bulk at the end of the drying process. For production of good quality grain or seed, this variability should be kept as low as possible. Frequent stirring in sun drying, grain turning in fixed bed dryers or circulation in re-circulating batch dryers will improve uniformity of drying, minimize the re-wetting of dried grains and thus maintain grain quality.

## **Drying Methods**

The many ways of drying seeds can be classed as natural and artificial.

**Natural:** Natural drying takes place with typical atmosphere air moving naturally around damp seed spread on trays, canvas, floors or fields.

**Artificial:** Artificial drying uses heated or unheated air that is forced mechanically through a drier. All drying operation involves some movement of air through the seed. In normal vaporization, each seed tends to become surrounded by a film of saturated vapor, which obstructs heat transfer and limits the evaporation of moisture air movement. If nothing more than a gentle breeze, is needed to replace this wetted air continuously with drier air. So the drying process can go on.

### **Sun Drying**

Sun drying is the traditional method for reducing the moisture content (MC) of paddy by spreading the grains in the sun. The sun heats up the grains and also the surrounding air. This causes the water to evaporate from the grains.

Sun drying is the traditional method for drying and is still preferred in Asia because it is cheap compared to mechanical drying. Since it uses the sun as heat source it is friendly to the environment.

### **Artificial Drying**

Artificial drying can be done with heated or unheated air dehumidified air, or a partial vacuum. In each the particular air condition facilitates drying when used in conjunction with a movement of forced air through the seed.

**Heated air:** Heating air raises its saturation point and creates a thirsty medium that absorbs moisture readily. The use of heated air assists drying also by heating the seed and thereby its contained moisture. The resulting rise in temperature stimulates the diffusion of internal moisture to the surface and increases vapor pressure of the liquid thus encouraging vaporization.

**Dehumidification air by chemicals:** Another form of artificial drying employs air that is dehumidified chemically or by refrigeration. Dehumidified, or dried, air can dry seed readily because some of the water vapor has been removed from it and its moisture absorbing tendency thereby is increased.

Actually, since vapor pressure of the atmosphere decreases with a drop in its moisture content, the vapor pressure of liquid to be removed becomes more effective in causing evaporation. The use of dehumidified air is especially helpful when seed is to be dried to a relatively low content of moisture. Certain chemicals that have a strong affinity for moisture are used to dry air in dehumidifying systems. Silica, for example, can pick up moisture from air in amounts up to 30 percent of its dry weight. When it will hold no more moisture it can be reactivated for further use by drying. Other common drying agents are calcium chloride, activated alumina, and anhydrous calcium sulfate.

**Dehumidified air by refrigeration:** An alternate method of dehumidifying air is to employ refrigeration to drop air temperature below its dewpoint-where moisture begins to condense. This will reduce the moisture holding capacity of the air and remove surplus vapor, which can then be withdrawn from the system.

**Vacuum Drying:** Vacuum drying is another way to remove moisture from seeds. It, like dehumidified air, usually is used in special situations where seed must be dried to a very low moisture content.

Vacuum drying is somewhat like drying with dehumidified air in that the vapor pressure of the surrounding atmosphere is reduced so seed moisture can vaporize more readily. When the total pressure in a vacuum-drying chamber is lowered, the component of this pressure due to vapor is reduced proportionately. In vacuum drying, The heat for evaporation must be supplied mainly by conduction or radiation, since there is little air available for heat transfer by convection.

**Infrared Heat:** In drying by infrared heat, the seed rather than the air, receives special attention, Radiant heat rays from infrared lamps will pass through air without warming it and be absorbed by the seed. The result is an increased temperature of seeds, which hastens movement of internal and surface moisture to the surrounding air. A feature of this method is its speed, especially when seeds are dried in a thin layer.

### **Drying Time**

The total drying time for any seed is influenced by its initial and final moisture content, its drying rate, the rate of airflow and the temperature of the drying air.

The higher the moisture level, the greater the time needed to reach the desired dry condition. The drying rate of seed also affects this time for drying. Most seeds have a fast drying rate at high contents of moisture, but have an increasingly lower rate as they approach the final, desired moisture content. Considerable time may be required to remove the last one percent of moisture.

The final moisture content for safe storage of seed is four percent to 14 percent, depending on the kind of seed, storage period, lower levels generally are desirable for longer storage times and confined storage conditions.

Airflow rate, too, can influence drying time. If an extremely low airflow rate is used, the drying air can become saturated before completing its passage through the seed and no further drying with the air can occur. Drying then is limited by the airflow rate through the seeds, and the greater airflow the lower the drying time.

On the other as airflow increases a point is reached at which the air is absorbing all the moisture that is made available to, it Beyond that point, additional airflow does not reduce drying time, because rate at which moisture diffuses from the inner parts of the seed to the surface are the main controlling factors.

When heated air is used for drying seeds, the drying temperature usually should not exceed 45 ° C. Some seeds such as peanuts and certain vegetables are dried at lower temperature. If the temperature sensitivity of a given type of seed is not known, it is wise to select the drying temperature according to the moisture level of seed.

## Different Kind of Driers

Bag Driers, In bin driers, Continuous driers, Principle Horizontal driers, Sloping and vertical driers etc.

There are many ways of drying harvested seeds but all are aimed at one goal to help provide seeds that grow vigorously when planted. Drying whether natural or artificial storage good seeds are available for their important place in agriculture.

## Seed Treatment

Seed treatment refers to the application of fungicide, insecticide, or a combination of both, to seeds so as to disinfect and disinfest them seed-borne or soil borne pathogenic organisms and storage insects. It also refers to the subjecting of seeds to solar energy exposure, immersion in conditioned water, etc. The seed treatment is done to achieve the following benefits.

### Benefits of Seed Treatment

1. Prevention of spread of plant diseases. The disease from a treatment standpoint may be conveniently grouped under three types.
  - (a) Systemic diseases that infest the seed during the harvest or storage period resulting in infection of the seed, e.g. bunt or stinking smut of wheat, loose kernel and covered kernel smuts, *Helminthosporium* stripe of barley, loose and covered smut of oats; head and kernel smuts of rye, loose kernel and covered kernel smuts of sorghum, and kernel and head smuts of millet. Appropriate seed treatment is significantly effective in controlling these diseases.
  - (b) Systemic diseases that infect seed during the flowering stage to become established within the seed and from there within the resulting plant. Such disease includes loose smuts of barley and wheat. Treatment with systemic fungicides, e.g. vitavax has been found effective.
  - (c) Non-systemic disease. Diseases that infest seed during the harvest or storage period. Such diseases includes *Helminthosporium* spots, blotches or blight of barley, oats, rice, rye, sorghum and wheat, Fusarium scab of barley, oats, rice, rye, sorghum and wheat, bacterial blights of barley, oats, and sorghum, anthracnose, bacterial and aschochyta blights of cotton; rust of safflower, and anthracnose and pasmo disease of flax. These diseases can be effectively controlled by appropriate seed treatment.
2. Seed treatment protects seed from seed rot and seeding blights. Seed treatment by its protective coating around the seed acts as a barrier once the seed is planted to ward off attack by both seed-borne and soil-borne and soil-borne organisms. These organisms affect all crop seeds and the degree of attack depends upon a number of factors. Of particular importance are the organisms *pythium spp.*

and *Rhizoctonia* that are present in all soils. They may rot the seed before germination gets well started, or they may kill the seedling it emerges, or so affect it that it dies after emergence or survives only as a weakened plant. The response to protective treatment varies with the kind of crop seed. The vigour of the particular seed, the amount of mechanical injury seeds, conditions of seed surface and adversity of planting conditions. The fungicide compensates by protecting these cracks and abrasions from entrance of fungi.

3. Improves germination. Seed treatment often improves the standard of germination through the control of seed surface mold. Though normally not considered pathogenic, this may infest the seed following moist harvesting and storage conditions. In the germination test it may smother the seed before it has a chance to germinate.
4. Provides protection from storage insects. The protection of seed from insect damage during storage is of increasing importance with the trend toward processing, treating and unit packaging of seeds at harvest time. For complete protection it is necessary to treat seed with insecticide also. More insecticides are needed in warm storage than cool storage.
5. Controlling soil insects. This can be done through combination treatment, the process of addition of an insecticide with fungicide for the added protection of the seed and seedling against certain soil insects, such as wire worm and the seed corn maggot. In contrast to storage insect protection. It is a means of giving limited protection to the seed and seedling until it becomes resistant to attack or can survive limited attack. It is not a means of disinfecting the soil.

## Seed Treating Products

### Mercurials

1. **Organic mercurials:** Organic mercurials are recommended for the treatment of small grains, flax, cotton and safflower, proper dosage is critical. Over treatment, however, may result in seed injury and under-treatment may not adequately control disease. In general, the seed treated with the more volatile organic mercury compounds cannot be stored for more than a few days without lowering the viability of the seed, especially if the moisture content is high. The rate of application of organic mercurials should be watched closely. It should never be applied at more than the recommended rates. If the seed is to be stored for a while after treatment with a volatile fungicide, the moisture content of the seed should be thirteen percent.

2. **Inorganic mercurials:** The use of inorganic mercurials for treating seeds is practically limited to mercuric chloride, mercurous chloride and mercuric oxide. These materials when used are limited primarily to seeds, roots, garden and vegetable crops. Extreme caution is necessary in using inorganic mercurials for seed treatment. Mercuric chloride is injurious, to some extent, to most seeds.

## **Non-Mercurials**

### **Organic non-mercurials**

The use of organic non- Mercurials has considerably increased in the recent past. Generally, they are less effective than organic Mercurials but are less damaging to the seeds and less dangerous to persons handling the seed. Excessive dosages are not harmful to the seed which may be stored for long periods of time without suffering injury from the treatment. Organic non-mercurials are not detrimental to the viability of injured seed. These fungicides act as seed disinfectants and/or seed Protectors. That is they may kill fungal sports on the surface of the seed and also serve as a protector to the seed against soil-borne organisms.

### **Inorganic non-mercurials**

Copper carbonate, copper sulphate, cuprous oxide constitutes the major inorganic non-mercurials compounds which are used as fungicides. Copper carbonate and copper sulphate are used on wheat as bunt preventives. Cuprous oxide prevents seed decay and damping-off in vegetables, but is injurious to seeds of lettuce, crucifers and onions.

## **Insecticides**

Insecticides are finding increasing use in seed treating. These may be merchandised in combination with the fungicide, or as distinct products for individual use, or combined with the fungicide in the treating process. The uses include:

1. Protection against storage insects, particularly various cereal crop seeds.
2. Protection against certain soil insects that attack the seed and germinating seedling particularly sorghum, corn, beans and vine crop seeds.
3. Protection of the growing plant through systemic action, such as certain organic phosphates in cotton.

## **Formulation of Fungicidal Materials**

Seed treatment materials are available in the form of dusts, wettable powders and liquids.

### **1. Dusts**

Dusts fungicides are usually applied at rates of 200 to 250 grammas per quintal of seed. They should be thoroughly mixed in a mechanical mixer. The dusty condition which prevails during treatment, and handling of the seed subsequent to treatment, is the main disadvantage of using dust fungicides.

## **2. Slurry**

This type fungicide is applied to the seed in a soup-like water suspension which is mixed with the seed in a special slurry treater. The used requires no drying and can be bagged immediately for sowing storage.

## **3. Liquids**

This use of liquid solution is known as the 'quick wet' method. A concentrated solution of a volatile fungicide is applied to the seed and is thoroughly mixed with them. This method is recommended for applying panogen, mercuran, etc.

## **Fungicide-insecticide formulation**

The insecticides mostly used for treating seeds are DDT, aldrin, linden, dieldrin, heptachlor, chlordane and metoxychlor. Insecticides used alone tend to damage the embryo of the seed. However, when used in combination with a fungicide, they interact with each other and the damage is not as severe. Dosage is very important (as shown in the table). There seems to be a narrow range between the amount of insecticide that can be used without injuring the seeds and the amount that will effectively protect the seeds from insects in the soil. Since the amount of insecticide on the seed is small, the only insects controlled are those that casually attack the seed. There is not enough of the chemical to treat the soil.

Seed should be treated with fungicide-insecticide mixtures only when they are to be planted in a soil infested with insects when with destroy the seeds or young seedling.

They should be applied with, or after, the seeds have been treated with a fungicide and should be applied just before the seeds are planted. If the seeds are to be stored after they are treated, the moisture content and storage temperature should be kept low to help prevent damage.

## **Equipment for Seed Treatment**

The equipment used to apply chemicals in any form to seed are classed as seed treaters, and can be divided into two broad categories.

### **1. Slurry treaters**

The slurry treatment principle involves suspension of wettable powder treatment material in water. The treatment material applied as slurry is accurately metered through a simple mechanism composed of a slurry cup and seed dump pan. The cup composed of a slurry cup and seed dump pan. The cup introduces a given amount of slurry. With each dump of seed, into a mixing chamber where they are blended. The slurry treaters are adaptable to all types of seed and rates of treating. The small amount of moisture added to the seeds, half to one percent of the weight of the seed, does not affect seed in storage, since the moisture is added to the seed surface and is soon lost.

### **2. Direct Treaters**

Direct treaters are the most recent development and include the 'panogen' and mist-o-matic treaters. Of these two, the mist-o-matic is being used more widely.

The mist-o-matic treater applies treatment as a mist directly to the seed. The metering operation of the treatment cups and seed dump is similar to that of the panagon treater. Cup sizes are designated by the number of cc's they actually deliver, e.g. 2½, 5, 10, 15. The treater is equipped with a large treatment tank, a pump, and a return that maintains the level in the small reservoir from which the treatment crops are fed. After metering, the treatment material flows to a rapidly revolving fluted disc mounted under a seed spreading cone. The disc breaks drops of the treatment into a fine mist. It sprays this outward to coat seed falling over the cone through the treating chamber, just below the seed dump are two adjustable retarders designed to give a continuous flow of seed over the cones between seed dumps. This is important since there is a continuous misting of material from the revolving disc. The desired treating is obtained through selection of treatment cup size and proper adjustment of the seed dump weight.

**Home-made drum mixer** A simple mixer can be made by running a pipe through a drum at an angle. The drum is then mounted on two sawhorses. The seed and treatment are placed in the drum and it is rotated slowly until all seeds are covered.

**Grain auger** Liquid materials can be dripped on to the seed, as they enter a grain auger or screw conveyer. By the time seeds have left the auger, the liquid is spread well over most seeds. Dust and slurry materials may also be applied in this manner, but with more difficulty.

### **Coloring of Seeds**

Most seed treatment contains dyes, and companies add their own 'color brand' dye to seed treatments. Dyes serve two purposes.

- i. As a warning that the seeds have been treated to prevent inadvertent contamination of food or feed.
- ii. As a visible means of evaluating the completeness of treatment coverage.

They dyes, if used for treating formulation of dry seed, are mixed with fungicide and insecticide treatment.

### **Causes of Poor Treatments**

**1. Wrong fungicides.** Use of inappropriate fungicides, old dusts, etc may prove relatively ineffective for protection against soil fungi.

**2. Inadequate dosages.** Failure to get sufficient fungicide on the seed results in poor seed treatment.

**3. Carelessness** The use of the best available fungicides and the latest equipment for treating seeds does not by itself guarantee proper seed treatment. Adequate care is necessary regarding machine adjustments, etc, to treat seeds effectively.

### **Precautions in Seed Treatment**

Most products used in the treatment of seeds are harmful to humans, but they can also be harmful to seeds. Extreme care is required to ensure that treated seed is never used as human or animal food. To minimize this possibility, treated seed should be clearly labeled

as being dangerous, if consumed. The temptation to use unsold treated seed for human or animal food can be avoided if care is taken to treat only the quantity for which sales are assured.

Care must also be taken to treat seed at the correct dosage rate, applying too much or too little material can be as damaging as never treating at all. Seed with a very high moisture content is very susceptible to injury when treated with some of the concentrated liquid products.

### **Seed Preservation and Storage Management**

During seed development, germination and vigour reach their peak at 'physiological maturity'. As the seed moisture is very high at this stage, seed crop is allowed to get sufficiently dried before the seed can be harvested till a stage, commonly referred to as 'field maturity' or 'harvest maturity', when the seed moisture reaches a safe level.

Most of the seeds have to be store for a period of several months, from harvest until the next sowing season with good physical and physiological condition from the time they are harvested until the time they are planted. The primary purpose of storing seeds is to save seed from one season to the next, but farmers and seed companies often find it useful or necessary to store seeds for at least two to three years, and sometimes longer. There are several reasons for this: (1) seed yields and seed quality (germination and vigor) may be unpredictable due to growing conditions, and (2), market demand for certain crops may vary significantly from one year to the next. Market demand itself can be strongly influenced by media coverage of certain varieties that may quickly fall in or out of favor depending on media exposure. Likewise, market demand may also be influenced by the psychological effects of poor growing conditions from the previous season.

In Bangladesh relative humidity is detrimental to seed preservation. High rainfall causing high relative humidity and resulting high moisture content of seed. So, seeds are not safe for long time preservation. Storing period of all kinds of seeds is April to October. Unfortunately, in Bangladesh has high rainfall, high relative humidity and high temperature from April to October, which are very much detrimental to the seed longevity.

High moisture content during storage causes -

- Heat buildup in the lot
- increased respiration
- Mold development
- Insect infestation
- Discoloration/Yellowing
- Loss of germination and vigor
- Loss of freshness/odor development
- Reduced head rice yield
- Reduced storage life

## Stage of Seed Storage

Seed are considered to be in storage from the moment they reach physiological maturity until they are sown, Storage period can be conveniently divided into following stages:

- i) Storage on plants (physiological maturity until harvest).
- ii) After harvest, until processed and stored in a warehouse.
- iii) In storage (warehouse).
- iv) In transit (truck, rail wagons, railway sheds, etc.).
- v) In retail stores/ Shop.
- vi) On the user's farm (Farmer's house)

### Safe storage of seeds for longer periods is possible if three conditions are met:

1. Grain is maintained at safe moisture levels or less and seed is stored at a moisture level less than safe
2. Grain is protected from insects, mold, rodents and birds
3. Grain is protected from re-wetting by rain or imbibing moisture from the surrounding air.

The longer the grain needs to be stored, the lower the required moisture content will need to be.

The longer the grain needs to be stored, the lower the moisture content required. Grain and seed stored at moisture content above 14% may experience growth of mold, rapid loss of viability, and a reduction in eating quality. The 'safe' moisture content required for different storage periods is seen in the table.

Storage	Required moisture content for safe storage	Potential problems if requirement not met
2 to 3 weeks	14–18 %	Molds, discoloration, respiration loss
8 to 12 months	12–13 %	Insect damage
more than 1 year	9% or less	Loss of viability

A rule of thumb for seed is that the life of the seed will be halved for every 1% increase in moisture.

## Principles of Seed Storing

Seeds are hygroscopic living materials. Deterioration of seed quality is a continuous process, it cannot be stopped totally. Only the process can be slowed down through appropriate measures. So, seed should not be stored like other commodities. The storage principles of seeds are:

- Storage structure should be such that no rainwater can enter and no serious gain in moisture can take place during the storage period.
- Seed storage condition should be dry and cool.

- Storage must be a heat trap that is, allowing seed to reach exclusively high temperature, e.g. steel bins exposed to the sun in a hot climate.
- Storage atmosphere should be neat and clean and must be dry and cool.
- Storage of high quality seeds only i.e. well cleaned, treated as well as of high germination and vigor and good pre-storage history.
- Seed should be undamaged to minimize decline in vigor and germination.
- Before storage, seeds must be cleaned to free them of trash, which may harbor insects or fungi and prevent free circulation of air.
- Before placing seeds into storage, they should be dried to safe moisture limits appropriate for the system.
- Proper sanitation in the seed store to be ensured.
- Effective and adequate pest control measures to be adopted.

**Harington's rule state that:**

- A. For every decrease of 1% in seed moisture content the life of the seed is doubled or, for every increase of 1% in seed moisture content the life span of seed is became half.
- B. For every decrease of 5<sup>0</sup>C in storage temperature the life span of the seed became nearly double or, for each increase of 5<sup>0</sup>C temperature the life of seed is halved.

**Another rule of thumb for practical use is that**

- A. The sum of the temperature in <sup>0</sup>F and the percent RH should not exceed 100. or
- B. The sum of the temperature in <sup>0</sup>C and the percent RH should not exceed 60.

**Effective Storage Life of Seed depends on-**

- The kind of Seed - Genetic make-up and chemical composition of seed.
- Its pre-storage history - Initial seed quality (harvesting & processing).
- Storage Environment - Temperature Humidity & Gaseous Composition
- Storage Structure & its Condition.
- Storage Sanitation & Pest Control
- Management level & Operation Skill

**Safe storage of seeds for longer periods is possible if three conditions are met:**

1. Grain is maintained at safe moisture levels or less and seed is stored at a moisture level less than safe
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## **Type of Storage**

### **Traditional**

In dry tropics seed is kept in open sacks or in heaps on the ground, with protection against animals. In temperate regions, seeds are stored in sacks or on barn floors. In wet tropics, seeds are often stored in earthenware bins or in gourds sealed with clay.

### **Buildings**

For storage of large quantities of seeds, well designed seed godown or warehouse should be constructed. Seed godown should be minimum 100 metres apart from food & fertilizer godown. Floor should be above ground level, wall should have smooth internal surface, fan and ventilation are required.

### **Dehumidified Store**

Generally, carryover seed and high valued seeds are preserved in this type of store. Temperature and relative humidity of dehumidified store will be 20-22°C and 40-50% RH. Refrigeration is used to keep the storage temperature below the usual ambient temperature.

# Disease and Insect Pest Management in Quality Seed Production

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## 1. Introduction

### Seed Quality

- Impact of pests and diseases on seed quality, germination and yield.
- Seedborne diseases and pests can affect seed health, leading to poor seed performance.
- Importance of disease and pest management in producing high quality seeds for agricultural sustainability and food security.

### Seed Production Process

- Steps involved in seed production: land preparation, sowing, care during growth, harvesting, seed processing and storage.
- How pests and diseases can interfere with each step in the seed production process?

## 2. Common Pests and Diseases in Seed Production

### Pests Affecting Seed Crops

#### Insects

- **Termites**: Damage to seeds in the field and during storage.
- **Aphids**: Transmission of viruses and causing damage to plants.
- **Fruit flies and weevils**: Destruction of developing seeds, affecting seed quality.

**Nematodes**: Affecting the root systems and hindering seedling growth, leading to lower quality seeds.

**Rodents**: Loss of seeds during storage and in the field.

### Diseases in Seed Crops

#### Fungal Diseases

- **Fusarium wilt**: Affects many crops, reducing seed quality and germination.
- **Damping-off disease**: Common in nurseries and affects seedling survival.
- **Downy mildew**: Impact on seed quality and viability in crops like vegetables.

#### Bacterial Diseases

- **Bacterial blight**: Leads to seed decay, specially in rice, affecting seedling growth.
- **Bacterial soft rot**: Affects the storage of seeds in cool and damp conditions.

## Viral Diseases

- **Tobacco mosaic virus:** Common in crops like tomato and pepper, which can be transmitted through infected seeds.
- **Rice yellow dwarf virus:** A major concern in rice seed production.

## Transmission of Diseases

- Seed borne vs. soil borne vs. vector borne transmission.
- The role of infected plant parts (e.g., leaves, roots) in spreading pathogens to seeds.
- How pests and vectors can carry diseases from one crop to another.

## 3. Integrated Pest/Disease Management (IPM/IDM) Strategies

### Cultural Control Methods

**Crop rotation:** Reducing pest and disease pressure by alternating crops.

**Sanitation and Field Management:** Removing plant debris, weeds, and infected plant material from the field.

**Field selection:** Choosing sites with optimal conditions that reduce pest and disease risks.

**Resistant varieties:** Use of pest and disease-resistant varieties of crops to reduce the risk of infestation.

**Proper spacing and planting:** To improve airflow and reduce conditions favorable for disease spread.

### Biological Control Methods

#### Beneficial Insects and Natural Predators

- Use of predators (Ladybird beetles, Lacewings, Hoverflies etc.), Parasitoids (*Trichogramma* spp, Braconid wasps), Pollinators (Honeybees, Wild bees and Butterflies) and Soil health insects (Dung beetles, Termites and Earthworms) to control pest populations.
- Trichoderma species as biocontrol agents against fungal pathogens.

Insect Name	Type	Target Pest	Application in Bangladesh
Ladybird Beetles ( <i>Coccinellidae</i> )	Predator	Aphids, Whiteflies	Used in vegetable and fruit crops
<i>Trichogramma</i> spp.	Parasitoid	Lepidopteran pests	Released in rice and vegetable fields
Honeybees ( <i>Apis</i> spp.)	Pollinator	Mustard, Cucurbits	Pollination improvement in horticulture
Hoverflies ( <i>Syrphidae</i> )	Predator	Aphids, Thrips	Used in vegetable IPM programs
Dung Beetles ( <i>Scarabaeidae</i> )	Organic matter decomposition	Soil health	Soil fertility enhancement

**Bio-pesticides:** Use of microbial pesticides such as *Bacillus thuringiensis* (Bt) for pest control.

**Plant Growth Promoting Rhizobacteria (PGPR):** Promoting beneficial microorganisms that outcompete harmful pathogens.

## Chemical Control Methods

### Use of Seed Treatment Chemicals

- Seed dressing with fungicides, insecticides, and nematicides to protect seeds from pests and diseases.
- Systemic insecticides: Absorbed by the plant to kill pests that feed on the plant.

**Pesticide Application:** Strategies for using chemicals safely and efficiently to avoid resistance development and ensure environmental sustainability.

**Integrated Use of Fungicides and Insecticides:** When to use them and how to avoid harmful residues in the seed.

## Physical Control Methods

**Heat Treatment:** Using hot air to kill pests and pathogens on seeds before storage.

**Cold Treatment:** Freezing seeds to eliminate insect larvae and pathogens.

## 4. Seed Quality Assurance and Certification

### Importance of Seed Certification

- Seed certification processes that ensure seed health and quality.
- Role of agencies like Seed Certification Agency (SCA) in inspecting and certifying seed lots.

### Monitoring and Quality Control

- Regular inspection of seed lots for pests and diseases.
- Laboratory testing for seedborne pathogens and pest infestation.

### Post-Harvest Management

- Best practices for seed drying, processing and storage to avoid pest and disease contamination.
- Ensuring proper storage conditions (temperature, humidity) to maintain seed viability and prevent pest infestation.

## 5. Case Studies and Real-Life Applications

### Case Study-1: Managing Rice Seedborne Diseases

- Control of Rice Blast and Bacterial Leaf Blight in rice seed production through IPM strategies.
- Use of resistant rice varieties and seed treatment with fungicides.

### Case Study-2: Vegetable Seed Production

- Managing Downy Mildew and Powdery Mildew in vegetable seed production using resistant varieties and cultural practices.
- Biological control with beneficial fungi like Trichoderma to control fungal pathogens in seedling production.

## **6. Future Directions and Research Needs**

### **Advances in Seed Treatment Technologies**

- Exploration of new chemical and biological seed treatments for better pest and disease protection.
- The potential of nanotechnology and other advanced methods for improving seed health.

### **Climate Resilient Seed Varieties**

- The importance of developing disease and pest resistant seed varieties that are also tolerant to changing climatic conditions.

### **Ongoing Research Needs**

- Research on pest and disease resistance mechanisms in seeds.
- Developing low-cost and effective management solutions for smallholder farmers.

## **7. Conclusion**

- Managing diseases and insect pests is essential for ensuring high quality seeds, improving agricultural productivity that supporting economic growth.
- Integrated approach combining cultural, biological, chemical and physical control methods need to be emphasized.
- Continuous R&D is needed for improving pest and disease management practices that will enhance seed viability, maintain purity and contribute to sustainable farming.

## **Raising Farmer Awareness on Quality Seed Use with Post Harvest Handling**

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To improve farmer awareness regarding the use of quality seeds and proper post-harvest handling, several key strategies should be implemented. These include conducting educational workshops and field demonstrations, emphasizing the importance of selecting certified seeds, teaching proper harvesting techniques, providing information on suitable drying methods, and promoting safe storage practices to maintain seed viability and quality. Throughout this process, it's essential to highlight the direct impact these practices have on crop yield and income.

*Key points* to include in [farmer awareness](#) campaigns: -

### **Benefits of quality seeds**

Explain how high-quality seeds lead to better germination rates, uniform plant growth, increased yield, and resistance to diseases and pests.

### **Seed selection criteria**

Educate farmers on how to choose certified seeds based on variety suitability, adaptation to local climate, and desired traits.

### **Proper harvesting techniques**

Teach farmers the optimal time to harvest crops to ensure seed maturity and minimize damage.

### **Importance of timely drying**

Emphasize the need for proper drying methods to reduce moisture content in seeds, preventing mold and maintaining viability.

### **Storage practices**

Demonstrate appropriate storage conditions like cool, dry areas with good ventilation to protect seeds from pests and environmental factors.

Implementation methods:

### **Field demonstrations**

Conduct practical demonstrations on seed selection, harvesting, drying, and storage techniques in farmers' fields.

### **Extension services**

Utilize agricultural extension agents to reach a wider audience and provide targeted information based on local needs.

**Farmer training programs**

Organize workshops and training sessions to educate farmers on the principles of seed quality and post-harvest management.

**Community outreach**

Engage with farmer groups, cooperatives, and local markets to disseminate information through meetings, posters, and leaflets.

**Technology adoption**

Introduce simple, low-cost technologies like seed cleaning machines and improved drying structures to improve seed quality.

Important considerations:

**Crop specific needs**

Tailor information to the specific crops grown in the region, as different crops may require unique post-harvest handling practices.

**Local context**

Consider local cultural practices and challenges when designing awareness campaigns.

**Sustainability**

Promote environmentally friendly practices in seed production and storage.

By raising awareness about the importance of quality seeds and proper post-harvest handling, farmers can significantly improve their crop yields and overall economic viability.

# Role of Biotechnology in Seed Quality Improvement

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## Introduction

Seeds are, quite literally, the kernels of life that sprout into plants, providing food, fiber, and a multitude of other resources essential for human survival. As the foundation of agriculture and food production, the quality of seeds directly impacts the productivity, resilience, and sustainability of our agricultural systems.

Thus, seed quality is a critical factor influencing agricultural productivity and food security globally. Traditionally, seed quality improvement relies on selective breeding and seed treatment techniques. However, these methods have limitations in terms of time, resources, and precision. In response to these challenges, the field of seed science has been revolutionized by the advent of biotechnology, offering unprecedented opportunities for seed quality enhancement. The applications of genetic engineering, marker-assisted selection, and the integration of genomics, proteomics, and metabolomics- collectively termed as ‘omics’ technologies have created tremendous opportunities in seed quality enhancement. The advent of modern agriculture has brought a frame-shift transformation in seed quality enhancement.

## Importance of Seed Quality Enhancement

Seeds are remarkable biological entities, possessing the unique ability to give rise to a new generation of plants. The quality of a seed determines its potential to germinate and establish a healthy, vigorous plant under varying field conditions. Seed quality is a complex trait encompassing several characteristics, such as genetic and physical purity, germination capacity, vigor, freedom from seed-borne diseases, and the presence of adequate seedling nutrition. Each of these attributes contributes to the overall performance of a seed in the field and, consequently, the productivity of the crop. Enhancement of seed quality is crucial for several reasons. Firstly, high-quality seeds have been shown to increase crop yields by providing uniformity and vigor in early plant growth. This robust early growth can contribute to better tolerance against biotic and abiotic stress factors such as pests, diseases, drought, and suboptimal soil conditions, ultimately leading to improved crop yields. Secondly, as we face the challenges of climate change and a growing global population, the need for high-yielding, stress-tolerant crops becomes even more pressing. Seed quality enhancement can be a key player in developing such crops. By improving seed quality, we can develop crops that are not only high-yielding but also resilient to the changing climate and capable of growing in less than optimal conditions. Furthermore, seed quality enhancement is vital to

maintain the genetic integrity of the crop. High-quality seeds ensure that the desired traits selected by breeders are accurately passed on to the next generation. This is especially important in an era where crop improvement programs are striving to meet the increasing demand for food, feed, and fiber.

### **Parameters of Seed Quality**

Seed quality can be broadly defined as the potential of a seed to germinate and develop into a healthy plant under optimal conditions. This quality is determined by a number of intrinsic and extrinsic factors that collectively constitute the parameters of seed quality. One primary parameter is genetic purity, referring to the consistency of a seed's genetic composition with that of its parent crop. This ensures the preservation of desirable traits, such as high yield or disease resistance, in the offspring. Physical purity, another key aspect, concerns the absence of extraneous matter (like weed seeds or debris) within the seed lot, as these could affect germination and crop yield. The vigor of a seed, defined by its ability to germinate and establish under a wide range of field conditions, is another important quality parameter. Seeds with high vigor often exhibit rapid, uniform germination and robust seedling growth, even under less than optimal conditions. Germination capacity refers to a seed's potential to develop into a full-grown plant under optimal conditions. It is a critical parameter in seed quality, as high germination rates translate to a greater number of plants per unit of seed sown. Another significant parameter is the health of the seed, which involves freedom from seed-borne pathogens. Pathogens can drastically affect a seed's viability and the subsequent crop's health, making seed health a vital consideration in seed quality. Finally, nutritional content, particularly in the form of endosperm, which nourishes the young seedling, is a significant quality aspect, affecting the initial growth and establishment of the plant.

### **Traditional Approaches for Seed Quality Enhancement**

For centuries, farmers and agricultural scientists have worked to enhance seed quality through various traditional approaches. These practices, deeply rooted in human history, have shaped agriculture as we know it today. Yet, while these methods have achieved remarkable feats, they are not without their limitations. Traditional approaches for seed quality enhancement can be broadly categorized into three primary methods: selective breeding, seed treatment, and optimal storage conditions. Selective breeding is one of the oldest practices for enhancing seed quality. This involves choosing parent plants with desirable traits to breed the next generation. Over time, traits such as high yield, disease resistance, or tolerance to environmental stress can be propagated and enhanced within a crop population. This practice has been central to agriculture, leading to the development of most modern crop varieties. Seed treatment, another traditional approach, involves various methods to improve seed germination and protect the seed from pathogens. This may include physical treatments such as scarification or stratification, which work by breaking down the seed's dormancy and thereby enhancing germination. Chemical treatments, including fungicides or insecticides, protect the seeds from pests and diseases,

while biological treatments involve beneficial microorganisms that can promote plant growth. Proper seed storage is also crucial to maintaining seed quality. This involves storing seeds under optimal conditions of temperature and humidity to maintain their viability and vigor over time. For some seeds, this may also involve periods of dormancy, during which the seeds require specific conditions to remain viable.

### **Limitations of Traditional Methods**

While these traditional methods have proven invaluable to agriculture over the centuries, they come with inherent limitations that restrict their efficiency and scope. Selective breeding, though effective, is a slow and labor-intensive process. It often takes many generations to develop a new variety, and the process is complicated by the fact that desirable traits may be linked with undesirable ones due to genetic linkage. Furthermore, selective breeding is limited to the genetic diversity available within a species or closely related species, restricting the range of possible improvements. Seed treatment, while helpful in improving germination and protecting seeds from pathogens, may not be sufficient to combat increasingly virulent pests and diseases or to cope with environmental stresses due to climate change. Furthermore, chemical treatments can have environmental implications, and their excessive use can lead to the development of resistant pest populations. Lastly, the preservation of seed viability during storage can be challenging. Environmental factors such as temperature, humidity, and pests can degrade seed quality over time. This is particularly problematic for seeds with short shelf lives or those from species that don't naturally produce seeds that can survive the drying process. These limitations, coupled with the increasing demands of a growing global population and a changing climate, have necessitated the development of more efficient, precise, and sustainable methods for seed quality enhancement. This has led to the emergence of biotechnological approaches, which promise to revolutionize seed quality enhancement by overcoming some of the inherent limitations of traditional methods.

### **The Biotechnological Approaches in Seed Science**

Biotechnology has opened a new era of possibilities in seed science. By manipulating the genetic makeup of seeds, biotechnological techniques offer promising approaches to enhance seed quality, presenting potential solutions to overcome the limitations of traditional methods. This technology enabled scientists to manipulate an organism's genetic material directly, marking a significant shift from the relatively imprecise methods of selective breeding. The subsequent development of genetic engineering techniques further advanced biotechnology's potential in seed science. These techniques allow scientists to introduce specific traits into a plant by inserting genes directly into its genome. This has led to the development of genetically modified (GM) crops with traits like insect resistance, herbicide tolerance, and enhanced nutritional content, many of which are now grown extensively around the world. Another milestone was the completion of the Human Genome Project in the early 2000s, which spurred the development of high-throughput sequencing technologies. These technologies have made

it possible to sequence entire plant genomes quickly and affordably, paving the way for the fields of genomics, proteomics, and metabolomics in plant science. Marker-assisted selection (MAS), another major biotechnological approach, has also emerged as an important tool in seed science. By using molecular markers associated with desirable traits, MAS allows for more precise and efficient selection in breeding programs.

### **Potential of Biotechnology for Seed Quality Enhancement**

The potential of biotechnology for seed quality enhancement is vast. Genetic engineering allows for the introduction of traits that could not be achieved through traditional breeding, such as resistance to specific pests or diseases, tolerance to abiotic stresses like drought or salinity, and enhanced nutritional content. This has the potential to increase crop yields, improve crop resilience, and enhance the nutritional value of food crops, all of which are crucial in the face of a growing global population and a changing climate. MAS and genomic selection also hold great promise for seed quality enhancement. By allowing for the precise selection of desirable traits, these techniques can greatly speed up the breeding process compared to traditional methods. This could lead to the development of new crop varieties with enhanced seed quality in a fraction of the time it would take with traditional breeding. Furthermore, the 'omics' technologies - genomics, proteomics, and metabolomics - offer unprecedented opportunities for understanding and manipulating seed quality. By providing a holistic view of the genetic, protein, and metabolic profiles of a seed, these technologies can reveal the molecular mechanisms underlying seed quality traits, enabling scientists to manipulate these mechanisms to enhance seed quality. Overall, biotechnological approaches hold great promise for seed quality enhancement. Yet, they are not without challenges, including technical difficulties, regulatory hurdles, and societal acceptance. Despite these challenges, the potential benefits of these technologies make them a vital area of research and development in seed science. It is expected that with continued advancements and careful stewardship, biotechnology will play an increasingly important role in the future of seed quality enhancement.

### **Genetic Engineering in Seed Quality Enhancement**

Genetic engineering has emerged as a powerful tool in the quest to enhance seed quality, offering potential solutions to some of the most pressing challenges in agriculture. Genetic engineering, also known as genetic modification, involves the direct manipulation of an organism's genome using biotechnology. This is in contrast to traditional breeding methods, which involve crossing plants with desirable traits and selecting offspring that exhibit these traits. Recently, the advent of CRISPR-Cas9 gene editing has revolutionized the field of genetic engineering. This technique allows for precise, targeted changes to the genome, including the addition, removal, or alteration of specific sequences of DNA. This level of precision and flexibility has opened up new possibilities for seed quality enhancement. Genetic engineering has already been successfully used to enhance seed quality in several ways. One of the most well-known

examples is the development of Bt crops. These genetically modified plants express a toxin from the bacterium *Bacillus thuringiensis* (Bt), which is lethal to many insect pests but harmless to humans and most non-target organisms. Bt cotton, corn, and brinjal (eggplant) have been extensively adopted in many countries, leading to significant reductions in pesticide use and increases in crop yield. Golden Rice is another prime example of how genetic engineering can enhance seed quality. This genetically modified rice variety produces beta-carotene, a precursor of vitamin A, in its grains. This has the potential to combat vitamin A deficiency, a major public health problem in many developing countries where rice is a staple food. Recently, genetic engineering has also been used to develop crops with improved tolerance to abiotic stresses such as drought and salinity. For example, scientists have developed genetically modified wheat and maize varieties with enhanced drought tolerance, offering potential solutions to the challenges of climate change. The above advancement demonstrates the potential of genetic engineering for seed quality enhancement. However, it's important to note that the use of genetically modified crops is subject to regulatory approval and public acceptance, both of which can vary significantly between countries and regions. Furthermore, the long-term environmental and health impacts of genetically modified crops are still under investigation. Therefore, while genetic engineering offers promising tools for seed quality enhancement, it must be applied with careful consideration of these potential risks and challenges.

### **Marker-Assisted Selection (MAS) in Seed Quality Enhancement**

Marker-Assisted Selection (MAS) has emerged as a powerful strategy in modern plant breeding programs, allowing breeders to enhance seed quality more efficiently and precisely. MAS is a biotechnological approach that uses molecular markers - identifiable DNA sequences that are associated with specific traits - to select desirable traits during breeding. Unlike conventional breeding, which relies on the visible expression of traits, MAS enables breeders to identify and select for traits at the genetic level, even before a plant reaches maturity or in conditions where the trait is not expressible. The process of MAS involves several key steps. Firstly, molecular markers associated with the trait of interest need to be identified. This is often done using mapping populations and statistical methods to find associations between markers and traits. Once markers have been identified, they can be used to screen breeding populations. Plants with the desired marker profile are selected for the next generation, and this process is repeated until a stable, desirable variety is obtained. With the advent of high-throughput genotyping technologies, it is now possible to scan thousands of markers across the genome simultaneously. This has paved the way for genomic selection, an extension of MAS that uses a genome-wide set of markers to predict the breeding value of individuals in a population. MAS holds significant potential for seed quality enhancement, with several successful applications already reported. One notable example is the use of MAS to develop rice varieties with improved grain quality. By using markers associated with grain quality traits such as aroma, amylose content, and grain size, breeders have been

able to develop new varieties that combine superior grain quality with high yield potential. MAS has also been used to improve resistance to diseases and pests, which can significantly affect seed quality. For example, markers associated with resistance to Fusarium head blight, a devastating disease of wheat, have been used to develop resistant varieties. Similarly, MAS has been used to improve resistance to pests such as the pod borer in cowpea, enhancing both yield and seed quality. In addition to disease and pest resistance, MAS can also be used to improve tolerance to abiotic stresses, such as drought, salinity, or extreme temperatures, which are becoming increasingly important with climate change. By selecting for markers associated with stress tolerance, breeders can develop crops that maintain high seed quality even under adverse conditions. Overall, MAS offers a promising tool for seed quality enhancement, providing a precise and efficient approach to select for desirable traits. As genotyping technologies continue to advance and our understanding of the genetic basis of seed quality traits improves, the application of MAS in seed quality enhancement is likely to become even more widespread.

### **Role of Genomics in Seed Quality Enhancement**

The advent of genomics – the study of an organism's entire genetic makeup or genome – has opened up unprecedented opportunities for enhancing seed quality. By providing a comprehensive understanding of the genetic basis of seed quality traits, genomics allows for the development of more efficient and precise strategies for seed quality improvement. Genomics involves the sequencing and analysis of an organism's entire genome. This is in contrast to genetics, which traditionally focused on the study of individual genes. Genomics provides a more holistic view of an organism's genetic makeup, taking into account the interactions between genes and their regulatory elements. A key aspect of genomics is the use of highthroughput sequencing technologies, which allow for the rapid and cost-effective sequencing of entire genomes. Once a genome is sequenced, bioinformatic tools are used to assemble the sequences, identify genes and other functional elements, and predict their functions. One significant application of genomics in plant science is the development of genomic resources, such as reference genome sequences, gene expression databases, and single nucleotide polymorphism (SNP) databases. These resources provide valuable tools for understanding the genetic basis of traits and for developing molecular markers for use in breeding. Genomic approaches have a wide range of applications for seed quality improvement. One of the most direct applications is the identification of genes associated with seed quality traits. For example, genomics can be used to identify genes that control traits such as seed size, seed composition (e.g., protein, oil, and starch content), seed dormancy, and resistance to seed-borne diseases. Once these genes are identified, they can be targeted for manipulation through genetic engineering or marker-assisted selection to improve seed quality. In addition, genomics can be used to study the genetic diversity of crop species, which is crucial for breeding efforts. By understanding the genetic variability within a species, breeders can select parents that combine a wide range of desirable traits,

ultimately leading to improved seed quality. Another significant application of genomics is the development of molecular markers for use in marker-assisted selection. By identifying markers associated with desirable seed quality traits, breeders can select for these traits more efficiently and accurately. Finally, genomics can also facilitate the study of gene-environment interactions, which are critical for understanding how different growing conditions can impact seed quality. For example, genomics can be used to study how gene expression changes in response to environmental stresses, providing insights into how to breed crops that maintain high seed quality under a range of conditions. Overall, genomics offers powerful tools for enhancing seed quality. As sequencing technologies continue to advance and become more affordable, the role of genomics in seed quality enhancement is likely to become even more significant. However, like all technologies, the application of genomics also comes with challenges, including the need for advanced bioinformatic tools and expertise, and ethical considerations related to genetic manipulation.

### **Proteomics in Seed Quality Enhancement**

Proteomics, the comprehensive study of proteins, has emerged as a potent discipline complementing genomics in our quest to understand and enhance seed quality. With a focus on the protein complement of an organism, proteomics offers insights into functional biology and directly reflects the dynamic response of a plant to environmental stimuli and genetic modifications. Proteomics involves the large-scale study of proteins, including their structures, functions, and interactions. It focuses not just on the quantity of various proteins, but also post-translational modifications, protein-protein interactions, and the dynamic changes that occur in response to various conditions. High-throughput protein sequencing has also been facilitated by the development of next-generation sequencing technologies. Bioinformatics plays a crucial role in proteomics, enabling the analysis and interpretation of large-scale proteomic data. Tools have been developed to predict protein structures, model protein-protein interactions, and annotate protein functions based on sequence similarity. Proteomics offers unique perspectives in the field of seed science, providing crucial insights into the molecular mechanisms underpinning seed development, germination, and responses to environmental conditions - all vital to seed quality. One of the primary applications of proteomics in seed quality enhancement involves understanding the seed's response to environmental stress. For instance, drought, high salinity, and extreme temperatures profoundly affect seed quality. Proteomic analyses enable the identification of proteins or protein pathways involved in the response to these stressors, helping breeders develop varieties with better stress tolerance. Proteomics has also been instrumental in studying seed germination, a critical phase in a plant's life cycle. Proteomic studies can help unravel the complex molecular mechanisms of germination, including metabolic pathway shifts, signaling pathways, and the role of hormone-mediated processes. This information is valuable for enhancing germination rates, improving seedling vigor, and ultimately enhancing crop establishment - all critical components of seed quality. In addition, the study of seed storage proteins (SSPs) has

been an area of significant interest in seed proteomics. SSPs, which include gluten in wheat and casein in legumes, directly influence seed nutritional quality. Detailed proteomic analysis of SSPs can help improve seed protein content and quality, leading to nutritionally enhanced crops. Moreover, proteomics is used to assess and understand the mechanisms of seed longevity and vigor, traits highly desired in seeds. The proteins associated with seed aging can be targeted to improve storage potential and overall seed quality. In conclusion, proteomics holds immense potential in seed quality enhancement, offering a molecular lens to view the complex dynamics of seed biology. It will play a critical role alongside other 'omic' technologies in shaping the future of seed science, contributing significantly to sustainable and productive agriculture. However, like other high-throughput technologies, proteomics faces challenges such as data complexity and the need for sophisticated analytical tools. Still, the potential benefits undoubtedly make it worth the effort.

### **Metabolomics in Seed Quality Enhancement**

Metabolomics, the study of metabolites within an organism, offers an avenue for understanding and improving seed quality through an examination of the complex biochemical processes that take place within seeds. Metabolomics encompasses the comprehensive study of the metabolome - the complete set of small molecule metabolites present within an organism or biological sample. Metabolites are the end products of cellular processes, and their levels can be regarded as the ultimate response of biological systems to genetic or environmental changes. Thus, metabolomics can provide a snapshot of the physiological condition of an organism at a particular time. The application of metabolomics to seed science offers a dynamic tool for understanding and manipulating seed quality. Metabolomics has been used to study seed development and maturation, providing insights into the biosynthesis and accumulation of primary and secondary metabolites that impact seed quality. For example, the accumulation of storage compounds like proteins, lipids, and starch during seed development has a direct bearing on seed nutritional quality. Similarly, secondary metabolites can influence seed properties such as color, taste, and resistance to pests or diseases. In seed germination, metabolomics can be employed to study the metabolic changes that accompany the transition from a quiescent seed to an actively growing seedling. Understanding these changes can help improve germination rates and seedling vigor, crucial factors in seed quality. Metabolomics can also provide insights into the metabolic basis of seed dormancy and longevity, traits that have important implications for seed storage and viability. By identifying the metabolites associated with these traits, it may be possible to manipulate their levels to enhance seed quality. Furthermore, metabolomics can elucidate the metabolic responses of seeds to various environmental stresses such as drought, salinity, and temperature extremes. This knowledge can aid in developing stress-tolerant varieties that maintain high seed quality under adverse conditions. Metabolomic profiling can also help in seed authentication and quality control. By generating metabolic fingerprints for different seed varieties, it may be possible to verify seed identity and

purity, which are essential for the maintenance of seed quality in the seed industry. In conclusion, metabolomics, by offering an intricate view of the metabolic processes within seeds, holds great potential for enhancing seed quality. As technologies advance and our understanding of seed metabolomics improves, we can expect this field to play an increasingly important role in our quest for better seeds. However, as with other ‘omic’ technologies, the application of metabolomics in seed science requires advanced analytical tools and expertise, highlighting the need for continued investment in this area.

### **The Integration of ‘Omics’ Technologies in Seed Quality Enhancement**

In the pursuit of enhancing seed quality, the amalgamation of genomics, proteomics, and metabolomics—collectively termed as ‘omics’ technologies—has emerged as an incredibly potent tool. The fusion of these disciplines brings to light a holistic perspective, enabling a comprehensive understanding of seed biology that no single ‘omics’ can achieve alone. Each ‘omics’ technology focuses on a distinct aspect of cellular function: genomics on DNA sequences, proteomics on protein expression, and metabolomics on the final metabolites. These layers of biological information are interconnected, with changes in one often affecting the others. Genomics provides the blueprint of life, detailing the set of genes present in an organism. Yet, it's only a part of the story. Not all genes are expressed at all times, and their expression can alter in response to various factors. Proteomics deciphers the expressed proteins, their modifications, and interactions. But even then, the biological narrative remains incomplete. While proteins carry out most of the cell's functions, they do so by catalyzing chemical reactions, leading to the production of metabolites. Metabolomics provides insights into the final outcomes of gene expression and protein activity, essentially offering a real-time snapshot of cellular physiology. Each ‘omics’ technology complements the others, providing a more comprehensive view of biological processes when used synergistically. For instance, if genomics identifies a gene associated with seed quality, proteomics can detect whether the gene's protein is indeed expressed in the seed, and metabolomics can further identify the metabolic pathways influenced by this protein.

### **Integrated ‘Omics’ Approach for Future Seed Quality Enhancement**

The integrated ‘omics’ approach is a cutting-edge frontier in seed science, with potential applications spanning various facets of seed quality enhancement. One of the most significant applications of integrated ‘omics’ is in understanding complex traits, many of which are crucial for seed quality. These traits, influenced by multiple genes and environmental factors, are often difficult to dissect using a single ‘omics’ approach. An integrated ‘omics’ approach can help unravel the complex genetic, proteomic, and metabolic interactions that underlie these traits, enabling the development of strategies to improve them. Moreover, this integrated approach can help in studying the seed's responses to environmental stresses at multiple levels, from changes in gene expression to alterations in metabolic profiles. This could aid in the development of varieties with enhanced stress resilience, ensuring high seed quality even under adverse conditions.

Another potential application is in the optimization of seed storage and longevity. An integrated ‘omics’ approach could help identify the genetic, proteomic, and metabolic changes associated with seed aging, potentially leading to strategies for enhancing seed shelf life. Furthermore, the integrated ‘omics’ approach could be valuable for quality control in the seed industry. By creating comprehensive genomic, proteomic, and metabolomic profiles for different seed varieties, it may be possible to develop more accurate and robust methods for seed authentication. In conclusion, the integration of ‘omics’ technologies offers an exciting avenue for seed quality enhancement. By providing a holistic view of seed biology, this approach promises to significantly advance our understanding and manipulation of seed quality. However, the integrated ‘omics’ approach also presents considerable challenges, including the handling and interpretation of vast and complex datasets. It calls for robust data integration and analysis methods and interdisciplinary collaborations, underscoring the need for continued research and development in this exciting field.

### **Future Prospects and Emerging Technologies**

As we look to the future, biotechnology continues to offer promising and exciting prospects for enhancing seed quality. The rapid advancements in technology are driving a new era in seed science, paving the way for a future where high-quality seeds are the norm, not the exception. Upcoming Technologies in Biotechnology one of the most exciting frontiers in biotechnology is the use of genome-editing technologies such as CRISPR/Cas9. While traditional genetic engineering has made substantial strides in seed quality enhancement, genome editing takes it a step further by enabling precise, targeted modifications to the plant's genome. This allows scientists to enhance desirable traits or remove undesirable ones with unprecedented precision. The future impact of these technologies on seed quality enhancement is vast and multifaceted. With precise genome editing, we could see the development of seeds with tailored traits such as enhanced nutritional profiles, improved germination rates, greater stress tolerance, or increased shelf life. These seeds could significantly boost agricultural productivity and sustainability. AI and ML could help breeders develop high-quality seeds more efficiently by streamlining the breeding process and improving the accuracy of trait selection. This could reduce the time and resources required to bring improved seed varieties to market. Nanotechnology could enable more targeted and efficient delivery of enhancement factors to seeds, reducing waste and potentially leading to more effective seed enhancement strategies. Furthermore, nanosensors could provide a wealth of information on seed health and status, allowing for timely interventions to maintain seed quality. Synthetic biology could revolutionize seed quality enhancement by enabling the creation of seeds with novel and improved traits. These 'designer seeds' could offer solutions to various agricultural challenges, from climate change resilience to improved nutritional content. Finally, advanced imaging technologies could offer non-destructive methods for assessing seed quality, leading to more reliable and accurate quality control processes. In conclusion, the future of seed quality enhancement looks bright with the advent of these

upcoming technologies. As we continue to advance our understanding and capabilities in biotechnology, we are moving closer to a future where high-quality seeds are accessible to all, promoting sustainable and productive agriculture worldwide. However, as we embrace these technologies, we must also address potential challenges, including ethical considerations, regulatory issues, and the need for technology access and capacity building, especially in developing countries.

## **Conclusion**

The advent of biotechnology in seed science, particularly the integration of genomics, proteomics, and metabolomics, has unfolded an expanded scope for seed quality enhancement. Genetic engineering, marker-assisted selection, and the holistic 'omics' approach, each contribute uniquely to this field, offering unprecedented insights into seed biology and mechanisms of seed quality traits. Genomic studies identify genes associated with seed quality traits, whereas proteomics unravels their actual expression and interaction. Complementing these, metabolomics offers a real-time snapshot of cellular physiology, tracing the final outcomes of gene expression and protein activity. The amalgamation of these 'omics' technologies offers a synergistic perspective, enabling an intricate understanding of seed biology. Emerging technologies such as CRISPR/Cas9, AI, ML, nanotechnology, synthetic biology, and advanced imaging technologies promise to revolutionize seed quality enhancement. These technologies, while posing their own set of challenges, hold the potential to address existing limitations and propel the field into a new era of unprecedented possibilities.

# Seed Marketing and Supply Chain Management in Bangladesh

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Seed marketing and supply chain management are critical to ensuring that quality seeds are produced, made available on time, and distributed affordably to farmers in Bangladesh. The seed sector in Bangladesh comprises public institutions, private companies, and informal systems like farmer-to-farmer exchanges. A robust seed system is vital for achieving higher agricultural productivity and food security.

## Seed Marketing Strategies

In Bangladesh's seed sector, implementing effective marketing strategies is critical for ensuring farmers that can access high-quality seeds at affordable prices. Following strategies can be implemented in seed market.

### 1. Affordable Pricing Mechanisms

- **Subsidy and Incentives:** Government-supported subsidies to make quality seeds affordable for smallholder farmers.

In Bangladesh, many smallholder farmers face financial constraints, which often limit their ability to purchase high-quality seeds. Government-supported subsidies can play a pivotal role in making these seeds more affordable. The government can provide financial assistance to seed producers or directly subsidize the cost of seeds for farmers. This can help overcome the initial cost barrier, making it easier for farmers to access seeds that are more likely to produce higher yields and improve agricultural productivity. In Bangladesh, such subsidies are often provided for high-quality seeds of major crops like rice, maize, and vegetables. Providing tax exemptions or reduced import duties on imported seeds or essential seed production inputs, can allow producers to sell seeds at a lower cost.

- **Tiered Pricing:** Offering variable pricing based on farmer capacity to ensure equitable access.

Tiered pricing involves offering different price points for seeds based on the farmer's financial capacity or landholding size. This pricing strategy ensures that even low-income or smallholder farmers can access quality seeds, while larger-scale farmers can still benefit from bulk purchases at a reasonable price. In Bangladesh, tiered pricing can be especially useful as it takes into account the economic diversity of farmers. For instance, smallholder farmers, particularly who own less land, could pay a lower price for seed packets, while medium to large farmers could be offered larger quantities at a more competitive price. This approach can also encourage farmers to invest in high-quality seeds that would otherwise be beyond their financial means. For example, selling seeds in smaller

and more affordable packets to smallholders while offering bulk packages at discounted rates to larger farmers. Also, providing concessional seed pricing for farmers with less than a certain amount of land, ensuring equal access to good-quality seed varieties.

- **Bulk Purchasing Programs:** Encouraging farmer cooperatives to buy seeds in bulk, reducing per-unit costs.

Bulk purchasing programs encourage farmers to organize into cooperatives or groups, allowing them to collectively buy seeds at discounted rates. By consolidating demand, cooperatives can negotiate better prices with seed producers, thereby reducing the per-unit cost of seeds for each farmer. This model benefits both the seed producers with a guaranteed customer base and the farmers who benefit from lower costs. In Bangladesh, where cooperative farming has been successful in some regions, this model can be expanded to promote the collective purchase of seeds. Farmer cooperatives can act as intermediaries between seed companies and farmers, helping them access seeds at more affordable prices, while also ensuring quality control and traceability.

- **Cost-Effective Breeding:** Promoting low-input, high-output seed varieties through research and development.

Cost-effective breeding involves the development of seed varieties that require lower input costs while still offering high yields. Research and development (R&D) programs focused on breeding these low-input, high-output varieties are essential in Bangladesh, where agricultural production costs are a concern for many farmers. Seed varieties that are resistant to diseases, pests, and adverse climatic conditions (such as drought or flooding) can help reduce the need for expensive inputs like fertilizers and pesticides, thereby making farming more affordable. Bangladesh's agricultural research institutions, such as the Bangladesh Agricultural Research Institute (BARI) and Bangladesh Rice Research Institute (BRRI), have been involved in breeding varieties of rice, maize, and vegetables that are both cost-effective and high-yielding. These varieties can help lower the overall cost of seed production and make it more affordable for smallholder farmers to grow crops sustainably. Krishibid Seed Limited has also introduced some high-yielding varieties of vegetables.

## 2. Farmer Awareness and Capacity Building

- **Farmer Education Programs:** Demonstrating the benefits of using certified seeds through field trials and campaigns.

Farmer education programs are crucial for demonstrating the advantages of using certified seeds and educating farmers on proper seed selection and usage. These programs can be organized in various formats such as workshops, training sessions, and field days, where farmers are introduced to the latest seed technologies, new varieties, and improved farming practices. In Bangladesh, where the majority of farmers are smallholders with limited access to technical

knowledge, these programs can help bridge the knowledge gap. Field trials showcasing improved seed varieties can serve as practical demonstrations of the benefits, allowing farmers to see first-hand how certain seed varieties perform under local conditions. Government and NGO-led programs, like the Seed Sector Development Program (SSDP), can provide training on how to identify and use certified seeds for higher yields and better disease resistance. NGOs, agricultural extension services, and private companies can conduct training sessions, demonstrating the economic benefits of switching from traditional or recycled seeds to certified, high-yielding varieties.

- **Mass Media Outreach:** Utilizing television, radio, and social media for promoting new seed varieties.

Mass media outreach is an important tool to promote the availability and benefits of new seed varieties. Using television, radio, and social media platforms can reach a large audience, including remote areas where farmers might have limited access to direct educational programs. By broadcasting agricultural programs, advertisements, and informational content, mass media can influence farmers' perceptions and behavior towards the adoption of quality seeds. In Bangladesh, radio and television are widely used in rural areas, and social media has increasingly become a powerful tool to connect with the younger generation of farmers. Mass media campaigns can not only promote specific seed varieties but also raise awareness about seed-related issues, such as seed quality, handling, and storage.

- **Extension Services:** Expanding agricultural extension programs to educate farmers about new seed varieties and their benefits.

Expanding agricultural extension services is one of the most effective ways to build farmers' capacity in adopting new seed varieties. Extension officers can offer direct support and guidance to farmers in their local areas, providing them with technical advice on seed selection, planting techniques, pest management, and crop rotation. Extension services also help build farmers' confidence in using quality seeds and understanding the broader benefits of better seed management practices. In Bangladesh, strengthening the capacity of extension services, especially in rural regions, will play a critical role in ensuring farmers receive accurate and timely information. Extension officers can work closely with seed producers, agricultural scientists, and NGOs to deliver knowledge and practical training to farmers.

- **Field Demonstrations:** Conducting on-farm trials to showcase the performance of quality seeds.

Field demonstrations, or on-farm trials, are an essential hands-on approach to showcasing the performance of quality seeds in real-world conditions. By setting up trials in the farmer's local environment, these demonstrations allow farmers to observe the actual benefits of using certified seeds in terms of yield improvement, disease resistance, and overall crop health. In Bangladesh, where agricultural

practices are diverse and often influenced by local conditions, field trials help farmers directly compare the performance of different seed varieties under their own farming conditions. These on-farm demonstrations can be organized in collaboration with agricultural research institutions, seed companies, and local farmer groups.

- **Information Campaigns:** Using mass media and social platforms to inform farmers about seed availability and proper usage.

Information campaigns leverage various media channels, including print, digital platforms, and even mobile apps, to disseminate important information about seed availability, proper seed storage, and optimal usage. These campaigns can raise awareness about specific seed varieties, promote good agricultural practices, and inform farmers about the sources where they can buy quality seeds. In Bangladesh, many farmers still rely on informal channels for seed purchasing, which can lead to challenges related to seed quality. Information campaigns can help farmers identify trusted sources of certified seeds and ensure they are educated about proper seed storage techniques to maintain quality throughout the planting season.

### 3. Efficient Distribution Systems

- **Certified Dealers:** Expanding networks of authorized seed dealers to improve access.

Expanding networks of certified seed dealers ensures that high-quality, certified seeds are readily available to farmers. Certified dealers act as the primary link between seed producers and farmers, providing access to authentic and approved seed varieties. These dealers must be trained to recognize and promote quality seeds, as well as to offer advice to farmers on proper seed handling, storage, and usage. In Bangladesh, where counterfeit and low-quality seeds are sometimes sold in local markets, expanding the network of certified seed dealers ensures that farmers have access to trustworthy sources. Dealer networks can be supported by government or private organizations to ensure seed quality standards are upheld. Authorized dealers can also offer additional services, such as advising farmers on suitable seed varieties for specific climates or soil types, and helping them understand the best sowing practices.

- **Mobile Seed Vendors:** Leveraging mobile vans for last-mile delivery in remote areas.

Mobile seed vendors, typically operating in vans or trucks, can bring seeds directly to remote farming communities, reducing the need for farmers to travel long distances to purchase seeds. This is particularly valuable in rural Bangladesh, where many farmers live in hard-to-reach areas and may lack access to urban seed markets. Mobile vendors can provide last-mile delivery of quality seeds, making it easier for farmers to purchase the right seeds at the right time, ensuring better crop yields. Mobile seed vendors can be equipped with a range of seed varieties and support materials, including leaflets or brochures to educate farmers on seed

varieties, pricing, and proper usage. By traveling from village to village, these vendors can serve farmers who would otherwise struggle to find quality seed supplies.

- **Decentralized Distribution Channels:** Establishing local distribution points to reduce transportation costs and improve seed availability.

Establishing local distribution points, such as village-level retail outlets, agricultural shops, or farmer cooperatives, can help to reduce transportation costs and improve the accessibility of certified seeds. By decentralizing the distribution network, seeds are made available closer to the places where they are most needed, making it easier for farmers to obtain quality seeds without incurring additional travel expenses. Decentralized distribution points also make it easier for farmers to access seeds at the right time of year, ensuring they have the appropriate varieties for planting seasons. Local distribution hubs can be staffed by knowledgeable individuals who can offer advice on seed selection, storage, and handling, further improving the service provided to farmers.

- **Digital Platforms:** Leveraging e-commerce and mobile applications for seed ordering and delivery, especially in remote areas.

Leveraging digital platforms such as e-commerce websites, mobile apps, and SMS-based services can help make seed distribution more efficient and accessible, particularly in remote areas where physical infrastructure might be lacking. By allowing farmers to order seeds online or via mobile platforms, digital systems can offer a wide range of seed options, order tracking, and delivery services that bypass traditional retail channels. This also opens up a channel for farmers to learn about new varieties and place orders directly from their homes. For instance, mobile applications could provide farmers with information on certified seed varieties, ordering options, and delivery schedules. Digital platforms can also allow seed companies to reach farmers in rural areas without the need for a physical retail presence. In Bangladesh, where mobile phone usage is widespread, this can be an effective tool to expand seed distribution.

- **Seed Dealer Networks:** Expanding networks of licensed seed dealers to improve last-mile delivery.

Expanding networks of licensed and authorized seed dealers enhances the ability to deliver quality seeds to farmers at the local level. A strong dealer network ensures that seed distribution is continuous and that seed availability is never a bottleneck during planting seasons. Seed companies and government organizations can work together to incentivize local businesses to become certified dealers and stock high-quality seeds. This network of dealers can be supported by ongoing training programs to ensure that they have up-to-date knowledge about new seed varieties, best practices for seed storage and handling, and how to provide customer support to farmers. Additionally, dealers can be part of a broader network of extension services that helps farmers make informed decisions about the seeds they purchase.

## 4. Enhancing Storage and Preservation

- **Modern Storage Infrastructure:** Investment in cold storage and controlled atmosphere facilities to maintain seed quality.

Investing in modern storage infrastructure is essential for preserving the quality of seeds, especially hybrid or high-yielding varieties that require specific storage conditions to maintain their viability. Cold storage facilities, controlled atmosphere (CA) storage, and humidity-controlled warehouses are essential to extend seed shelf life and ensure that they remain in optimal condition for planting. Cold storage helps to slow down the aging process of seeds and prevent deterioration due to high temperatures, humidity, or pests. In Bangladesh, with its tropical climate, the high levels of heat and humidity can adversely affect seed quality, leading to poor germination rates if not properly stored. By establishing cold storage and CA facilities in strategic locations—close to seed production areas or large distribution hubs—seed companies can ensure that seeds remain viable for longer periods and can be sold or distributed when needed, including during off-season periods.

- **Village-Level Storage Units:** Training farmers and cooperatives to construct low-cost, local storage solutions.

While modern cold storage facilities are vital, their cost and scale might not be feasible for all farmers, particularly in rural and remote areas. Village-level storage units are a more accessible solution for smallholder farmers and farmer cooperatives. These storage units can be designed to maintain proper ventilation, humidity control, and pest management to ensure that seeds are stored in conditions that preserve their quality. Training farmers and cooperatives to build and use low-cost, local storage solutions is a key strategy for improving seed preservation. These storage units can be constructed using locally available materials, such as bamboo, mud, or brick, and designed with simple, effective methods to prevent moisture, pest infestation, and temperature fluctuations. Farmer cooperatives can come together to construct these storage units and share the use of the facilities, reducing the individual cost of building and maintaining them.

## 5. Policy Support and Regulation

- **National Seed Policy Implementation:** Streamlining regulations to encourage investment in seed production and distribution.

A well-defined National Seed Policy is essential for the sustainable growth of the seed sector. In Bangladesh, the implementation of a comprehensive national seed policy would streamline regulations, provide guidelines for seed production, quality control, and distribution, and set clear roles for both public and private sectors in the seed supply chain. The policy should address several aspects:

- i) **Seed Quality Control:** Establishing standards for seed quality and certification processes, ensuring that seeds sold in the market meet specific germination rates, purity standards, and freedom from pests or diseases.
- ii) **Seed Production and Distribution:** Outlining the roles of different stakeholders, including government bodies, private companies, cooperatives, and farmers, in seed production, packaging, and distribution.
- iii) **Research and Development:** Supporting research to develop high-yielding, drought-resistant, and pest-resistant seed varieties suited to Bangladesh's diverse agro-climatic conditions.
- iv) **Regulatory Framework:** Defining the responsibilities of regulatory bodies in overseeing seed quality, registration, and the import/export of seeds.

By streamlining these regulations, the government can encourage investment in the seed sector, ensuring a continuous supply of quality seeds and fostering innovation in seed production.

- **Market Incentives:** Offering tax benefits to private companies investing in seed supply chains.

Offering market incentives is an effective way to attract private sector investment into the seed supply chain. The seed sector in Bangladesh can benefit from tax incentives, subsidies, or other financial benefits to stimulate private investment in seed production, distribution, and innovation. Encouraging private companies to invest in the seed industry can lead to improved seed quality, more efficient distribution systems, and the development of new seed varieties suited to local conditions. Some of the incentives could include:

- i) **Tax Breaks and Exemptions:** Offering tax benefits or exemptions for companies involved in the production, processing, or sale of certified seeds. This would help reduce production costs, ultimately lowering the price of seeds for farmers.
- ii) **Subsidies for Research and Development:** Providing financial support for private companies or research institutions working on developing new, high-yielding, and pest-resistant seed varieties.
- iii) **Public-Private Partnerships (PPP):** Encouraging collaborations between the government and private seed companies to co-invest in seed research, production, and distribution systems.

By offering such incentives, the government can stimulate the growth of a robust seed industry, ensuring that high-quality seeds are available at competitive prices and that the sector is equipped to meet the increasing demand for seeds.

- **Anti-Hoarding Laws:** Preventing artificial shortages and price manipulation. To prevent price manipulation and ensure fair access to seeds for all farmers, it is essential to have strong anti-hoarding laws in place. Hoarding occurs when traders, dealers, or unscrupulous actors buy large quantities of seeds and store them with the intent of releasing them into the market at higher prices during times

of shortage. This artificial scarcity can lead to inflated seed prices, leaving farmers unable to afford the seeds they need for planting.

Anti-hoarding laws help ensure a fair and transparent seed market by:

- i) **Regulating Seed Stockpiling:** Setting legal limits on the amount of seed that can be stored by traders or dealers to prevent market manipulation. For instance, limits could be placed on the quantity of seeds one company or individual can hold in stock during peak planting seasons.
- ii) **Monitoring and Enforcement:** Establishing mechanisms to track seed inventories at various points in the supply chain and ensuring that seed dealers do not engage in unethical practices like hoarding to create artificial shortages.
- iii) **Penalties for Violations:** Enforcing penalties, such as fines or even suspension of business licenses, for those found guilty of hoarding seeds and engaging in price manipulation.

These regulations would also require periodic inspection of storage facilities to ensure that seeds are being stored properly and are not being withheld from the market for price manipulation purposes.

## 6. Promotional Activities

- o **Bundling Offers:** Combining seeds with fertilizers or pesticides at a discounted price.  
Bundling offers are an effective promotional strategy to provide farmers with a comprehensive solution that goes beyond just seeds. By combining seeds with complementary agricultural inputs like fertilizers, pesticides, and herbicides, seed companies can help farmers streamline their purchasing process, reduce costs, and ensure they have all the necessary products to achieve better yields. In Bangladesh, many smallholder farmers may lack access to high-quality fertilizers or pesticides, which are essential for optimizing seed performance and protecting crops. Bundling seeds with these inputs at discounted prices can encourage farmers to invest in certified seeds, as they perceive more value in receiving a complete package. Key aspects of bundling offers include:
  - i) **Discounted Prices:** By offering bundled products at a lower overall cost compared to purchasing them separately, farmers are incentivized to buy the entire package, ensuring they have access to all essential farming inputs.
  - ii) **Quality Assurance:** Bundling also ensures that farmers receive high-quality, complementary inputs that are designed to work well with the seeds being purchased, improving the likelihood of successful crop production.
  - iii) **Convenience:** Farmers can purchase everything they need in one place, reducing time and effort spent searching for individual inputs, especially in remote or rural areas.
- o **Loyalty Programs:** Incentivizing repeat purchases through reward schemes for farmers.

Loyalty programs are an effective way to build long-term relationships with farmers, incentivizing them to return for future seed purchases. By offering rewards for repeat purchases, seed companies can encourage farmers to stick with high-quality, certified seeds over time, which can lead to better productivity and crop outcomes. Loyalty programs for farmers can take several forms:

- i) **Points-Based Systems:** Farmers earn points for each seed purchase, which they can later redeem for discounts on future seed purchases, fertilizers, pesticides, or other agricultural inputs.
- ii) **Cashback Offers:** Offering a cashback incentive after a certain number of purchases can also encourage farmers to buy more seeds and inputs, improving their overall productivity.
- iii) **Tiered Rewards:** A tiered reward system can offer greater incentives for larger or repeated purchases. For example, farmers who consistently buy higher volumes of seeds might earn more significant discounts or benefits, such as free or discounted inputs.
- iv) **Exclusive Benefits:** Loyalty program members could also receive exclusive access to new seed varieties, early-bird offers, or specialized farming advice and support from agricultural experts.

By providing these incentives, seed companies not only increase their sales volume but also foster brand loyalty among farmers. This type of program can also work as an educational tool, motivating farmers to invest in quality seeds over lower-cost, lower-quality alternatives.

## Challenges in Seed Marketing and Supply Chain Management

### 1. Fragmented Supply Chains

- Lack of integration among seed producers, distributors, and retailers results in inefficiencies.

The seed supply chain in Bangladesh faces fragmentation, where there is limited coordination between seed producers, distributors, and retailers. This lack of integration causes delays, higher operational costs, and uneven distribution of seeds, resulting in inefficiencies that affect the overall seed availability and quality.

- Smallholder farmers often struggle to access quality seeds.

Due to these inefficiencies in the supply chain, smallholder farmers frequently face challenges in accessing high-quality seeds. Many are forced to rely on local, non-certified seeds, which may not yield optimal results, ultimately impacting their agricultural productivity and income.

## 2. Limited Private Sector Participation

- Dependence on public sector entities for seed distribution restricts innovation and scalability.

In Bangladesh, the heavy reliance on public sector entities for seed distribution limits the scope for innovation and growth in the seed sector. Public sector entities, while essential, often face resource constraints and bureaucratic challenges that hinder rapid adaptation to new technologies, market demands, and efficient distribution methods. This dependency stifles private sector participation, reducing opportunities for competition and the development of innovative, scalable solutions that could improve seed quality and accessibility for farmers.

## 3. Inadequate Storage Facilities

- Insufficient infrastructure leads to seed deterioration, reducing availability and quality.

The lack of adequate storage facilities in Bangladesh results in poor seed preservation, causing deterioration in seed quality. Without proper storage, seeds are exposed to unfavorable conditions like moisture, heat, and pests, which reduce their viability and germination rates. This leads to a decreased availability of quality seeds for farmers, affecting crop productivity and ultimately, food security.

## 4. Price Volatility

- High production and transportation costs result in price fluctuations, making seeds less affordable for smallholders.

Price volatility in the seed market in Bangladesh is driven by fluctuating production and transportation costs. These fluctuations make seeds less affordable for smallholder farmers, who often operate with limited financial resources. When prices increase, farmers may not be able to access high-quality seeds in time for planting, leading to reduced agricultural productivity and income.

## 5. Limited Awareness and Outreach

- Farmers often lack information on the availability of high-yielding and resilient seed varieties.

In Bangladesh, many farmers are unaware of the availability of high-yielding and resilient seed varieties that could significantly improve their crop production. The lack of proper outreach and communication channels means farmers continue to use traditional or low-quality seeds, which can limit their productivity. Without access to accurate information, farmers miss opportunities to adopt better seed varieties that could help them withstand environmental challenges and improve overall yields.

## Supply Chain Management

A supply chain is a chain of activities that are undertaken in the production, processing, marketing and sales of a product of any kind; it is the process in which raw materials are transformed into a finished product that is sold and consumed. The term value chain reflects that value is added at each point in the chain.

Three different levels can be distinguished in a value chain. The first level of activities is handled by value chain operators, which are the owners of the product at some stage in the chain. operators include producers, collectors, processors, wholesalers, retailers and consumers. The second level consists of service providers, which assist the operators in performing their tasks. Support functions include input supply, financial services, quality assurance, extension and research. The third level is the enabling environment that refers to the environment in which operators and service providers do business. Market related infrastructure, policies, regulations and business agreements are part of the enabling environment. Box 1 shares the terminology in value chain analysis.

### Box 1: Terminology used in supply chain analysis

**Operators:** Actually, own the product at some stage in the chain. They are usually the producers, processors, traders, wholesalers, retailers and consumers

**Service Providers:** Support the operators in their activities with knowledge, inputs, finance, certification, research and extension

**Enabling Environment:** Relates to context in which operators and service providers perform their functions and include governance, legislative and regulative frameworks and economic environment

Supply chain analysis refers to the appraisal of the functioning of the chain, and maps all stakeholders involved and their interactions. Flows of the product, services, financial resources and knowledge are analyzed, to explore whether linkages between stakeholders are effective and efficient in terms of the performance of the entire value chain. These include linkages among operators, but also between operators and service providers. The analysis provides insights in the strengths of the linkages, and identifies bottlenecks and entry points for interventions to increase value chain performance. It also provides insights in institutional barriers relating to policies and regulations.

### What is seed supply chain?

A seed value chain covers the process of activities from the use of plant genetic resources to the marketing or distribution of seed of a specific variety and a certain type of quality to farmers. Seed value chain analysis identifies the operators and service providers and their activities in the seed chain. Box 2 explains the basic activities of the operators; they include plant genetic resources management, variety development, early generation seed production, seed multiplication, and seed marketing and dissemination. Even though many variations in composition and structure of value chains exist among dissimilar seed

systems, the chain of operational activities is generally the same, and within a seed system even independent from the crop reproduction system.

### **Box 2: Activities of operators in seed supply chains**

- **Plant genetic resources management:** the genetic resources base maintained as basis for variety development
- **Variety development:** the process of breeding and selection of new varieties, including the testing of varieties within different agro- ecologies for different user groups
- **Early generation seed production:** the maintenance of breeders' seed, and the production and dissemination of pre-basic and basic seed
- **Seed multiplication:** the multiplication of early generation seed into the certified, quality declared, or other quality classes of seed, to be used for crop production
- **Seed marketing and dissemination:** the collection, distribution and sales of seed

### **Box 3: Types of services provided within seed supply chains**

- **Rural seed extension:** promoting variety management and seed quality at farmer's and community levels; strengthening of informal seed systems through community seed banks, seed fairs, organization of farmers in community-based seed production schemes, etc.
- **Variety testing and release:** Identification varieties matching specific agro- ecologies and demands of farmers; and subsequent release of these varieties for seed production
- **Plant variety protection:** implementation of incentive structure promoting the investment in plant breeding and rewarding those investors with intellectual property rights
- **Quality assurance in seed production:** different quality assurance mechanisms, varying from seed in informal systems (seed of confidence), to quality declared and certified seed, and accreditation of seed producers and companies
- **Quality assurance in seed commercialization:** quality management mechanisms ensuring that the commercialization of seed and varieties follows agreed standards in terms of quantity, quality, price and time
- **Business management services:** development and business plans for entrepreneurs, and support in associated investments
- **Financial services and management:** specific financial products for financing seed production (basic seed and input purchase) and seed marketing (promotion); facilitating investment through loans for the purchase of processing equipment, transport and storage facilities
- **Marketing information and promotion:** rural extension promoting the use of quality seed and providing vital marketing information back to operators in the seed value chain (plant breeders, early generation and quality seed producers, seed dealers)

Linking between operators on the one hand, and between operators and service providers at the other hand, are guided by the enabling, in the seed value chain related policies, regulations and guidelines, but also government land policies, credit conditions, etc. interactions between the three levels in the seed value chain are driven by incentives. Analyzing incentives that motivate collaboration in the seed chain is helpful in defining strategies for enhancing supply chain efficiency. In this regard incentives promoting entrepreneurship are powerful.

The early generation seed production, seed multiplication and seed distribution are in the hands of different organizations in the public enterprises seed supply chain, they are all in the hands of one organization in the case of the international company system. These two chain face of number of common but also a number of different challenges. For example, whereas public seed companies all depend on public breeding programmes for the same few varieties and have no competitive position in the market, national and international seed companies have their own varieties and a distinct market niche. Also, the enabling environment is different, e.g. with public companies regulated by government policies on seed price setting, private seed companies can determine their own seed price.

Applying value chain analysis to seed systems has the advantage that it emphasizes the importance of the farmers, i.e. seed consumers as main drivers of the value chain. Farmers who buy the seed as input for their crop production may be the first operators in a larger product value chain. The commercial seed connects the seed value chain and the product value chain. Well established product value chains often request for quality seed, and are very powerful in pulling seed value chains.

## Seed Supply Systems

The seed supply in the country in general comes from different sources including from commercial sector (the seed enterprise), farmers-based seed production on contractual basis or on-farm the farmers. In the earlier times, most of the cases the seed supply system focused on the organized seed sector (enterprise) and accordingly it has been attempted to define the national seed system from those perspectives. But recently, the concept has been developed and expanded to include the other component-the ‘informal’ seed sector. Even these days a number of scholars argue that there is semiformal seed system (like the farmers-based seed production and marketing) which lies between the two systems. Be that as is may here the formal system and the informal system categorizing farmers-based seed production into the later system for simplicity is discussed very briefly as follows.

### a) Formal seed supply

The formal seed supply system generally consists of institutional and organizational arrangements comprising institutions, enterprises and different organizations involves in the supply of improved varieties from the research system to the communities at grass root level (farmers). The actors include research institutions like BARI, BRRI, BINA, BJRI, BMWRI, BSRI, public seed enterprise BADC in the system since 1976.

The NARS is responsible for breeding and importing improved varieties of crops and multiplication of breeder seeds to supply to BADC and private sector so that enough certified seed is produced and supplied to farmers. The institute runs breeding activities in number of main research centers and sub-centers on cereal crops, pulse, oilseeds and other crops. The center also produces basic seed of different crops on its farm on small scale and supply through the BADC to farmers in different areas order to contribute to the alleviation of the critical seed shortage prevailing in the zone.

The BADC seed established in 1978 by the then called BADC is a public enterprise engaged in the production, processing and distribution of quality seed to farmers. The rural to date BADC is the main product and supplier in the formal seed sector. In the country, the enterprise is working on 24 different crops and 109 crop varieties, though HYV rice and potato takes lions share in its seed production.

### b) Informal seed supply

In Bangladesh, the informal seed supply plays a significant role, especially for smallholder farmers who rely on local seed exchanges, farmer-to-farmer networks, and traditional seed-saving practices. Farmers often exchange seeds with neighboring farmers or local traders, which provides immediate access to seeds without the need for formal markets. Additionally, many farmers save seeds from their previous harvests to plant in the next season, allowing them to reduce costs. However, while these informal systems help meet seed demands, they come with several challenges. One of the main issues is the inconsistency in seed quality. Seeds exchanged or saved by farmers may not meet the necessary standards for germination or disease resistance, leading to lower yields and

increased risks of pest and disease outbreaks. The lack of regulation and quality control in the informal seed supply also means that farmers may unknowingly plant subpar seeds. Furthermore, the informal seed sector often lacks the capacity to provide farmers with new or improved seed varieties, limiting access to technologies that could enhance productivity and resilience to environmental stressors.

Though informal seed systems can be more affordable, especially for resource-constrained farmers, the trade-off is that they do not always guarantee reliable availability or consistent seed quality. The seeds may only be available during specific times of the year, making it difficult for farmers to plan effectively for planting seasons. Despite these drawbacks, the informal sector remains crucial for farmers who cannot access formal seed markets, and improving the quality and reliability of the informal seed supply is essential. Strengthening this system through better training, storage techniques, and integration with the formal seed market could help ensure a more reliable and productive seed supply for smallholder farmers in Bangladesh.

## **Conclusion**

Effective seed marketing and supply chain management in Bangladesh require an integrated approach that combines public and private sector efforts. Investments in infrastructure, farmer education, and quality assurance, along with digital innovation, can significantly enhance seed availability, affordability, and access. Addressing these challenges will not only boost agricultural productivity but also contribute to the overall food security and economic stability of the country.

# Success Stories of Seed Quality Management in Bangladesh

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## Seed Sector Development History

1. Seed is one of the most important inputs for increased productivity.
2. Farmers traditionally used to keep their own seeds and exchange among themselves.
3. In early 50s, a couple of seed traders started selling seed at Kaptan Bazar
4. Gradually more people got involved in seed trading and shifted to Siddique Bazar
5. In 1962 BADC (The then PADC) first produced formal seed and marketed 13.6 MT of wheat seed.
6. After independence in 1972, a few private seed traders started importing vegetable seeds and started selling in the market.
7. After proclamation of Seed Policy 1993, a good number of private seed companies came in the seed business.
8. In late 1990, few companies started commercial seed production and research activities in the private sector.
9. In 1998, Lal Teer Seed, the erstwhile East-West Seed Bangladesh Limited first developed hybrid vegetable variety and multiplied locally.
10. In 2005-06, a number of private companies started producing hybrid rice seed locally for the first time.
11. At this moment there are more than 40,000 registered seed dealers, over 300 seed production companies, above 40 seed industries and 12 multinational companies are operating in the private sector.

## Seed Sector Development Facts

1. Our 1 lakh contract farmers producing seeds for BADC and private companies.
2. Last 20 years, hybrid rice seed production technology became available in the country. Most of the hybrid rice seeds are produced through contract farming.
3. Hybrid rice introduced 1999- by now the country is producing most of its requirement and has the capacity to export.
4. The country used to import 100% hybrid vegetable seeds. Now a substantial quantity is produced locally by private companies.
5. The country is exporting hybrid vegetable seeds.
6. More than 400 hybrid vegetable seed varieties developed by the private companies.
7. Private sector got approval of first ISTA accredited lab in the country

## Seed Requirement and Supply

1. The annual requirement of seeds (paddy, vegetables, potato, jute, maize, wheat pulses, spices, oil seeds etc.) is around 12.50 lakh metric ton.
2. The quality seed supply increased to 4.06 MT in 2021-22 (32%) from 1.17 lakh MT in 2005-06 (12%)
3. Supply of BADC seed increased to 1.5 lakh MT in 2021-22 from 55000 in 2005-06 period.
4. Private sector seed supply increased remarkably from 61,758 MT in 2005-06 to 2.15 lakh MT in 2021-22.
5. Excluding potato seed the National requirement is 467,221 MT against which, supply amounts to 277,094 MT (60%) out of which share of BADC is 115,611 (41%) and private sector is 120,000 MT (43%) approximately.

## Conclusion- What Next?

1. The growth of private sector is very encouraging.
2. BADC needs to act more to improve the quality of seed.
3. SCA needs to be strengthened more with independent capacity.
4. The government should take stronger measures for market monitoring.
5. Need more collaboration of public private in R&D.
6. The government should create congenial environment to enable public private grow together.