CHAPTER 2

DEFINITION OF COVERING AND PROPERTIES OF COVERING MATERIALS

2.1. INTRODUCTION

There are many kinds of covering materials and techniques available and used in practical agriculture. It is rather difficult to distinguish one technique from another in some cases because the principle involved is the same. The following terms are used for these systems: mulchings, row covers (tunnels), floating mulches (floating row cover), rain shelters, and unheated greenhouses.

There is a definite difference between mulching and the other techniques. In mulching, plants grow over the cover; in the others, they grow under. Some techniques are combined in use. Figure 2.1 shows pictorial definitions of these techniques.

2.2. MULCHING

Several kinds of materials -- not only plastics but also organic materials -- are used for mulching. In mulching, the soil surface where crops are growing is covered directly by these materials, with a very thin air space between the cover and the soil surface. In order to improve the thermal environment of the soil, film mulching is widely used both in open fields and in greenhouses.

The soil surface of each row is covered by a sheet of film with many holes. Plants are sown or transplanted into each hole, and grow over the cover. Since most of the soil surface is covered by film, evaporation from the surface is prevented. It is clear that the soil is kept warmer than it would be without mulching.

Table 2. 1. Effect of plastic mulch on marketable yields of early cucumbers and muskmelons in summer of 1965 (after Jensen, 1988)

Treatment	*Cucumber (kg/ha)*	*Muskmelon (kg/ha)*
Clear plastic	37,569	13,362
Black plastic	33,336	9,786
No plastic	26,043	911

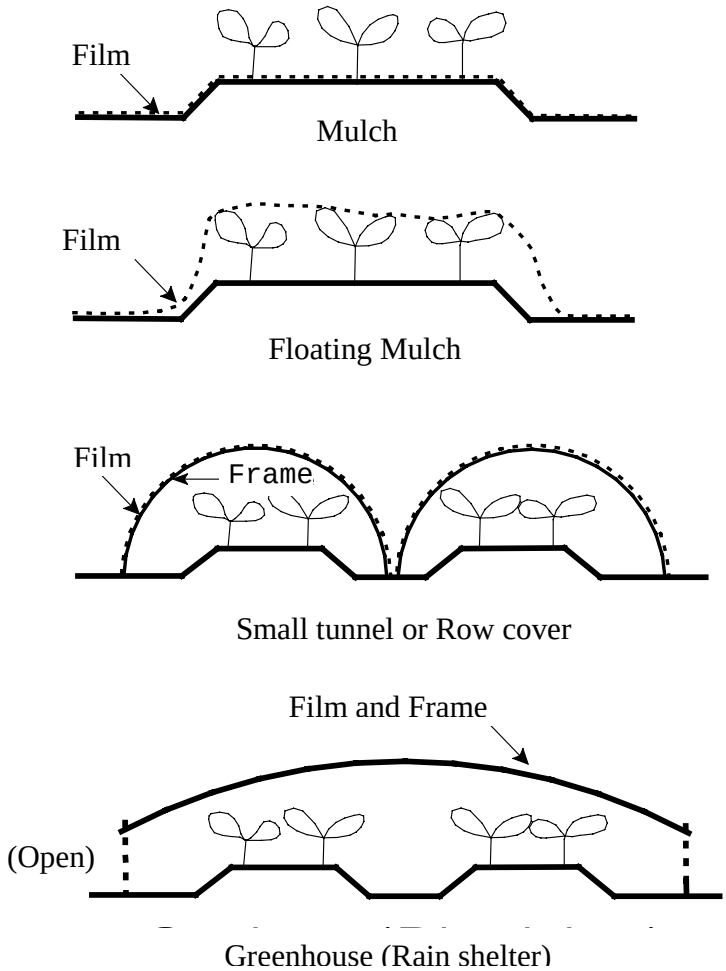

Figure 2.1. Covering techniques.

The color of film used for mulching varies, from black to white to clear. Each has its own specific characteristics, (details are discussed in Chapter 6).

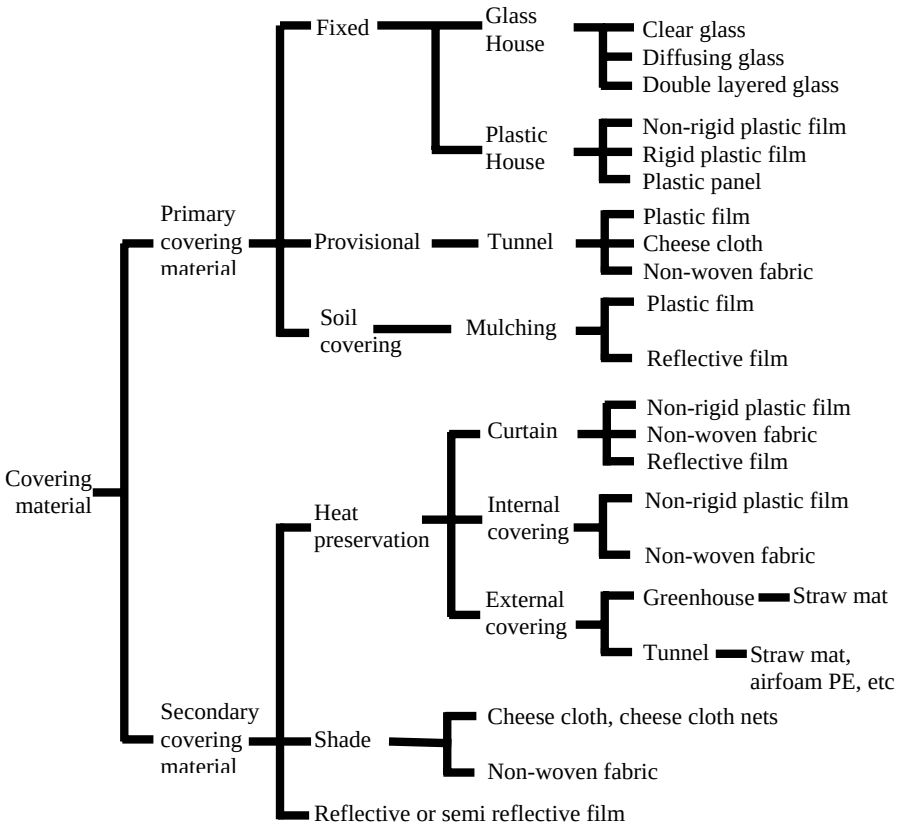

Figure 2.2. Classification of covering materials (JGHA, 1986).

Transparent film creates the highest soil temperatures because solar radiation penetrates the soil directly. With black film, the temperature in the soil is slightly lower than that in transparent-film covered soil; but weeds are killed in the absence of light, and the soil environment and crop yields are improved. Some examples of crop yields are shown in Table 2.1. Covering with reflective film reduces the temperature of the soil during the hot summer months. Water conditions and virus infections in soils are also largely affected by coverings. Greenhouse floor soils are often covered with white-colored film to protect rockwool systems from soil diseases. The use of mulching not only improves the temperature environment but also achieves various

other goals, such as moisture control in soil, sterilization for weed control and soilborne diseases, and enhanced light reflection for early production.

2.3. ROW COVERS (TUNNELS)

Row covers or small tunnels are film-covered shelters with small frames; normally, farmers cannot work inside them. Size is the main difference between row covers and unheated plastic greenhouses. For row covers, a sheet of film is placed over the plants in a row with an arch-shaped frame for support. The shape of the frame can vary, but one unit of frame fits only one row, as is shown in Fig. 2.1, and the sheet of film covers more than one row. This can be thought of as a kind of floating row cover or floating cover, which usually does not use any frame.

The thermal properties of films are very important in row covers because the rows are not heated. PVC film has a very high emissivity for long wave radiation (similar to glass), which creates slightly higher air temperatures in the sheltered space. This improvement in thermal environment completely outweighs the price advantage of the less expensive PE film. The big advantage of row covers is that the films can be removed during the summer season. On the other hand, thermal insulation may also be improved by multi-layer coverings. Inside row covers are used especially for growing seedlings and can be removed when the crops grow to a certain height. Opaque sheets can also be applied at night. Floating mulches have been used recently as an alternative to inside row covers. More than 90% of heated greenhouses in Japan have at least one layer of thermal screen, which is retractable.

2.4. FLOATING MULCHES (FLOATING ROW COVER)

Floating mulch is the technique of covering crops with film without using any frame, although tape or wire over the film is sometimes used to fasten and stabilize the film against wind.

In most cases, the plants are covered by sheets of film or net without frames. If frames are used it is rather difficult to separate this method from row covering, but floating methods have been developed recently for wider purposes using various coverings such as nets for wind protection. If introduction of frames seems likely to improve the situation, frames may be added.

Floating mulch has various advantages: 1) reduction in damage by typhoons; 2) protection from severe swings in weather; and 3) reduction in damage by birds and insects.

2.5. RAIN SHELTERS

It can be said that rain shelters are unheated greenhouses with wider side openings. They are used year-round but particularly in the warmer season for protection from rain.

2.6. UNHEATED GREENHOUSES

Greenhouses without any heating or cooling facility are basic structures for environmental control and can achieve a better temperature environment in the passive sense than rain shelters. The basic behaviour of greenhouses cannot be changed by the addition of sophisticated environmental control facilities. In cool regions, greenhouses and row covers are often used in combination. Solar energy is stored during the daytime; therefore, the inside temperature is normally higher than outside during the nighttimes, which contributes to plant growth.

2.7. COVERING MATERIALS

Various kinds of coverings are used for each method because each method has its own specific characteristics (see Fig. 2.2). In the descriptions that follow, the differences between production methods and detailed characteristic structures, such as low and high density and linear low density, are not mentioned, because durability and economic aspects are beyond the scope of this book.

There are mainly two ways to classify films: One is based on their components and production method, and the other is based on their physical properties such as reflectivity and permeability. In classification of the components, the use of abbreviations is popular. PVC (Polyvinyl chloride) and PE (Polyethylene) films are two predominant films used for almost all methods. Other films include EVA (Ethylene vinyl acetate), EVOH (Polyethylene vinyl alcohol), PP (Polypropylene), PETP (Polyethylene telephtalate), FRP (Fiber reinforced plastic), FRA (Fiber reinforced acrylic), PMMA (Polymethyl methacrylate) and PC (Polycarbonate).

Films for agriculture are mostly made from PVC, EVA, EVOH and PP. Rigid films (which are not necessarily thicker but are harder in nature) are made from PVC and PETP. The difference between soft and hard films that are both made from PVC is the plasticizer content. Films composed of less than 15% plasticizer are soft in general. Rigid panels of thickness 0.45 to 1.7 mm are made from FRP, PRA, PMMA and PC. Not only flat panels but also corrugated and double sheet panels are available.

Reflective films, non-woven materials and nets are some other types of covering materials. Anti-droplet, anti-dust and water vapor permeability are their most important properties. Infra-red transparency is again an important draw back resulting in the

poor ability of these materials to maintain higher temperatures inside. Some improvement has been noted for PE, which is originally mostly transparent to infra-red radiation.

The general characteristics of main covering materials are summarized in Table 2.2. The workability of films is in general good. Stickiness, an undesirable property as it is considered to accelerate dust accumulation, is high for PVC. Adhesion, a desirable property for most uses, is also the highest for PVC. Transparency is more or less the same for all materials, but is high in PVC and glass. Heat resistance is high in PVC, FRP and glass. Weather tolerance is rather poor in PE and EVA.

Cost is high for rigid covering materials such as FRP and glass; PVC is the most expensive among the films.

Table 2. 2. Characteristics of covering materials

		PVC	*PE*	*EVA*	*FRP*	*Glass*
Physical Properties	Transparency	◎	**O**	**O**	△	◎
	Strength	**O**	△	△	◎	**O**
	Thermal resistance	**O**	**X**	△	**O**	◎
	Dust prevention	**X**	**O**	**O**	**O**	**O**
	Anti-droplets	**O**	**X**	△	△	**O**
	Weather tolerance	**O**	△	△	**O**	◎
Workability		**O**	**O**	**O**	**X**	**X**
Cost		△	◎	**O**	**X**	**X**

Note: ◎ excellent, **O** good, △ fair, and **X** poor.

Other important characteristics are those related to thermal radiation characteristics such as transmissivity, absorptivity and reflectivity for long-wave radiation. The characteristics are listed in Table 2.3. They are monochromatic and change according to radiation wavelength. Here, in the practical sense, total values integrated over all wavelengths are shown. This approach is common in engineering. The two important rules are 1) that the sum of the three thermal radiation properties is unity; and 2) that absorptivity is equal to emissivity. Therefore, in this case, transmissivity = 1.0 – reflectivity – absorptivity.

Table. 2.3. Thermal radiation characteristics of covering materials (after Okada in JGHA, 1987)

Films	*Thickness, mm*	*Absorptivity*	*Transmissivity*	*Reflectivity*
PE	0.05	0.05	0.85	0.1
	0.1	0.15	0.75	0.1
EVA	0.05	0.15	0.75	0.1
	0.1	0.35	0.55	0.1
PVC	0.05	0.45	0.45	0.1
	0.1	0.65	0.25	0.1
PETP	0.05	0.6	0.3	0.1
	0.1	0.8	0.1	0.1
	0.175	> 0.85	< 0.05	0.1
Non-woven		0.9	-	0.1
EVOH		> 0.9	-	< 0.1
Glass	3.0	0.95	-	0.05
PMMA		0.9	-	0.1
Aluminum powder mixed PE		0.65-0.75	-	0.25-0.35
Aluminized PE		0.15-0.4	-	0.6-0.85

PROBLEMS

1. What is the difference between mulch and floating mulch?

2. Spell out PE, PVC, EVA, FRP and FRA.

3. Describe the main differences in the thermal radiation characteristics of the covering materials PE, PVC and glass.