Special equipment exists for applying these types of formulations, but if such equipment is not available the treatment may be done with a revolving metal drum or cement mixer. In agro-chemistry old products are continuously replaced by more effective ones. However, some of the commonly used seed treatment chemicals are listed in Table 6.3.

Table 6.3 Commonly used seed treatment chemicals

Name of chemical	Active ingredient (%)	Crop	Disease
Arasan 5 red	Thiram 50%	Maize, rice, sorghum, safflower, flax, millet, soybean, pea	Damping off, seed rot, blights
Agroson–GN	1% Dust	Tomato, okra, onion, squash, watermelon, cucumber, pumpkin	Loose and kernel smuts
Ceresan–wet	2.15%	Rice	Loose and kernel smuts
Captan–4 (flowable SPR)	Captan 39%	Alfalfa, clover, bean, beet, rice, barley, rye, wheat, maize, cotton, grasses, vegetables	Seed decay, damping off, seedling blight
Agrox 2-way	Captan Diazinon	Maize, soybean	
Agrox 3-way	Lindane Graphite	Bean, pea	

6.8 Seed storage

The purpose of storing seeds of cultivated plants is to preserve planting stocks from one season until the next. The basic reason behind various storage practices is the effort to maintain the physiological quality of seed throughout the storage period by minimizing the rate of deterioration.

6.8.1 Factors affecting seed quality

The following factors affect the storage life of seeds.

1. Humidity
2. Temperature
3. Air (oxygen and carbon dioxide content)
4. Direct sunlight
5. Kind of seed
6. Kind and number of fumigations
7. Effect of seed treatment
8. Attack by rodents, insects, and moulds

Humidity control. Seeds are hygroscopic and freely exchange moisture with the immediate environment. If seeds come into contact with moist air, their viability deteriorates sooner than if they are kept in dry storage. If the relative humidity in a storage area exceeds 60%, special dehumidification measures become necessary. Humidity can be removed from a storage area by either refrigeration-type or absorption-type humidity control systems.

Cereal seeds should never be stored with 14% or more moisture content. For ideal seed storage, a moisture content below 9% is necessary. This will also slow down the aging process.

Temperature. Every crop species has maximum and minimum levels of temperature for germination, and if the temperature exceeds the maximum limits, the seed loses viability rapidly. Low temperature prolongs seed life, therefore temperatures in storage areas should be kept as low as possible considering the length of storage planned and economic considerations. Also, the temperature most conducive to insect and fungal activity ranges from 21 to 27°C, therefore the temperature in the storage area should be kept below this level.

The following two simple rules quantify the effect of moisture and temperature on seeds.

1. For every decrease of 1% in seed moisture content, the life of the seed is doubled.
2. For every decrease of 5°C in storage temperature, the life of the seed is doubled.

Sources of unwanted heat in storage areas include:

a. *Heat leakage*: Flow of heat through the floor, walls, and roofs into the storage area from outside when the outside temperature is higher than the temperature inside.
b. *Field heat*: Heat produced by seed, packaging material, pellets, and bales of bags, etc.
c. *Respiration heat*: Heat produced through respiration of seeds.
d. *Incidental heat*: Heat from accidental sparking, electric lights, external heat that enters through doors when the doors are open, and heat produced from the respiration and bodies of workers inside the storage.

Refrigeration is any process by which heat is removed and the storage temperature is kept below the usual ambient temperature for long-term storage of seeds.

6.8.2 Types of storehouses

The type of storage facility and environment needed are related to the length of storage time expected. The following storage categories are useful in planning storage facilities.

1. Farm storage. This type of storage is usually for a few days or weeks, or at the most from harvest to the next planting season.

2. Commercial seed storage. This category of seed accounts for about 75–80% of the total quantity of seed stored. In this case, the storage period is longer and extends up to several months. This category includes certified seed and labelled seeds. The following conditions must be satisfied to make storage more effective in maintaining the quality of seed.

a. Seeds to be stored must be free of trash.
b. Seeds should be sound and healthy.
c. Seeds must be thoroughly dried before storage.
d. Storage area should be safe from rain.
e. Storage area should not be a heat trap (have a high temperature).
f. Adequate pest control must be ensured in the storage area.

3. Carryover. Seeds left to the second year are called carryover seeds. This category of seed is usually stored from one to one-and-a-half years. In cool and dry regions, seeds can maintain their viability; whereas in humid and hot climates, the deterioration of seed is very rapid and special storage is required, with the following specifications.

a. Insulation of the storehouse is necessary to keep the storage as cool as possible.
b. The seed and storage area should be kept dry.

4. Prebasic and basic seeds. These classes of seeds are kept for several years. Since these quantities are small, a comparatively smaller space is required for this type of storage. This storage can be artificially cooled and dehumidified.

5. Germ plasm seeds. This class of seeds is kept for prolonged periods in very cold conditions. Germ plasm storages (banks) built so far can maintain a temperature of 5° to −10°C with 30% relative humidity.

6.8.3 Structure of a storehouse

A large amount of seed becomes useless every year because of improper storage. The longevity of seed is closely related to the environmental conditions in the seed storage locations. Some locations provide satisfactory seed storage conditions naturally, while others require special storage structures. That is, they should have arrangements for protection against water, rodents, birds, insects, and fungi, as well as from theft and fire.

In order to attain these objectives, a storage area or warehouse should have no windows and only one door, which should be made of metal and which can be closed tightly and locked. Strong, water and rodent-proof material like stone, concrete, brick, metal, or wood should be used for construction. A foundation of stone or concrete should be made to raise the floor about 90 cm off the ground.

In areas where natural climatic conditions do not permit safe-storage of seed, temperature and humidity must be controlled inside the storage area. Since heat always flows from a warmer to a cooler area and seeds exchange moisture with their immediate environment, the storage rooms/bins must be insulated. Thickness of the insulation depends upon the insulating material and the difference between the outside and inside temperatures and humidity. Some good insulators are air (room temperature), corkboard, chipboard, polystyrene foam, fibreboard, sawdust, chaffed straw, sand, and wood. Good vapour barriers are plastic sheeting, styrofoam, and weatherproof emulsions like asphalt. The insulation material, besides retarding the flow of heat, should have the following qualities.

a. Durability
b. Low thermal conductivity
c. Low cost and easy availability
d. Easy to install
e. Resistant to rodents, insects, and moulds
f. Low combustibility
g. Should not trap moisture

Figure 6.11 diagrams the structure of a good seed store.

6.8.4 Pests and diseases

Losses in seed storage may be caused by (1) insects, (2) moulds (fungi), (3) rodents, or (4) birds.

Insects are very difficult to control. They frequently infest the seed in the field and are brought into the store with the seed. They can hide in cracks and enter the store through small openings. Used bags may contain insects and reinfest a clean store when brought into it. Before storage, seed must be treated or fumigated so that the danger of insect pests and rodents is minimized. The practice of good housekeeping in the seed store can do much to prevent infestation of seed if it is free of insects when brought into the storage area. Every store should be cleaned thoroughly each season. All cracks in the walls and floors should be sealed. The walls and floors should be sprayed with a residual insecticide such as Malathion or Furadan.

Seeds may be invaded by pathogens before harvest or in storage. Storage fungi invade damaged or cracked seeds much more rapidly than they do good seeds. The best way to prevent damage from storage fungi is to keep

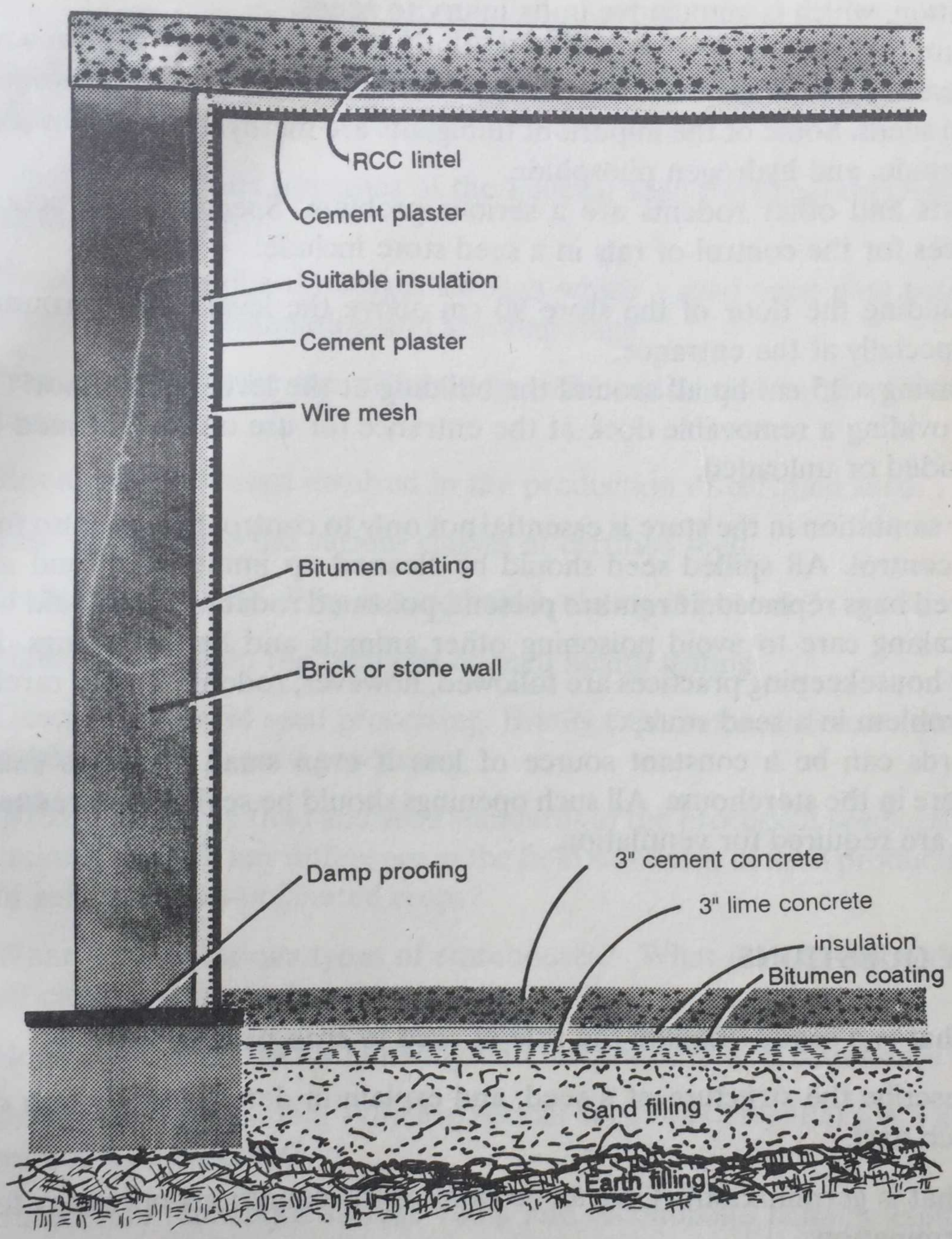

Figure 6.11 Cross-section of a properly insulated and moisture/vapour-proof seed store. Redrawn by Habib-ul-Rahman Mian following Feistritzer 1975a.

the seed moisture at a safe storage level. Insect and fungal activity is at a maximum between 21° and 27°C. As much as possible, storage temperature should be kept below 21°C. Damage to seeds is not great if seed moisture content is below 14% and storage temperature below 30°C. Keeping seed at a moisture content below 9% so that most species of insects cannot

multiply, is a much safer method of keeping seed insect-free than repeated fumigation, which is cumulative in its injury to seeds.

Fumigation should be used only if all other precautionary and preventive measures fail, because fumigants harmful to insects are also somewhat toxic to seeds. Some of the important fumigants are methyl bromide, hydrogen cyanide, and hydrogen phosphide.

Rats and other rodents are a serious problem. Specific construction measures for the control of rats in a seed store include:

a. Building the floor of the store 90 cm above the level of the ground, especially at the entrance.
b. Having a 15 cm lip all around the building at the level of the floor.
c. Providing a removable dock at the entrance for use only when seed is loaded or unloaded.

Proper sanitation in the store is essential not only to control rats but also for insect control. All spilled seed should be cleaned up immediately and all torn seed bags replaced. If rats are present, poisoned rodent baits should be used, taking care to avoid poisoning other animals and human beings. If proper housekeeping practices are followed, however, rodents should rarely be a problem in a seed store.

Birds can be a constant source of loss if even small openings exist anywhere in the storehouse. All such openings should be sealed, or screened if they are required for ventilation.

STUDY QUESTIONS

1. What is a seed? Explain the role of seed in crop production.
2. Describe the structure of a seed, and explain in detail the function of each part.
3. What is germination? Give an account of the conditions necessary for germination.
4. What are monocotyledonous and dicotyledonous seeds? How do they differ from each other?
5. What are the qualities of a good seed? State the factors affecting seed quality.
6. What does the science of seed technology involve? Explain its importance in present day agriculture.
7. (a) What are the different modes of seed germination? (b) Find out the names of the numbered structures in Figure 6.2.

8. What is seed dormancy? What are its causes?
9. What are the disadvantages of seed dormancy?
10. Describe the organizational structure of the seed certification system in Pakistan.
11. What are the chief functions of the Federal Seed Certification Department in Pakistan?
12. Name and describe the stages through which a seed must pass before it reaches the germination and seedling stage.
13. Name and describe the different growth media used in germination tests.
14. Enumerate the steps involved in the production of certified seed.
15. List and describe the various classes of certified seed.
16. Define seed health. Why is seed health testing important?
17. Name and explain the methods of seed health testing.
18. Describe the term seed processing. Briefly explain the different operations involved in seed processing.
19. What is meant by field and seed standards in the process of seed certification? Is there any difference in the field standards of seed production of self and cross-pollinated crops?
20. What are the various types of storehouses? What features should an efficient storehouse have?
21. How would you control humidity and temperature in a storehouse?
22. Define seed legislation. Why are special seed laws essential for a successful seed industry?
23. Enumerate the major storage pests and recommend suitable control measures.
24. Define and/or briefly describe the following: (a) seed treatment, (b) truth-in-labelling, (c) pure seed, (d) roguing, (e) debearding, (f) inert matter, (g) weed seeds, (h) scalping, (i) double-cross seed, (j) micropyle, (k) aspiration, (l) hypocotyl.