
WELCOME
To Our Presentation Topic

GERMINATION

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What is Germination

- **Germination** is the process by which a plant grows from a seed.
- **Germination** is emergence of normal seedlings from the seeds under ideal conditions of light, temperature, moisture, oxygen and nutrients.
- **Germination** is emergence of radicle and plumule through Seed Coat

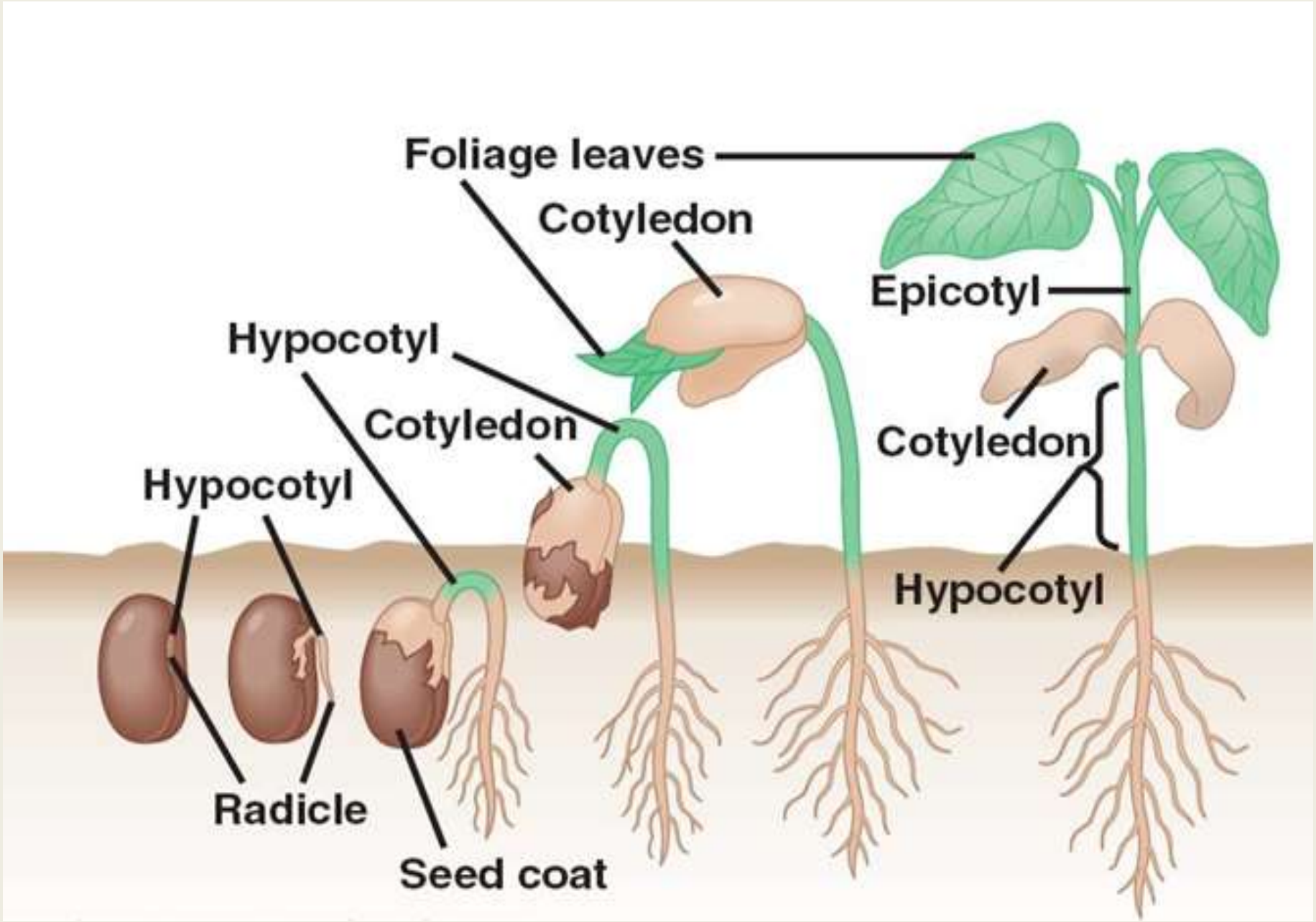


Fig.: Germination of Common bean

Requirements for Germination

External factors:

- ✓ Water,
- ✓ Temperature,
- ✓ Oxygen or aeration,
- ✓ Light or darkness,

Internal factors:

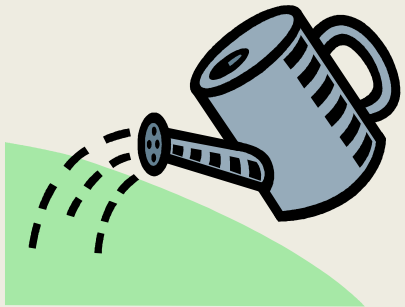
- ✓ Seed vitality,
- ✓ Genotype,
- ✓ Seed maturation,
- ✓ Seed dormancy.

Often this depends on the individual seed variety and is closely linked to the ecological conditions of a plant's natural habitat

Requirements for Germination

Water

- Mature seeds have relatively little moisture to prevent decay
- Seeds usually mature in fall
- To germinate, seeds must to take in water
- Uptake of water by seeds is called imbibitions
- Imbibitions leads to the swelling and the breaking of the seed coat



Requirements for Germination
Oxygen (Aeration)

- Oxygen in the presence of enough moisture causes respiration to start metabolism
- This creates energy for the germination process
- Respiration rates for germinating seeds are very high, therefore adequate oxygen is necessary.
- The germination percent of most seeds will be retarded if the oxygen percent goes below 20 percent (Normal air is 20 percent oxygen.)
- Seedbeds that are over-watered or poorly drained will cause the oxygen supply to become limited, so the germination percent will diminish

Requirements for Germination

Temperature

- Most seeds go through a cold period before germination
- Helps prevent seeds from Sprouting as soon as they mature
- Most common annual vegetables have optimal germination temperatures between 75-90 ^{0}F (24-32 ^{0}C)

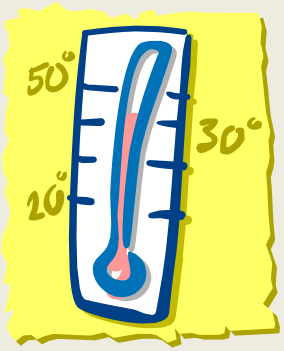


Table 1: Soil Temperature Conditions for Vegetable Seed Germination (in degrees C)

Crop	Minimum Temperature (°C)[1]	Optimum Temperature (°C)[1]	Maximum Temperature (°C)[1]	Days to Germination into Soil	Minimum Germination % (federal standards)[2]
Celery	4	21-23	30	10-14	55
Bean, Snap	15	23-29	35	7-13	75
Broad beans	5	8-15	30	7-13	70
French beans	8-10	16-30	35	7-10	75
Beet	4	23	35	7-14	65
Broccoli		30		4	75
Carrot	4	23-26	35	12-15	55
Cabbage	4	18-29	38	5-10	75
Cauliflower	4	18-29	38	5-10	75
Broccoli	4	18-29	38	5-10	75
Cucumber	15	21-29	40	7-10	80
Eggplant	15	21-29	35	10	60
Lettuce	0	18-21	30	7-10	80
Melon	15	26-30	38	5-10	75
Onion (bulb)	0	21-23	35	10-14	70
Okra	16	35	40	6-8	70
Pea	4	18-21	30	7-14	80
Pepper	15	23-29	35	10	55
Chilies	16	18-35	35	10-12	55
Pumpkin	15	21-25	38	7-10	75
Squashes	16	21-35	38	7-10	75
Radish	4	18-21	35	5-7	75
Spinach	0	21	30	7-14	60
Sweet Corn	10	21-29	40	7-10	75
Tomato	10	23-26	35	7-14	75
Watermelon	16	29-35	40	4-6	80

Requirements for Germination:

Light

❖Generally seeds require darkness to germinate but sometime it requires light.

❖Photoblastic : Seeds respond to light for germination named as.

❖Three categories of photoblastic seeds:

a) Positive photoblastic (lettuce, tobacco, mistletoe, etc. require exposure to sunlight)

b) Negative photoblastic (onion, lily, Amaranthus, Nigella, etc. do not require exposed to sunlight)

c) Non-photoblastic (non-exposure of light).

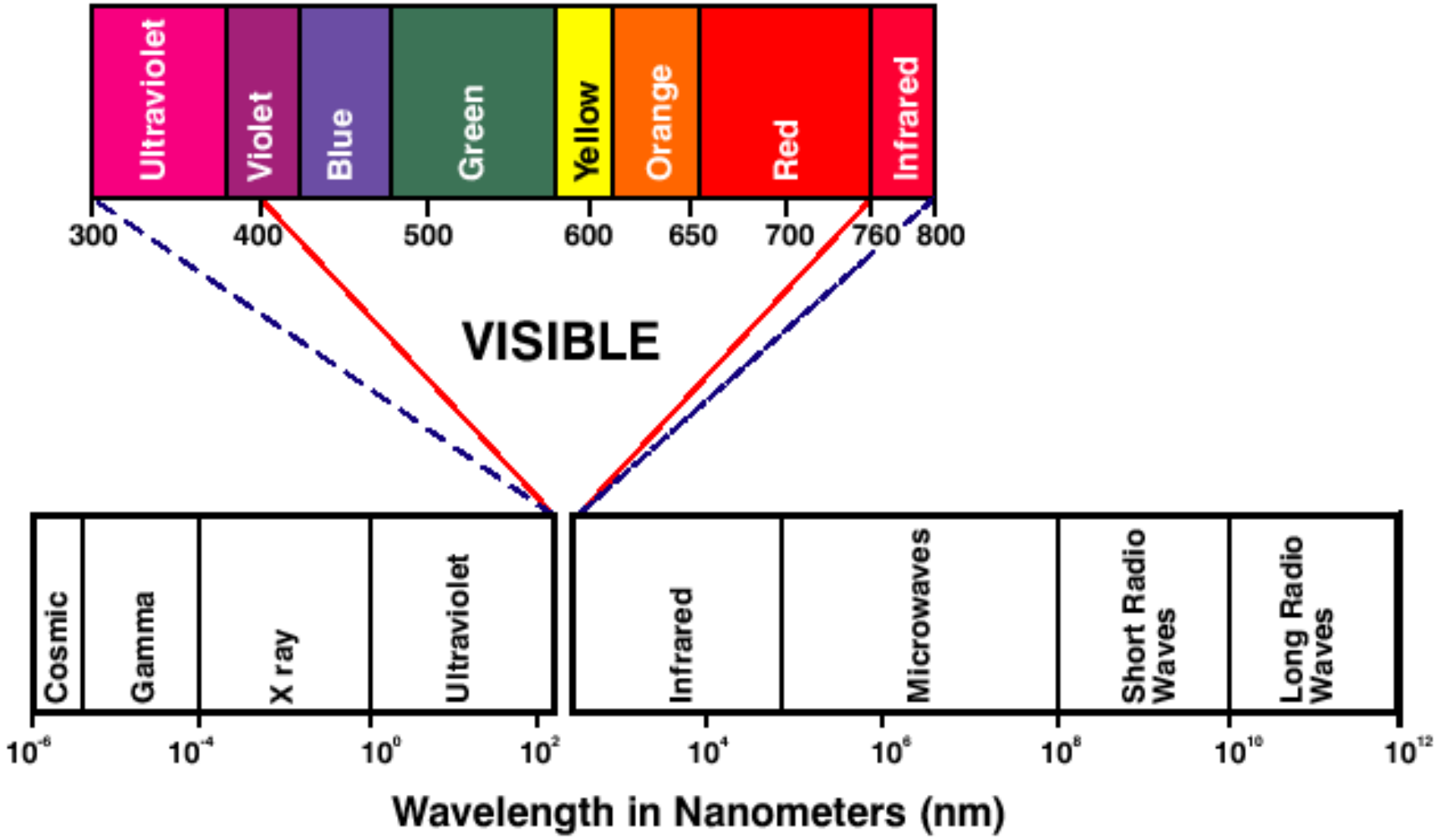
Requirements for Germination

Light

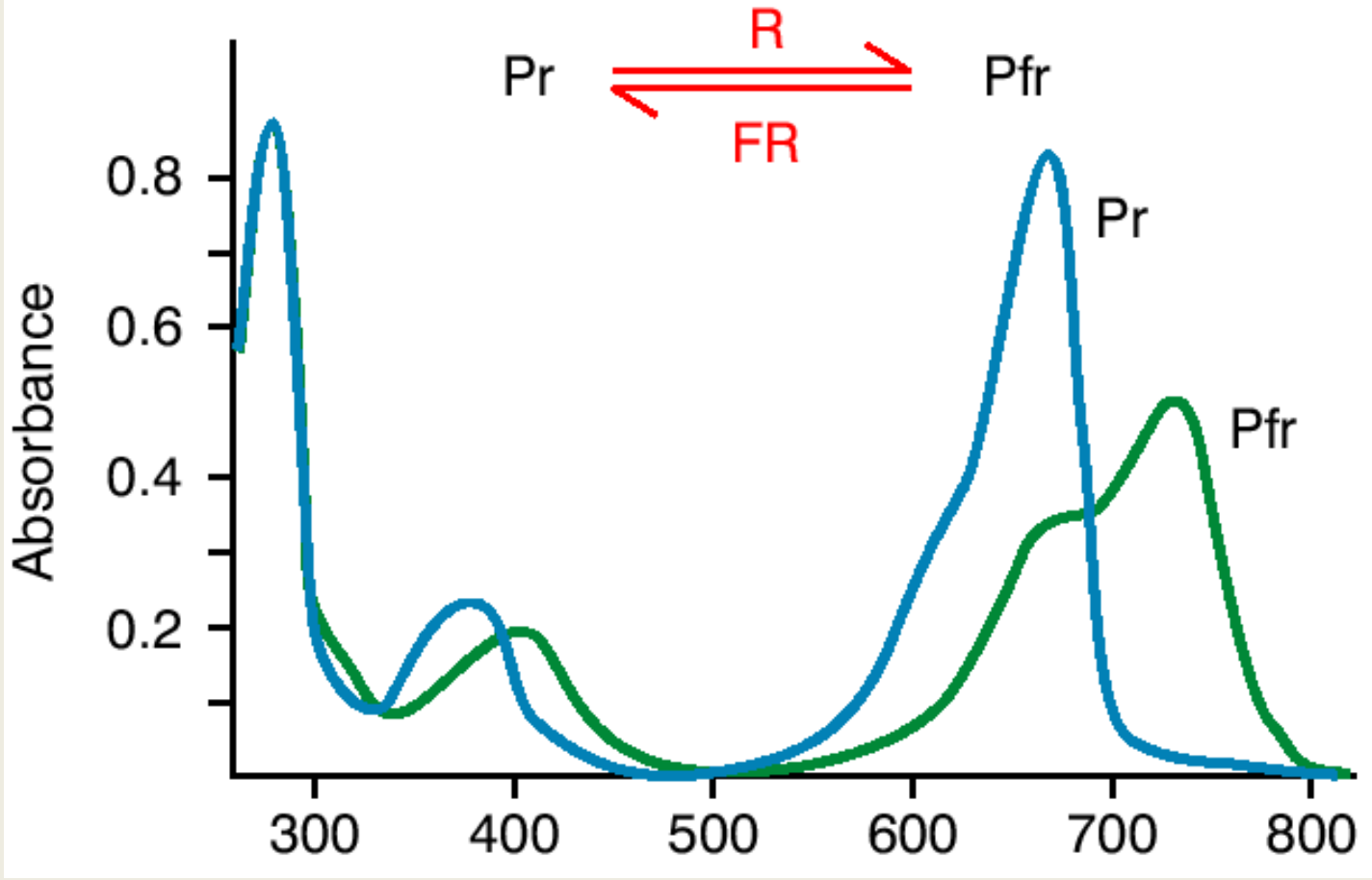
- ***Phytochrome*** is a plant pigment found in cytoplasm that senses the presence of red light.
- Phytochrome absorbs light in two inter-convertible forms.

1) Pr is metabolically inactive & absorbs red light (660 nm.)
2) Pfr is metabolically active and gets transformed from Pr. The latter promotes germination and other phytochrome-controlled processes in plants. Pfr reverts back to Pr after absorbing far-red (730 nm.).

LIGHT SPECTRUM



PHYTOCHROME ABSORBANCE



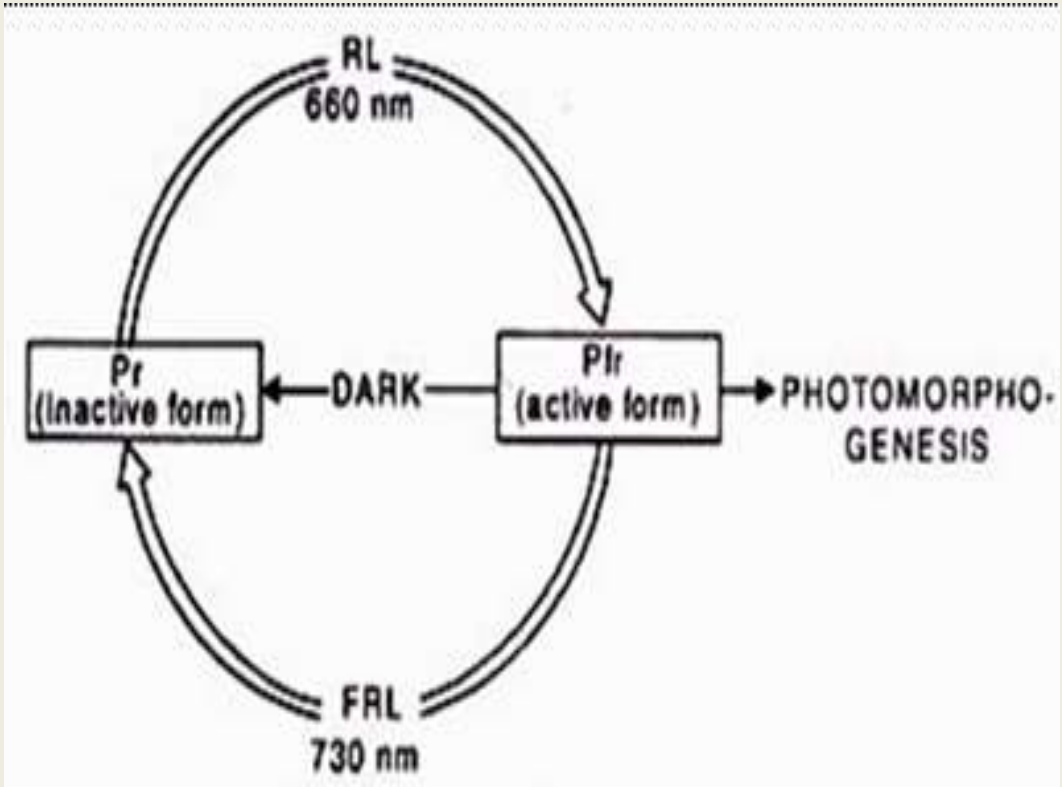


Fig.: Functioning of phytochrome system

Whole of this can be shown as given ahead:

R	Germination
R+FR	No germination
R+FR+R	Germination
R+FR+ R+FR	No germination
R+FR+ R+FR+R	Germination

Stages of Seed Germination

STAGE	EVENTS
PREGERMINATION	(a) Rehydration – imbibitions of water. (b) RNA & protein synthesis stimulated. (c) Increased metabolism – increased respiration. (d) Hydrolysis (digestion) of food reserves by enzymes. (e) Changes in cell ultrastructure. (f) Induction of cell division & cell growth.
GERMINATION	(a) Rupture of seed coat. (b) Emergence of seedling, usually radicle first.
POST GERMINATION	(a) Controlled growth of root and shoot axis. (b) Controlled transport of materials from food stores to growing axis. (c) Senescence (aging) of food storage tissues.

Factors for Germination

Seed Factor for Germination	Field factor for Germination
➢ Viability	➢ Good tilth
➢ Vigor	➢ Optimum soil moisture
➢ Seed age	➢ Optimum soil temperature
➢ Free from Dormancy	➢ Aeration
➢ Free from injury	➢ Free from obstacle

Germination Testing

Principles:

- to assess seed quality or viability
- to predict performance of the seed and seedling in the field
- to obtain information about the planting value of the seed sample
- to comparing the performance potential of the different seed lots

The general purposes:

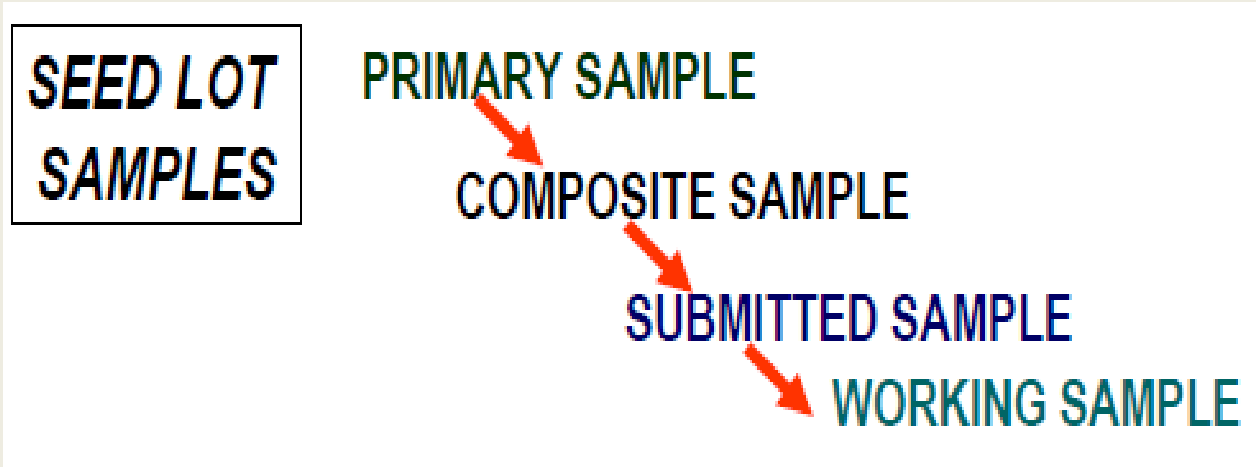
1. Sowing purposes
2. Labeling purposes
3. Seed certification purposes
4. Seed Act and Law Enforcement purposes

Germination Testing

Procedure

1. Collection of Sample

- **Primary sample** takes from different parts of the seed lot or bag or container
- Primary samples are combined and mixed to form a **Composite sample**



Collection of Sample

- Seed lots in containers between 15 to 100 kg : the minimum number of primary samples depends on the number of containers

Number of containers in the seed lot	Number of primary samples to be drawn
1-4 containers	3 primary samples from each container
5-8 containers	2 primary samples from each container
9-15 containers	1 primary samples from each container
16-30 containers	15primary samples from each container
31-59 containers	20 primary samples from each container
60 or more containers	30 primary samples from each container

Collection of Sample

- Seed lots in containers greater than 100 kg : the minimum number of primary sample depends on the size of the seed lot :

Lot size	**Number of primary samples to be drawn**
up to 500	At least five primary samples
500-3,000 kg	One primary sample for each 300 kg but not less than 5
3,001-20,000 kg	One primary sample for each 500 kg, but not less than 10
20,001 kg and above	One primary sample for each 700 kg, but not less than 40

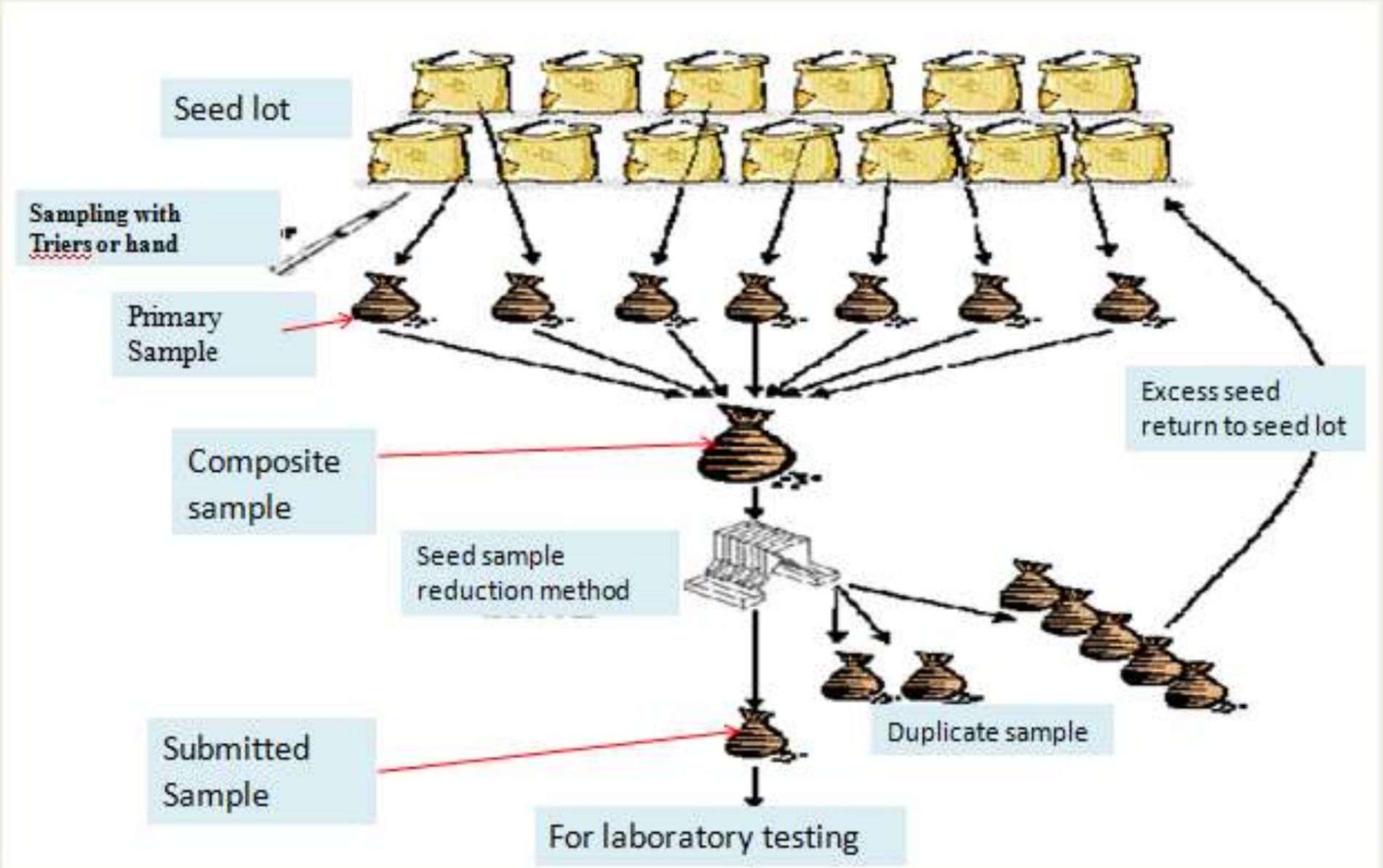
- The formula allows the calculation of the number of sampling units in a seed lot:

Number of sampling units = (number of containers x size of a container) /100

For example, if a seed lot is made of 10,000 bags of 0.5 kg of seeds. 50 sampling units of 100 kg can be combined out of these 10,000 bags. According to the sampling method used for containers between 15 to 100 kg, 20 primary samples must be take in total of the seed lot.

Collection of Sample

The sampling methodology is represented in the following scheme:



Equipment for germination test

a) Seed Germinator

- Cabinet germinator
- walk in germinator

b) Counting devices

It includes the counting boards, automatic seed counter and vacuum seed counter

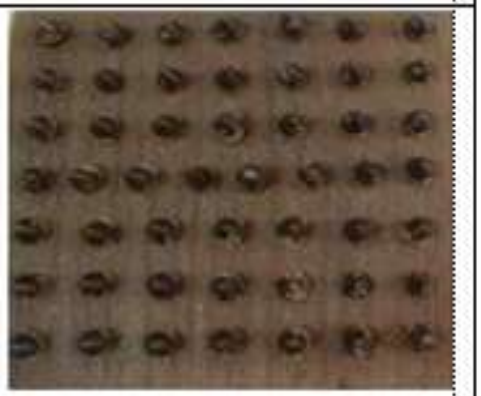
c) Other equipment

It includes the refrigerators, scarified, hot water bath, incubator, forceps, spatula, germination boxes, plastic plates, roll- towel stands and plastic or surgical trays, etc

d) Miscellaneous

- Germination paper
- Sand
- Some glassware
- certain chemicals etc

Equipment for germination test

		
Seed germinator	Plant Growth Chamber	
		
Seed Counting Board	Vacuum seed counter	Impression board

Care of equipment

The seed analyst must ensure that:

i. All the equipment is in proper working condition
ii. The germinators are maintaining correct temperature
iii. The relative humidity inside the germinator is maintained 90-98%
iv. The phytosanitary conditions of the germinators and germination trolleys are adequate
v. The germinators are disinfected periodically by flushing with hot water; solution of Potassium permanganate or chlorine water.
vi. The temperature and the R.H. of the walk-in-germinators are recorded daily and displayed on a char
vii. The floor, ceiling and walls of the walk-in-germinator are devoid of cracks, crevices; evenly plastered and duly painted to avoid contamination by fungus, bacteria or insects.

Handling of substrata

The accuracy and reproducibility of the germinator result are very much dependent on the quality of the substrata (paper and sand) used for germination testing. The germination substrata must meet the following basic requirements:

- It should be non-toxic to the germinating seedlings.
- It should be free from mould sand other microorganisms.
- It should provide adequate aeration and moisture to the germinating seeds.
- It should be easy to handle and use.
- It should make good contrast for judging the seedlings
- It should be less expensive.

Handling of substrata

a) **Paper substrata-** The paper substrata are used in the form of top of paper (TP) or between paper (BP) tests. In most of the laboratories, paper-toweling method (Roll towel test) is most commonly used for medium sized and bold seeds. The paper substrata are not reusable.

b) **Sand substrata-**The sand substrata have advantage of being relatively less expensive and reusable. The results in sand media are more accurate and reproducible in comparison with 'roll towel' tests especially in case of seed lots that are aged or heavily treated with chemicals.

Laboratory procedures

Germination procedures in Paper Substrata:

1. Soak the towel paper in water.
2. Remove the water.
3. Wash the paper with running water.
4. Remove extra moisture by pressing the soaked paper by hand and holding it in plastic/Surgical trays placed on the table top in slanting position.
5. Place two layers of wet paper toweling as substratum.
6. Check Test number provided on the Analysis Card sample and label tally each other.
7. Record the test number, crop and date of putting on the wax paper or tag.
8. Check the moisture level of the substrate regularly, especially when humidity inside the cabinets is not controlled or when the temperature is set at 25°–30°C. Blotters usually need to be watered several times during the test.

Laboratory procedures

Germination procedures in Paper Substrata:

9. Alternatively, keep the containers in a thin plastic bag (loosely folded at the open end, but not sealed to allow diffusion of oxygen) to prevent the substrate from drying.
10. Record the test number, crop and date of putting on the wax paper or tag.
11. Run the test for the recommended period (see guidelines for testing germination of the most common crop species) and count the number of seeds that have germinated.
12. If some seeds have not germinated and appear to be dormant, treat with appropriate techniques to stimulate germination and continue the test until all seeds have germinated or until no further germination has occurred after two consecutive counts.
13. Make a note of the seeds that did not germinate but are firm and sound at the end of the first count, and those that failed to germinate and are presumed dead at the end of the germination test.

Laboratory procedures

Top Paper Germination test

Top Paper Germination test

Petriplate method is suitable for those seeds which require light

Roll towel method

Between Paper Germination test

Between Paper Germination test

Fig.: Germination procedures in Paper Substrata

Laboratory procedures

Germination procedures in Sand Substrata(s): This method is most suitable for species with seeds smaller than 2 mm in diameter such as small-seeded vegetables and forage grasses. The seeds are germinated on top of moist absorbent paper in containers with close-fitting lids to prevent moisture loss. Commonly used containers include 9 cm glass or plastic Petri dishes.

1. Soak the towel paper in water.
2. Remove the water.
3. Remove extra moisture by pressing the soaked paper by hand and holding it in plastic/Surgical trays placed on top of the table.
4. Check Test number provided on the Analysis Card sample and label tally each other on tray or plastic bowl.
5. Spread the seeds uniformly on the surface of the paper so that they are not touching. It is recommended that the distance between seeds should be at least three to five times the seed diameter.
6. Cover the containers and ensure that there is no air lock resulting from excess moisture on the covers.

Laboratory procedures

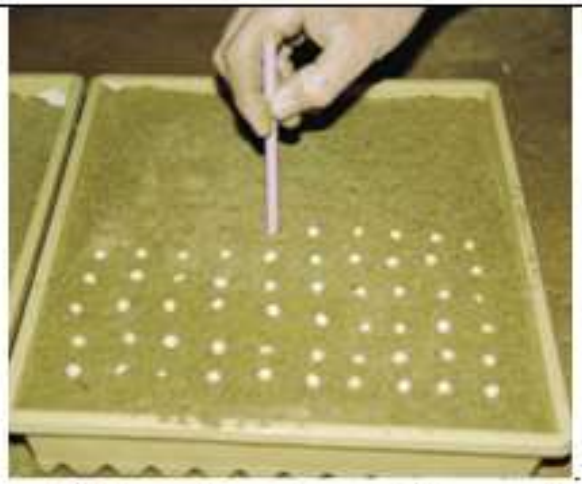
Germination procedures in Sand Substrata(s):

8. Determine the, moisture holding capacity of the sand
9. Put required quantity of water to moisten the sand.
10. The moisture level of the sand will vary according to the kind of seed.
11. Place moist sand in plastic boxes/germination tray. The depth of sand bed should be approximately **2".**
12. Space the counted seed on the sand bed contained in the germination boxes.
13. Cover the seed with moist sand layer, approximately **1/4”** in thickness.
14. Place them under prescribed controlled Temperature conditions.

Laboratory procedures

Germination tray

Sand on tray method



Place 100 seeds on top of the sand and push them in 2-3 cm deep before covering.

Fig.: Sand method

Duration of testing

❖The duration of the test is determined by the time prescribed for the, final count (ISTA Seed Testing Rules)

❖The time for the, first count is approximate and a deviation of 1-3 days is permitted. Final count is taken in between 7-14 days.

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❖Intermediate counts should betaken where it is necessary. But in each count, we should remove the evaluated seedlings either it is normal or abnormal

Table: First and Final days' count basis on different Substratum of different crops

Crop	Substratum	Temp (°C)	First count days	Final count days
Paddy	BP, TP, S	20-30	5	14
Maize	BP, S	20-30	4	7
Bean	BP, TP, S	25-30	4	7
Yard Long Bean	BP, TP, S	20-30	4	10
Cotton	BP, S		4	12
Cowpea	BP, S	20-30	5	8
Peas	BP, S	20	5	8
Sunflower	BP, S	20-30	4	10
Cotton	BP, S	20-30	4	12
Brinjal	TP, BP	20-30	7	14
Tomato	TP, BP	20-30	5	14
Chilies	TP, BP	20-30	7	14
Bhendi	BP, S	20-30	4	21
Onion	TP, BP	15-20	6	21
Carrot	TP, BP	20-30	7	14
Cucumber	BP, S	20-30	4	8
Pumpkin	BP, S	20-30	4	8
Spinach	BP, S	15-25	7	21
Radish	TP, BP	20-30	4	10
Cauliflower	TP	20-30	5	10
Ash gourd	S	30-35	5	14
Bitter gourd	BP, S	20-30	4	14
Bottle gourd	BP, S	20-30	4	14
Ridge gourg	BP, S	30-35	4	14
Sponge gourd	BP, S	20-30	4	14
Snake gourd	BP, S	30-35	4	14
Watermelon	BP, S	20-30	4	14
Mustard	BP, TP	25-30	3	10

Evaluation of germination test

❖**Normal** Seedlings that possess essential structures that is indicative of their ability to produce useful mature plants under favorable field conditions.

❖**Abnormal** Seedlings that exhibit some form of growth but have insufficient plant structures to maintain a healthy plant, such as missing roots or shoots.

❖**Fresh Seeds.** Seeds that have failed to germinate but have imbibed water. They appear firm, fresh and capable of germination, but remain dormant.

❖**Dormant Seeds.** Viable seeds (other than hard seeds) that fail to germinate when given the prescribed or recommended germination conditions.

❖**Hard Seeds.** Seeds that remains hard at the end of the prescribed test period, because their seed coats are impermeable to water.

❖**Dead Seeds.** Seeds that cannot produce any part of a seedling.

Feature Normal Seedling

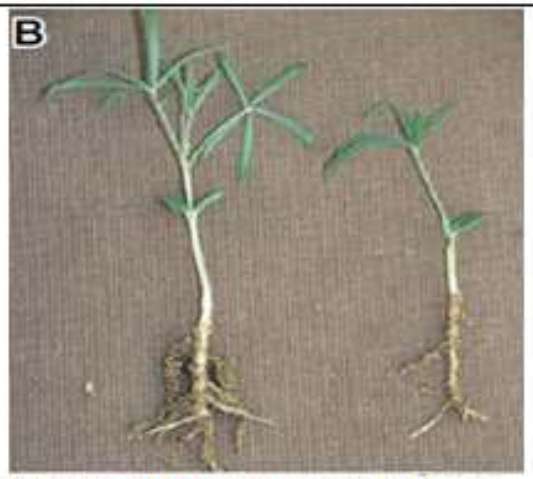
Characters of normal seedlings

•A well-developed root system with primary root except in certain species of graminae which normally produce seminal root or secondary root.
•A well-developed shoot axis consisting of elongated hypocotyls in seedlings of epigeal germination.
•A well-developed epicotyl in seedlings of hypogeal germination.
•One cotyledon in monocotyledon and two in dicotyledons.
•A well-developed coleoptile in graminae containing a green leaf.
•A well-developed plumule in dicotyledons.

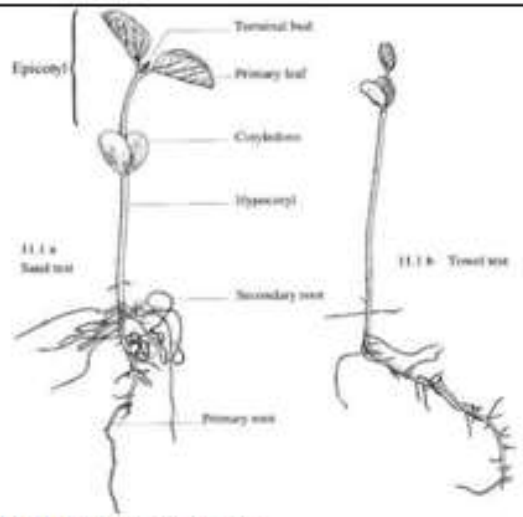
Seedlings with following slight defects are also taken as normal seedlings

•Primary root with limited damage but well developed secondary roots in leguminaceae (Phaseolus, Pisum), graminae (Maize), cucurbitaceae (Cucumis) and malvaceae (cotton)
•Seedlings with limited damage or decay to essential structures but no damage to conducting tissue.
•Seedlings which are decayed by a pathogen with a clear evidence that the parent seed is not the source of infection.

Normal (left) and Abnormal (right) field pea seedling



Normal (left) & Abnormal(right) field lupin seedling



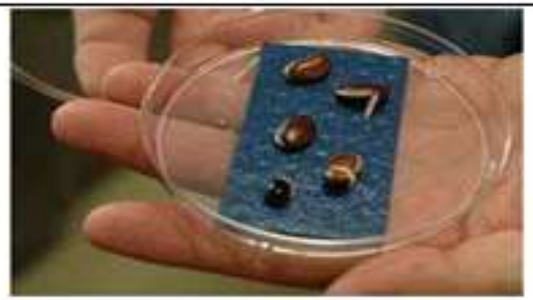
Normal seedlings

Normal seedlings

Abnormal seedlings of bean.

Abnormal seedlings of bean.

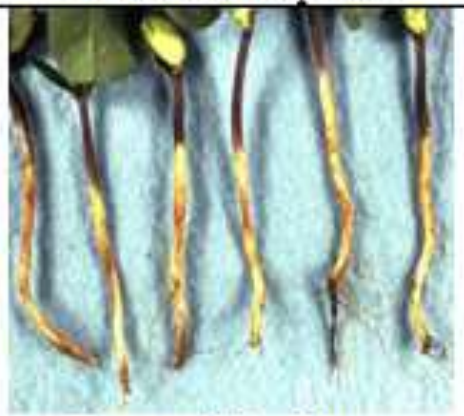
Hard Seeds



Dead seeds

Dead seeds

Types of abnormal seedlings

Damaged seedlings are with no cotyledons, with splits, cracks and lesions or essential structures and without primary root.	 Damaged seedlings
Deformed seedlings are weak or unbalanced development of essential structures such as spirally twisted or stunted plumule or hypocotyls or epicotyls, swollen shoot, stunted roots etc.	 Twisted coleoptiles
Decayed seedlings are with any one of the essential structures showing diseased or decayed symptoms as a result of primary infection from the seed which prevents the development of the seedlings.	 Decayed Seedlings

Calculation of result

Results are expressed as percentage by number.
Germination rate is the average number of seeds that germinate over the five-day and 10-day time period.

Germination (%) = G / X * 100

Where:
G = number of normal germinated seedling
X = number of seed sown (excluding empty and infested)

For example, if you planted 50 radish seeds and 35 seeds germinated, you would write 35/50 = 70/100 = 70%. The germination rate is 70%.

Germination Resister Book

Lal Teer Seed Limited
Department: Vegetables & Others
Germination Resister Book

			Moisture %		Production Season:												
Grower Name	CGR No.	Crop Code	Primary	Final	Set Up date	Seed No./ Pot	1st cont. date	1st cont. No. (a)	Final cont. date	Final cont. No. (b)	Normal Seedling no. (a+b=c)	Abnormal Seedling no.	Hard seed	Dade seed	Germination %	Signature	Remarks

Seed viability

Seed viability may be defined as the capability of the seed to germinate and produce a normal seedling for some specific period of time

Viable is capable of living or germinating in seed.

The viability of the seed accession is a measure of how many seeds are alive and could develop into plants which will reproduce themselves, given the appropriate conditions.

Objective

To determine the maximum Germination potential of a seed lot.

Vegetable seed viability is tested by seed companies and on seed packets the germination percentage and test date are listed

Seed viability

Factors affecting seed viability:	Causes of less viability
➢ Harvesting of seed ➢ Duration between harvesting and threshing ➢ Methods of threshing ➢ Moisture Content and Relative Humidity of the stored seed ➢ Age of seed ➢ Temperature of the stored seed ➢ Aeration in store house ➢ Contaminate of the seed ➢ Chemical treatment ➢ Harvesting of seed	➢ Degeneration of enzyme ➢ Disappearance of stored food ➢ Abnormal seed coat ➢ Loss of power to protect the protoplasmic molecule from the inert molecule ➢ Gradual coagulation of protein of embryo

Seed viability

Seed viability test

•Chemical method

•Excised embryo method

•Germination test method

Above those tests, Germination test is most commonly used to determine seed viability.

When should viability be determined?

Viability will need to be determined at the start of storage and at regular intervals during storage to predict the correct time for regeneration of the accession. The viability test takes from a few days to weeks or even months to give an accurate result.

Seed viability

Seed Viability test (%) = (G+F+A) / X * 100

Where:

F = number of fresh seed

A = number of abnormal seed

G = number of seed germinated

X = number of seed sown (excluding empty and infested)

Seed Vigor

Seed vigor is the sum of those properties which determine the potential level of activity and performance of the seed or seed lot during germination and seedling emergence. (ISTA)

Seed vigor leads to rapid and uniform emergence of healthy seedlings under both favorable and unfavorable conditions in field.

Seed viability is the state of being alive, while vigor denotes the degree of their aliveness.

Seed Vigor

Factors affecting seed vigor:	Effects of less vigorous seed
➢ Genetic makeup ➢ Seed maturity ➢ Soil fertility ➢ Seed size ➢ Mechanical damage ➢ Seed age and deterioration ➢ Attack of micro-organism ➢ Temperature and Moisture availability	➢ Late ripening of crop ➢ Yield loss ➢ Reduce crop quality

Seed vigor may be affected

•During ripening
•During Pre & Post harvesting (threshing, drying and grading)
•During storage
•External and Internal structure of seed
•At the time of seed setting just after pollination

Relationship between seed germination and vigor

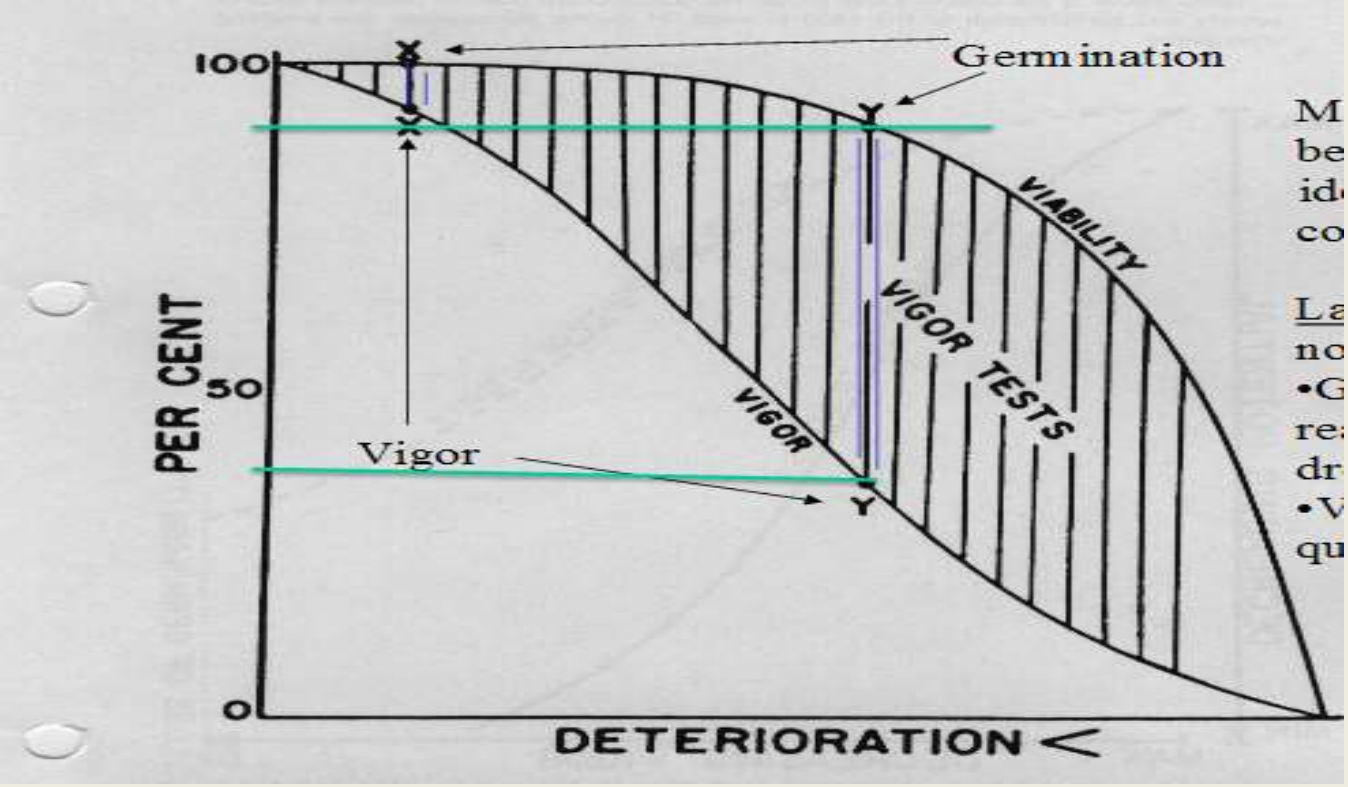


Figure 3 − Relationship between seed germination and vigor in association to the progress of deterioration. The X and Y points on the germination and vigor curves correspond to different seed lots and illustrate the increasing difference between germination ability and vigor as deterioration progresses. (Adapted from Delouche and Caldwell, 1960). A high quality seed lot (X) that is less deteriorated will show relatively small difference in results from germination and vigor tests. However, a lower physiological quality seed lot (Y) with higher deterioration level will have higher germination performed under optimum conditions, but extremely low vigor.

Methods of measuring seed vigor

A. Physical test	B. Performance test	C. Stress test	D. Biochemical test
❖ Seed size	❖ First count days	❖ Cold test	❖ Tetrazolium test (TZ test)
❖ Physical soundness	❖ Speed of germination	❖ Accelerated Aging test	❖ Respiration test
❖ X-ray test	❖ Seedling growth rate	❖ Electric Conductivity test	❖ Membrane integrity test
	❖ Seedling dry weight	❖ Osmotic / Moisture test	
	❖ First count days	❖ Brick gravels	

Methods of measuring seed vigor

By germination test we can get results of seed vigor of respective seed lot. One methods are given below:

Speed of germination: One hundred seeds each in four replications are planted in recommended substratum for germination. Numbers of seedlings emerging daily are counted from day of planting the seeds in the medium till the time germination is complete. Germination Index (G.I.) is computed by using the following formula: **G.I. = n/d**
Where, n = number of seedlings emerging on day'd'
d = day after planting
The seed lot having greater germination index is considered to be more vigorous.

Example

Seed lot A	No. of counted seedlings= 0,0,0,40,30,12,7	
	Day of counting = 1,2,3,4,5,6,7	
G.I. of Seed lot A	= 0/1+0/2+0/3+40/4+30/5+12/6+7/7	=10+6+2+1 =19
Seed lot B	No. of counted seedlings =0,0,0,0,30,42,21	
	Day of counting = 1,2,3,4,5,6,7	
G.I. of Seed lot B	= 0/1+0/2+0/3+0/4+30/5+42/6+21/7	=6+7+3 =16

In this example seed lot A has greater G.I. (19) than seed lot B (16), so seed lot A is more vigorous than seed lot B.

Dormancy

A period when seed is alive but not growing is called **Dormancy**

Proper condition can break dormancy

Seed dormancy is defined as a state in which **seeds** are prevented from germinating even under environmental conditions normally favorable for germination.

Causes of Seed dormancy

- Impermeable seed coat
- Mechanically resistant seed coat
- Rudimentary embryo
- Dormant embryo
- Insufficient development

Types of Dormancy

Primary dormancy involves a variety of reasons as to why the seed cannot germinate. It may involve a seed coat that is too strong to allow the seedling to emerge from the seed. Or it may be that the embryo is immature at the time of harvest and it needs to ripen further.

Secondary dormancy can occur after the seed has imbibed moisture, but some factor prevents it from continuing to germinate. Generally, this can be attributed to inappropriate temperatures, light, moisture or oxygen.

Special dormancy is due to the dormant conditions of some structure like epicotyls, hypocotyle etc.

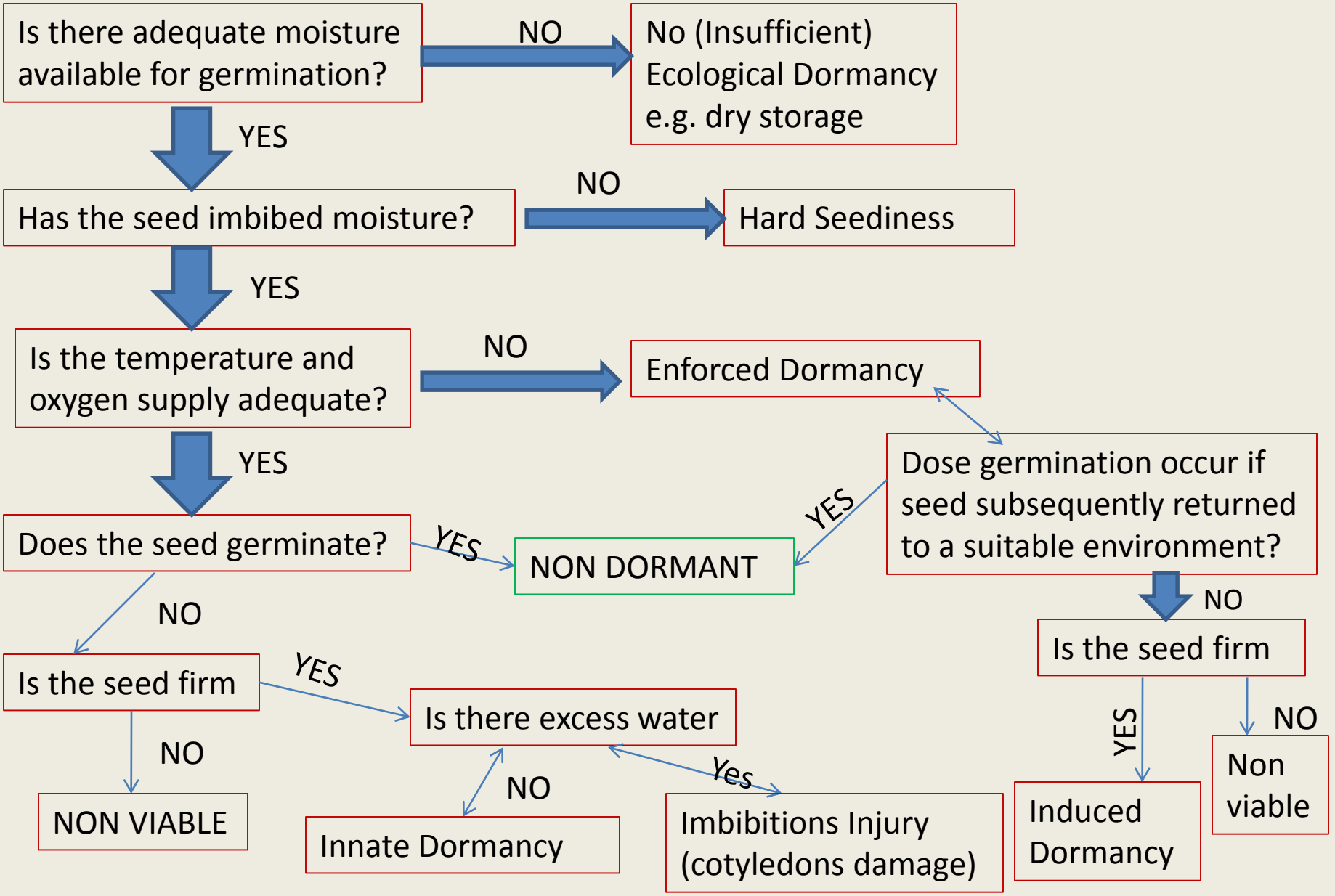


Fig.: Schematic representation of the different categories of dormancy together with associated problem

Treatments to overcome Dormancy

Temperature Fluctuation – Placing seeds in a germination chamber with sharp temperature fluctuations twice per day (15-25C for example) can have a great effect on breaking dormancy. Seed is held at the higher temperature for 8 hrs and at the lower temperature for 16 hrs. This simulates warm days and cool nights.

Prechilling – Some species require a long period of cold followed by a warming period before they will germinate – simulating the cold winter conditions followed by the warmth of the spring. In this case, the seeds must be hydrated during the prechill in order to break dormancy. Prechilling normally involves the exposure of an imbibed (moist) seed to a constant low temperature (5-10º C). Normally three to five days is sufficient but often longer durations are required. In some cases, midchilling or rechilling may be used to break a deep dormancy.

Predrying or Preheating – Some seeds require a dry or hot environment to break dormancy; this is often used with recently harvested seeds with high moisture content. The seeds are not hydrated in this scenario but are subjected to temperatures of 35-40º C for five to seven days in order to break dormancy.

Treatments to overcome Dormancy

Scarification – This is when the seed coat is softened or injured to become more permeable to water and/or to enable the seedling to emerge. This action can be done either mechanically or chemically.

Light – Some seeds require a constant source of light for a certain duration of time before being put into a germination test. This can be used with reed canary grass and several vegetable crops.

Prewashing/ Soaking– In certain seeds, inhibitors may exist within the seed coat and by washing these away, the seed can then germinate. This process of prewashing allows for these inhibitors to be removed from the seed. This is often used with beet seed.

Treatments to overcome Dormancy

Potassium Nitrate – A solution of potassium nitrate (0.2%) can be used as a substitute for water. It is a naturally occurring mineral, known as salt peter or Nitrate of potash, and is a common fertilizer salt.

Overall dormant seeds are not included in germination because it is very difficult to predict if seed that appears dormant is truly viable. A dormant seed may be alive but until the dormancy is broken and the seed germinates there is no conclusive way to confirm if the seedling has the capacity to produce a useable plant under field conditions.

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So

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to

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