Seed Processing and Preservation for Seeds Quality

The World Vegetable Center

Genetic Resources and Seed Unit

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AVRDC-The World Vegetable Center

Gene bank

- Up to August 2016 Germplasm collection
- Accession ：61,952
- Genera：173
- Species：442
- Origin countries：156

Activity and man power of GRSU

- Researcher：**7**
- Administrative：**1**
- R. Assistant：**2**
- Technician：**2**
- Helper：**3**
- Regular labor：**2**
- Total：**16**
- Casual worker：**5 -12**

- Accessions regenerated yearly

  1400 – 1600 accessions
- Accessions character

  1200 – 1300 accessions
- Distribution yearly

  5000 – 6000 samples
- Safety duplicated

  GCDT, RDA, NPGRC、Other Genebank

Regeneration of Angiosperms – flowering plants

- **Plants without seed (ex: garlic)**

  - by bulb (clove) or other types

- **Plants producing seed**

  1. Recalcitrant seed (mostly in tropical fruit)

  2. Orthodox seed

  3. Intermediate

What to do if there is no seed?

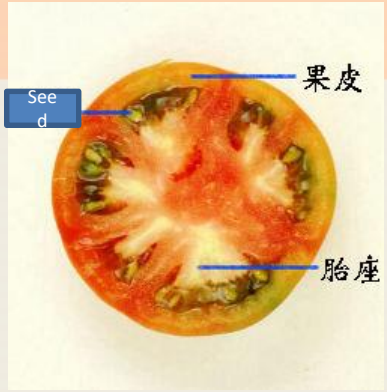
Bulb or Root

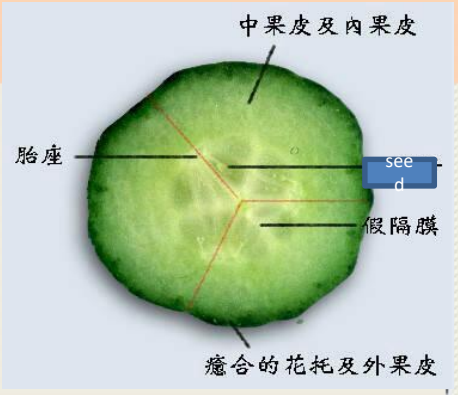
- Collect and keep the surface dry

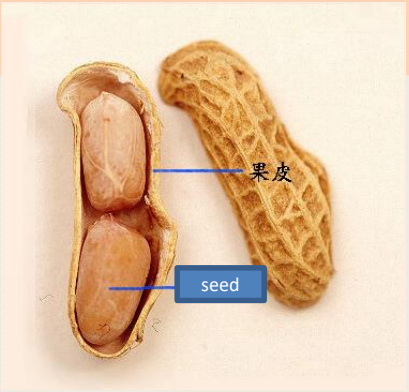
Living material (plant)

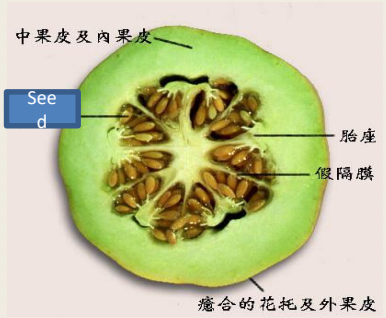
- Collect and keep it alive

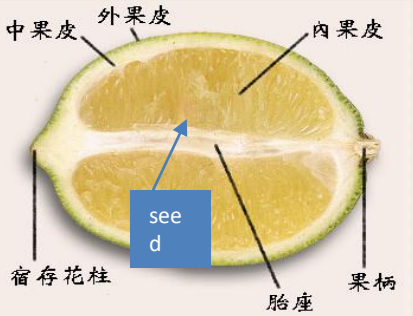
Where is the seed?

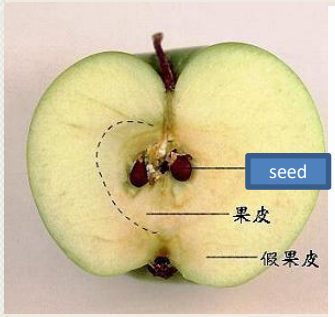












Fruit

Seed is dry in:

- Capsules
- Pods
- Nuts

Beans, okra, pepper, basil, onion, carrot, luffa

Seed is wet in:

- Berries
- Drupes (peach, plum, cherry)
- Pome/citrus fruits
- Gourd fruits

Tomatoes, eggplant, squashes, melons

Fermentation: tomatoes, squash, eggplant

Factors affecting seed quality during seed processing, storage and priming

During seed production

- Climate
- Cultural practices
- Isolation distance and rogueing
- Seed maturity
- Fruit and seed position on mother plant
- Insect pests and diseases

During seed processing and storage

- Seed moisture
- Seed drying
- Storage temperature
- Relative Humidity
- Oxygen
- Storage insect pests and diseases

Factors affecting seed quality during seed production

During seed production

- Climate
- Cultural practices
- Isolation distance and rogueing
- Seed maturity
- Fruit and seed position on mother plant
- Insect pests and diseases

Post Harvest ！ How about Pre-harvest?

- **Field Management**

- Proper water and fertilizer

To have strong and well growth plant

- Suitable fruit amount per plant

To have fully developing fruits and seeds

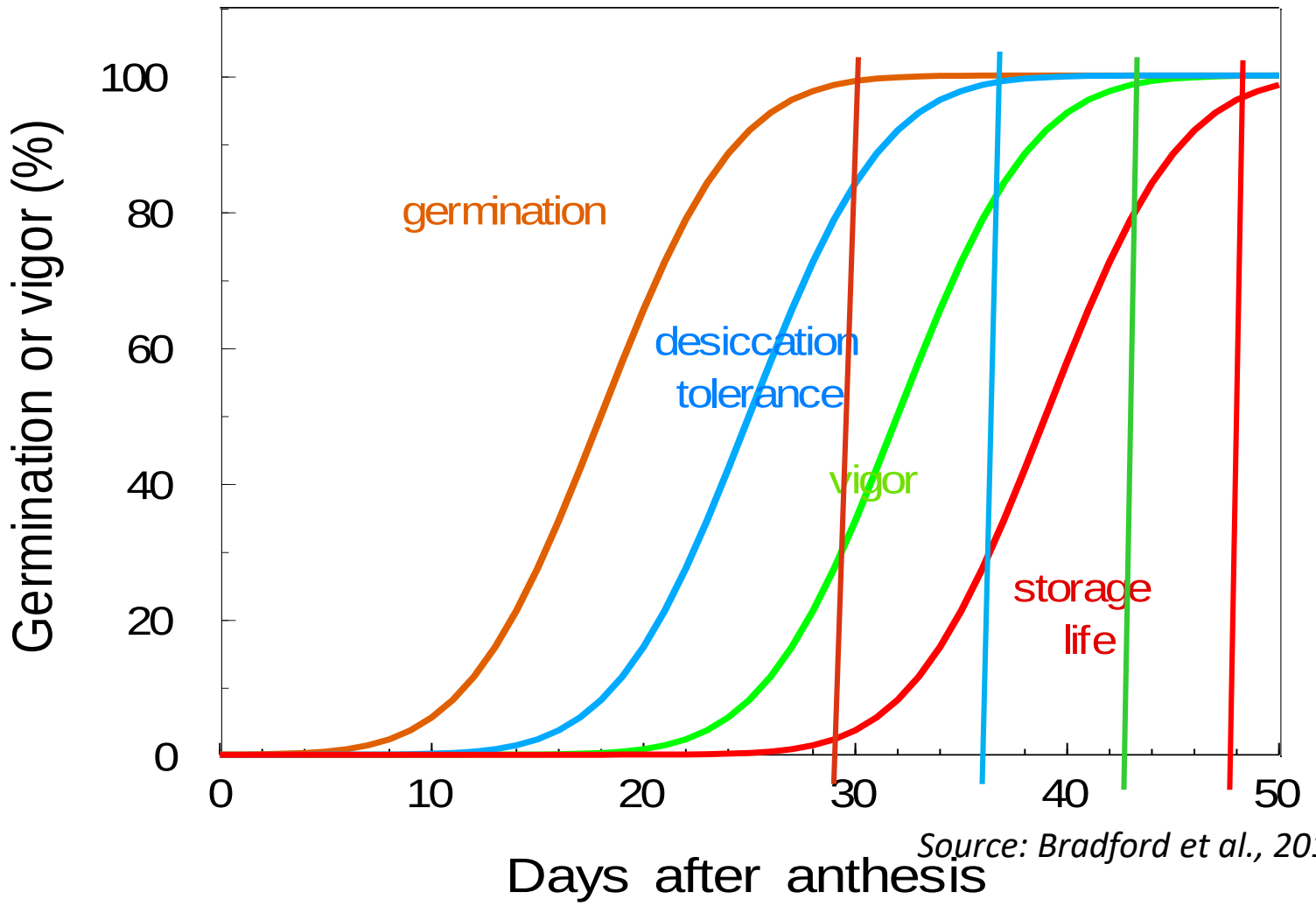
- Pest (disease and insect) control

To have good quality seeds

Harvest, When?

- **Harvest earlier**
  - **Seed may not mature yet**
  - **Seed storage ability may not complete yet**
- **Harvest lately**
  - **Seed may start aging**
  - **Seed may sprout inside fruit**

Development of seed quality attributes during seed maturation



Source: Bradford et al., 2012

Harvest the seed, than what？

Harvest from field

1.Fruit - Seed extraction(late mature?)

berry、Melon scoop、capsule

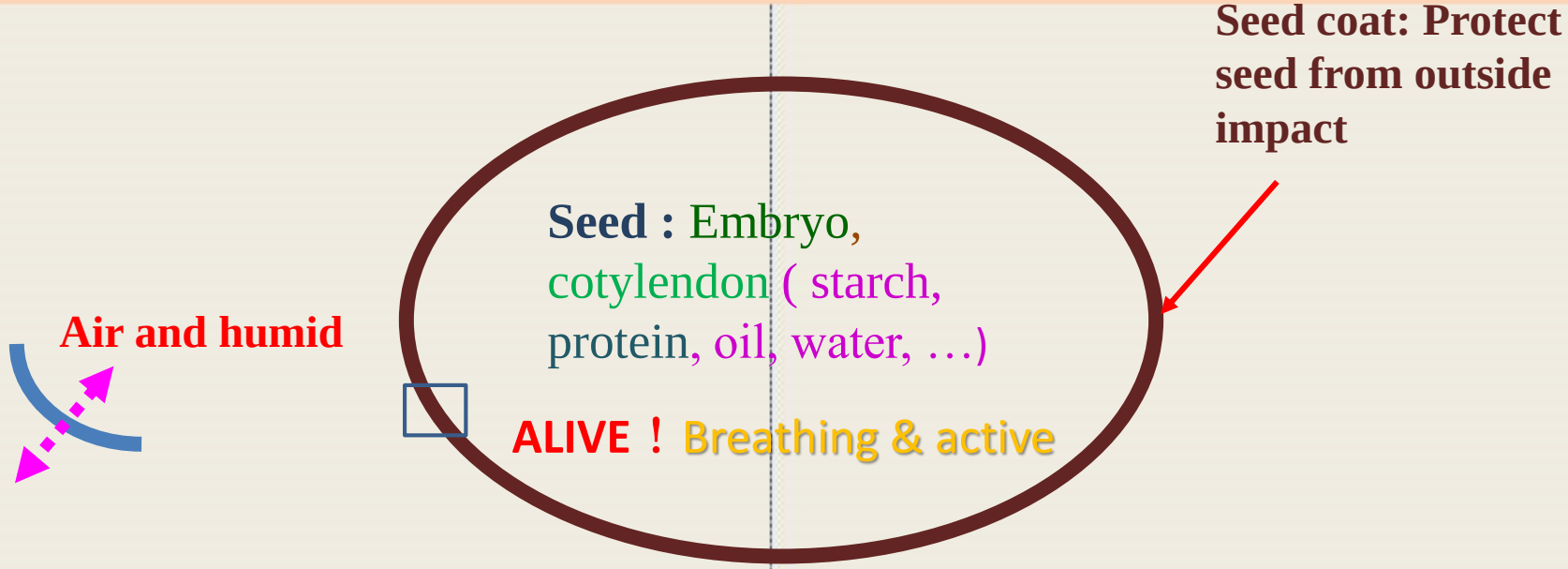
2.Pod - Seed extraction

break by hand、extracted by machine

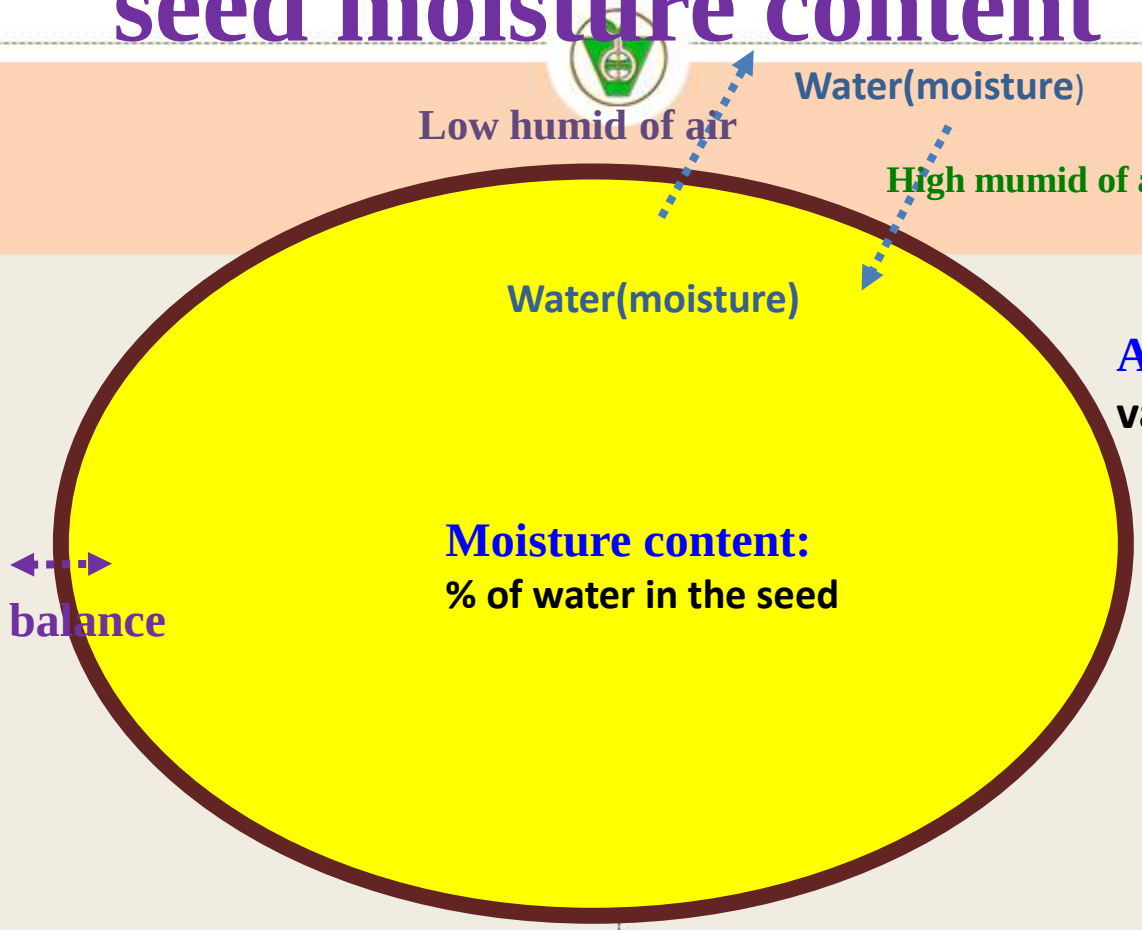
3. Ear - seed fall

by hand, by machine

Vegetable Seed



Relationship of air humidity and seed moisture content



Factors affecting seed quality during seed processing, storage and priming

During seed processing and storage

- Seed moisture
- Seed drying
- Storage temperature
- Relative Humidity
- Oxygen
- Storage insect pests and diseases

Standard Post-harvest procedure(1)

- **Preliminary drying**

  wash：centrifugal、air dry under shade

  (Seed moisture 40-65%➡12-15%)

  extraction： air dry under shade

  (Seed moisture 20-25%➡12-15%)

- **Cleaning**

  Remove non-seed material & broken、bed developed seed

Standard Post-harvest procedure(2)

- **Advanced drying (Drying condition：RH<？%、Temp.=？)**

  ⬇**moisture to？10-13%？7-10%？**

  4-7%？ <4%？

- **Sealed packing (Seed coating?)**

  Packing material！Storage Temp.！

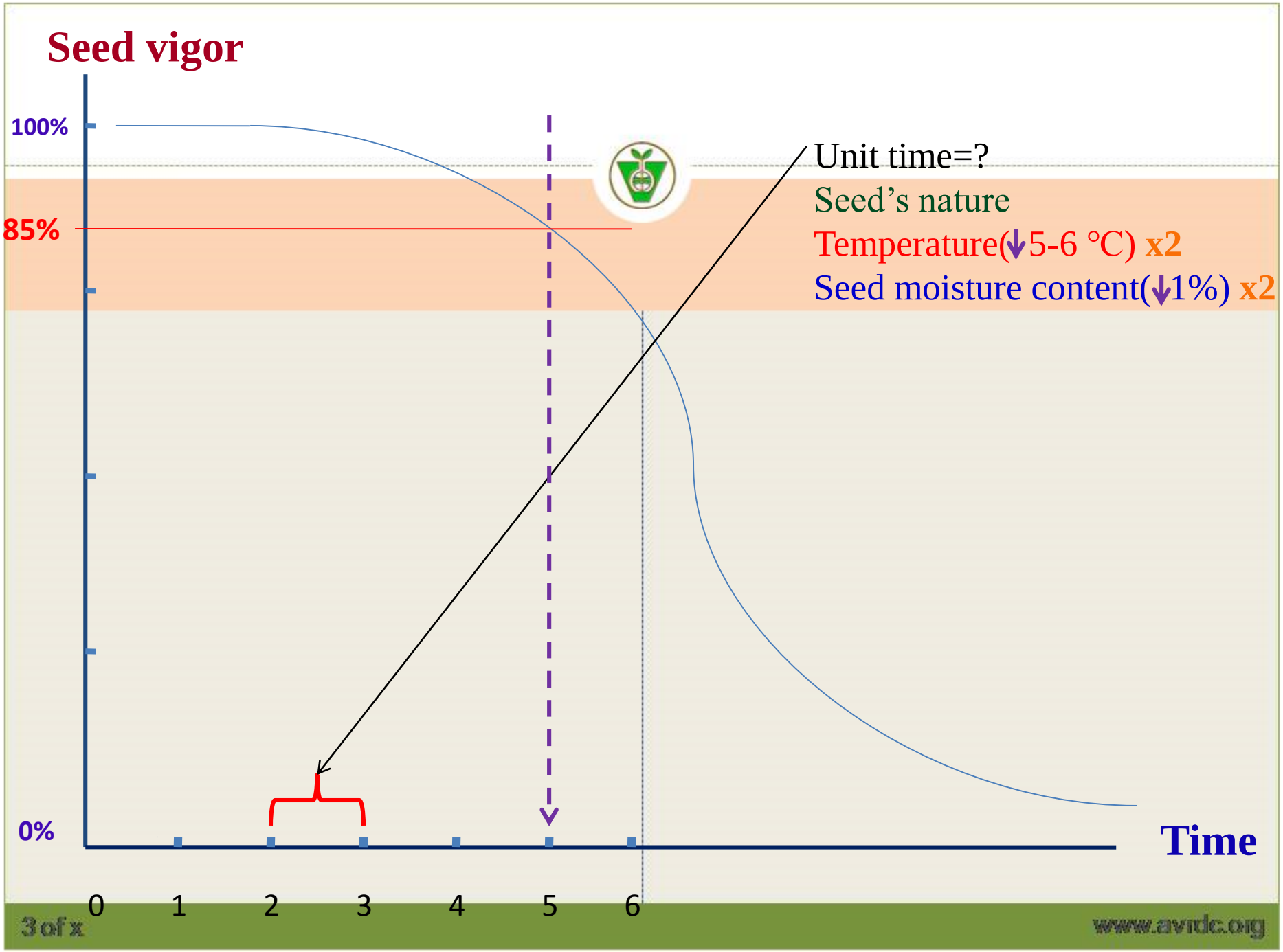
Seed(orthodox) vigor estimate

$$v = K_i - p/\sigma$$

$$\log \sigma = K_E - C_W \log m - C_H t - C_Q t^2$$

$$v = K_i - p \Big/ 10^{K_E - C_W \log m - C_H t - C_Q t^2}$$

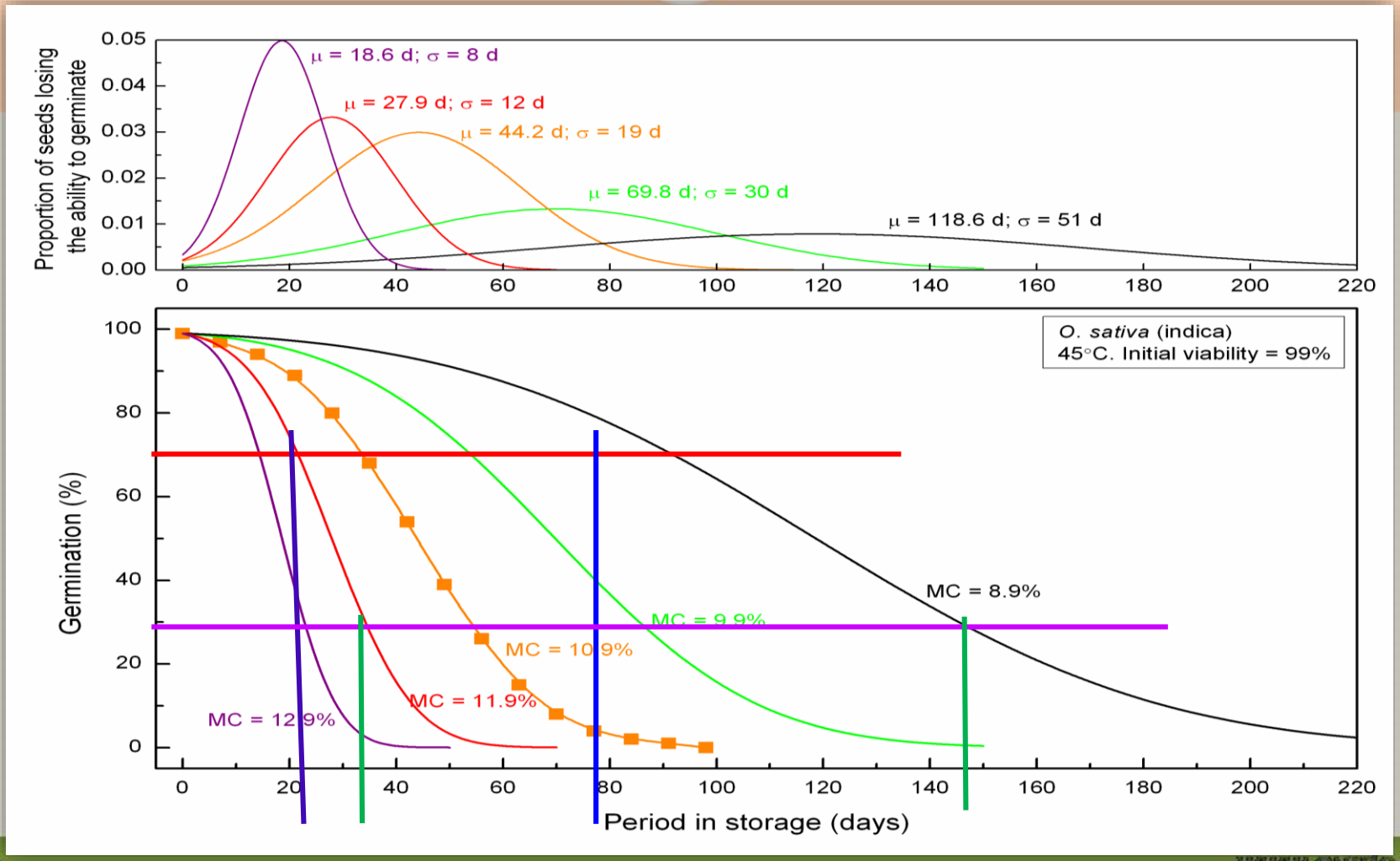
(Ellis & Robert 1980)



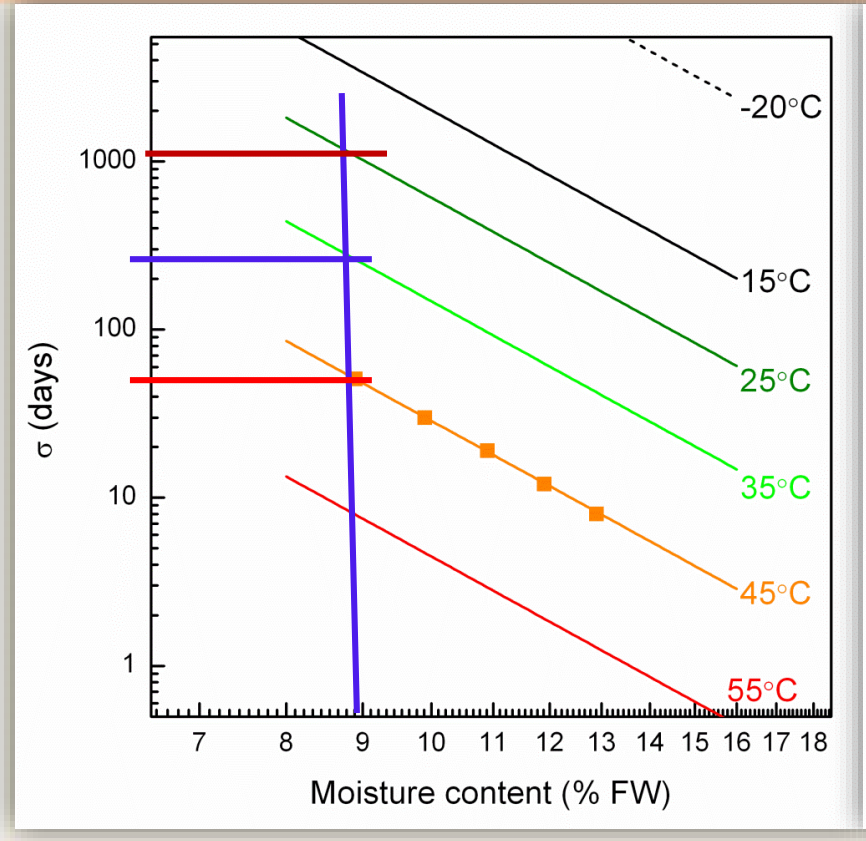
M.C. of seed v.s. Storage Temp.

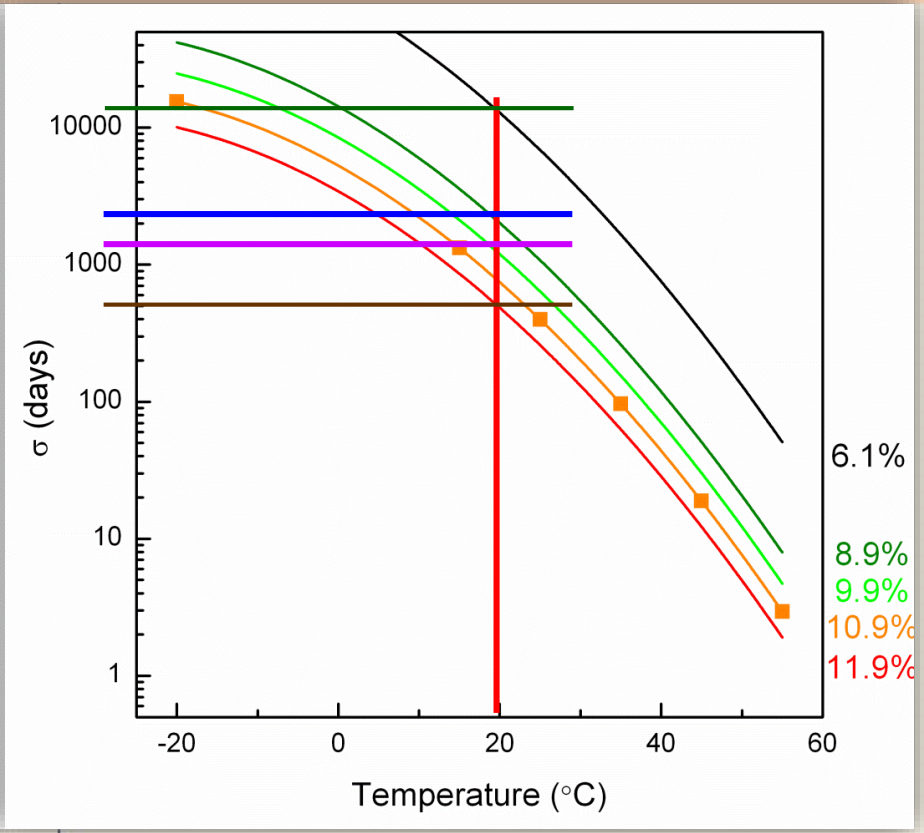
Seed moisture content	Seed story temperature
• ↓1%(Life x2)	• ↓5-6ºC(Life x2)
• One time dried	• Keep for long time
• Packed by humi-proved material	• Cooling machine
• No more energy cost	• Keep using energy
• Fail possibl: Bag broken	• Fail possible :power failure、machine out of order

Effect of seed M.C.to storage life



Moisture vs. Temperature





Temperature control of a genebank

- **Short term storage(Est for 5-10 Yr.)**

  10 ~ 15 ℃ 40-50% RH
- **Medium term storage(Est for20-50Yr.)**

  0 ~ 5 ℃ 40-50% RH
- **Long term storage(Est for>50-100Yr.)**

  -15 ~ -20°C Forest free(RH:50-60%)

Seed M. C. v.s. Storage Temp.

- Storage temp. the lower the better

But .....

1.Possible problem of intermediate type

Ex：Bitter gourd (can be dried SMC to 4%) but can not stored in sub-zero temperature

- 2.If the Seed M.C . Too high - >10% ，

Freezing temp can kill the seed due to ice formed

Seed drying after harvested

- **Preliminary (pre-drying)**

For un-extracted seed in pod or extracted and washed seeds

Air drying under shade → Seed M. C.12-15%

- **Advance drying**

For seed after 1st stage drying and cleaned seed

Artificial drying treatment to →4 – 7 %

Seed Dryer of AVRDC's genebank-1

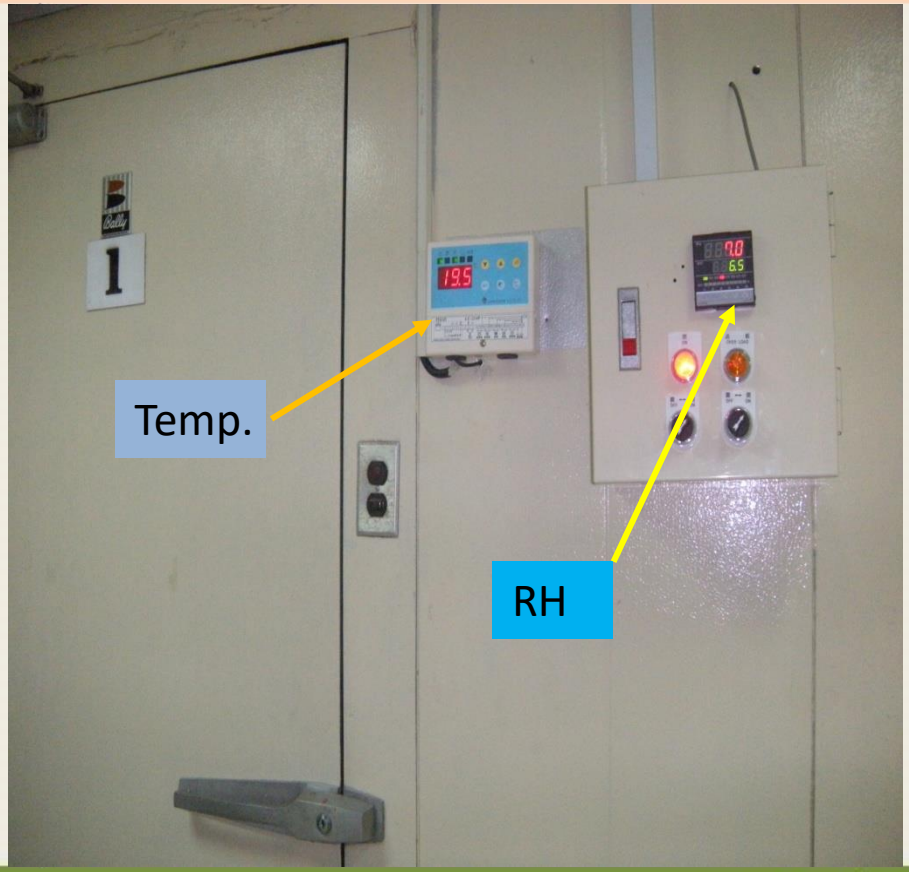
Munters Dryer ML1100E TK

Cooling machine

Seed dryer of AVRDC's genebank-2

Shelves inside drying room

Moniter of Temp. and R.H.



Operation of the Seed Dryer

- **Set up**

  Temperature：18 ℃

  R. H.：10%

- **Record(2011.8 – 2012.9)**

  Temperature：16 – 20 ℃

  R. H.：4% - 15%

Gene bank drying method

- **Advantages**

  Treat large amount seeds、Stable and reliable、Easy for further procedure

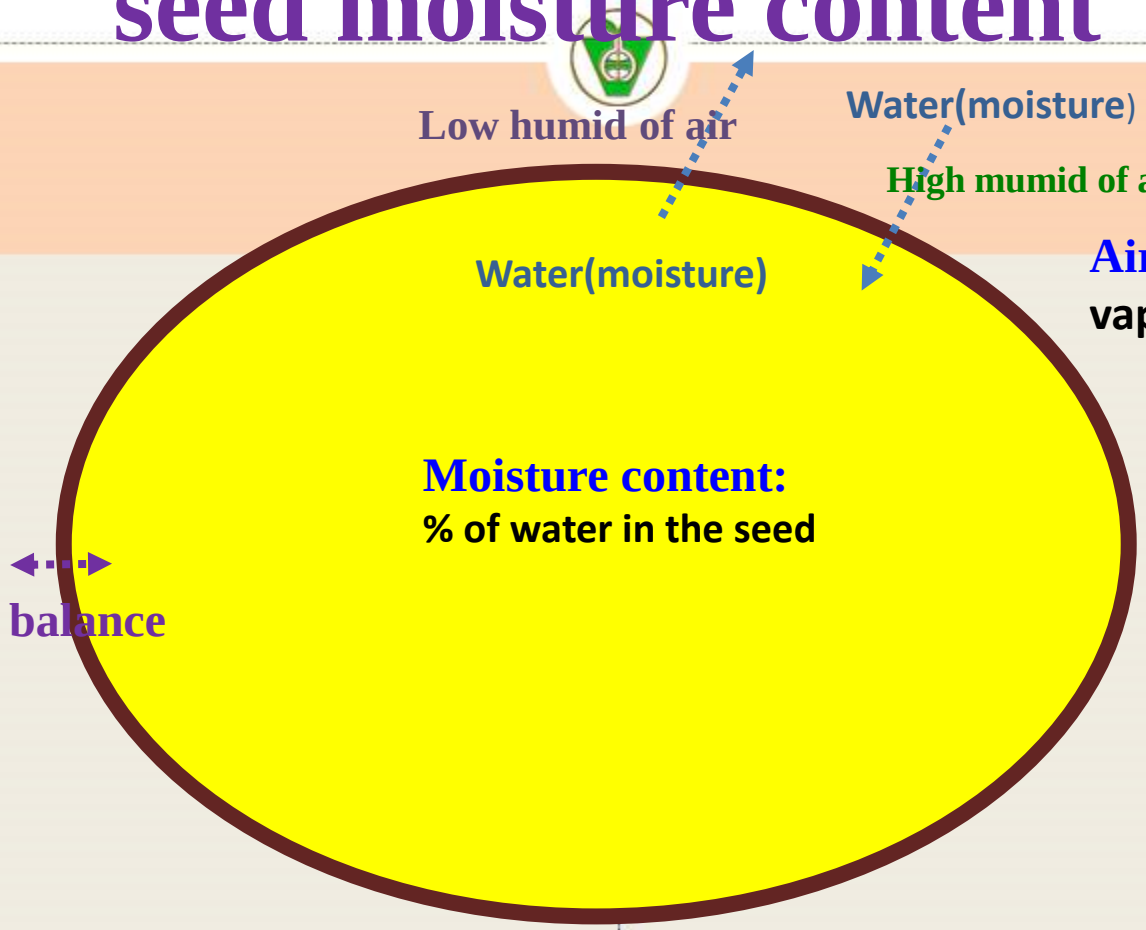
- **Disadvantages**

  Expensive equipment, energy cost, need a reliable maintain system

Seed preservation need other than genebank

- Research and breeding of seed company
- Institute, college without genebank
- Independent researcher, breeder
- Farmer(Keeping local varities)

Relationship of air humidity and seed moisture content



Air humidity: Water vapor in the air

How can we dry the seed

- **Principle of drying seed:**

Supply a low Relative humidity (surround the seed) air, Based on diffusion and equilibrium of water (H_2O) to let seed release the moisture

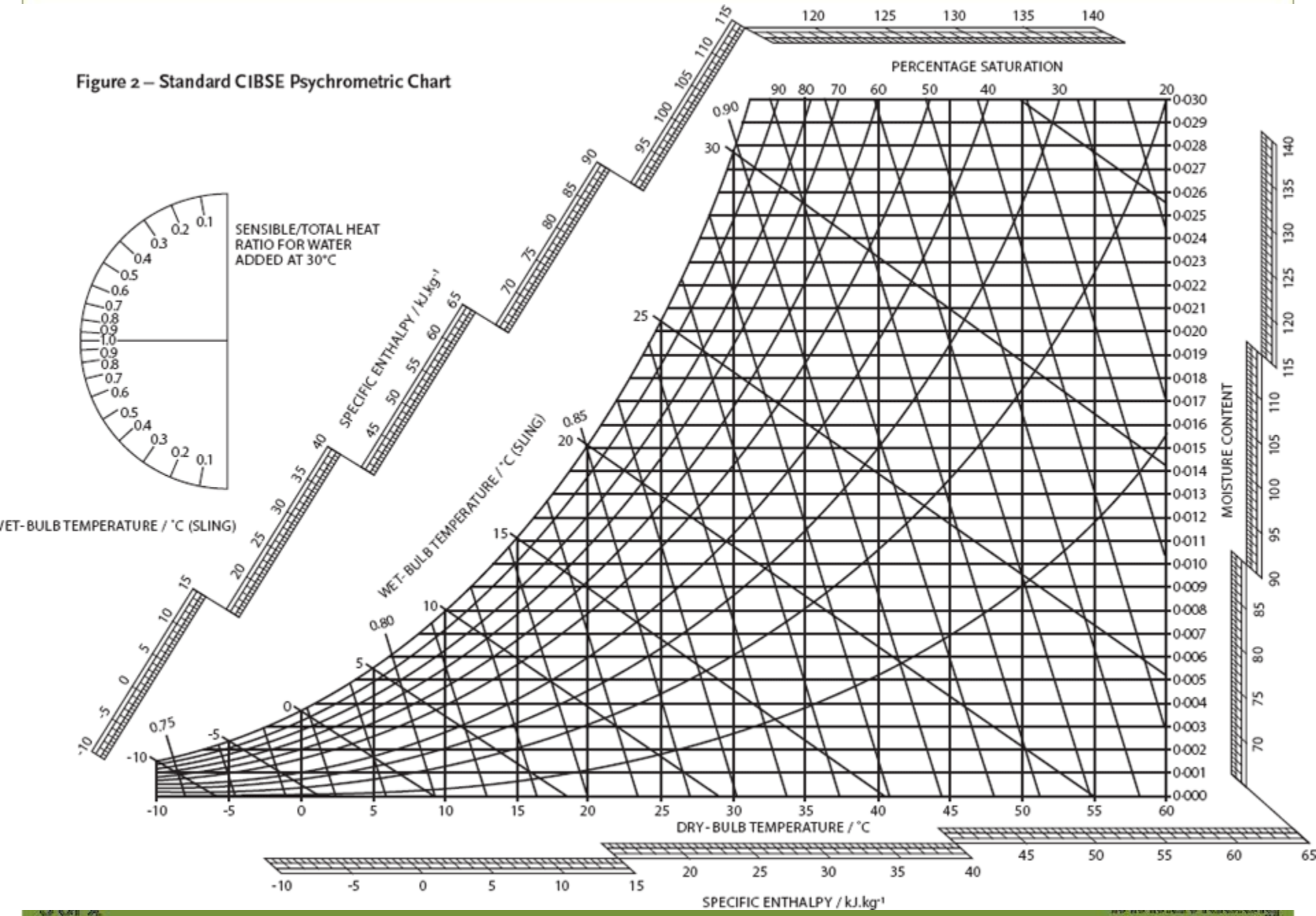
Principles of seed drying

- **Seeds are hygroscopic and absorb or give off moisture (depending on RH in surrounding air and gradient in water potential).**
- **Absorption or desorption occurs until water vapor pressur in the seed and surrounding air are balanced.**
- **For a given species: clear relationship between RH and SMC. Seeds loose or absorb water until balance is reachedbetween SMC and RH of surrounding air at a specifictemperature (moisture isotherm - MI).**

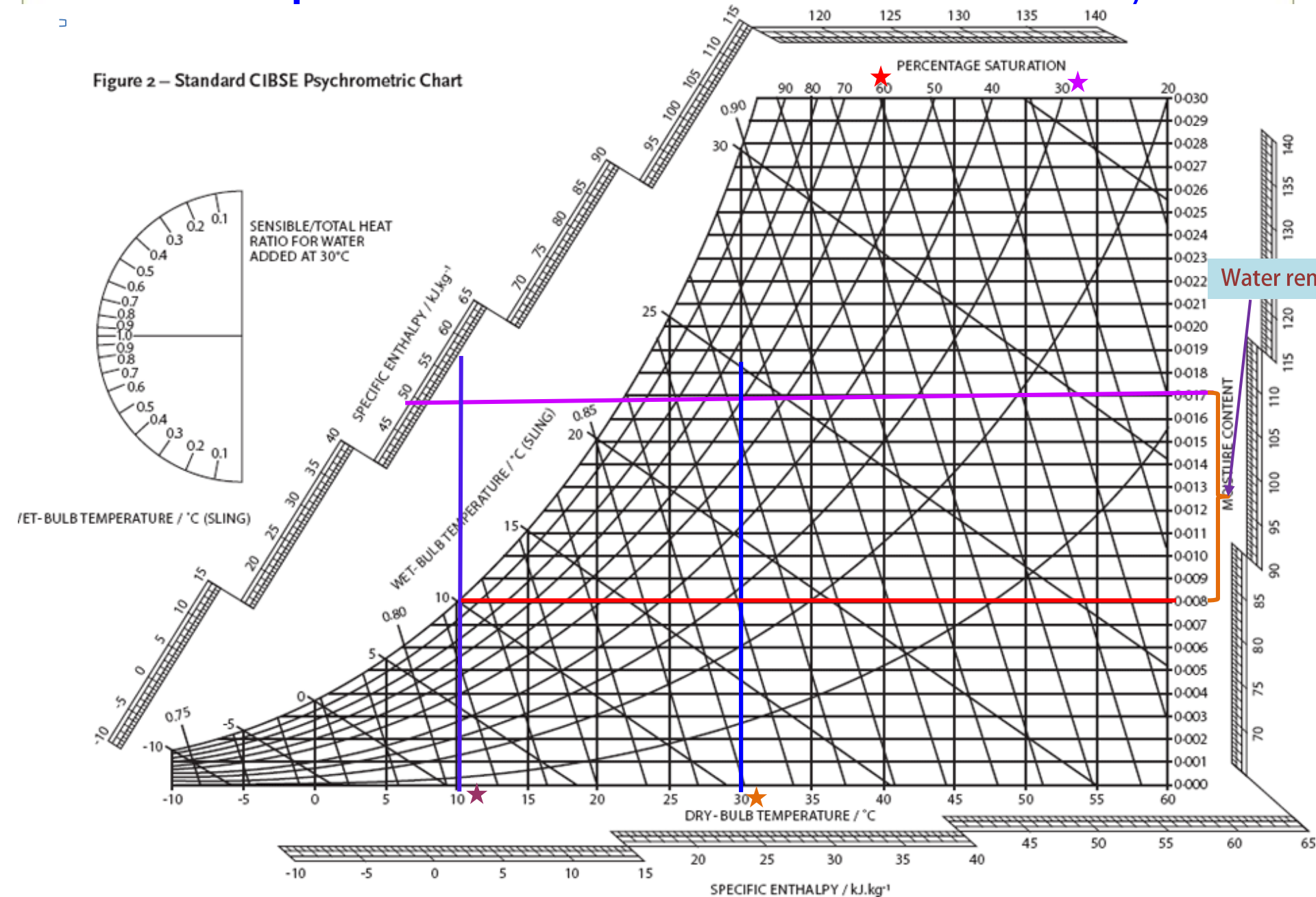
Equilibrium moisture content of crop seeds at 25 ºC

Species	30% RH	45% RH	60% RH	75% RH
Bean, Lima	7.7	9.2	11.0	13.8
Beet	5.8	7.6	9.4	11.2
Cabbage	5.4	6.4	7.6	9.6
Carrot	6.8	7.9	9.2	11.6
Cucumber	5.6	7.1	8.4	10.1
Eggplant	6.3	8.0	9.8	11.9
Lettuce	5.1	5.9	7.1	9.6
Mustard	4.6	6.3	7.8	9.4
Okra	8.3	10.0	11.2	13.1
Soybean	6.5	7.4	9.3	13.1
Tomato	6.3	7.8	9.2	11.1

Figure 2 – Standard CIBSE Psychrometric Chart



Temp/Moisture/Relative humidity



Methods of drying seed

- **Gene bank(Low Temp. low R.H.)**
- **35 - 40 °CHigh temperature**
- **Sun dry**
- **Desiccant**

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X:>30°C will damage seed

Methods of drying seed

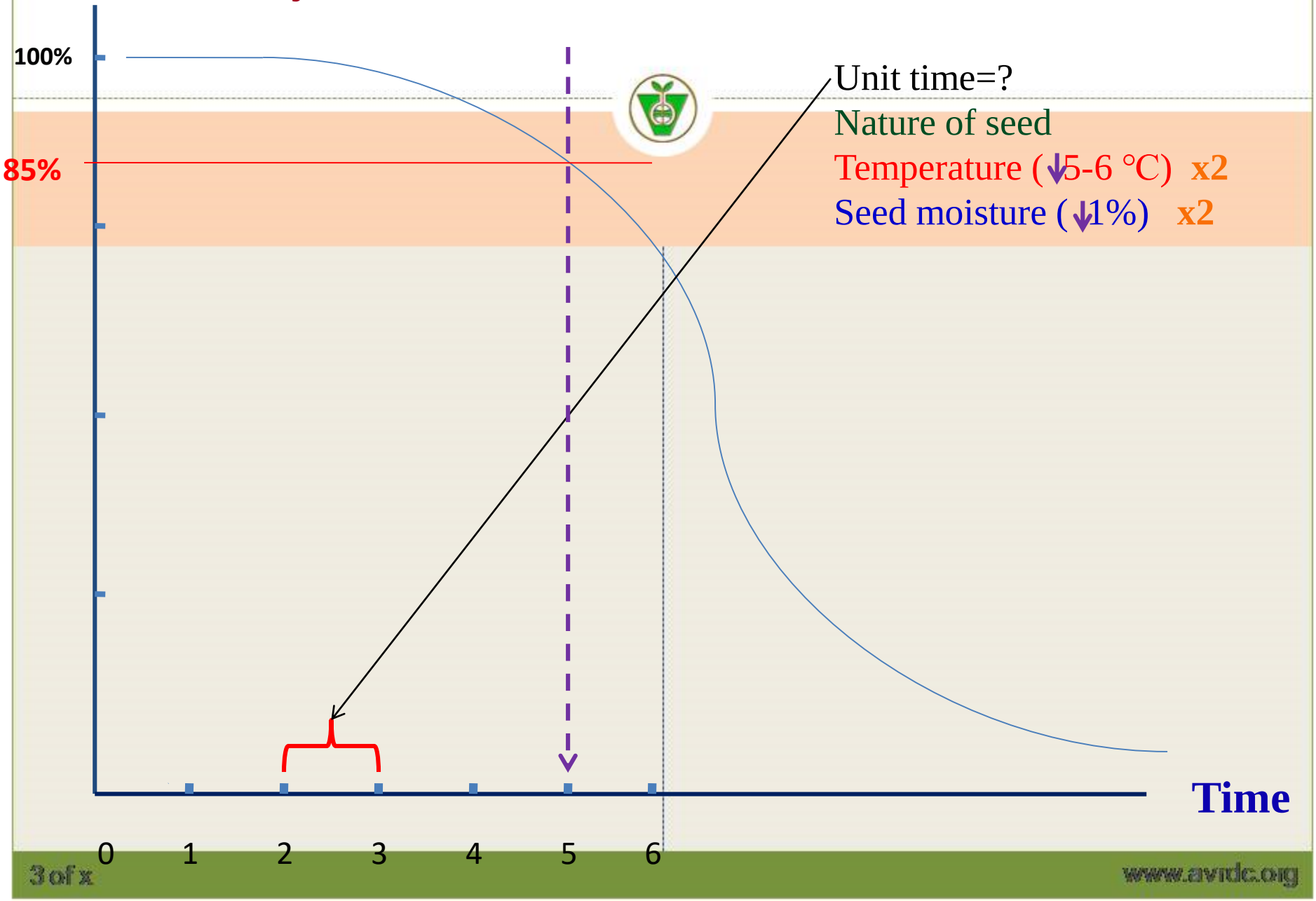
- **Gene bank(Low Temp. low R.H.)**
- **35 - 40 ℃ High temperature**
- **Sun Dry**
- **Desiccant**

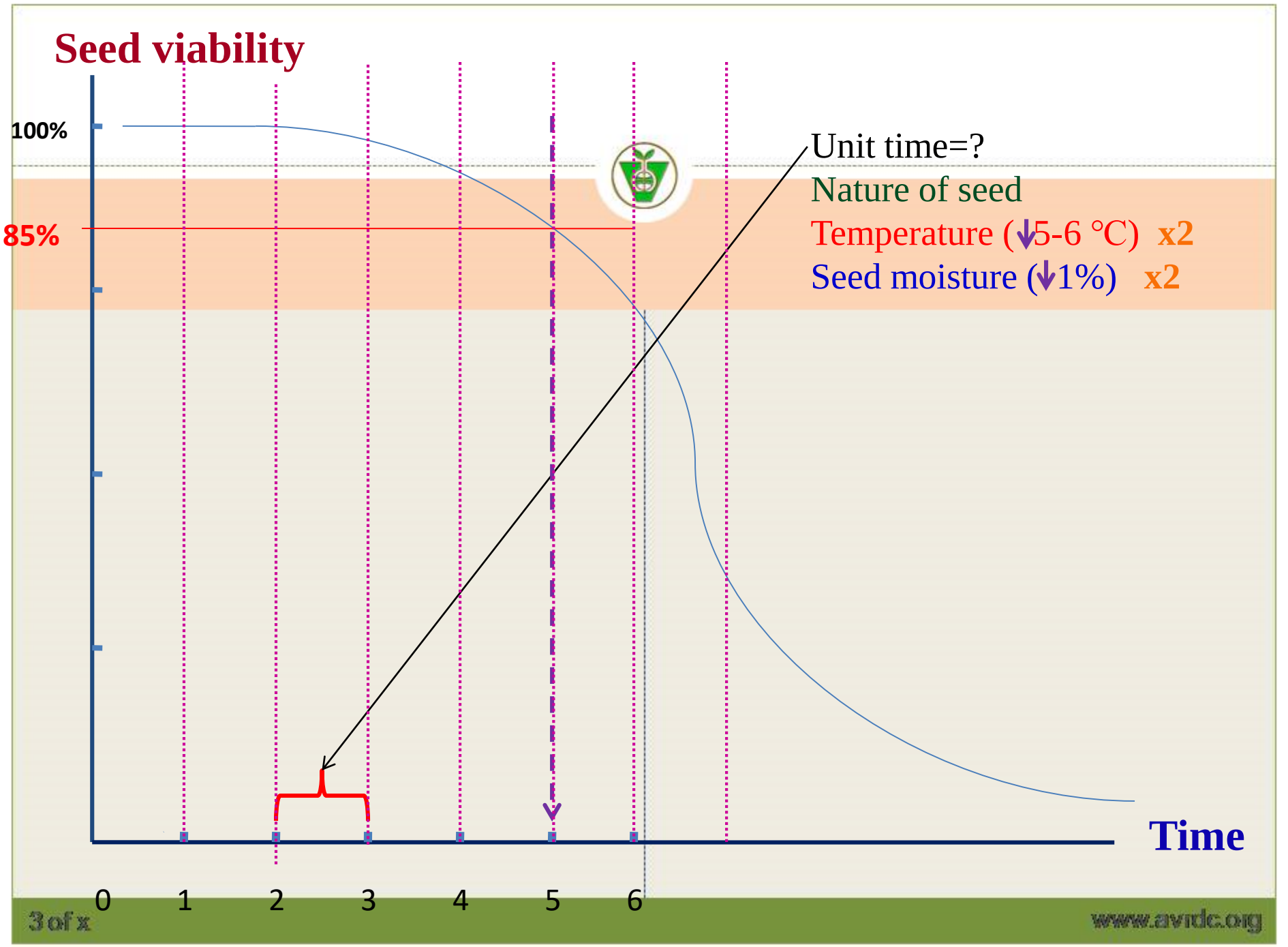
X:UV light will damage seed

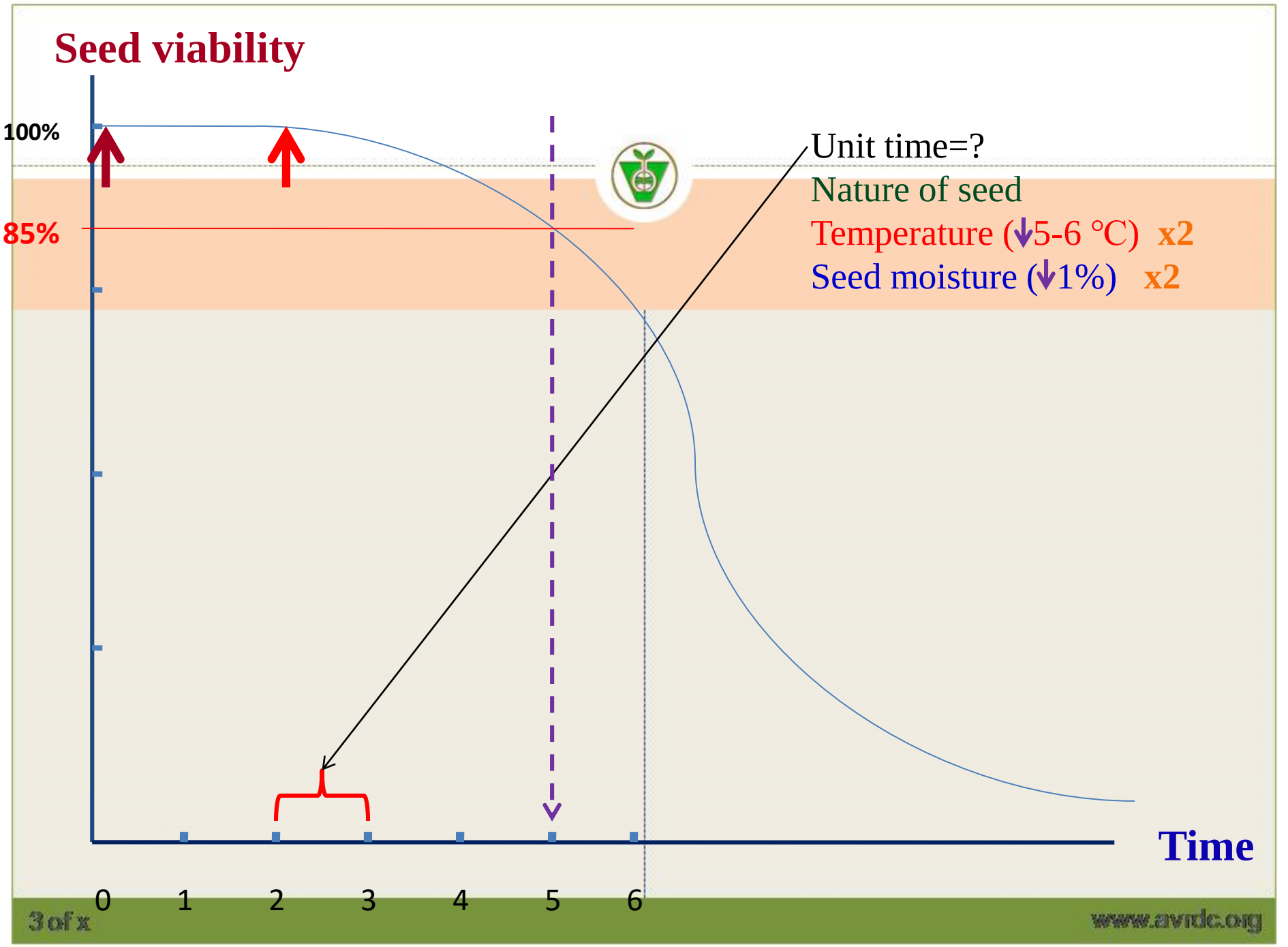
Methods of drying seed

- **Gene bank(Low Temp. low R.H.)**
- **35 - 40 °C High temperature**
- **Sun dry**
- **Desiccant**

Seed viability




Seed viability
100%
85%
Unit time=?
Nature of seed
Temperature (↓5-6 °C) x2
Seed moisture (↓1%) x2
Time
0
1
2
3
4
5
6
3 of x
www.avrdc.org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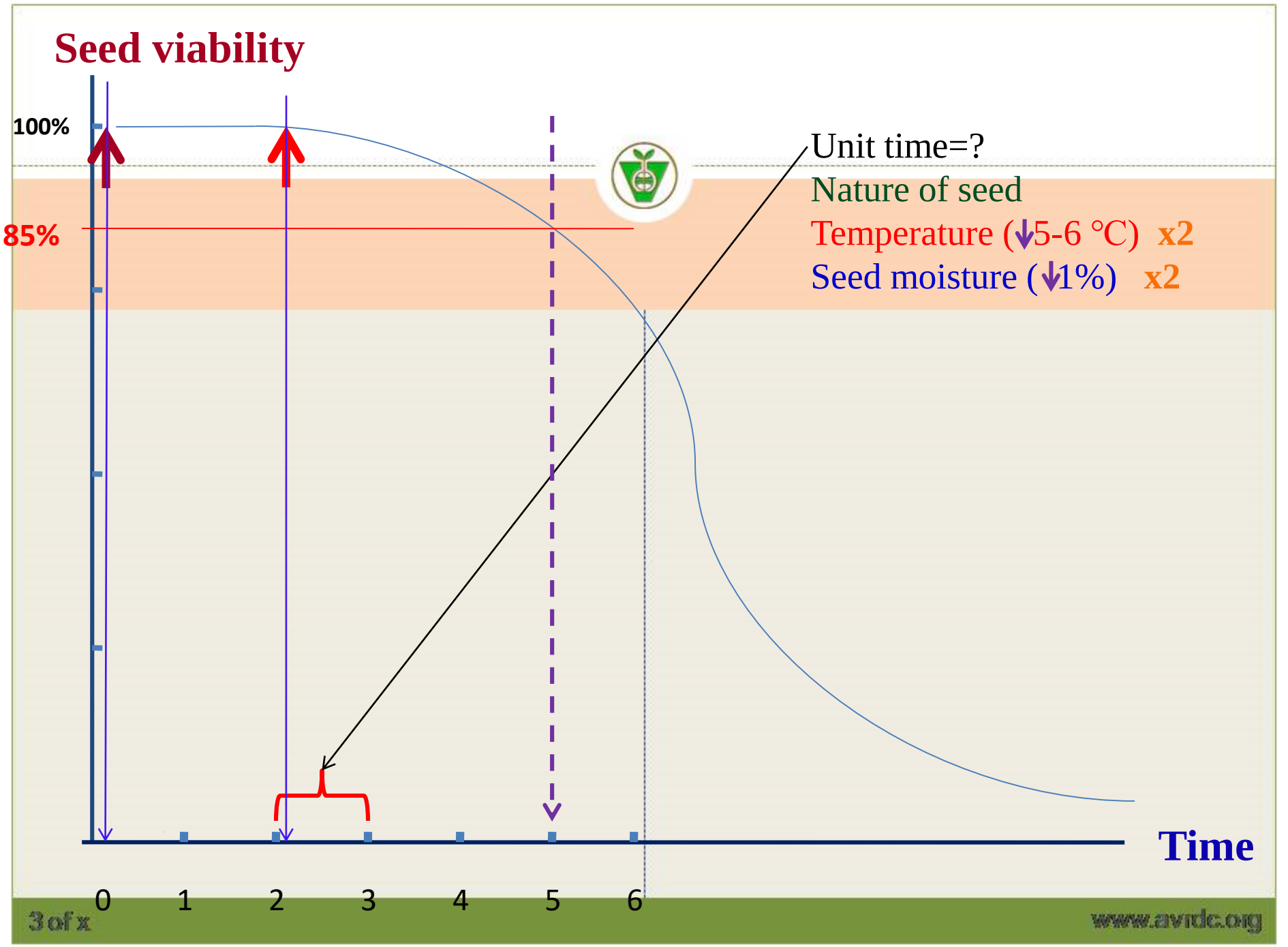
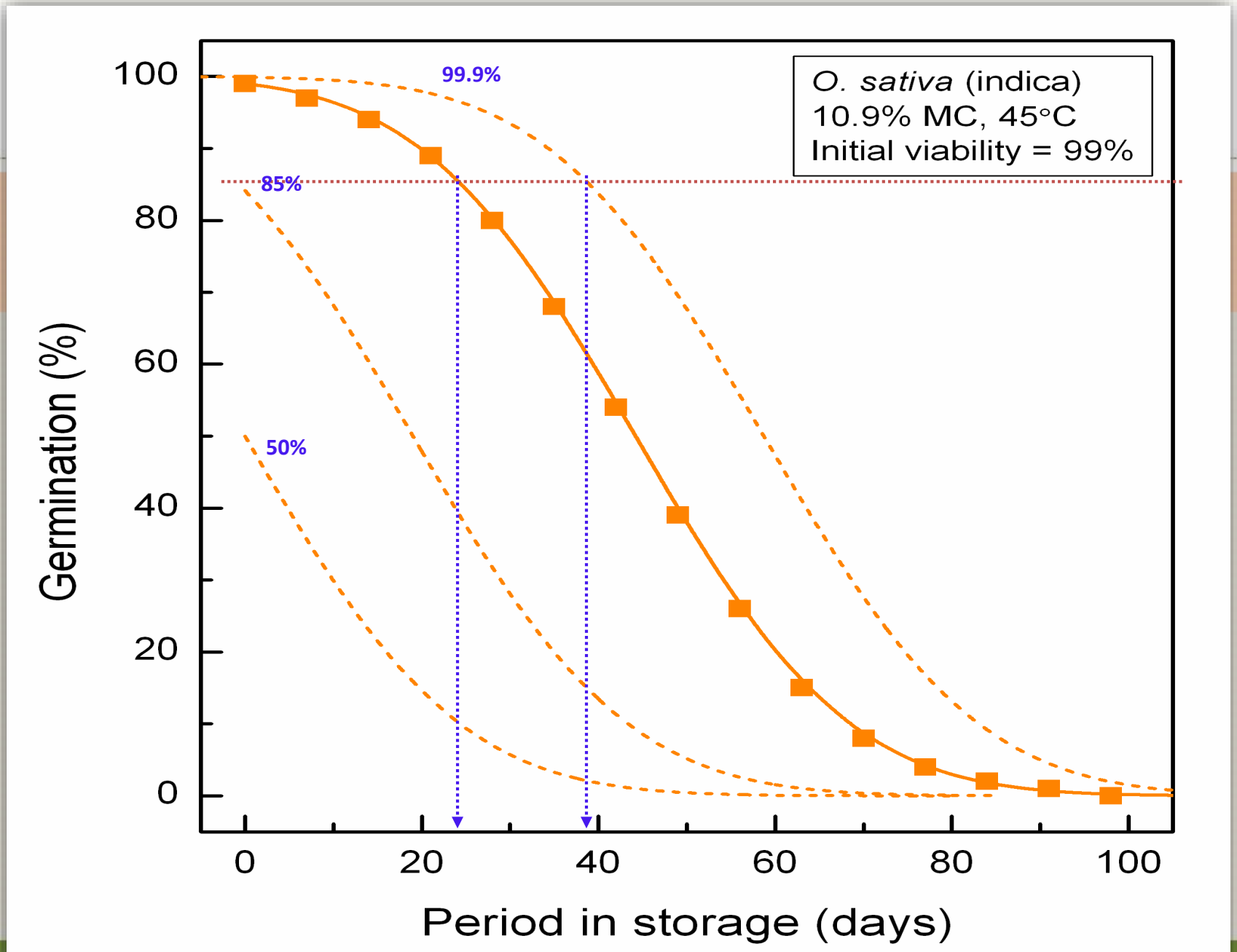


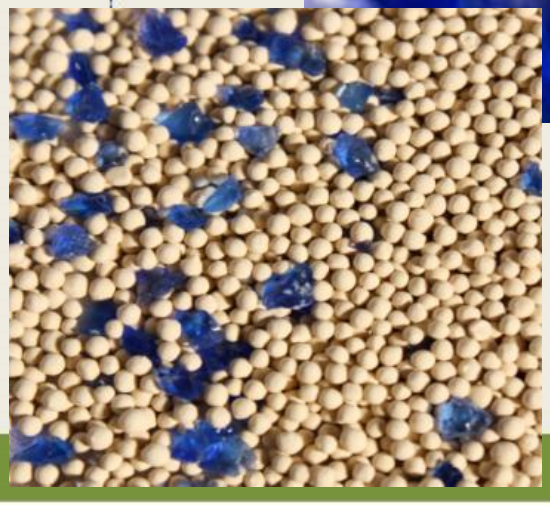

O. sativa (indica)
10.9% MC, 45°C
Initial viability = 99%
99.9%
85%
50%
Germination (%)
Period in storage (days)
0
20
40
60
80
100

Method of drying seed

- **Low Temp. + Low R.H.(genebank)**
- **Use 35 - 40 ℃ high temp.**
- **Sun dry**
- **Use desiccant**

Desiccant

- **Very low moisture，able to absorb humid from surrounding。**
- Desiccant for drying seed
  1. Ash (traditional farmer)
  2. Silica gel
  3. Drying beads
  4. Other chemical

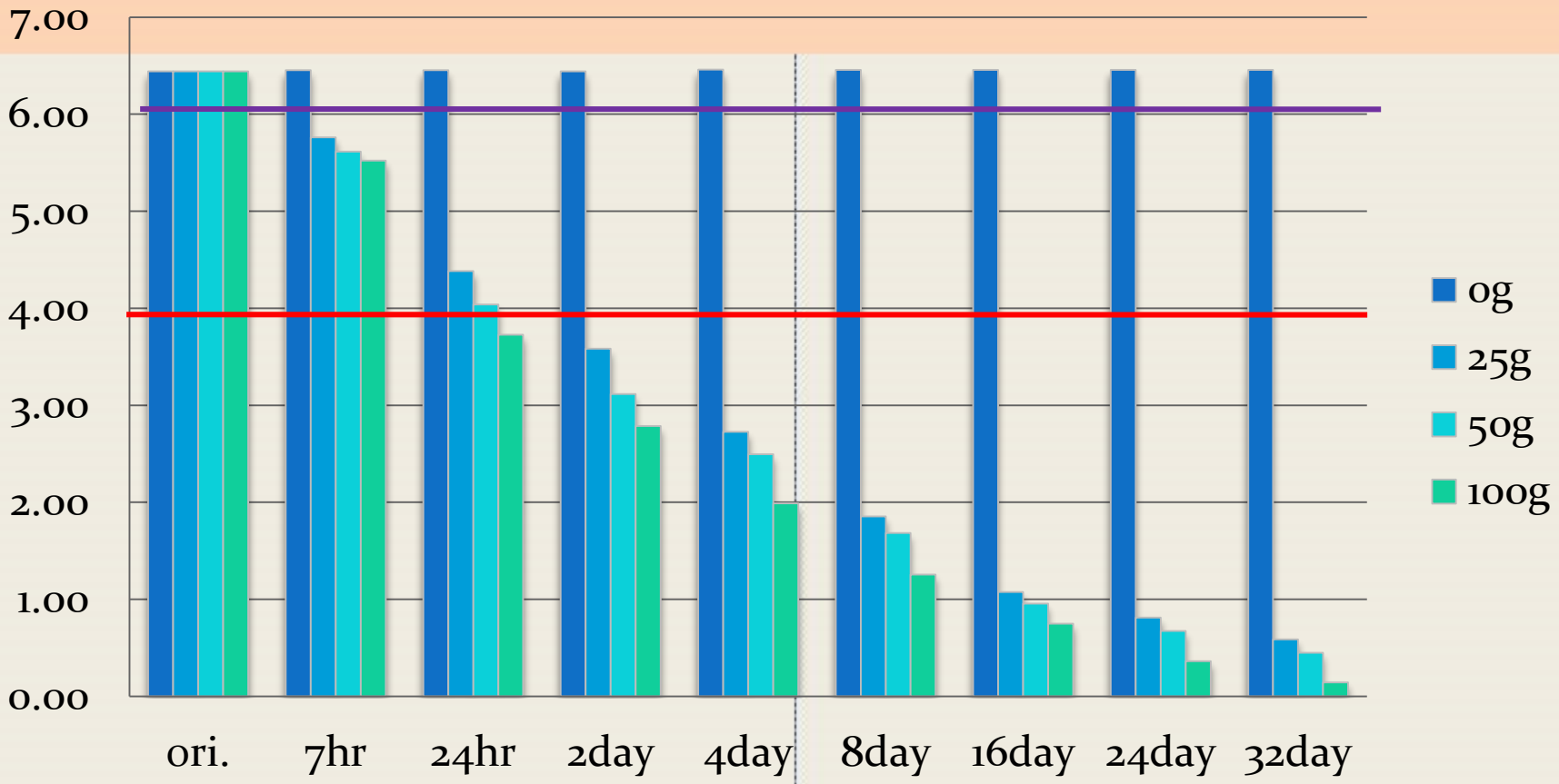


Silica gel &Drying Beads ability test of drying seed (Temp. 25-27°C)

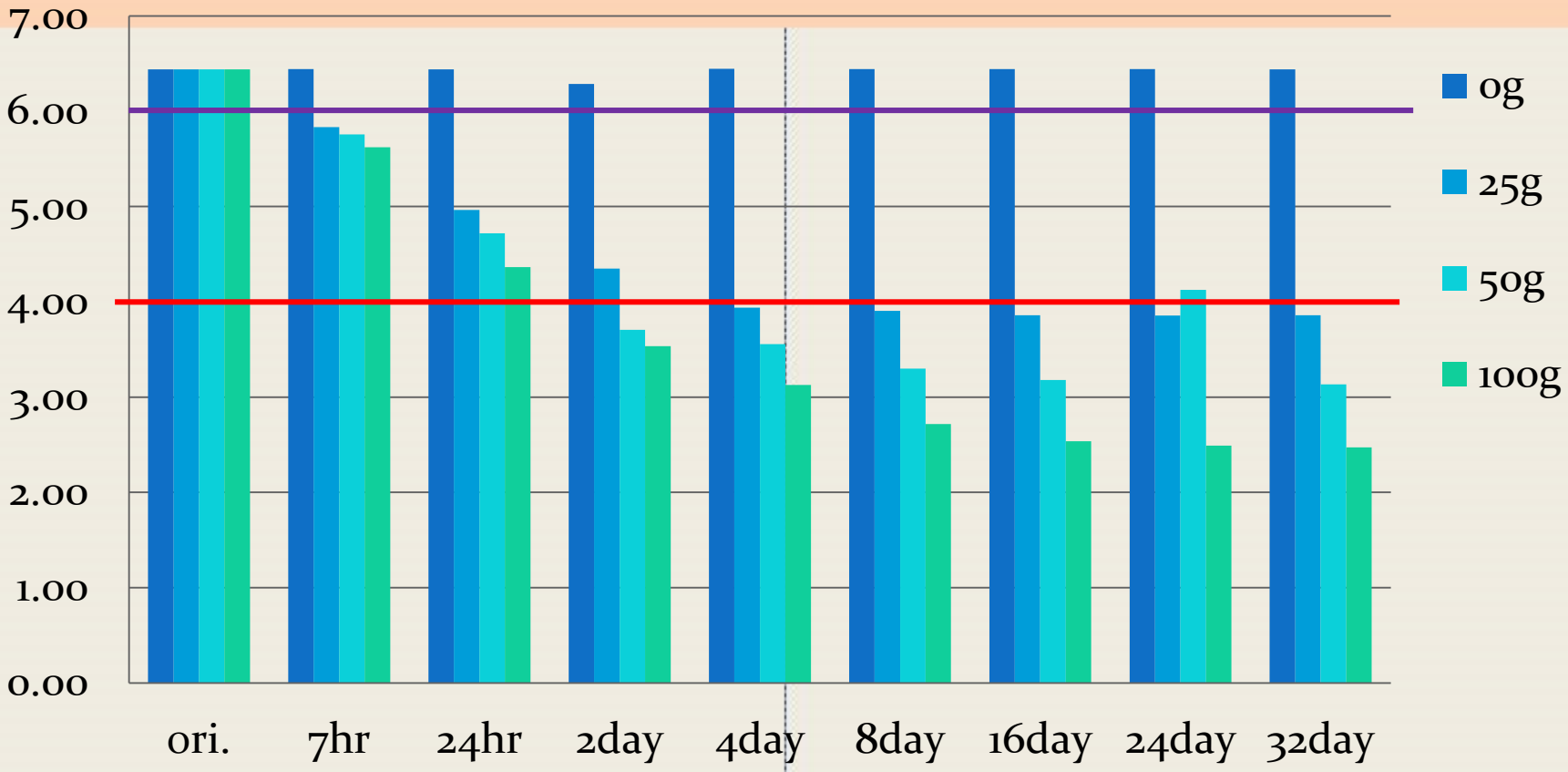
- Tested crops: Cabbage,Mung bean, pepper, Lablab bean
- Desiccant Wt./Seed Wt. =

  0.5, 1.0, 2.0
- Time of drying: 7hr, 24hr, 2D, 4D, 8D, 16D, 24D, 32D

Moisture content change of cabbage seed by drying by Drying Beads



Moisture content change of cabbage seed by drying by Silica gel



Actual M.C. of cabbage seed

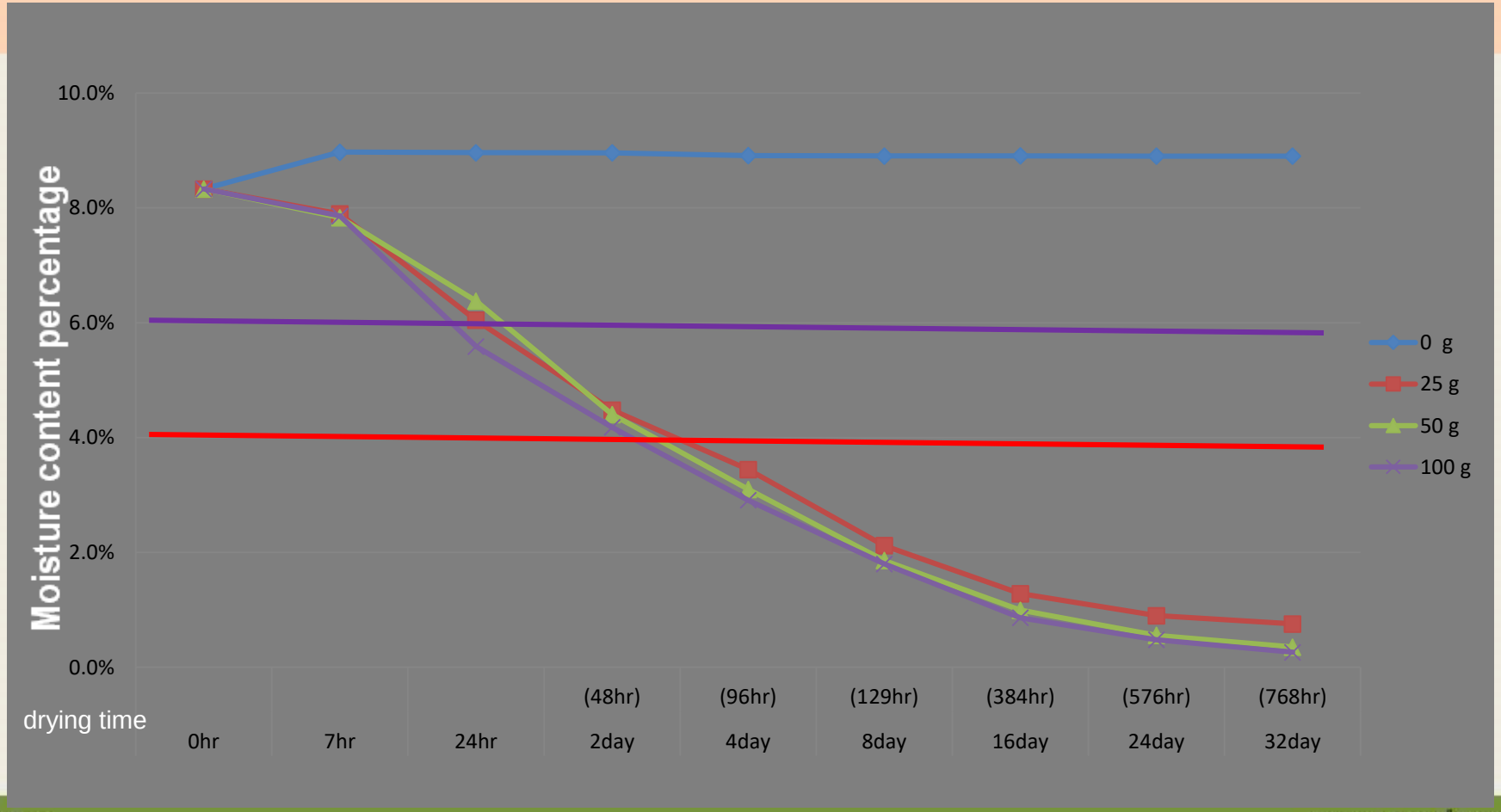
Drying Beads

D.B.	0g	25g	50g	100g
0hr	6.44	6.44	6.44	6.44
7hr	6.45	5.76	5.61	5.52
24hr	6.45	4.38	4.04	3.73
2day	6.44	3.58	3.12	2.79
4day	6.46	2.73	2.49	1.99
8day	6.46	1.85	1.68	1.25
16day	6.46	1.08	0.95	0.75
24day	6.46	0.81	0.67	0.36
32day	6.46	0.59	0.45	0.14

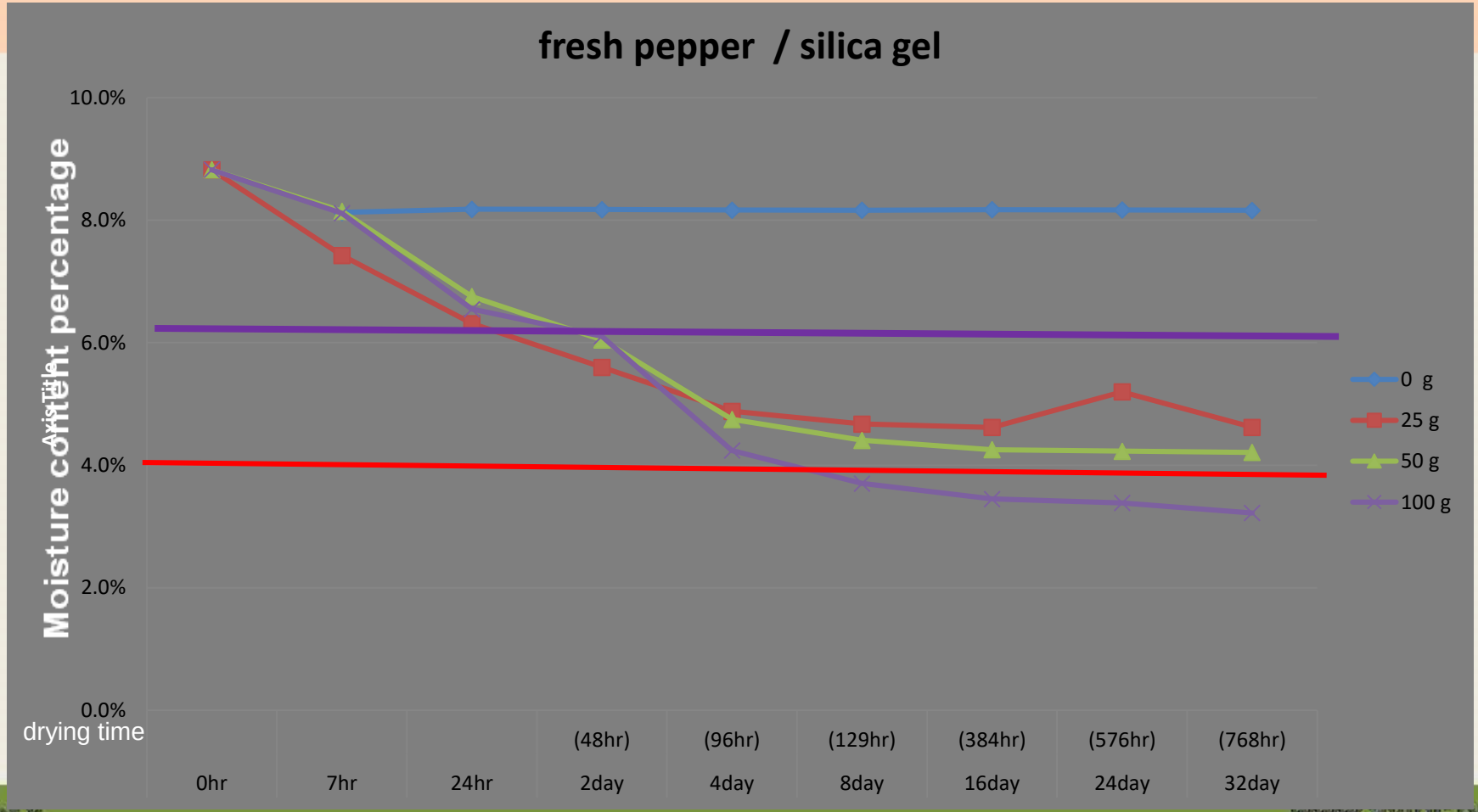
Silica gel

S.G.	0g	25g	50g	100g
0hr	6.44	6.44	6.44	6.44
7hr	6.44	5.84	5.76	5.62
24hr	6.44	4.96	4.72	4.36
2day	6.29	4.35	3.71	3.54
4day	6.45	3.94	3.56	3.13
8day	6.44	3.90	3.30	2.72
16day	6.44	3.86	3.18	2.54
24day	6.44	3.86	4.13	2.49
32day	6.44	3.86	3.13	2.47

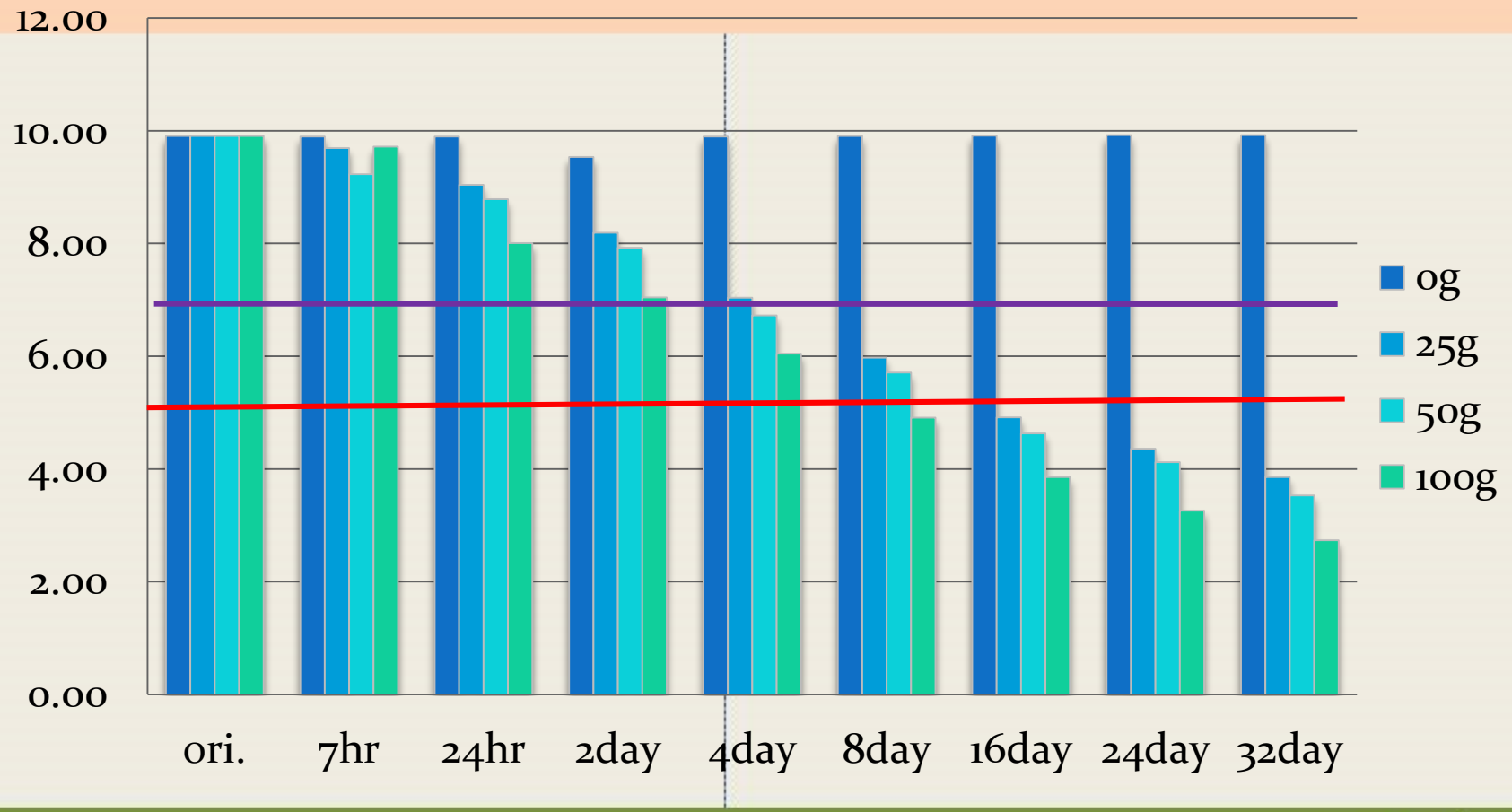
Moisture content change of pepper seed by drying by Drying Beads



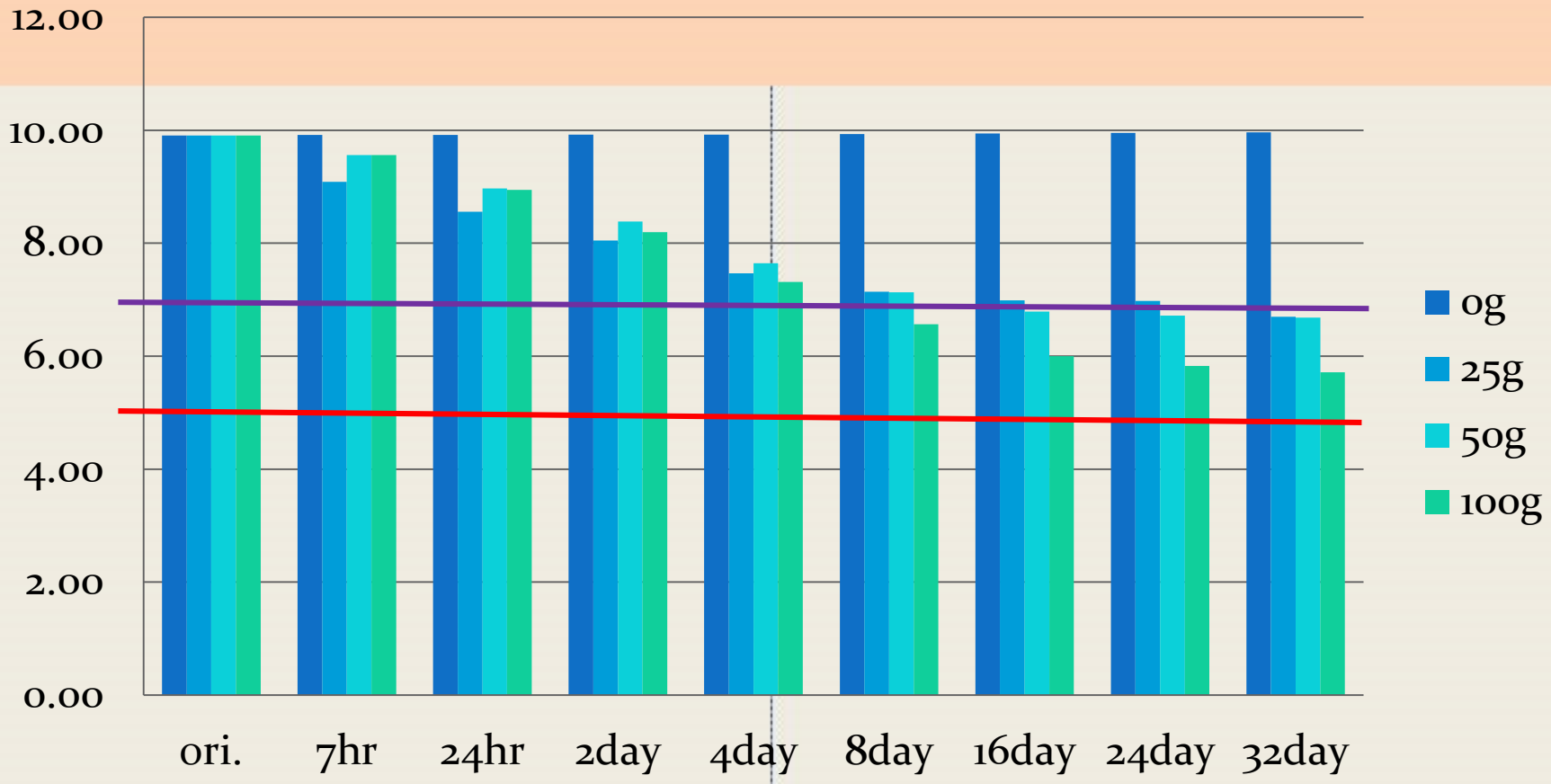
Moisture content change of pepper seed by drying by Silica gel



Moisture content change of lablab bean by Drying beads



Moisture content change of lablab bean by Silica gel



Actual M.C. of lablab bean

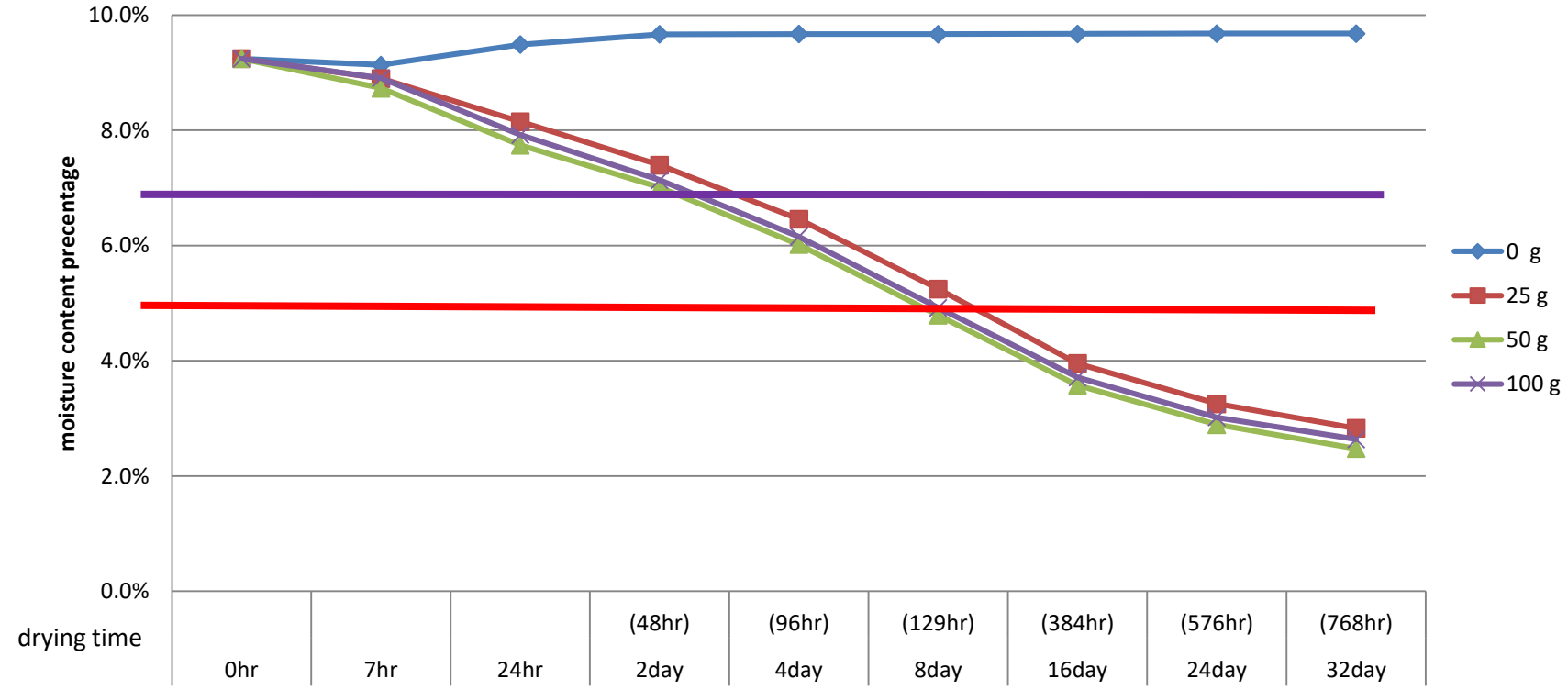
Drying Beads

D.B.	0g	25g	50g	100g
0hr	9.91	9.91	9.91	9.91
7hr	9.90	9.69	9.23	9.72
24hr	9.90	9.04	8.79	8.01
2day	9.54	8.19	7.93	7.04
4day	9.90	7.04	6.72	6.04
8day	9.91	5.98	5.71	4.91
16day	9.91	4.91	4.63	3.86
24day	9.92	4.36	4.12	3.26
32day	9.92	3.86	3.53	2.73

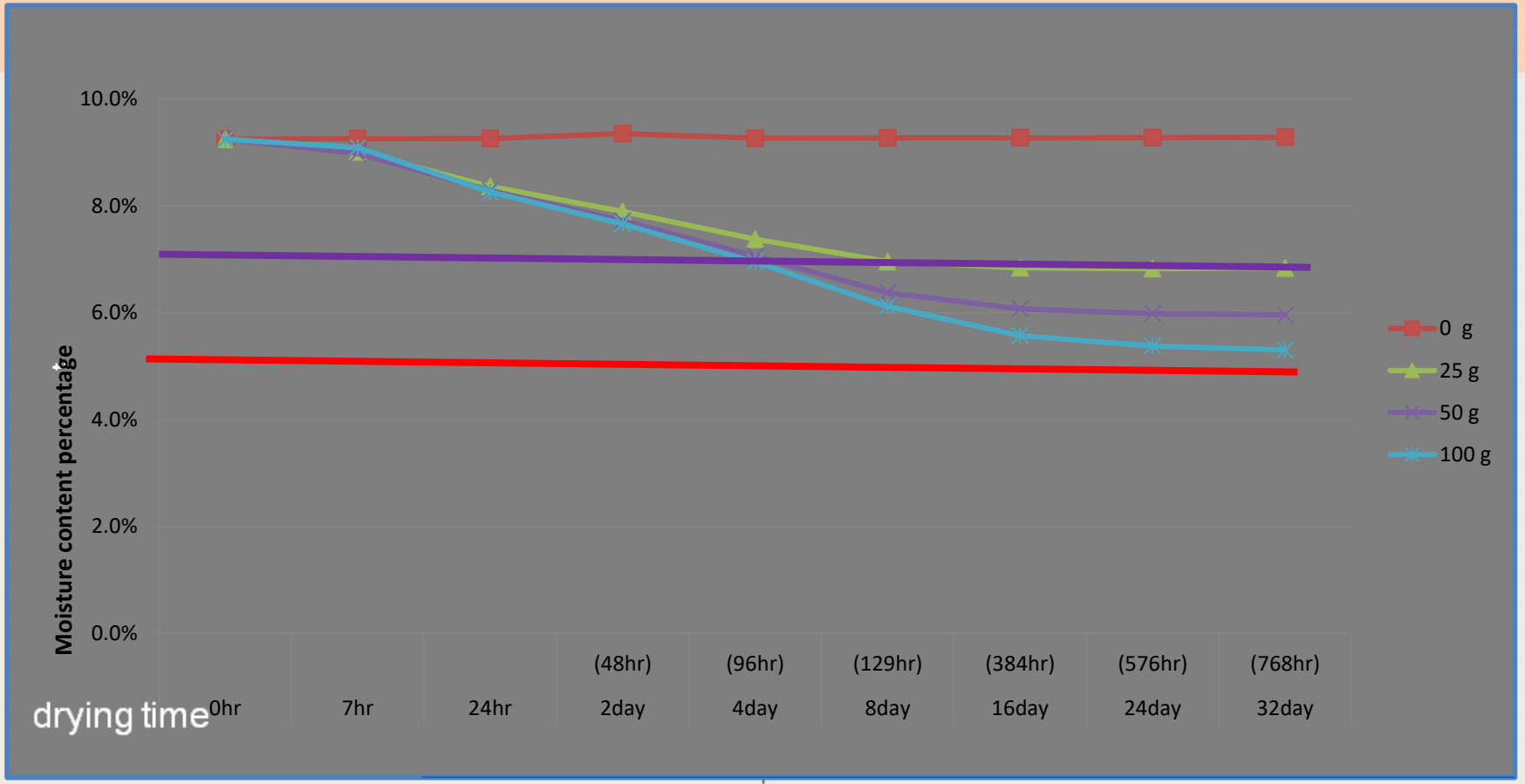
Silica gel

S.G.	0g	25g	50g	100g
0hr	9.91	9.91	9.91	9.91
7hr	9.92	9.08	9.56	9.56
24hr	9.92	8.56	8.97	8.94
2day	9.92	8.05	8.39	8.19
4day	9.92	7.47	7.65	7.31
8day	9.93	7.14	7.13	6.56
16day	9.94	6.99	6.79	6.00
24day	9.95	6.98	6.72	5.83
32day	9.96	6.70	6.68	5.72

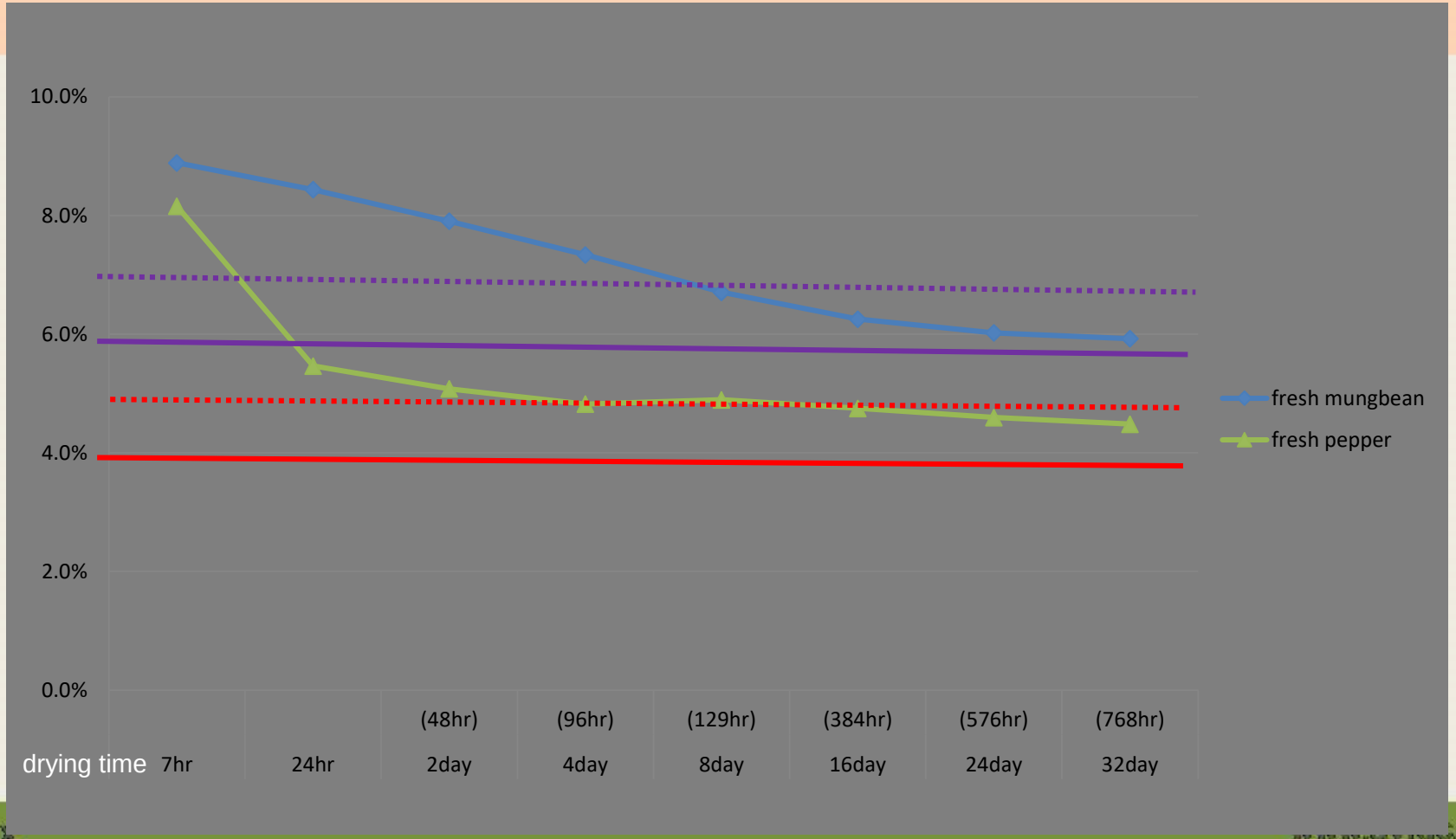
Moisture content change of Mung bean seed dried by Drying Beads



Moisture content change of Mung bean seed dried by silica gel



Mung bean and pepper seed M. C. in Drying room



Moisture content change of Mung bean and pepper seed in AVRDC's drying room

Time of drying	M.C. of Mung bean seed	M.C. of pepper seed
0 hrs	9.2 %	8.8 %
7 hrs	8.9 %	8.2 %
24hrs	8.4 %	5.5 %
2 days	7.9 %	5.1 %
4 days	7.3 %	4.8 %
8 days	6.7 %	4.9 %
16 days	6.3 %	4.7 %
24 days	6.0 %	4.6 %
32 days	**5.9 %**	**4.5 %**

Compare Silica gel vs. Drying Beads ability of absorb moisture

Time	0 day	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days
S.G.	100	119	131	137	139	140	140	140	140
D.B.	100	134	136	137	138	140	142	142	142

What is seed M.C. ? How to measure

- **Seed moisture content：**

  Percentage of water ($\mathbf{H_2O}$) in seed's weight.

- **Fresh base：**

  Total seed Wt.-Dried seed Wt.(water Wt.)/Total seed Wt.

- **Dry Base：**

  Total seed Wt.-Dried seed Wt.(water Wt.)/Dried seed Wt.

Measurement of seed M. C.

- **Remove moisture and weight(Standard method)**

$$\frac{\text{Fresh Wt.} - \text{Dried Wt.}}{\text{Fresh Wt.}} \times 100\%$$

- Conductivity Different seed moisture cause different conductivity
- **Equilibrium of air R.H.**

  Seed moisture and R. H. balance

Remove moisture and weight (Standard method)

Measurement of seed M. C.

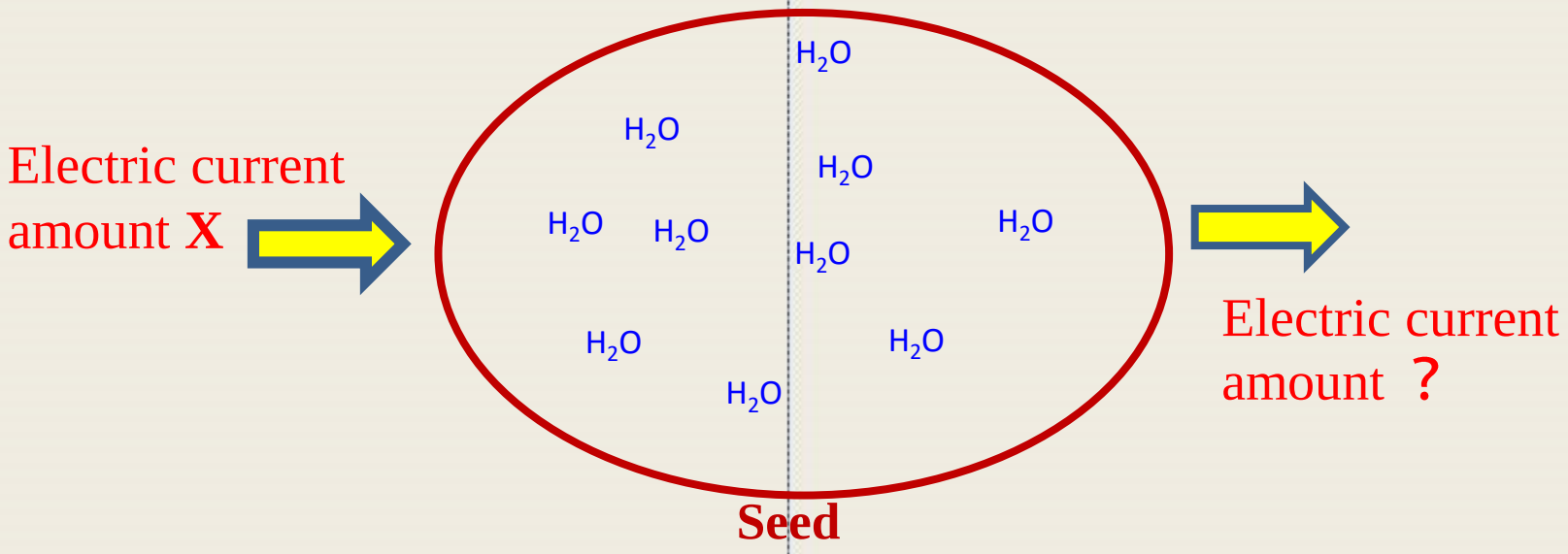
- Remove moisture and weight(Standard method)

  $$\frac{\text{Fresh Wt.} - \text{Dried Wt.}}{\text{Fresh Wt.}} \times 100\%$$

- **Conductivity** Different seed moisture cause different conductivity
- **Equilibrium of air R.H.**

  Seed moisture and R. H. balance

Conductivity method



Measurement of seed M. C.

- Remove moisture and weight(Standard method)

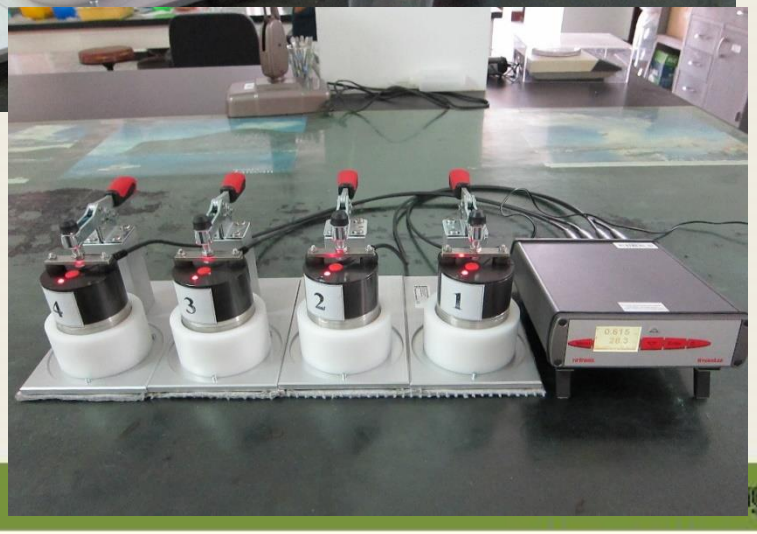
  $$\frac{\text{Fresh Wt.} - \text{Dried Wt.}}{\text{Fresh Wt.}} \times 100\%$$

- **Conductivity** Different seed moisture cause different conductivity
- **Equilibrium of air R.H.**

  Seed moisture and R. H. balance

Machine for measure R.H. of a seal container

- Balance model: need 50-60 minutes
- Fast model (Estimate):need 5-6min



Measurement of seed M. C.

- **Remove moisture(Standard) 4g - 10g**

  Standard and precise**(±0.3%)**→**Seed dead**
- **Conductivity100 - 250g**

  Not precise**(±2%)** →**seed alive**

  Need build reference parameter
- **R.H. equipbrium 5 - 30g**

  Acceptable**(±1%)** →**seed alive**

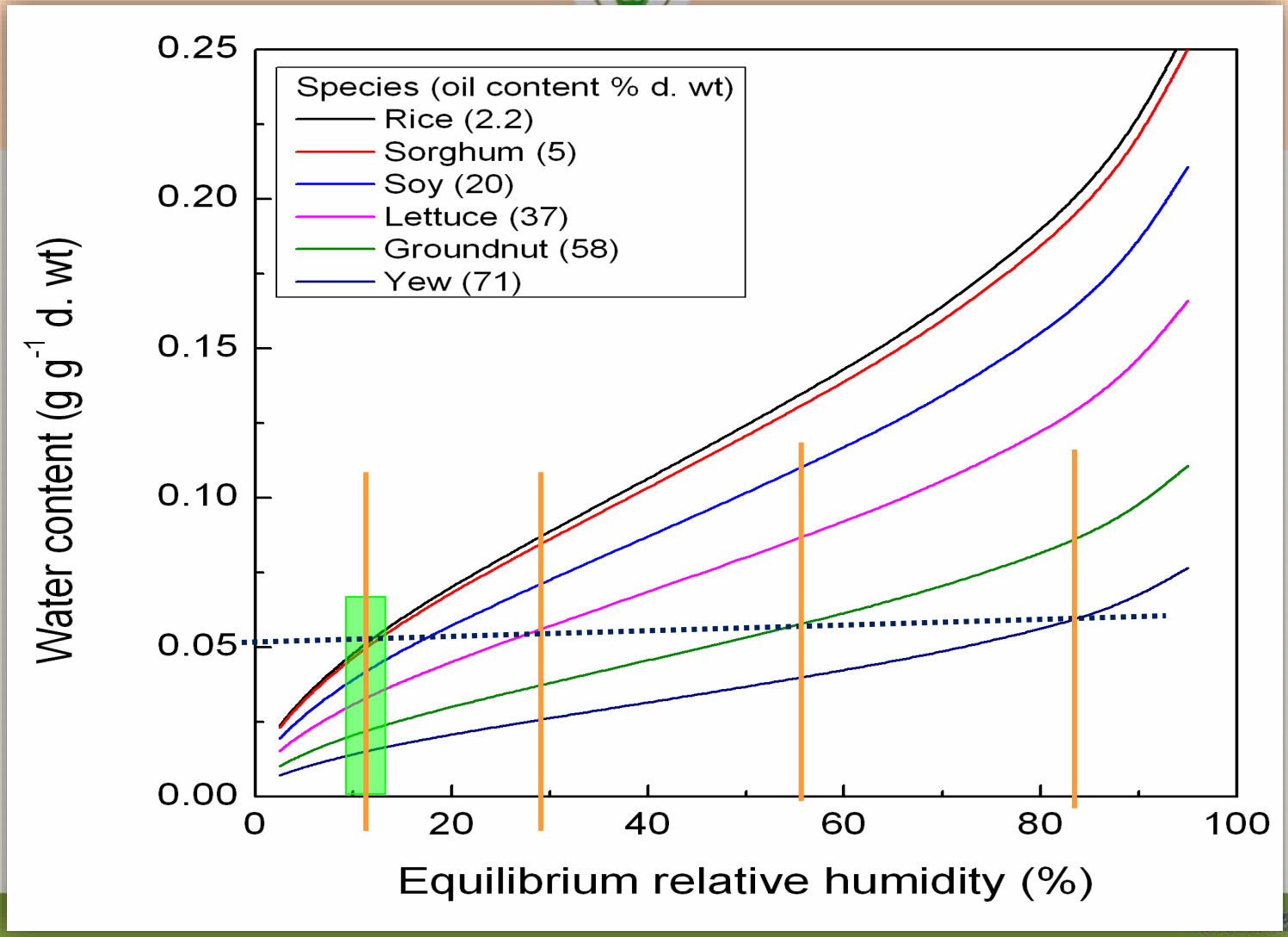
  Need build reference parameter

Relative humidity vs. Seed M.C.

25°C

R.H.	10%	30%	45%	60%	75%
Onion	4.6%	8.0%	9.5%	11.2%	13.4%
Celary	5.8%	7.8%	9.0%	10.4%	12.4%
Cabbage	2.4%	4.6%	6.3%	7.8%	9.4%
Cucumber	2.6%	5.6%	7.1%	8.4%	10.1%
Lettuce	2.8%	5.1%	5.9%	7.1%	9.6%
Tomato	3.2%	6.3%	7.8%	9.2%	11.1%

Relation of R. H. and seed oil content



How to dry your seed correctly

- Reduce seed M.C. & store Temp. are 2 controllable factors can effect seed's storage life.
- Seed M.C. is extreme important to seed storage life
- Ideal seed M.C. for storage：small seed (<2g/100seed) 4-6%, Large(>2g/100seed) 5-7%
- Good Drying method can keep seed viability
- Create low temp. & low R. H. are most important keys for drying seed
- High Temp & U.V. will damage seed

Is seed coating (pesticide) need?

Seed M. C.<7%

- R.H. in pack<30%
- No activity of pets
- Pesticide dangers people
- No need to coating seed
- May coating seed before sowing
- Seed M. C. may rise to >7% if the packing not humid proved

Seed M. C.>7%

- R.H. in pack>30%
- Pets may acting (Damage may happen)
- Pesticide dangers people
- Seed coating may prevent damage from insect or fungus in storage period

Standard procedure of post-harvest (1)

- Preliminary drying
- Washed seed：

Centrifugal and Air dry under shade：

(Seed M. C. 40-65%➡12-15%)

Period：Not more than 2days

Direct extraction： Air dry under shade

(Seed M. C. 20-25%➡12-15%)

- Seed cleaning

Remove foreign material & broken, No-good seed

(Not fully developed, damaged by insect or fungus)

Standard procedure of post-harvest (2)

- **Advance drying(condition：RH< 30%、Temp=lower than 20ºC will be better)**

  Seed M.C.：10-13%(for1-2 yr.)、

  7-10% (for 3-5 yr.)、4-7%(For>5yr.)

- **Packing & storage**

Packing material！ (metal、grass the absolutely humid proved material)

Storage temperature！(the lower the better but need stable)

Thank you for your attention

IVTC/World Vegetable Center