

**Storage Pests**

Consideration should also be given to the effects of seed moisture content, ambient room temperature, and relative humidity in relationship to storage pests. Seed moisture content below 14% typically will not provide conditions that are conducive to the successful development and reproduction of many insects, including most beetles and weevils, and storage mold fungi such as *Alternaria*, *Aspergillus*, and *Penicillium*. These fungi are not capable of growth and reproduction if the seed moisture content is low. Additionally, many insects become inactive at temperatures below 59° F. However, as temperatures increase above 60° F, insect movement, feeding, growth, reproduction, etc., will increase proportionally to the increase in temperature.

**CONCLUSION**

Much of the vegetable seed that is available today is a high value product. As such, care needs to be given to seed storage conditions and the resulting effect on shelf life and performance. Proper seed storage conditions and facilities can be developed based on the desired length of storage, the type of crop, the packaging materials, and environmental conditions. For example, it may not be necessary to control RH in dry, desert areas, but controlling RH could be critical in tropical or moist areas. Even with ideal storage conditions, shelf life will vary by species, and even from seed lot to seed lot. Therefore, it is important to test the seed at regular intervals to ensure that it is maintaining germ and vigor.

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**References:**

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**Sources for chart data:**

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**The Effects of Storage Conditions on Seed Shelf Life**

*Making Superior Vegetables a Reality™*



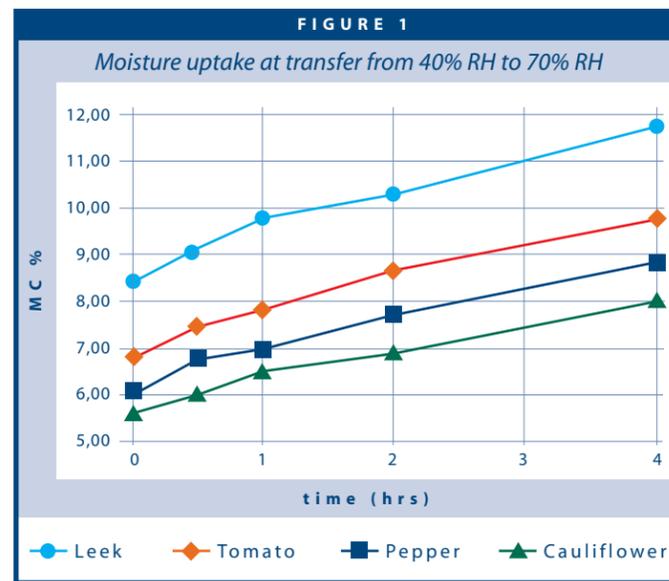
*The need for adequate seed storage in North America has been present since early man moved from nomadic wandering to established settlements. The ability to sustain life, as civilization moved from hunting to cultivation, was dependent on the successful retention of seed that maintained viability.*

Nowadays, whether it's stored in a clay pot, a hole in the ground, or a highly refined and controlled storage unit, successful seed storage depends primarily on the percentage of relative humidity (RH) and temperature in the storage facility.

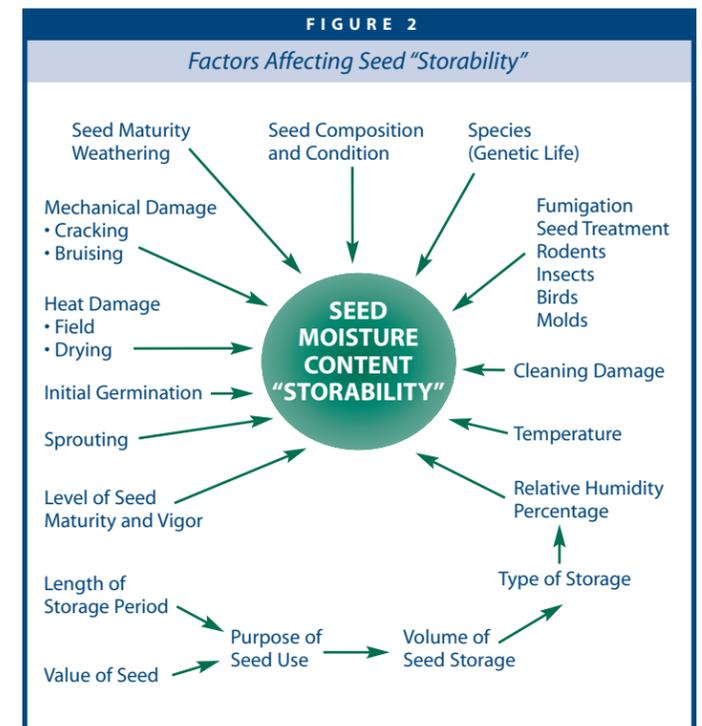
Using what is commonly known as the James Rule (James Harrington), it is generally accepted that the RH value, when added to the temperature in degrees Fahrenheit, must be equal to or less than 100° F for optimum seed storage conditions to exist. Storage buildings at Syngenta Seeds, Inc.'s plant in Nampa, Idaho, for example, store commercial inbred corn parent seed and are maintained at 50° F and 50% RH to maximize shelf life potential. Seed moisture uptake can be impacted in a relatively short period of time (See Figure 1, which plots increase of percent moisture during a four hour period of time).

species or varieties may also maintain quality in storage longer than others. For some species of seeds that exhibit orthodox storage behavior, Professor Harrington suggested that storage life could be doubled for each 1% reduction in seed moisture content when combined with a 10° F reduction in storage temperature, assuming that the initial seed moisture content was between 5% and 14%.

There is a risk of shelf life reduction, however, if the seed is stored at either too high or too low a moisture content. Therefore, it is critical to know the ideal seed moisture content for each species that is being stored. Consistency of the temperature and humidity could also contribute to increased duration of seed quality.



Various species are predisposed to maintain seed quality better and longer than others while in storage, and the storage conditions directly impact the longevity of the seed quality. It is possible that within each of these species, seed of certain sub-





## SUCCESSFUL SEED STORAGE

While multiple factors contribute to the rate of seed deterioration (See Figure 2), it is widely agreed that successful seed storage is dependent upon three primary factors: (1) initial seed moisture content, (2) storage temperature combined with relative humidity, and (3) initial seed quality. By looking at each piece of the storage triangle we can make a few basic recommendations:

### Initial Seed Moisture Content (MC)

Initial seed moisture content for storage should range between 5% and 14% to maximize shelf life (See Figure 3). When combined with the correct RH, the correct seed MC can help produce safe seed storage conditions for up to one year.

The type of seed packaging/container used can also have an effect on shelf life, particularly if the RH is high. Some types of packaging can absorb moisture from the air, or allow it to penetrate to the seed. Seed will then imbibe the moisture, eventually equilibrating with the surrounding air. This can result in shelf life reduction if the seed becomes too moist. RH is not so important if seed is stored in hermetically-sealed containers or other non-absorbent packaging that does not allow the moisture to penetrate in to the seed.

### Storage Temperature

Storage temperature must be derived from this formula when assessing storage unit effectiveness:

$$^{\circ}\text{F} + \text{RH} \leq 100$$

Lower relative humidity means higher allowable storage temperatures, as long as their sum does not exceed a combined value of 100. For example, storage areas with an RH value of 60% need to be cooled to 40° F to enhance maximum storage potential. Higher temperatures can be especially damaging if the seed is stored at higher moisture contents. Seed stored with lower moisture contents may tolerate higher temperatures better.

### Initial Seed Quality

Initial seed quality needs to be established as a base for evaluation of seed deterioration. This can be done as a combination of germination testing and vigor tests (such as cold, emergence rate,

**FIGURE 3**

CROP	MC	RH
Bean	12	65
Brassica	8	70
Carrot	10	67
Pea	14	63
Radish	9	65
Sweet Corn	12	74
Tomato	9	60

*Recommendations of safe storage moistures for a period of 1 year.*



*Cold Storage space for parent seed at Syngenta Seeds, Inc.'s Nampa, Idaho plant.*

and/or electroconductivity tests). The type of vigor test selected will be dependent on the species to be evaluated. Update testing for germination and vigor is highly recommended, with a six-month cycle being the most common. However, seed that has been enhanced with processes such as priming may require more frequent monitoring to ensure that seed quality is being maintained.

## STORAGE FACILITY DESIGN

The design of storage facilities can be approached two ways: (1) creating a cold storage environment or (2) using the conditioned storage concept. Both approaches can achieve the desired result as long as conditions provide for lower temperatures, give adequate ventilation, and exclude moisture as necessary.

**Lower temperatures** can be facilitated in various ways. Simple solutions include using reflective paint, increasing insulation, or using the more expensive approach of cooling units. With cooling units, the issue of relative humidity must be addressed.

**Adequate ventilation** can be obtained with the use of various types of fans in combination with correct venting for the room involved.

**Moisture exclusion** can be maintained with the installation of dehumidification systems. However, this approach can certainly increase the cost of a storage facility. The two methods normally used for dehumidification involve using either chemical desiccants or refrigeration units. Moisture removed through refrigeration/heating units must exit the storage area.

### Seed Packaging

Each available option for facility design should typically take into account some of the following factors: the type of seed being stored, the value of that seed, the intended time period for storage, and the seed packaging components. Seed being placed in conditioned storage, which provides a cool, dry environment, will be best stored in packages that allow for air exchange (such as woven poly bags or paper bags). Seeds stored for extended periods in cold storage, where relative humidity is much harder to control, are better protected when placed in sealed containers such as jars, cans, poly lined bags, or foil packets.



*Storage conditions should provide for lower temperatures, give adequate ventilation, and exclude moisture as necessary.*



*Stored seeds can be better protected from relative humidity when placed in sealed containers such as jars, cans, poly lined bags, or foil packets.*