631.521
W439a

Environmental and Structural Requirements for Seed Storage.
Mississippi State Univ. Seed Technology Laboratory.
Environmental and Structural Requirements for Seed Storage. G. Burns Welch and James C. Delouche. Jan. 1968.
14 p.
Bibliography: p. 8.
Proj. 931-11-130-203.
AID-W-607.
1. Seeds - Storage. I. Welch, G. Burns. II. Delouche, James C. III. Contract. IV. Title.

AID-W-607

JOURNAL NO. 1607
JANUARY, 1968

PN-ABJ-079
73285

ENVIRONMENTAL AND STRUCTURAL REQUIREMENTS FOR SEED STORAGE

G. BURNS WELCH
AND
JAMES C. DELOUCHE

SEED TECHNOLOGY LABORATORY
MISSISSIPPI STATE UNIVERSITY
MISSISSIPPI STATE, MISSISSIPPI

ENVIRONMENTAL AND STRUCTURAL REQUIREMENTS FOR SEED STORAGE

By

G. Burns Welch
Associate Professor
Agricultural and Biological Engineering Department
Mississippi State University
State College, Mississippi

James C. Delouche
Professor
Seed Technology Laboratory
Mississippi State University
State College, Mississippi

For Presentation at the 1968 Annual Meeting
of Southeast Region
American Society of Agricultural Engineers

Journal No. 1607

Mississippi Agricultural Experiment Station
State College, Mississippi

ENVIRONMENTAL AND STRUCTURAL REQUIREMENTS FOR SEED STORAGE

By

G. Burns Welch and James C. Delouche

Introduction

A consistent and adequate supply of high quality seed is essential to an efficient and productive agriculture. Generally, effective systems have been devised to insure high standards of genetic, physical, and biological purity of seed. Maintenance of the physiological quality of seed, however, has been difficult and continues to be one of the major problems in both developed and developing seed industries.

Viable and vigorous seed contribute greatly to timely and uniform stand establishment, vigorous growth, and plant development. They are necessary for the precision planting practiced for many crops. Many factors such as adverse climatic conditions prior to harvest, improper and poorly timed harvesting, improper drying procedures, mechanical abuse during processing and handling, and poor storage conditions contribute to the decline of viability and vigor in seed (deterioration). Although this paper considers only the storage conditions for seed, it is well to bear in mind that good storage does not improve quality - it only maintains quality. The seeds taken from storage can be no better than those placed in storage.

Many theories have been advanced as to the cause of seed deterioration: depletion of food resources in embryonic tissue, inactivation of enzyme and respiratory mechanisms, mutagenic changes in nuclei, and physical changes in the structure of proteins and other constituents of livign cells. Actually, very little is known about deterioration or degeneration of seed; and it is unlikely that there is a single cause. Rather, deterioration probably encompasses all the changes that occur in seed as they die, and the rate of deterioration is influenced by many factors.

The respiratory system in seeds is highly complex and very sensitive to change. Thus, it provides a good index of the degree of deterioration of seed. The rate of respiration is extremely low in seeds with a moisture content below 11%, but increases rapidly as moisture content increases (Harrington, 1959). Rate of respiration also varies directly with temperatures up to approximately 50° C. Seeds with a moisture content above 11% deteriorate quite rapidly when stored in a warm environment.

Helmer (1964) reported that sorghum seeds with 17% moisture content stored at 86° F. would not germinate after 4 months. However, seed from the same lot maintained good germination for several years when stored at 7% moisture content and 50° F. Thus, by providing an environment to reduce respiratory rate to a low level, seed viability and vigor can be maintained for several years.

Environmental Conditions to Maintain Seed Qaulity

Relative humidity and temperature are the two atmospheric properties that most influence seed longevity. Both of these properties also influence the equilibrium moisture content of seeds. Therefore, the percent relative humidity and temperature inside a storage room must be such that the seed equilibrium moisture content will be low enough for safe storage.

The results of a storage study in which sorghum seeds were stored at different relative humidities and temperatures are shown in Table I. These data show that the relative humidity has a more pronounced effect on seed longevity than temperature. The data also indicate that as the moisture content of the seed increases, the temperature must be decreased for safe storage and vice versa.

The graphs in Figures 1 and 2 show the results of a similar study conducted by Sittisroung (1967) with rice seed. Again it is evident that high moisture contents have a detrimental effect on seed viability.

Harrington (1960) has given three general rules of thumb that are commonly used in designing facilities for storing seeds for more than one season. These rules are as follows: (1) for safe storage conditions longer than one season, the sum of the percent relative humidity plus temperature in degrees Fahrenheit should be near 100; (2) for each 1 percent decrease in moisture, the storage life is doubled; and (3) for each 10° F. decrease in temperature, the storage life is doubled. According to these rules, seeds stored at 8% moisture content will maintain good viability twice as long as seeds stored at 9% moisture content. Seeds stored at 60° F. will maintain good viability twice as long as seeds stored at 70° F. There is also a complementary effect between the two factors; therefore, theoretically, seeds stored at 8% and 60° F. will maintain good viability four times as long as seeds stored at 9% moisture and 70° F.

Where seeds are to be stored only from the harvest season to the following planting season, the above requirements can be somewhat relaxed. The relative humidity-temperature index can be increased up to 120-125 without causing excessive seed deterioration, if the relative humidity is low enough to maintain the seeds at a low moisture content. Most of the increase in the index should be in the temperature side, but should not exceed 75° F.

Construction of Storage Room

A strong and tightly constructed storage room is the first requirement for good storage conditions. The room must be provided with a good vapor barrier to reduce or eliminate the ingress of moisture through walls, ceiling and floor. If the temperature is to be controlled, the room must also be well insulated to reduce heat transmission through the structure. The thickness of insulation required depends upon the type of insulation and the differential between the outside and inside temperatures. In the South a 65° F. room would require about 3 inches of Styrofoam or 3 inches of blanket insulation on the walls and ceiling. If the temperature is lowered to 40° F., 4 inches of Styrofoam or 2 inches of Urethane would be required.

The floor of a storage room may or may not be insulated; it depends on the temperature and the size of the room. There is considerable savings in omitting floor insulation in large rooms. If the floor insulation is omitted, the wall insulation should extend down the foundation at least two feet, if the type of floor construction will allow it. The floor should be moisture sealed with polyethylene film, preferably 6 mil, or another suitable moisture proof membrane. All the joints should be lapped several inches, sealed with mastic, and turned up along the wall a foot or so.

Masonry walls should be plastered smooth and true before applying the insulation. This assures good contact between the wall and the insulation. Board type insulation can be attached to the wall with an adhesive. Some types of adhesives are also good vapor barriers when applied at recommended thicknesses. The boards should be applied in two or more layers with the joints lapped or staggered, so that air or heat will have a longer travel to get to a joint. This is probably more important with Styrofoam or Urethane. These materials have a high resistance to vapor transfer, so we especially want to seal the cracks. A plaster or some other type finish should be applied on the walls to protect the insulation. Typical examples of floor and wall construction are shown in Figure 3.

When insulation is applied to a wood wall, a film of polyethylene or other vapor proof material is tacked and sealed with mastic to the wood. The insulation is then nailed to the wood wall. The mastic seals the nail holes.

The ceiling insulation can be placed above or below the supporting ceiling. Placing the insulation above the supporting ceiling permits easier installation, and eliminates the problems of sagging and pulling loose. Construction of this type is generally used when there is ample working space between the top of the storage room and the roof of the building.

When the insulation is placed below a wood ceiling, it should be nailed through the vapor barrier with galvanized or treated big headed

insulation nails. When a second layer is used, it is placed beneath the first, using wooden skewers, adhesive, or large headed nails to hold it in place.

It is more difficult to install insulation underneath a plaster ceiling especially when the insulation is supported only with an adhesive. In warm climates, some adhesives tend to become soft and pull loose. A new type small metal anchor that can be stuck to the ceiling and extends through the insulation to support it might be the solution to this problem. Another method is to install wood nailers (furring strips) spaced approximately 18 inches apart in one direction below the ceiling. These furring strips, which should have a thickness equal to a layer of the insulation, are secured to the supporting ceiling with mechanical fasteners. The first layer of insulation board coated with vapor proof adhesive is installed between the nailers. Further securing can be done by toe-nailing the edges of the insulation to the nailers. The second layer also coated with an adhesive is applied at right angles to the first and secured by nailing with large head nails spaced 12 inches apart to the furring strips. This type installation would be somewhat more expensive due to the additional labor and material required. However, the additional expense is justified in most cases because of the assurance of obtaining a good ceiling installation. Examples of ceiling construction are shown in Figures 4 and 5.

Doors can be a problem in admitting moisture into a storage room. They should be well insulated, tightly fitted, and kept closed. When there is frequent traffic through a door, an entrance way with two doors is desirable. This acts as an air lock and reduces moisture intake and heat loss considerably. All conduit and pipe openings through the insulation and vapor barriers should be tightly sealed.

Methods of Controlling Storage Environment

The environment in a seed storage room can be controlled by mechanical refrigeration, combination of desiccant dehumidification and mechanical refrigeration, or dehumidification alone.

Mechanical refrigeration: In this method, both the temperature and the humidity are maintained at low levels by the same equipment. Dehumidification by mechanical refrigeration operates on the principle that the water vapor in the atmosphere will condense when it comes in contact with a surface at a sufficiently low temperature. The temperature at which condensation occurs is referred to as the dewpoint. To accomplish dehumidification with a refrigeration system, the cooling coils must be a few degrees below the dewpoint for the desired combination of relative humidity and temperature. For example, suppose we wish to maintain an atmospheric condition of 60° F. and 50% relative humidity in a storage room. Referring to a psychrometric chart, we find that the dewpoint for this combination

of temperature and relative humidity is 40° F. The refrigeration system would be designed to have a coil temperature a few degrees below the dewpoint. Any time moisture is added to the room to cause the relative humidity to increase above 50%. this additional moisture will condense on the coils and drain out until the relative humidity is decreased to 50% at 60° F.

Let us now consider another example in which the desired storage conditions are 40° F. and 50% relative humidity. Referring again to the psychrometric chart, we find the dewpoint to be 25° F. which is below freezing. The moisture that collects on the coils will freeze and build up a layer of ice on the coils. When the system is operating with a coil temperature below freezing, it is necessary to provide some type of heating system to defrost the coils. The system can be controlled with a time clock to stop the refrigeration compressor periodically and turn on the heat system to defrost the coils.

The coil temperature for this type system is always below the design room temperature. Therefore, it is necessary to add heat to the room to raise the air temperature up to the design temperature. This is referred to as reheat. The additional heat is usually provided by electric heating strips placed on the discharge side of the cooling coils.

Designing a system of this type is a very technical problem. It is of utmost importance that the different components in the system be well balanced. Anyone desiring to use reftigeration dehumidification at temperatures below 65° F. should seek the service of a competent refrigeration engineer.

Dehumidifiers: When it is desired to control only the relative humidity at a low level, a desiccant or a self-contained portable refrigeration dehumidifier can be used. These units can be controlled by a humidistat to maintain the relative humidity at the desired level.

In the desiccant type dehumidifier, air in the storage room is passed through a bed of desiccant material such as silica gel. This is a highly porous hygroscopic material capable of absorbing as much as 40% of its own weight in water vapor. The desiccant dehumidifier can operate efficiently over a temperature range from -40° F. to plus 120° F.

The dual-bed and the rotating desiccant wheel are the two types of desiccant dehumidifiers most commonly used for seed storage installations. The dual-bed type consists of two beds of desiccant about 4 inches thick. While one bed is removing moisture from the air in the storage room, the other bed is being reactivated. Reactivation is accomplished by blowing outside air through the bed of material while the material is being heated to drive off the moisture. The duration of the dehumidifying and reactivating cycles are automatically controlled by a timer which alternates the operation of the two desiccant beds at pre-set intervals.

The rotating wheel dehumidifier consists of a wheel packed with desiccant. The sides of the wheel are made of expanded metal to allow free passage of air. The wheel is mounted in a dual air duct system so that a section of the wheel area is available for dehumidifying while the remaining surface is in the reactivating circuit.

The portable self-contained refrigeration dehumidifier can also be used for controlling the relative humidity in a seed storage room. However, it becomes inefficient at temperatures below 65° F. and relative humidities below 40%.

Both the desiccant and the self-contained refrigeration dehumidifiers will add a certain amount of heat to the storage room. This is due to the latent heat of adsorption or condensation, sensible heat gain from reactivation of the desiccant, and the heat dissipated from electric motors. If this additional heat should cause the temperature to exceed the desired level, some means must be provided for removing it. Cooling can be accomplished by providing enough air conditioning to remove the excess heat load. Desiccant dehumidifiers also can be equipped with a water cooled heat exchange in the dry air discharge duct.

The amount of heat given off by dehumidifiers is an important factor that must be considered when planning a storage facility

Combination of refrigeration cooling and desiccant dehumidification: A combination of these two systems has proven to be quite satisfactory for maintaining the temperature and relative humidity at low levels such as 40° F. and 40% R.H. The initial equipment cost of a combination installation is more than for an all refrigeration system, but this is partly offset by simplifying the design and assurance of desired environmental conditions. Several storage facilities originally designed for an all refrigeration system failed to maintain design conditions and had to be modified by installing a supplemental desiccant dehumidifying system.

Summary

Seeds must be stored in a suitable environment to maintain good viability and vigor. Both temperature and relative humidity influence the longevity of seeds, but relative humidity has the most pronounced effect. The viability of seeds can be maintained for a period of several years in an environment in which the sum of the percent relative humidity and temperature in degrees Fahrenheit is near 100.

All seed storage facilities should be provided with a good vapor barrier to reduce the ingress of water vapor. When the temperature is maintained at a lower temperature than ambient conditions, the facility

should be well insulated. The thickness of insulation depends upon the temperature differential.

The environment in a storage facility can be controlled by an all-refrigeration system, combination of refrigeration cooling and desiccant dehumidification, or dehumidification alone. The initial cost of a combination system is usually more expensive, but it is simpler in design and will maintain desired conditions with minimum attention.

SELECTED BIBLIOGRAPHY

1. Christensen, C. M. and Lopez, L. C. Pathology of Stored Seed. Proc. Inter. Seed Test. Assoc. 28:701-711. 1963.

2. Delouche, J. C. Deterioration of Crimson Clover Seed in Storage. Proceedings Assoc. of Off. Seed Anal. 55:In Press, 1965.

3. Delouche, J. C. An Accelerated Aging Test for Predicting Relative Storability of Crimson Clover and Tall Fescue Seed Lots. Agronomy Abstracts, 1965, p. 40.

4. Delouche, J. C. Measurement of Seed Deterioration. Symposium on Seed Deterioration. American Society of Agronomy, Agronomy Abstracts, 1965, p. 40.

5. Harrington, J. F. Drying, Storage, and Packaging Seeds to Maintain Germination and Vigor. Proc. 1959 Short Course for Seedsmen, Seed Technology Laboratory, Miss. State University, State College, Miss., 1959.

6. Harrington, J. F. Practical Instructions and Advice on Seed Storage. Proc. of the Inter. Seed Test. Assoc. 28:989-994, 1963.

7. Harrington, J. F. New Theories on the Biochemistry of Seed Aging. Symposium on Seed Deterioration, American Society of Agronomy. Agronomy Abstracts, 1965, p. 41.

8. Helmer, J. D. Basic Causes of Poor Storage, and Refrigerated Dehumidification. Proc. 1964 Short Course for Seedsmen, Seed Technology Laboratory, Miss. State University, State College, Miss., 1964.

9. Nutile, G. E. Basic Factors Affecting Seed Longevity. Agronomy Abstracts, 1964, p. 82.

10. Munsford, R. S. Controlled Temperature and Humidity Storage. Proc. 1965 Short Course for Seedsmen, Seed Technology Laboratory, Miss. State University, State College, Miss. 1965.

11. Sittisroung, Prasoot. Storage of Rice and Cowpea Seed. Master of Science Thesis on file at the Mississippi State University Library, 1967.

Table I. Germination percentages of sorghum seed after various intervals of storage at different temperatures and relative humidities.

Relative Humidity %	Temperature °F.	Months of Storage 0	2	4	6	8	10	12
20	50	95.2	93.5	94.2	95.7	95.7	94.7	96.5
	68	95.2	94.0	94.2	94.7	95.0	96.5	95.7
	86	95.2	93.2	92.5	95.2	93.0	94.0	94.5
40	50	95.2	94.2	93.7	95.0	95.0	96.2	95.0
	68	95.2	93.0	93.7	92.7	93.7	93.0	94.7
	86	95.2	93.0	93.7	95.5	93.2	95.2	92.0
60	50	95.2	93.2	93.2	95.2	93.5	94.5	97.2
	68	95.2	92.2	94.5	94.7	95.0	93.7	92.2
	86	95.2	92.5	94.2	89.2	89.5	86.2	75.2
80	50	95.2	92.7	92.3	56.7	47.5	44.5	38.0
	68	95.2	56.5	47.2	39.2	10.5	0.0	0.0
	86	95.2	45.0	0.0	0.0	0.0	0.0	0.0
100	50	95.2	85.5	44.0	22.7	0.0	0.0	0.0
	68	95.2	41.0	0.0	0.0	0.0	0.0	0.0
	86	95.2	1.0	0.0	0.0	0.0	0.0	0.0

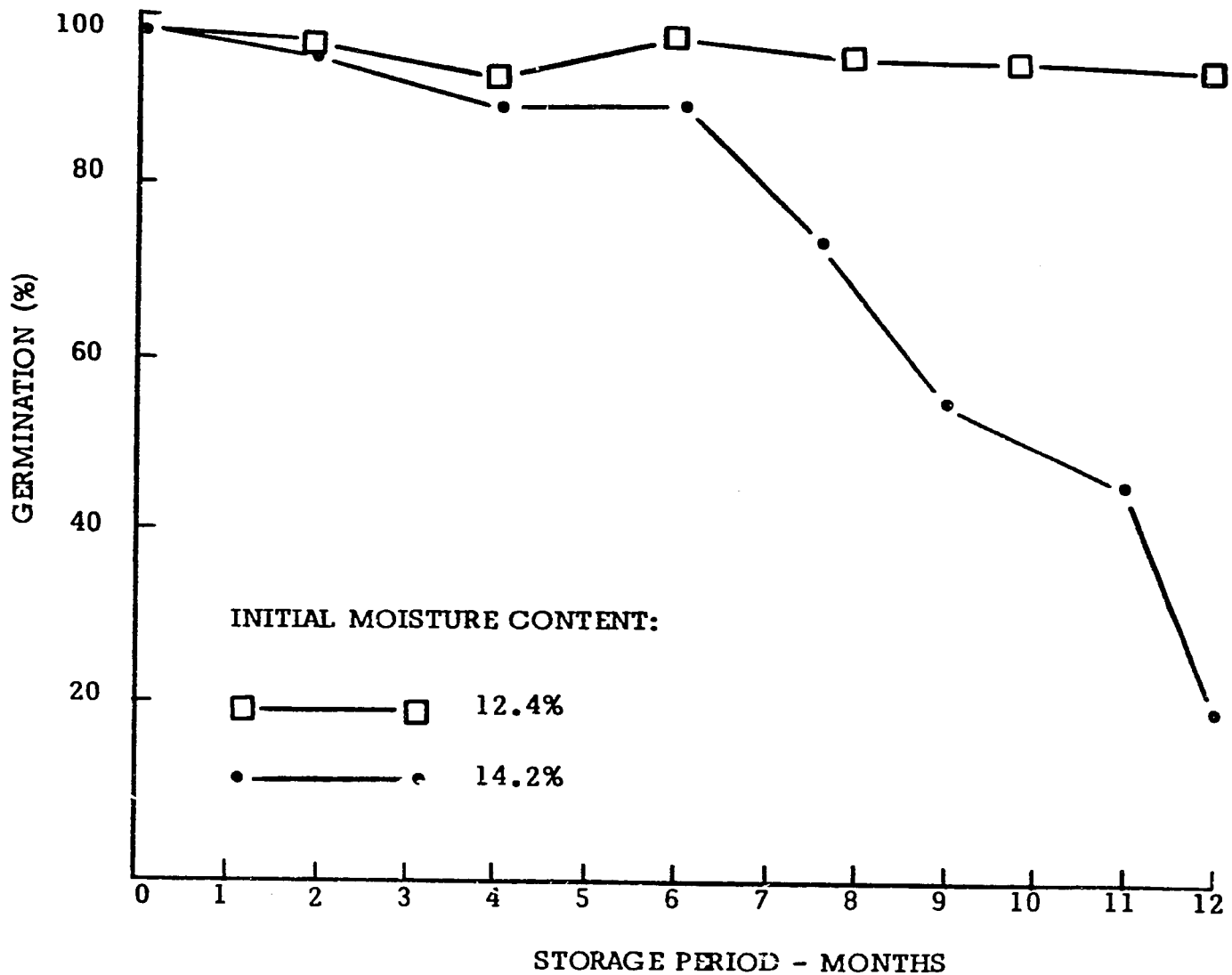

Figure 1. The effect of seed moisture content on the viability of Bluebonnet 50 rice stored at 20° C.

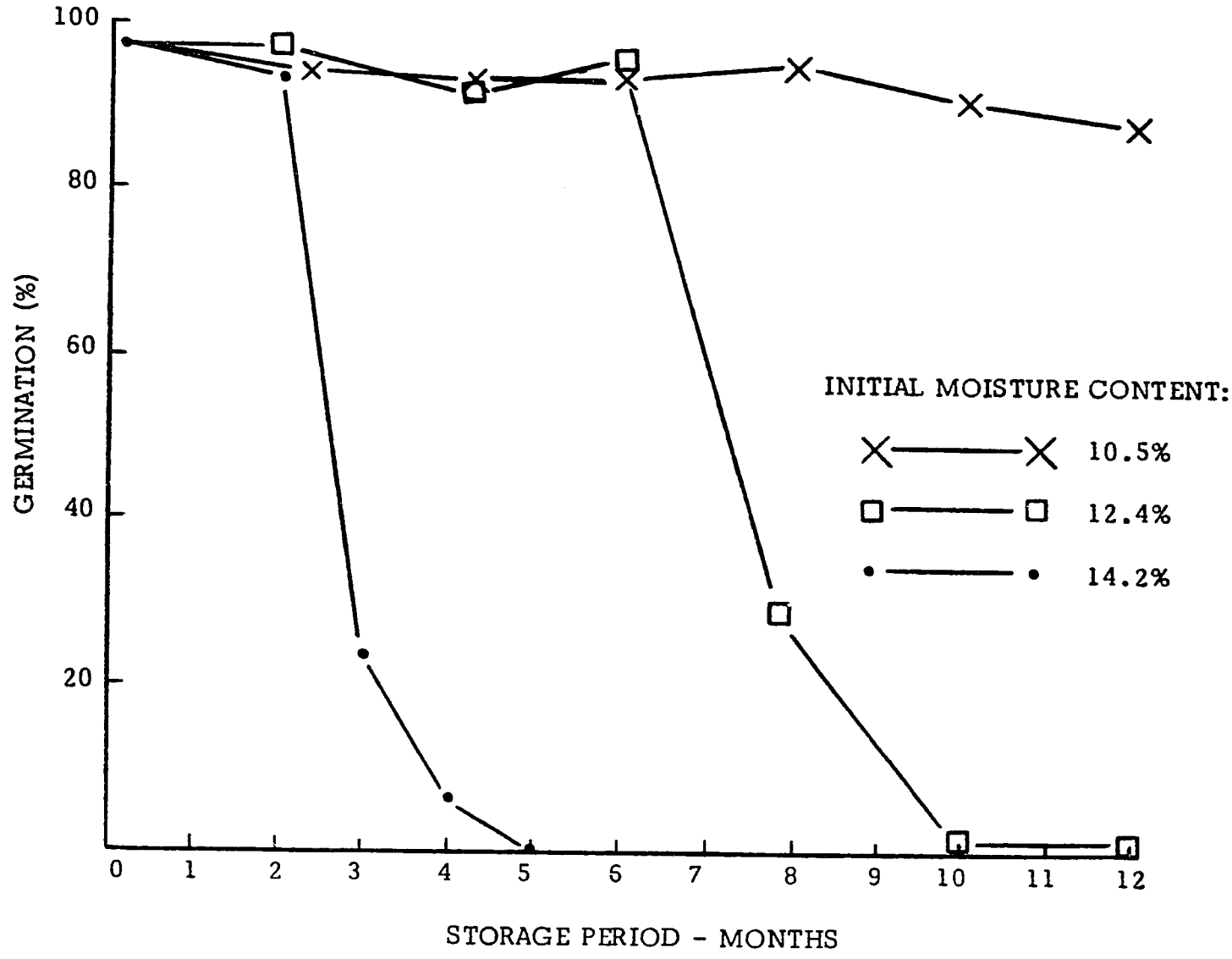

Figure 2. The effect of seed moisture content on the viability of Bluebonnet 50 rice stored at 30° C.

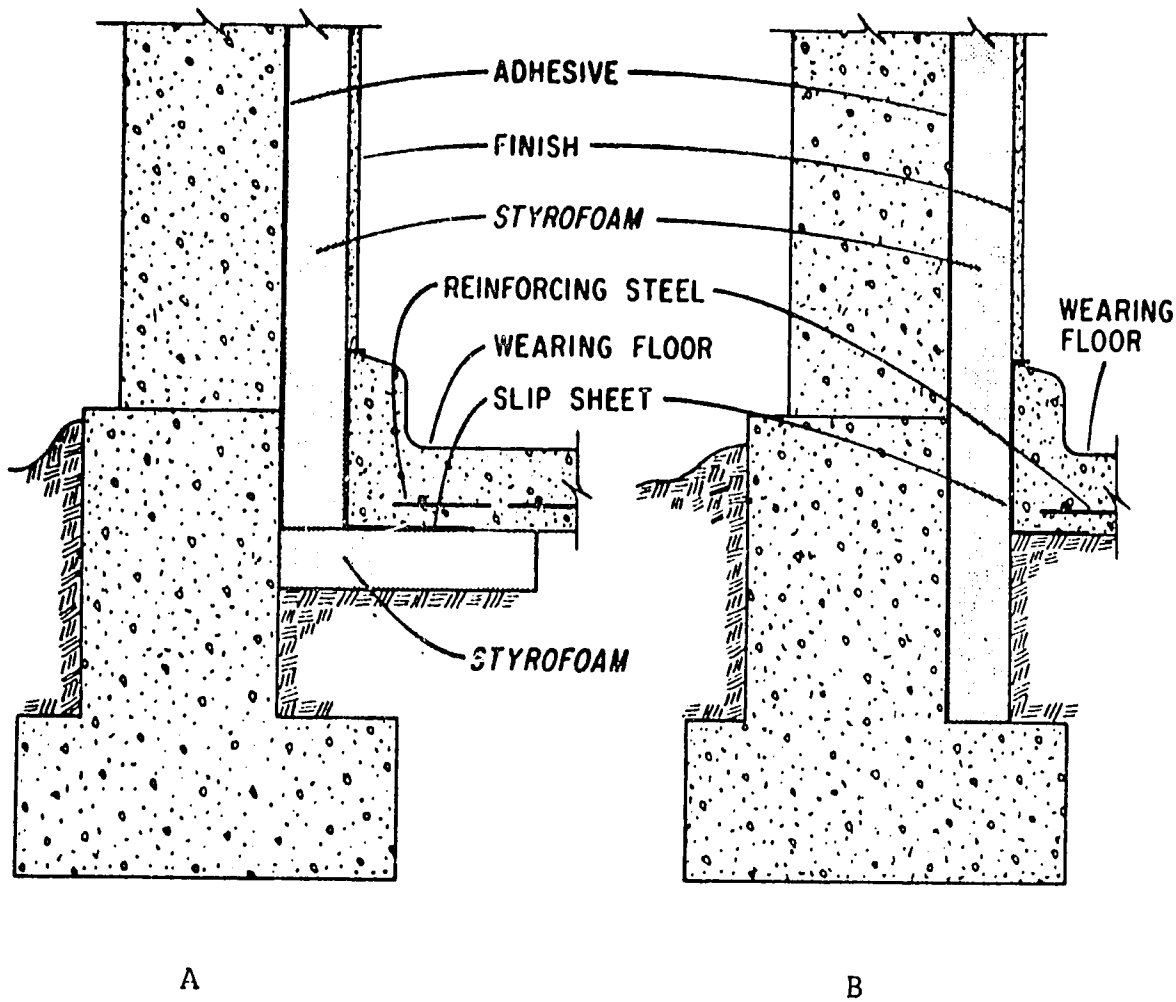

Figure 3. Sections showing (a) wall and floor insulation (b) wall insulation when floor insulation is omitted.

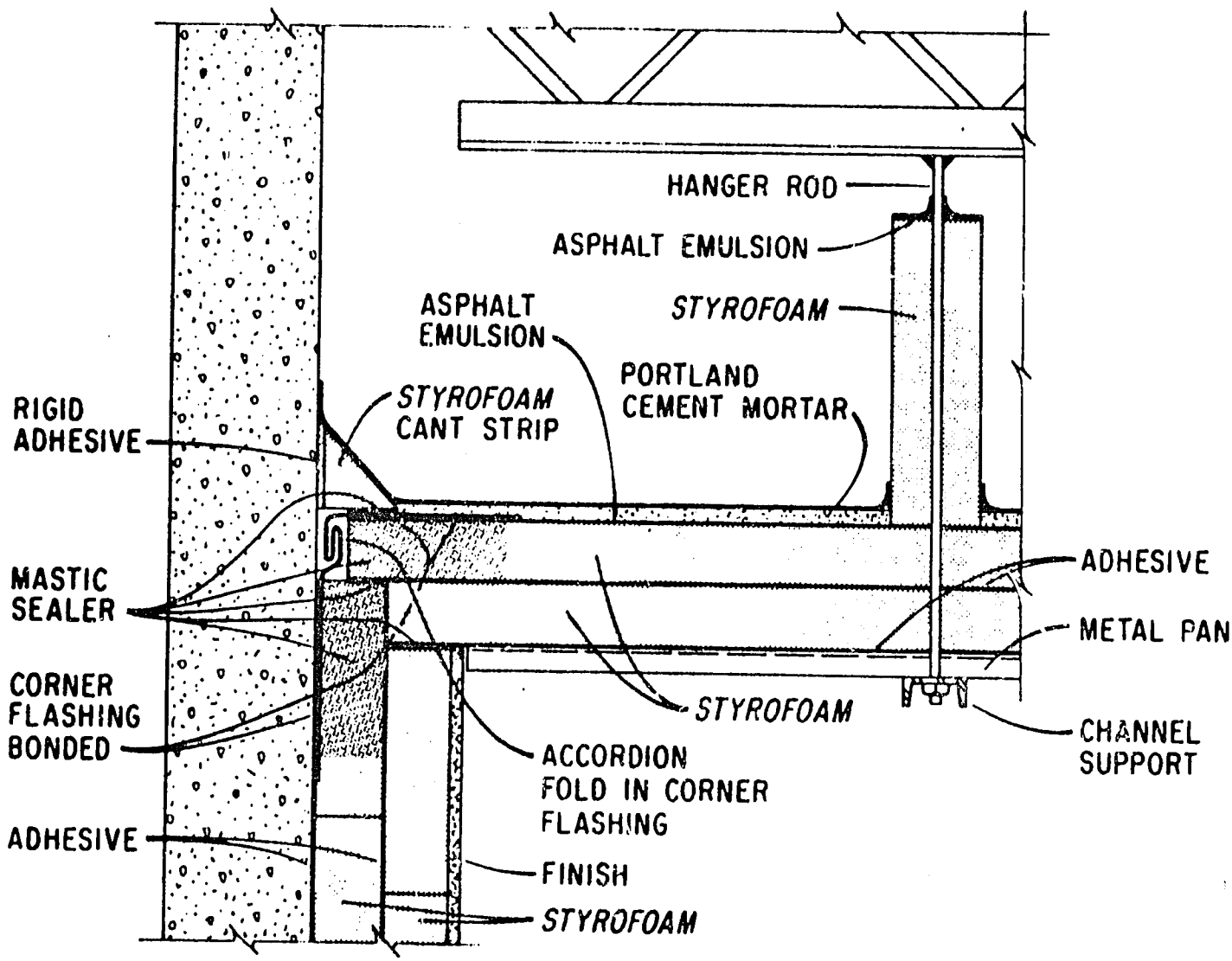

Figure 4. Section showing ceiling insulation supported on metal pan suspended from roof joist.

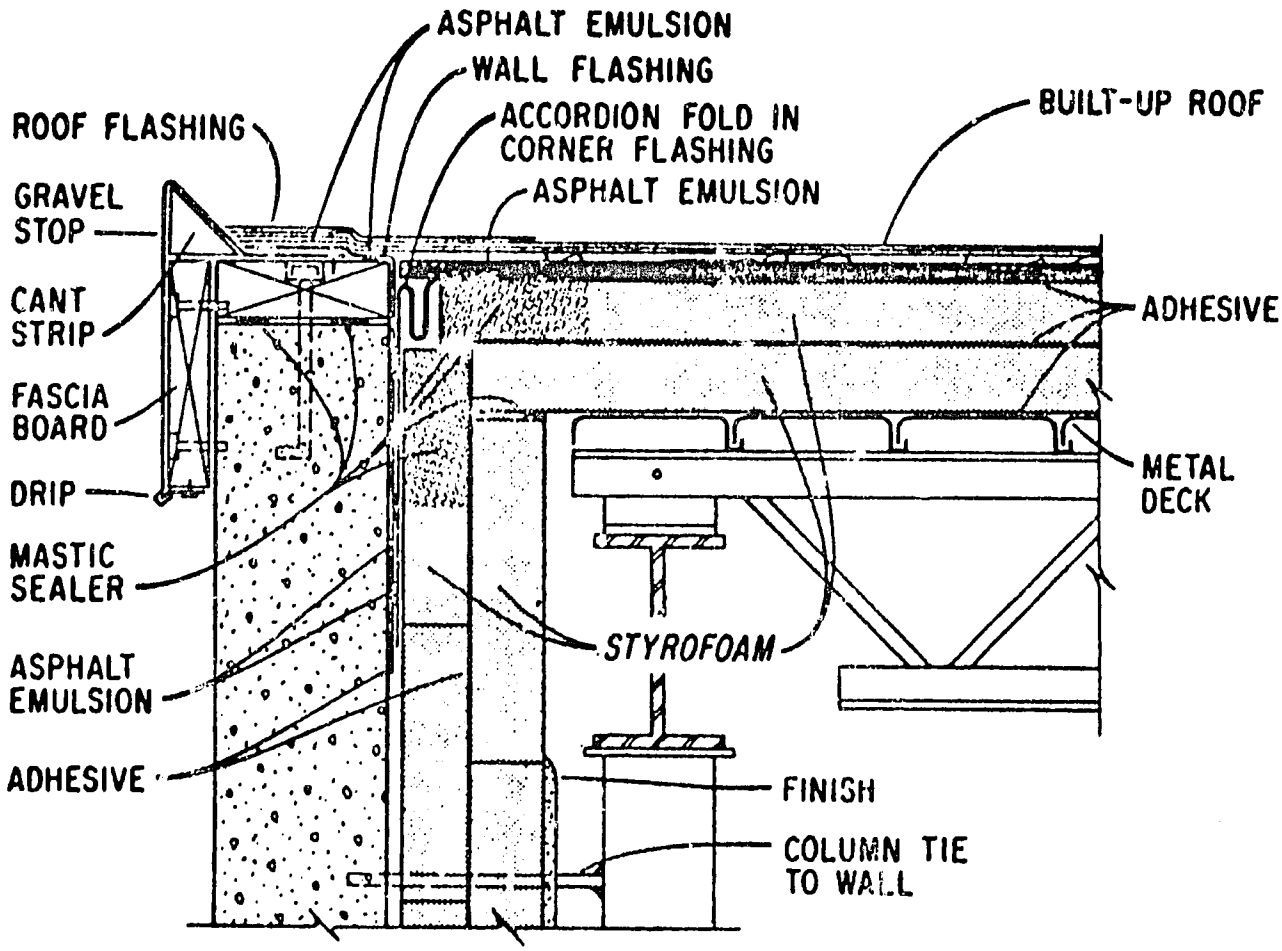

Figure 5. Section showing ceiling insulation placed above roof deck.