Article Title (3 to 12 words)	**SEED DORMANCY IN GROUNDNUT**
Article Summary (In short - What is your article about – Just 2 or 3 lines)	The inability of certain seeds to germinate readily even when they are provided with all conditions required for germination is known as seed dormancy. A dormant seed is not a 'failure'. It may be due to conditions associated either with the seeds itself or with existing environmental factors such as temperature and moisture. In general, in groundnut, bunch types are non-dormant while spreading and semi spreading types are having a varied period of dormancy. The seeds show marked dormancy, ranging from 30 to 360 days.
Category:	Genetics

Your full article (between 500 to 5000 words) - - Do check for grammatical errors or spelling mistakes

INTRODUCTION

The cultivated groundnut (*Arachis hypogaea* L.) is one of the most commercially important oilseed crops. It is also designated as **"Wonder Legume".** It is one of the principal economic crops of the world, ranking **13th** among food crops. It is also **first ranking oilseed crop of India**. Main groundnut growing countries are **India**, China, Brazil, Africa and South-East Asia India accounts about 40 per cent area and 30 per cent world production. It contributes about 35 per cent area and 40 per cent production of the total oilseed crops grown in the country

- **Fig. 1 Groundnut Growing Areas In INDIA**

As shown in the figure the groundnut growing states of the India are Gujarat, MP, MH, AP, Orissa, Karnataka, and TN, among them major groundnut growing area are located in the states Gujarat, AP, TN and Karnataka.

➢ **Taxonomy**

Name of crop	Groundnut, Pea nut, Monkey nut, Goose nut.
Botanical name	*Arachis hypogaea* L.
Family	Fabaceae
Chromosome number	2n = 4x = 40
Center of origin	South America and Brazil
Mode of pollination	Self-pollination
Out crossing percentage	< 1 %

➢ **Issues with groundnut seed chain**

- **High seed rate**, low seed multiplication ratio.
- Groundnut seeds belongs to Spanish and Valencia group bears **no seed dormancy.**
- Lacking of short term fresh seed dormancy cause ***in situ* sprouting**.
- Seeds produce during *rabi* and summer seasons lost about 50% viability within 4-5 months (Nautial *et al.* 2004).
- Improper seed storage conditions leads toward drastic drop in germination rate and seedling vigor.
- Patchy crop stand resulted by one or combination of above listed factors reduce crop yield.

➢ **Fig. 2 Origin of cultivated species**

➢ **What is seed dormancy?**

The inability of certain seeds to germinate readily even when they are provided with all conditions required for germination is known as seed dormancy. A dormant seed is not a 'failure'. It may be due to conditions associated either with the seeds itself or with existing environmental factors such as temperature and moisture. In general, in groundnut, bunch types are non-dormant while spreading and semi spreading types are having a varied period of dormancy.

➢ **Seed Dormancy in Groundnut**

Report	Scientist
Subspecies *hypogaea*	
The seeds show marked dormancy, ranging from 30 to 360 days. Their seeds also do not suffer from vivipary when harvesting is delayed.	Zade *et al.* (1986)
Long dormancy is needed to be broken to facilitate the use of fresh seeds for sowing the next crop soon after harvest of the previous crop.	
Subspecies *fastigiata*	
Yield losses due to *in situ germination* in bunch varieties have been estimated	Reddy *et al.*

to range between 20 to 40%.	(1985)
Found that *in situ germination* may cause more susceptibility to aflatoxin contamination in seeds thus, reducing the seed quality.	Martin (1999)

- **Significance of seed dormancy**
  - It may be essential boon or evil.
  - Avoids germination at wrong moment.
  - Distribution of germination in time.
  - Minimizes effects of "unfavorable event".
  - Avoids germination at the wrong place.
  - Prolonged seed storage life.
- **Problem associated with seed dormancy**
  - Create problem for plant establishment.
  - Seed testing problems.
  - Deteriorates the quality of seeds.
  - Long periods of time needed to overcome dormancy causes uneven germination.
  - While raising a crop, it is very difficult to maintain the population in the field.
- **Categories and General listing of seed dormancy**

1. Primary dormancy

Dormancy inherent in the seed at the end of its development on the mother plant. Dormancy arises in the developing and maturing seeds.

A. **Exogenous dormancy** - Due to factors outside the embryo
   i. Physical – Legume **ii.** Mechanical – Olive **iii.** Chemical - Desert plants.

B. **Endogenous dormancy** - Due to factors within the embryo itself
   1) Morphological
      a) Rudimentary - Ranunculaceae, Papaveraceae **b)** Linear - Umbelliferaea, Ericaceae
      c) Undifferentiated-orchid

   2) Physiological
      a) Nondeep – Lettuce **b)** Intermediate-Conifers **c)** Deep - Temperate trees

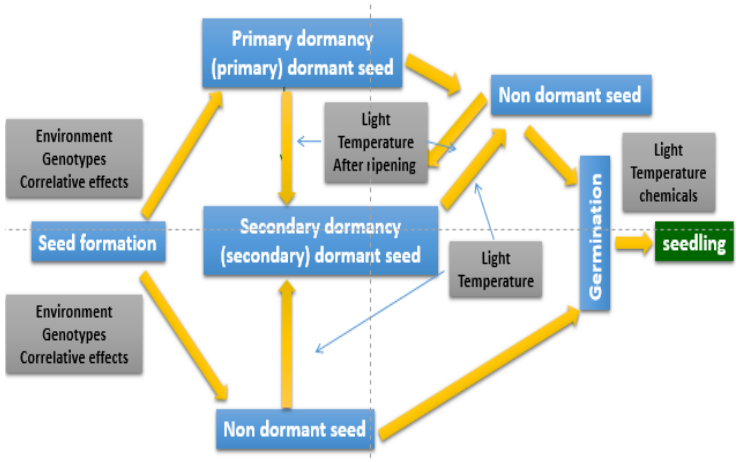
C. **Combinational (two kinds of dormancy)**
   1) Morphophysiological
      a) Epicotyl - Lilum, Viburnam, Peony **b)** Epicotyl and radicle(double dormancy)
   2) Exo-endodormancy

2. Secondary dormancy

Seeds whose germination has been inhibited fail to recover even when the inhibitory factor is removed. These seeds are said to enter in a state of dormancy called secondary or induced dormancy.

1. Thermo dormancy - Lettuce, Cellery
2. Skoto dormancy
3. Photo dormancy
4. Osmotic dormancy
5. Anaerobic dormancy - Paddy

- **Fig. 3 Response of environment and genetic factors on seed dormancy**



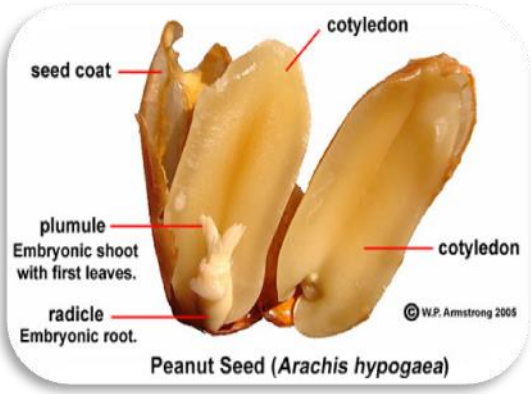
This figure indicate hoe the genetic factors, prevailing environmental conditions like light, temperature, relative humidity etc. and their interaction factors at seed formation stage, after seed maturation i.e. storage stage, and at seed germination stage decide the Groundnut seed dormancy.

➢ Mechanisms of Seed Dormancy

There are basically two types of dormancy which involve different mechanisms.

1. Embryo dormancy: Where the control of dormancy resides within the embryo itself.

2. Coat imposed dormancy: In which the dormancy is maintained by the structures enclosing the embryo, *viz*. seed coat.



➢ Control of Embryo dormancy in groundnut

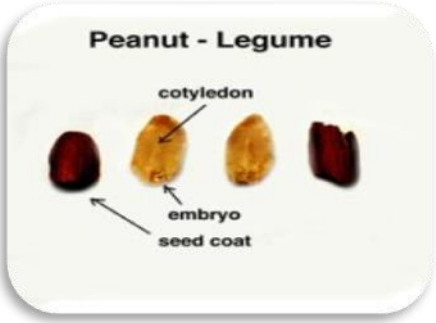
Different parts of groundnut seed being involved in imposing dormancy, which included the seed coat, cotyledons and embryo. **Nautiyal (2004)**

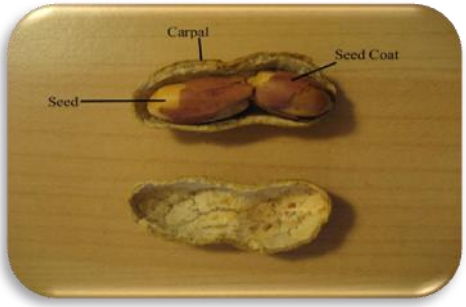
The inhibitory effect of different parts of dormant seeds on growth of embryonic axes are as follows:

seed coat > cotyledons >embryonic axes with seed coat **Ramulu (1996)**

Dormancy in groundnut is regulated mainly by testa in the Spanish type, but by cotyledons, and embryonic axis as well as testa in Virginia types. **Bandyopadhyay *et al.* (1999)**

➢ Coat - imposed dormancy





Seed dormancy in the majority of species is imposed by the structure surrounding the embryo. These are often referred to as the seed coat imposed dormancy. The mechanism of seed coat imposes dormancy is poorly understood

- **Control of Seed Dormancy in groundnut**
  1. Genetic factors
  2. Environmental factors
  3. Hormones
  4. Seed coat
- **Genetic factors**

The dispersal units generally consist of three genetically different tissues:

I. A diploid embryo produced by fertilization of the ovum,
II. A triploid endosperm containing one set of paternal genes and two sets of maternal genes
III. The diploid testa, pericarp all of maternal genetic constitution. Dormancy can be inherent within the embryo or can be imposed by these extra embryonic tissues.

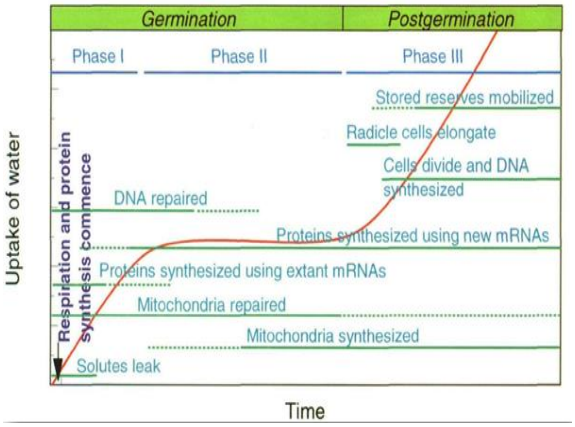
- **Inheritance of Seed Dormancy**

Reference	Reports
Khalfaoui (1991)	Dormancy is a quantitatively inherited trait and additive, dominance and digenic epistasis effects were involved in its genetic control.
Nautiyal *et al.* (1994)	The character may be quantitatively inherited.
Kumar (1999)	Additive dominance gene action
Ndoye (2001)	Beyond additive and dominance effects, there is duplicate epistasis in the control of fresh seed dormancy.
Upadyay & Nigam (1999); Asibuo et al. (2008); Yaw et al. (2008)	Monogenic inheritance with dormancy dominant over non dormant

- **Environmental factor**
  1. **Water**
     - The availability of water in the environment
     - The seed coat's permeability to water
     - Chemical composition of the seed
  2. **Oxygen**
     - The process of germination requires an expenditure of energy, therefore oxygen is essential for aerobic respiration.
  3. **Temperature**
     - Very low and very high temperatures prevent the germination of seeds.
  4. **Light**

- Red light (660 nm) promotes germination
- Far-red light (730 nm) inhibits germination

Fig. 4 Major events for germination and subsequent post germinative growth



The time for events to be completed varies from several hours to many weeks, depending on the germination conditions **Bewly (1997).** This figure is diagrammatic representation of collected biochemical events taken place over a time slot during germination and post germination stage. Holding any one or few in that sequence can either stop germination or cause altered irregular physiological processes leads toward premature death or abnormal growth of seedling.

- **Hormones**
  - Dormancy is controlled by interacting promoters and inhibitors.
  - The inhibitor Abscisic acid (ABA) is an important inducer of dormancy.
  - ABA appears in the seeds during their development and is retained upto maturity by the dormant varieties but not by those which are non-dormant.
  - Inhibitors extracted from dispersal units form variety of chemical compounds like coumarin, oxalate and vanillic acid.
  - Abscisic acid also inhibit RNA and protein synthesis *in vivo.*

Plant hormone and their seed phenotypes

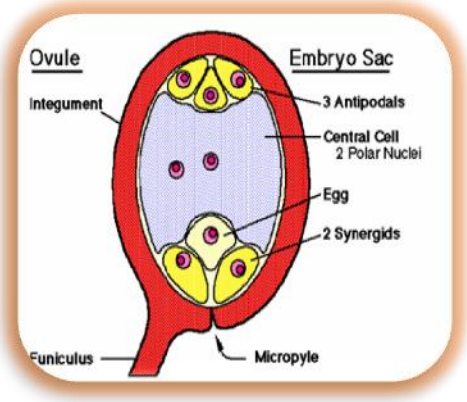
Hormone	Class	Seed dormancy
ABA	Deficiency	Reduced
	Over reproduction	Enhanced
	Insensitivity	Severely Reduced
	Hyper sensitivity	Enhanced
GA	Deficiency	Enhanced
	Insensitivity	Enhanced
	Hyper sensitivity	Reduced

- **Role of germination-inhibitors**
  - An important inhibitor found in most of the dormant embryo is Abscisic acid (ABA).
  - Durand (1975) reported that enlargement and greening was prevented in cotyledons wetted with a solution of ABA.
  - ABA can prevent germination by affecting RNA synthesis.

- **Seed coat**

- Seed testa played an important role in imparting dormancy followed by the cotyledons, and embryonic axis.
- However, the nature of dormancy of embryonic axis appeared to be different than the testa and cotyledons.
- Seed dormancy in groundnut is regulated mainly by testa (a maternal tissue) in the Spanish type and by cotyledons, and embryonic axis (both zygotic tissue) as well as testa in Virginia type.

Bandyopadhyay *et al.* (1999)



➢ **Causes for prevention of embryo germination by seed coat**

- Interfere with the water uptake.
- Interfere with the gaseous exchange.
- Contain chemical inhibitors.
- Act as a barrier against the escape of inhibitors from emb
- Modify the light reaching to the embryo.
- Exert a mechanical restraint.

➢ **Methods to Induce Seed Dormancy**

- Dormancy is an important factor in commercial groundnut production.
- Short duration fresh seed dormancy is needed in Spanish type to prevent the product loss due to pre-harvest *in situ* germination of seed.
- For inducing seed dormancy in groundnut different methods have been developed.
- Growth retardants *viz.*, Maleic hydrazide and Abscisic acid, γ- radiation treatments

➢ **Maleic hydrazide**

Maleic hydrazide (diethanolamine salt of 1,2-dihydroxy-3,6 pyridazine-dione), has been successfully used to induce dormancy by foliar application at different stages of crop growth to control sprouting.

Different Maleic hydrazide concentration for induction of seed dormancy in groundnut

References	Conc.	Stage of Application	Findings
Nautial (2004)	1000 ppm	60 days after crop emergence	Induce seed dormancy in Spanish type.
Jagatap (2000)	250 ppm	-	The seed viability remains unaffected and seed dormancy could be induced up to 30 days for cv. RHRG-12, 10 days for cv. TAG-24 and 30 days for cv. RHRG-16.
Abrar and Jadhav (1991)	200 ppm	One month before harvesting	Seed dormancy period was increased from 5 to 25 days in cv. PI-139915 and PI-169292.
Bhapkar *et al.* (1986)	5000 ppm	70 DAS	Induce seed dormancy up to 30-40 *per cent*

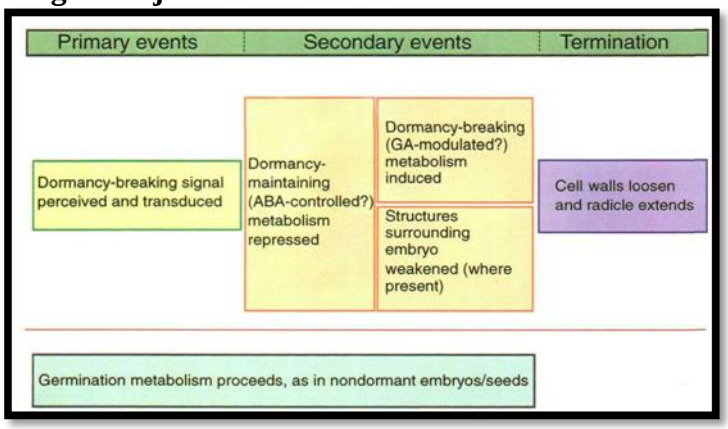
➢ **Methods to Overcome Seed Dormancy**

1. Scarification treatments
   A. Acid Scarification (100 ml conc. H_2SO_4/Kg seed for 2-3 minutes)
   B. Mechanical Scarification (sand and seed ratio 2:1 rub against 5-10 minutes)

C. Steam Scarification (steam for about 5-10 minutes)

2. Stratification
   A. Cold Stratification (0 to 5^{o}C for 2-3 days) B. Warm Stratification (40-50^{o}C for few days)
3. Hot water treatments (60-80^{o}C for 5-10 minutes)
4. Leaching of metabolites
5. Temperature treatments
6. Light and photo chrome treatments
7. Pressure treatments
8. Infrared radiation treatments
9. Magnetic treatments
10. Promoter vs. inhibitors treatments

➢ **Fig. 5 Major events associated with breakdown of seed dormancy**



Bewly in (1997) described the Major events associated with breakdown of seed dormancy. The metabolic processed were classified in to three stages initiated with induction of dormancy breaking signal followed by ABA dependent dormancy suppression metabolism and increase in GA dependent dormancy breaking metabolism in secondary event and radicle extension as termination event.

CONCLUSION

- The lack of seed dormancy in groundnut causes huge losses due to *in situ* germination in Spanish bunch groundnut.
- Groundnut seed dormancy seems to be a complex adaptive trait reported to control by maternal and zygotic tissues as well environment.
- It is believed to be induce by physiological and biochemical phenomenon.
- The mechanisms of dormancy have been understood partially.
- Considerable genetic variability has been observed for seed dormancy in groundnut.
- The efforts have been made to induce dormancy in bunch type groundnut.

FUTURE THRUST

- Emphasis needs to be devoted for proper understanding the mechanism of seed dormancy through interdisciplinary approaches.
- It needs to resolve weather the dormancy is govern by genotype of zygote or predetermined by maternal tissues.
- Inheritance pattern of seed dormancy needs to be study by making large numbers of crosses.
- The complete insight into the breakdown of dormancy could also be made through recent molecular tools.

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