BRAHMASHTRA FOR IBPS AFO MAINS BY INDIAN IQ

SEED TECHNOLOGY

Seed and Its Formation

1. Seed
    - A fertilized ovule containing the plant embryo, enclosed in a seed coat
    - Product of the ripened ovule of gymnosperm and angiosperm plants after fertilization and growth within the mother plant
2. Seed Components
    - Embryo: Immature plant that grows into a new plant under proper conditions
        - Radicle: Embryonic root
        - Plumule: Embryonic shoot
        - Epicotyl: Embryonic stem above the cotyledon(s) attachment point
        - Hypocotyl: Embryonic stem below the cotyledon(s) attachment point
    - Endosperm: Store of nutrients for the seedling
        - Triploid in angiosperms, derived from double fertilization
        - Haploid in gymnosperms, part of the female gametophyte
    - Seed Coat (Testa): Develops from the integument, protects the embryo from mechanical injury and drying out
3. Types of Seeds
    - Monocot seeds: Contain a single cotyledon (e.g., cereals, grasses)
    - Dicot seeds: Contain two cotyledons (e.g., pulses)
    - Photoblastic seeds:
        - Positive photoblastic: Good germination in the presence of light (e.g., tobacco, lettuce)
        - Negative photoblastic: Good germination in the absence of light (e.g., onion)
        - Non-photoblastic: Good germination under any condition (most crops)
    - Best wavelength for seed germination: 662 nm (red light); germination stops above 730 nm

Pollination and Seed Formation

1. Pollination: Transfer of pollen grains from anther (male part) to stigma (female part)

2. Types of Pollination
    - Self-Pollination (Autogamy): Transfer of pollen grains from anther to stigma of the same flower
        - Leads to homozygosity and development of homozygous balance
        - No significant inbreeding depression
    - Cross-Pollination (Allogamy): Transfer of pollen grains from the anther of one plant to the stigma of another plant
        - Common form of out-breeding, leading to heterozygosity
        - Development of heterozygous balance and significant inbreeding depression on selfing
3. Mechanisms Promoting Self-Pollination
    - Bisexuality: Presence of male and female organs in the same flower
    - Homogamy: Maturation of anthers and stigma of a flower at the same time
    - Cleistogamy: Pollination and fertilization occur in unopened flower buds
    - Chasmogamy: Opening of flowers only after the completion of pollination
    - Position of Anthers: Stigmas surrounded by anthers, ensuring self-pollination
4. Mechanisms Promoting Cross-Pollination
    - Dicliny: Unisexual flowers
        - Monoecy: Male and female flowers on the same plant (e.g., maize, castor, banana)
        - Dioecy: Male and female flowers on different plants (e.g., papaya, date palm, spinach)
    - Dichogamy: Maturation of anthers and stigma at different times
        - Protogyny: Pistil matures before anthers (e.g., pearl millet)
        - Protandry: Anthers mature before pistil (e.g., maize, sugarbeet)
    - Heterostyly: Styles and filaments in a flower are of different lengths (e.g., linseed)
    - Herkogamy: Physical barriers such as a hyaline membrane around the anther preventing self-pollination (e.g., alfalfa)
    - Self-incompatibility: Genetic mechanism preventing self-pollination and promoting cross-pollination (e.g., Brassica, radish, Nicotiana)

- Male sterility: Non-functional pollen grains preventing self-pollination and promoting cross-pollination (genetic, cytoplasmic, and cytoplasmic-genetic types)

Additional Terms

- Geitonogamy: Transfer of pollen grains between different flowers on the same plant
- Xenogamy: Transfer of pollen from the anther of one plant to the stigma of another plant

Mode of Pollination and Reproduction in Crop Plants

Mode	**Examples**
Autogamous Species	
- Seed Propagated	Rice, wheat, barley, oats, chickpea, pea, cowpea, lentil, green gram, black gram, soybean, common bean, moth bean, linseed, sesame, sunhemp, chillies, brinjal, etc.
- Vegetatively Propagated	Potato
Allogamous Species	
- Seed Propagated	Maize, pearl millet, rye, alfalfa, radish, cabbage, sunflower, sugarbeet, castor, clovers, safflower, spinach, onion, garlic, cucurbits, oilpalm, carrot, papaya, etc.
- Vegetatively Propagated	Sugarcane, coffee, cocoa, tea, apple, pears, peaches, cherries, grapes, almond, strawberries, pineapple, banana, cashew, cassava, taro, rubber, etc.
Often Allogamous Species	Sorghum, cotton, triticale, pigeonpea, tobacco

Important Terms

- Genetic purity: Seed free from other variety seeds or other crop seeds
- Physical purity: Seed free from gravel, stones, and broken seeds
- Seed Germination: Emergence and development of seedlings from the seed embryo, capable of producing a normal plant under favorable conditions
- Types of Germination:

    - Hypogeal: Cotyledons remain under the soil (e.g., cereals, gram, kidney beans, lima beans, and green beans)
    - Epigeal: Cotyledons pushed above the soil surface (e.g., tamarind, mustard, castor, sunflower, onion, soybean)
- Essential factors for germination: Moisture, temperature, and oxygen supply
- Germination % = (Number of seeds germinated ÷ Total number of seeds) × 100
- Methods for testing germination: Petri dish, rolled towel, sand, mechanical, gunny sacks, etc.
- Seed Purity: Percentage of desirable seed from a lot of seeds with various impurities
    - Purity % = (Weight of pure seeds ÷ Total weight of the working sample) × 100
- Real Value of seeds = (Purity % × Germination %) ÷ 100
- Viability: Capacity of seed to germinate
    - Potassium permanganate method: Qualitative method of testing viability
    - Electrical conductance method: Seeds soaked in distilled water and EC tested
    - Embryo culture method: Embryo removed from cotyledons and placed on peat moss or agar medium (7-10 days for results)
    - Tetrazolium chloride test (Biochemical test): Seeds soaked in 0.5-2% tetrazolium chloride solution; viable seeds take bright red coloration, dead seeds remain in original color
    - Grodex test: Germination indicator test based on triphenyl tetrazolium bromide powdered form

Classes of Seed

1. Nucleus Seed: 100% genetically pure seed with physical purity, produced by the original breeder/institute/SAU from basic nucleus seed stock
    - No certification needed, no tag color assigned
2. Breeder Seed: Progeny of nucleus seed, directly controlled by the originating or sponsoring breeder or institution
    - Basic seed for recurring increase of foundation seed
    - 100% genetic and physical purity, golden yellow tag (12×6 cm)
3. Foundation Seed: Progeny of breeder seed, handled to maintain specific identity and genetic purity

- Produced under careful supervision of an agricultural experiment station, NSC, government farms, or agricultural universities
- Source of all other certified seed classes directly or through registered seed
- 99.5% genetic purity, 98% physical purity, white tag (15×7.5 cm)

4. Registered Seed: Progeny of foundation seed, handled to maintain genetic identity and purity, approved and certified by a certifying agency
    - Not used in India, suitable for producing certified seed
    - Purple tag (15×7.5 cm)
5. Certified Seed: Progeny of foundation or certified seed, handled to maintain genetic identity and physical purity according to specified standards
    - Most generally available to farmers, minimum 99% genetic purity and 98% physical purity
    - May be progeny of certified seed if reproduction does not exceed two generations beyond foundation seed
    - Blue tag (15×7.5 cm)

Other Types of Seed

- Orthodox seeds: Capable of being dried to <12% internal seed moisture, stored at freezing temperatures, and surviving (e.g., cereals, pulses)
- Recalcitrant seeds: Cannot survive after drying and/or freezing at -20°C (e.g., mango, coconut, most fruit crops)
- Intermediate seeds: Age faster than orthodox seeds, 5-year lifespan when stored at -20°C, greatest longevity when dried between 45-65% RH
- Truthful Labeled Seeds: Produced by cultivators, private seed companies, and sold under truthful labels
    - Not under the purview of the Department of Seed Certification
    - Field and seed standards maintained as per seed act and certified seed stage
    - Producer and seller responsible for the seed under the seed act
    - Compulsory for notified varieties, tested for physical purity and germination
    - Opal green tag color
- Genetically Modified (GM) Seeds: Seeds with introduced genes for specific traits (e.g., Bt brinjal, Bt maize). In India, only Bt cotton is commercially approved.

- Organic Seeds: Seeds produced under organic farming standards, free from synthetic chemicals.

Certified Seed vs. Truthful Labeled Seed

Aspect	Certified Seed	Truthful Labeled Seed
Certification	Voluntary, quality guaranteed by certification agency	Compulsory for notified varieties, quality guaranteed by producing agency
Applicability	Notified kinds only	Both notified and released varieties
Standards	Must satisfy minimum field and seed standards	Tested for physical purity and germination
Inspection	Seed certification officer and seed inspectors can take samples	Only seed inspectors can take samples for quality checks

International Seed Analysis Certificate Attributes

- Orange certificate: Sample drawn officially from the lot under a member station's authority, sealed, labeled, and tested for quality by the same member station
- Green certificate: Sample drawn officially from the lot under a member station's authority, tested for quality by a member station of a different country
- Blue certificate: Testing done by a member station in the same country, sampling not done under the member station's responsibility

Models of Seed Generation

- Depends on genetic deterioration rate, seed multiplication ratio, and total seed demand
- THREE Generation model: Breeder seed → Foundation seed → Certified seed
- FOUR Generation model: Breeder seed → Foundation seed (I) → Foundation seed (II) → Certified seed
- FIVE Generation model: Breeder seed → Foundation seed (I) → Foundation seed (II) → Certified seed (I) → Certified seed (II)

Seed Moisture Content for Storage

- Long term: 6-8%
- Short term: 10-13%
- Cereals: 10-12%
- Pulses: 8-10%

- Oil seeds: 6-8%

Storage Substances in Crops

Crop	Storage Substance
Rice	Oryzein
Wheat	Glutenin
Barley	Hordein
Maize	Zein
Soybean	Nodulin
Sunflower	Inulin
Pea	Legumin
Grain legumes	Phaseolin

Seed Treatment: Chemical (e.g., Thiram, Carbendazim) and bio-agent (e.g., Trichoderma) treatments to protect against pathogens.

Seed Storage Structures:

- Traditional: Gunny bags, mud bins.
- Modern: Cold storage, hermetic bags.

Seed Longevity: Factors affecting seed longevity include moisture, temperature, and seed type.

National Seed Storage Facilities: Indian Agricultural Research Institute (IARI), National Seed Corporation (NSC), and gene banks like NBPGR (National Bureau of Plant Genetic Resources).

Cryopreservation: Long-term storage of seeds at ultra-low temperatures (–196°C) using liquid nitrogen.

Seed Policies and Landmarks

- National Seed Corporation established: 1963
- National Seed Act passed: 1966
- International Seed Testing Association (ISTA) established: 1924
- First Seed Testing Lab, IARI: 1961
- Indian Seed Act: 1966 (came into force in 1969)
- Seed Rules: 1968
- PPV&FR Act: 2001
- National Seed Policy: 2002

- New Seed Act formulated: 2004 (came into force in 2005)

  Seed (Control) Order, 1983: Declares seeds as an essential commodity under the Essential Commodities Act, 1955.

  New Seed Bill (Proposed): Aims to replace the Seed Act, 1966, with provisions for mandatory registration of seed varieties and stricter quality control.

  National Seed Plan: Targets increasing SRR and promoting high-yielding varieties.

  International Agreements: India is a member of ISTA and OECD Seed Schemes for global seed trade.

Isolation Distance for Seed Production

Crop Type	**Foundation Seed (m)**	**Certified Seed (m)**
Self-Pollinated Crops		
- Rice, wheat, ragi, etc.	3	3
- Black gram, green gram, etc.	20	10
- Tomato	50	25
Cross-Pollinated Crops		
- Maize, mustard, rapeseed	400	200
- Pearl millet	1000	200
- Sunflower, safflower	400	200
- Cabbage, cauliflower	1600	1000
- Onion	1000	400
Often Cross-Pollinated Crops		
- Pigeonpea	100	50
- Cotton	50	30
- Sorghum, red gram, brinjal	200	100
- Okra, chilli	400	200

Seed Replacement Rate (SRR)

- Rate at which farmers replace seeds instead of using their own, expressed as a percentage

SRR for various crops:

Crop	**SRR (%)**
Brinjal	63.4

Crop	SRR (%)
Cabbage	100
Cauliflower	86.4
Chilli	83.7
Gourds	73.5
Peas	93.5
Melons	89.2
Okra	92.4
Tomato	99.3
Beans	62.2
Onion	87.3

SRR for Field Crops

Crop	SRR (%)
Paddy	17
Bajra	8
Maize	6
Red gram	6.1
Black gram	17.7
Green gram	11.7
Cowpea	14.2
Groundnut	5
Sunflower	50
Sesame	15

Seed Multiplication Ratio (SMR)

- Number of seeds produced from a single seed when sown and harvested
- Can be altered by proper seed and crop management techniques

Crop	SMR	Crop	SMR
Wheat	1:20	Lucerne	1:25
Paddy (Varieties)	1:80	Oats	1:15
Paddy (Hybrids)	1:100	Bhindi	1:100
Maize (Varieties)	1:80	Tomato	1:400

Crop	SMR	Crop	SMR
Maize (Hybrids)	1:100	Brinjal	1:450
Sorghum	1:100	Chillies	1:240
Bajra	1:200	Watermelon	1:100
Ragi	1:80	Pumpkin	1:160
Gram	1:10	Bitter gourd	1:41
Black gram	1:40	Bottle gourd	1:99
Green gram	1:40	Ridge gourd	1:83
Cowpea	1:40	Cucumber	1:200
Horse gram	1:40	French bean	1:9
Moth bean	1:40	Cluster bean	1:50
Red gram	1:100	Peas	1:19
Cole crops	1:433	Onion	1:171
Potato	1:4	Radish	1:100
Groundnut	1:8	Carrot	1:83
Linseed	1:50	Mustard and rapeseed	1:100
Cotton	1:50	Soybean	1:16
Jute	1:100	Sunflower	1:50
Mesta	1:40	Sesame	1:250
Sunnhemp	1:30	Safflower and castor	1:60
Berseem	1:10	Lucerne	1:25

Germination and Purity Standards for Foundation and Certified Seeds

Crop	Pure Seed (min %)	Moisture (max %)	Germination (min %)
Hybrid maize	98	12	90
Maize (composites & OPVs)	98	12	90
Hybrid jowar & varieties	98	12	80
Hybrid bajra & OPVs	98	12	75
Rice	98	13	80
Wheat	98	12	85
Barley	98	12	85

Crop	Pure Seed (min %)	Moisture (max %)	Germination (min %)
Cotton (varieties & hybrids)	98	10	60
Gram	98	9	85
Arhar	98	10	75
Urid	98	9	65
Mung	98	9	75
Rapeseed and mustard	97	8	85
Sesame (til)	97	9	80
Groundnut	96	9	70
Sunflower	98	9	60
Linseed	98	7	80
Soybean	97	12	70
Peas	98	9	75
Cowpeas	98	9	75
Tomato	98	8	70
Cauliflower	98	7	65
Bhindi	99	10	65
Watermelon & other cucurbits	99	7	60
Onion	98	8	70
Carrot	95	8	60
Chillies	98	8	60
Radish	98	6	70
Brinjal	98	8	70

Seed Dormancy

- Temporary suspension of growth of viable seeds with reduced metabolic activities
- Delays germination due to unfavorable climatic conditions, hard testa, immature embryo, or germination inhibitors

Types of Dormancy

1. Innate dormancy: Seeds incapable of germination even under suitable conditions due to immature embryo at the time of dispersal
2. Enforced dormancy: Seeds incapable of germination due to environmental restraints (moisture, oxygen, light, temperature)
3. Induced dormancy: Seeds fail to germinate under favorable conditions after imbibing water and being placed under extremely unfavorable conditions

Germination Inhibitors in Crops

Species	**Location of Inhibitor**	**Name of Inhibitor**
Gossypium spp.	Pericarp, testa	Abscisic acid (ABA)
Coriandrum sativum	Pericarp	Coumarin
Helianthus annus	Pericarp, testa	Hydrocyanic acid
Oryza sativa	Hull	Probably ABA
Triticum spp.	Pericarp, testa	Catechin, catechin tannins, several unknowns
Hordeum vulgare	Hull	Coumarin, phenolic acids, scopoletin
Elaeagnus angustifolia	Pericarp, testa	Possibly coumarin
Beta vulgaris	Pericarp	Phenolic acids, possibly ABA, high inorganic ions
Avena sativa	Hull	Unknown

Classification of Seed Dormancy

Type	**Reasons**	**Treatment**
Physical dormancy	Impermeability of seed coat	Scarification
Physiological dormancy	Inhibitory mechanism in embryo	Soaking in GA3, Ethrel, KNO3, Thiourea
Physical + Physiological	Combination of factors	Scarification & chemical treatment
Morphological dormancy	Underdeveloped embryo	Cold stratification
Morphological + Physiological	Underdeveloped embryo & physiological factors	Stratification + chemical soaking

Dormancy Breaking Treatments

1. Scarification (Acid/Mechanical)
    - Makes hard seed coat permeable to water or gases by softening or cracking
    - Chemical or physical treatment
    - Acid scarification: Concentrated H_2SO_4 @ 100 ml/kg for 2-3 minutes (time varies by species)
    - Mechanical scarification: Rubbing seeds with sandpaper or puncturing seed coat with a needle
    - Hot water treatment: Seeds soaked in boiled water for 2-5 minutes (used for legumes, but can be injurious if soaked for >1 min in some crops)
2. Stratification
    - Used when dormancy is caused by internal (embryonic) factors
    - Cold stratification: Seeds incubated at 0-5°C over a moist substrate for 2-4 days to a few months (used for cole crops)
    - Warm stratification: Some seeds require warm temperatures to break dormancy (e.g., rice, oil palm)
3. Chemical Methods
    - KNO_3: Strongest dormancy breaker
    - Thiourea (1%): Used for potato
4. Leaching of Metabolites
    - Seeds soaked in water for 3-4 days to leach inhibitors, with water changed every 12 hours
5. Temperature Treatment
    - High temperature: Early flowering winter annuals need high temperatures to germinate (e.g., bluebell)
    - Low temperature: Plants growing in cool temperatures require a period of chilling (e.g., apple seeds stored at 5°C)

Seed Processing

- Removal of dockage in a seed lot and preparation of seed for marketing
- Price and quality inversely related to dockage, which should not exceed maximum permitted levels for certification

Basic Steps

1. Drying
2. Receiving

3. Pre-cleaning
4. Conditioning
5. Cleaning
6. Separating or Upgrading
7. Treating (Drying)
8. Weighing
9. Bagging
10. Storage or Shipping

Principles of Seed Processing

- Based on physical differences found in a seed lot

Physical Difference	**Suitable Machinery**
Seed size (small to bold)	Air screen cleaner cum grader
Density (ill-filled, immature to well-matured)	Specific gravity separator
Shape (round to oval and different shapes)	Spiral separator
Surface texture (smooth to wrinkled and rough)	Roll mill / dodder mill
Color (light to dark)	Electronic color sorter
Conductivity (low to high)	Electronic separator

Phases of Seed Certification

1. Receipt and scrutiny of application
2. Verification of seed source, class, and other requirements
3. Field inspection to verify conformity to prescribed standards
4. Supervision at post-harvest stages, including processing and packing
5. Sampling and analysis to verify conformity to seed standards
6. Granting of certificate, issue of tags, labeling, sealing, etc.

Validity Period of the Certificate

- 9 months from the date of the initial test
- Can be extended for 6 months if seed conforms to prescribed standards upon retesting
- Eligible for extension as long as it conforms to prescribed standards

Seed Village

- A village where a trained group of farmers produces seeds of various crops to cater to the needs of themselves, fellow farmers, and farmers of neighboring villages at an appropriate time and affordable cost

Concept

- Organizing seed production in clusters or compact areas

- Replacing existing local varieties with new high-yielding varieties
- Increasing seed production
- Meeting local demand, timely supply, and reasonable cost
- Achieving self-sufficiency and self-reliance of the village
- Increasing the seed replacement rate

Features

- Seed available at farmers' doorsteps at an appropriate time
- Seed availability at affordable prices, even lower than market prices
- Increased confidence among farmers about quality due to known production source
- Mutual benefit for producers and consumers
- Facilitates fast spread of new cultivars

Seed Production in India (2023–24):

- Total certified seed production: ~400 lakh quintals.
- Major crops: Rice, wheat, maize, pulses, and oilseeds.

Seed Replacement Rate Targets:

- Cereals: 33–50%.
- Pulses: 50–65%.
- Oilseeds: 50–75%.

Seed Storage Capacity: NSC and state corporations have a capacity of ~20 lakh quintals.

Advances in Seed Technology

- **Priming**: Soaking seeds in water or osmotic solutions to enhance germination (e.g., hydro-priming, osmo-priming).
- **Pelleting and Coating**: Encasing seeds with protective materials to improve handling and germination (e.g., polymer coating for precision sowing).
- **Biotechnology in Seed Production**:
  - Marker-assisted selection (MAS) for developing stress-resistant varieties.
  - CRISPR/Cas9 for precise gene editing in seeds.
- **Nano-Seed Technology**: Use of nanoparticles to enhance seed germination and stress tolerance.
- **Climate-Resilient Seeds**: Development of drought-tolerant, heat-tolerant, and salinity-tolerant varieties (e.g., Sahbhagi Dhan for drought-prone areas).

- **Hybrid Seed Technology**: Advances in cytoplasmic male sterility (CMS) and genetic male sterility (GMS) for hybrid seed production.