Post-Harvest Management of Vegetable Seed Crops: Practices and Approaches

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Abstract

Healthy seeds are prerequisite for the good yield. Post-harvest management of vegetable seeds is crucial to ensure high-quality seeds for future planting. Proper handling after harvest preserves seed viability, vigor, and reduces the chances of contamination and deterioration of seeds. A number of biological and non-biological processes (improper moisture content, fluctuating temperature, faulty packaging) cause significant losses of seeds during storage. The quality of seeds can be maintained by using careful postharvest handling techniques. The major challenges of post-harvest management of vegetable seeds are inadequate infrastructure and limited access to technology. The ultimate goal of post-harvest management of vegetable seeds is to produce quality seed that meets both national and international standard to fulfill the requirement of the end user and seed related industry. This paper discusses and highlights post-harvest practices and approaches for vegetable seeds at both national and international levels, providing insights that may benefit stakeholders in the country's seed sector.

Keywords: Handling, Moisture, Post-Harvest, Quality, Storage, Vegetable Seeds

Introduction

Seed quality plays a significant role in attaining higher production and productivity in crop plants, including vegetables. Quality seed is a seed which possess all the seed quality attributes, viz. genetic purity, physical purity, germination, vigor, health, moisture, size, weight and color. Seed quality is one of the most demanding parameters within seed enterprises these days. It takes more time and money to grow a vegetable for seed production than it does to grow a crop for fresh consumption. The majority of the seeds especially vegetable seeds are produced by small-scale farmers and stored on the farms.

The major problem in seed enterprise is the damage due to meagre post-harvest management practices resulting from biological factors such as molds, and insects, that is often alleviated by ineffective storage techniques. The quality of the seeds is under strain from the environment. The physical damage caused during postharvest handling influence germination and vigor of crop seeds. Damaged seeds give rise to abnormal seedlings, have less resistance against pest and diseases and have minimum storage life (Salari et al., 2012). Jyoti and Malik (2013) revealed that deteriorated seeds reduces germination percentage, vigor, emergence, growth uniformity, yield impaired biosynthetic mechanisms, abnormal seedlings, and fungal infection such as purple stain. Any stage of post-harvest handling or production has the potential to degrade the quality of seed. All seed activities must be managed technically carefully in order to reduce these losses (Boxall et al., 2002).

Post-harvest management of vegetable seeds comprises a good harvesting method at proper maturity, curing, grading and sorting of fruits/pods for seed extraction, extraction of seeds from good quality fruits/pods, cleaning and grading, drying to maintain optimum moisture, seed treatment, packing and storing. Proper post-harvest handling and threshing techniques can enable more timely harvest with lower losses of seed quality. Maintenance of the seed quality is the major problem in the developing countries like Nepal. Thus, developing countries like Nepal needs to develop inexpensive, suitable and productive techniques for postharvest handling of seed crops and improvement in post-harvest management techniques. This paper discusses the required practices and approaches for post-harvest management of vegetable seeds in Nepal.

Post-Harvest Management Techniques in Vegetable Seed

1. Harvesting at proper maturity

Harvesting is a delicate process that requires careful timing (Alkimim et al., 2016). The method and condition of the harvest affect the further handling, processing, and storage of crops. Over-mature crop harvest causes biological and physical losses of crops by consistent wetting and drying of crops and harvesting too early can result in immature seeds that lack vigor and may not germinate properly (Kitinoja et al., 1999). Physiological traits such as the germination percentage, vigor, and yield are directly influenced by the stages of harvesting and drying. Inappropriate harvesting and handling can cause discoloration and damage on crops. Damage gives the open space for microbial assault that cause rotting, respiration increase and shortage (Yousaf et al., 2016). Different parts of plant are harvested by different harvesting methods; in case of fruit vegetables, the single fruit is trimmed off; in case of broad leaf mustard, whole branches of the plant are harvested and kept for curing.

2. Curing

Curing in seed production is a process of drying seeds to an optimal moisture level after harvest, ensuring that they maintain viability during storage and planting. The goal is to reduce the seed moisture content to a safe level that prevents microbial growth, seed deterioration, and physiological damage. Curing is essential for seeds with higher moisture content at the time of harvest. It not only ensures seed longevity but also helps in enhancing germination rates and preserving seed vigor. Curing can also improve the seed coat integrity, making the seeds more durable during handling and transport. In vegetables like Cole crops and Broad leaf mustard, pods are piled up for curing four to five days, and are again turned upside down to cure for another four to five days. This process makes seed threshing easy and improve the overall seed quality.

3. Grading and sorting of fruits/pods for seed extraction

It is a crucial step in ensuring the production of high-quality seeds. Proper grading helps in selecting fruits or pods with the best genetic traits and highest seed viability. It also ensures uniformity, reducing the chances of extracting poor-quality seeds. Navitha (2019) reported that medium sized fruits can be selected for good crop establishment and also assurance is given for production of good quality seeds and produce vigorous seedlings in cucumber. Fruits or pods with symptoms of fungal infections (rotting, black spots, mold growth) or insect pests damage (holes, chewed areas) should be discarded to prevent contamination of healthy seeds.

4. Extraction of seeds from good quality fruits/pods

Extraction of the seed is the process of removing seeds from the fruits, pods and siliquas of vegetable plants to prepare them for cleaning, drying, curing, and storage. The method of extraction varies depending on the type of vegetable and the seed's location within the fruit or pod. Proper seed extraction ensures that high-quality seeds are harvested without damage to their structure, enhancing their viability and germination potential. Dry seed extraction technique is used for vegetables that produce seeds in pods, capsules, or dry fruits (cowpea, beans, peas, okra, lettuce etc). Seeds from these vegetables becomes dry at the time of harvest and require minimal processing. Wet seed extraction technique is used for fleshy-fruited vegetables (tomatoes, cucumbers, peppers, melons etc.), where seeds are embedded in the pulp or flesh. This method requires the removal of seeds from the moist flesh and subsequent cleaning to ensure no pulp or debris is left.

5. Cleaning and grading

Cleaning and grading of vegetable seeds are critical steps after seed extraction to ensure that only the best, viable seeds are kept for storage and planting. These processes involve removing dirt, debris, and damaged seeds while also sorting seeds by size, weight, and quality, thereby enhancing the overall uniformity, vigor, and germination potential of the seed lot. Seed cleaning can be done through manual cleaning (hand picking, sieving or screening), winnowing (tossing the seeds in an air, hand held fan, winnower, mechanical blowers), water cleaning (floatation or washing), mechanical cleaning (air screen cleaners, gravity separator, magnetic separator) according to nature of seed materials and available facilities. Grading, is done again to sort the seeds by size, shape, weight, and sometimes color to ensure uniformity and quality. Size grading can be done through sieving or screening for small scale and rotary graders for large scale size grading. Weight or density grading can be done by gravity separator for large scale and manual water floatation for small scale. Color sorting are also done to prepare seed uniform seed lot by using optical color sorters for commercial purpose.

6. Drying

Drying of seed lots means the lowering down the seed moisture content to safe moisture limits. It is important step

to maintain seed viability and vigor, which may otherwise deteriorate fast due to mold growth, heating and increased micro-organism. When seeds have a moisture level between 10% and 14%, temperature has an impact on how long they can be stored. Timely drying of crops is essential for a high-quality yield. In most cases, fungal infection, insect and pests attack cause biologically active seeds to degenerate quickly. Reducing respiration in seeds is the primary goal of drying (Kiaya, 2014). The seed may deteriorate if it is dried extensively at a high temperature.

The drying of seeds can be done by two methods; sun drying and forced air drying. In the absence of forced air-drying facilities, the moisture content of seeds has to be reduced in the field before harvest, and later by sun drying on the threshing floor. The main advantage of sun drying is that it requires no additional expenditure, or special requirement. The disadvantages are delayed harvests, risks of weather damage and increased likelihood of mechanical admixtures. Dust, air pollution, insect infestation, and human or animal disturbance are all potential sources of yield contamination. For forced air drying, new technologies like mechanical driers, tray driers, radial drying bins, continuous flow dryers, cross flow, counter flow, concurrent flow, mixed flow tower and store- based or in store drying like large scale floor storage, bin drying and bag dryers are employed (Boxall et al., 2002). In our country, majority of vegetables seeds are dried while forced air drying is practiced in small scale.

7. Seed treatment

Seed treatment refers to the application of physical, chemical, or biological agents to seeds before planting to protect them from seed borne or soil borne pathogenic organisms, storage insect and environmental stress, or to enhance their germination and growth. Seed treatment helps improve seed quality, ensure better crop establishment, and reduce the need for pesticides and other interventions after planting. It comprises seed disinfection, disinfestation and protection.

8. Packaging

Seed packing is the final stage of seed processing before distribution or storage. After processing and treating are completed, seeds are packaged into containers, bag or other materials of specified net weight. Proper packing is crucial to maintaining seed quality, protecting seeds from environmental factors (like moisture, pests, and temperature fluctuations), and ensuring the seeds remain viable until they are used or sold. The packaging consists of the following operations

- Filling of seed bags to an exact weight.
- Placing leaflets in the seed bags regarding improved cultivation practices.
- Attaching labels, certification tags on the seed bags, and sewing of the bags.
- Storage/shipment of seed bags.

Common packaging materials for vegetable seeds include paper bags, plastics bag (polyethylene or polypropylene), foil packets, laminated pouches, jute or cloth bags, and vacuum sealed bags. Specialized packing technique like vacuum packing, control atmosphere packing and hermetically sealed containers are being utilized in Nepal by private seed companies.

9. Seed storage principles and practices

Seeds, when stored in natural environment or room temperature respond to changes in temperature, relative humidity and oxygen presence. Metabolic activities, age, and longevity of seeds can be manipulating by controlling the humidity temperature and oxygen (Mohammed, 2014). Reduction of seed moisture content up to an appropriate limit is prerequisite for storage as seed could be damaged because of desiccation. Seeds can be stored for a longer period due to lower level of humidity. According to the thumb rule, the life of the seed doubles by decreasing the moisture content to 1% in case if seed moisture content is between 5 and 14%. Higher moisture content is more affected by higher temperature so seeds need to be stored in cool location. The life of the seed doubles by decreasing the temperature to 5°C and is applicable between 0 and 50°C (Harrington, 1972).

The purpose of seed storage is to maintain the seed in good physical and physiological condition from the time they are harvested until the time they are planted. Vegetable seeds can be classified into different categories based on their storage behavior. Three main storage behavior categories have been described: 'recalcitrant' seeds are sensitive to drying; 'intermediate' seeds are tolerant of at least some drying (but less than orthodox seeds), and sensitive to freezing; and 'orthodox' seeds are tolerant of both drying to low moisture content and freezing.

9.1 Seed Storage Methods

Short-Term Storage: Used when seeds will be stored for up to one year. Seeds can be stored in cool, dry places like

cabinets, shelves, or rooms with good ventilation. Paper bags or breathable containers are often used to prevent moisture buildup. These storages are ideal for small-scale farmers or those planning to use seeds for the next planting season.

Medium-Term Storage: Suitable for storing seeds for 1-3 years. Seeds should be stored in a cool, dry environment, such as a refrigerator or a dedicated storage room.

Long-Term Storage: Used for storing seeds for more than 3 years. Requires highly controlled conditions with low temperatures (below 0°C) and low moisture content.

Seed/gene Banks: Seeds stored in seed banks are typically dried to very low moisture content and stored in hermetically sealed containers at extremely low temperatures (-18°C or lower). Vacuum-sealed or inert gas-sealed bags (e.g. nitrogen) are commonly used to reduce oxidation and maintain seed viability.

Post-Harvest Management Practices for Vegetables Seed followed in NARC Stations and DoA Farm

1. Radish

- Seed plants are allowed to mature fully before harvesting.
- Plants are cut when most of the pod turns brown.
- The crop is cut by sickle and brought to threshing and cured for 3-4 days.
- Threshing is done by beating with sticks.
- Seed after sifting is dried to 6-8% moisture content before storage.

2. Okra

- Only healthy fruits are chosen for seeding, malformed and distorted fruits are removed earlier.
- Healthy and straight type fruits are selected from plants free from disease and insect attack.
- Fruits are harvested as soon as they become mature and before shattering.
- Fruits are harvested by hand individually and thereafter fruits are dried in the sun.
- Threshing is also done by hand after the fruits are sufficiently dry.
- Light seeds are then removed by cleaning and winnowing.
- Collected seeds are sun dried to moisture level not exceeding 12% for open storage and up to 9% for sealed packets.
- During rainy day there is every possibility of damaging seeds if fruits are not harvested at proper stage.
- In rainy day if there is no sun, seeds are dried keeping them under electric fan.

3. Brinjal

- Ripened fruits are handpicked and usually seeds are collected from fruits formed at early and mid-fruiting stage.
- Good quality fruits are harvested from plants free from disease and insect attack.
- Seeds are collected through wet extraction method.
- Harvested fruits are cut into thin slices and these are then softened by soaking till the seeds are separated from the pulp.
- After extracting and washing, the seeds are cleaned and dried.
- Drying is done by spreading the seeds in the partial sunlight for few hours for one or two days up to a moisture content of 8% or below.

4. Tomato

- Larger size healthy properly ripened fruits are harvested from 1st and 2nd tier fruits for determinate varieties and up to 8th tier for indeterminate varieties and kept in room temperature for 2-3 days before extraction of seeds.
- Tomato seeds are extracted mainly by fermentation method.

- After cutting the tomato fruits seeds along with pulp are fermented for 12 hours.
- The pulp is stirred several times to maintain a uniform rate of fermentation and to avoid discoloration of the seed.
- Seeds are then cleaned with clean water and dried thereafter.

5. Carrot

- The crop is harvested when the secondary umbels are fully ripe and the tertiary umbels begin to turn brown.
- The umbels may ripen unevenly, hence 2-3 pickings may be required.
- Harvested umbels kept for curing and it require 5 to 12 days or even more depending on weather conditions.
- After the umbels are dried completely threshing and cleaning is done manually or mechanically. Then the seed is graded.

6. Cucumber

- Healthy fruits are chosen for seed purpose, malformed and deformed fruits are removed earlier.
- Brown or yellow colored straight type fruits are allowed to ripen fully.
- Fruits are collected from vines when fruit stalk adjacent to the fruit withers.
- After full maturity fruits are harvested and kept 5-7 days for post-harvest maturity.
- Fruits are cut into half and scoop out the seeds by hand.
- Bold size, fully filled and better looking seeds are extracted, cleaned and stored.

7. Spinach

- Spinach seeds mature in sequence even in the same plant and first formed inflorescence seeds mature first.
- When the seed stalks and seeds turn brownish yellow and harvesting is done by cutting.
- Harvested branches are dried in the sun over drying floor.
- Threshing is done by hand beating with a stick after being seed stalks are properly dried.
- Seeds are cleaned by winnowing and dried to 8-9% moisture content.

8. Bottle gourd, sponge gourd, ridge gourd and summer squash

- For seed purpose the earlier set, full size ripe/dried fruits are harvested as such fruits produce plump seeds and higher yield.
- Seed is extracted when fruits are dry and seeds rattle inside the shell.
- The shells have to be broken to extract the seed and clean them.

9. Onion

- Harvesting the seed heads at about 30% moisture (the heads have some opened capsules with black, ripened seed exposed) by hand cutting 10 to 15 cm of the flowering stem below the umbel. When cutting, the umbel is supported in the palm of the hand and held between the fingers to avoid seed shattering.
- Harvesting at 20-30% dehisced capsules resulted in seed with better quality.
- The seeds are dried enough for threshing when the capsules and small seed stems are brittle and readily break when rolled in the palm of the hand.

10. Chili and sweet pepper

- Red ripe fruits of chili are harvested and dried in the sun. Completely dried fruits are threshed and winnowed. Thereafter, the seed is dried to 8% moisture content.
- The fruits of sweet pepper should be picked when red ripe, cut and crushed. Seed is repeatedly washed to make it free from pulp and skin. After washing it should be dried in the sun.

11. Cauliflower, cabbage and broccoli

- The harvesting is done when the pods turn into brown color.
- After harvesting it is piled up for curing. After 4 to 5 days it is turned upside down and allowed for further curing for 4 to 5 days.

- Then the pods are threshed with sticks and then the seeds are dried to 7 % moisture content, and cleaned.

12. French bean

- The harvesting is done when the pods become completely dry.
- Dried beans are subjected to threshing by beaten with sticks followed by cleaning and dried up to 9% moisture level.

13. Cowpea

- The pods are harvested when it becomes yellowish brown. Then pluck the pods and dried in threshing floor for 1 to 3 days for drying.
- The dried pods are placed on bags and threshed by beaten with stick.
- Carry out the winnowing for removing the chaff and kept in sun drying for 2 to 4 days depending on the weather and maintain the moisture to 9%.

14. Lablab bean

- The pods will turn from green to tan/straw colored.
- The pods are then beaten using pliable sticks to prevent damage to seeds. After thorough beating, the seeds are separated from pods.
- The plant debris are removed and seeds cleaned by winnowing. Cleaned seeds are then dried on tarpaulin on the threshing floor until the moisture content is reduced to 10%.

15. Garden pea

- When almost 90% pods on the plants mature and turn dry, the whole plants are uprooted and collected on the threshing floor.
- After about a week the seeds are separated out from the pods by threshing and winnowing.
- Usually the moisture content of seeds at this time is higher therefore the drying must be resorted to maintain the specified moisture content of 8%.

16. Broad leaf mustard

- Harvesting of plant is done before complete drying of plant when the pod become yellow.
- At 2 days' interval, the heap should be aerated by inverted turning of plant in heap.
- Threshing is done either by manual or beating with stick or mechanical method or by any other means.
- The shattered seed should be collected and winnowing should be done.
- The winnowed seed should be sun dried 3-4 times.
- The moisture percentage should be 6-8 %.

17. Swiss chard

- When the seed stalks and seeds turn brownish yellow and harvesting is done by cutting.
- Harvested branches are dried in the sun over drying floor.
- Threshing is done by hand beating with a stick after being seed stalks are properly dried.
- Seeds are cleaned by winnowing and dried to 8-9% moisture content.

Conclusion

Post-harvest management of vegetable seeds is a crucial element in strengthening the overall seed sector development. Quality maintenance of the seeds is the major problem in the developing countries like Nepal these days. This paper has highlighted the key practices and approaches currently in use, along with the challenges that hinder effective seed management, such as limited access to technology and inadequate storage facilities. The integration of traditional knowledge with modern innovations, such as climate-controlled storage and improved drying techniques, has shown significant potential to improve seed quality and longevity. Governments and stakeholders should focus on capacity-building initiatives, facilitating access to affordable technology, and improving infrastructure to support better seed management. Further research is needed to explore innovative, low-cost solutions tailored to the unique needs of these nations, as well as the long-term socioeconomic benefits of improving seed post-harvest practices.

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