Vegetable Cultivation under the Plastic Rain Shelter

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In cool regions of Japan, vegetables are cultivated mainly during the summer-autumn season. Most of the cultivation has been made in open fields with only few cases under glasshouses or vinylhouses. As Japan belongs to the monsoon zone, the summer-autumn season has a relatively large amount of rain. Therefore, vegetables growing in open fields are liable to be damaged by rain. Although the degree of the damage differs with different kinds of crops, the rain damage often causes a serious problem in vegetable production. Along with the recent increase in vegetable production, more stability of production and higher quality of the products are strongly demanded.

In response to such situation, an attempt was made to use rain shelters to open field cultivation, and the effectiveness of the rain shelters was proved. As a result, the summer-autumn cultivation under rain shelters has become common throughout the country, and its acreage is now still increasing (Table 1). The area under rain shelters in 1983 was about 2,375 ha, which accounts for 7.6% of the total acreage under structures. The greatest area, 849 ha, is for tomato, followed by 756 ha of spinach, 206 ha of cucumber, 78 ha of melon, 63 ha of sweet pepper, and others (Chinese leek, garland chrysanthemum, Welsh onion, etc.). Houses to shelter crops from rain (hereafter referred to rain shelter houses) are utilized not only by vegetables but also widely by flowers and fruit trees.

Table 1. Acreage under rain shelters
(unit: 1000 m²)

Region	Acreage		
	1982	1983	1983/82
Hokkaido	455	648	1.42
Tohoku	4,487	5,250	1.17
Kanto	3,301	5,101	1.55
Hokuriku	443	391	0.88
Tokai	3,044	3,519	1.16
Kinki	942	1,569	1.66
Chugoku・Shikoku	1,034	2,853	2.76
Kyushu	2,967	4,415	1.49
Total	16,673	23,746	1.42

Source: Data of Ministry of Agriculture, Forestry and Fisheries

Merits of cultivation under rain shelters

The merit most strongly expected is to prevent vegetables from diseases. Many kinds of diseases attack leaves and stems of vegetables, except powdery mildew. It has been reported that highly humid conditions induced these diseases more frequently and severely. For example, cucumber downy mildew is caused by the infection with conidiospore of *Sphaerotheca fuliginea*. The optimum temperature for conidiospore formation is 15–20°C, and the higher the humidity, the more conidiospores are produced. Presence of water is essential for the conidiospores to release zoospores and to elongate hyphae. Then, the hyphae enter into leaf tissues through stomata when leaf surface is moist. Table 2 shows the relation among relative humidity, dew formation on leaf surface and the incidence of cucumber downy mildew. The occurrence of diseases attacking the top is generally promoted by moist condition of leaf surface. When the duration of moist condition is reduced to less

Table 2. Effect of relative humidity and leaf wetting on cucumber downy mildew[1)]

Treatment	Humidity		Dew period* on leaves	Degree of disease development**			Yield index
	Daytime	Night		June			
				5 th	9 th	12th	
Dry	53–92%	88–100%	0 hr	0	13.8	15.3	119
Standard	65–96	95–100	0– 5	5.3	33.0	34.8	100
Humid	67–96	100	8–12	64.5	90.3	97.8	51

* Dew formation occurred only for short time, ** Percentage of diseased area on leaves

Plate 1. Tomato plants under a rain shelter (Diseases hardly observed)

Plate 2. Tomato plants of open-field culture (Several diseases observed)

than 3–5 hr, preferably less than 1–2 hr, the disease occurrence is considerably decreased. Thus, the rain shelter is effective in preventing disease occurrence. Plates 1 and 2 show sheltered and unseltered tomato plants cultivated at the same time. Apparently, the former shows less disease incidence.

In areas with much insect incidence, the insect damage can be prevented by covering the side of rain shelters with net. Thus, good usage of rain shelter houses can prevent diseases and insect pests with reduced pest control measures like chemicals. It results in low cost of production and healthy environment to cultivators and consumers.

In the open-field cultivation, crops and soils are exposed to rain during the whole period, so that much runoff of fertilizers is induced. To the contrary, fertilizer runoff hardly occurs under rain shelters. Particularly, this effect of rain shelters is great in heavy rain areas, increasing efficiency of fertilizer utilization.

Runoff of nutrients by rain occurs not

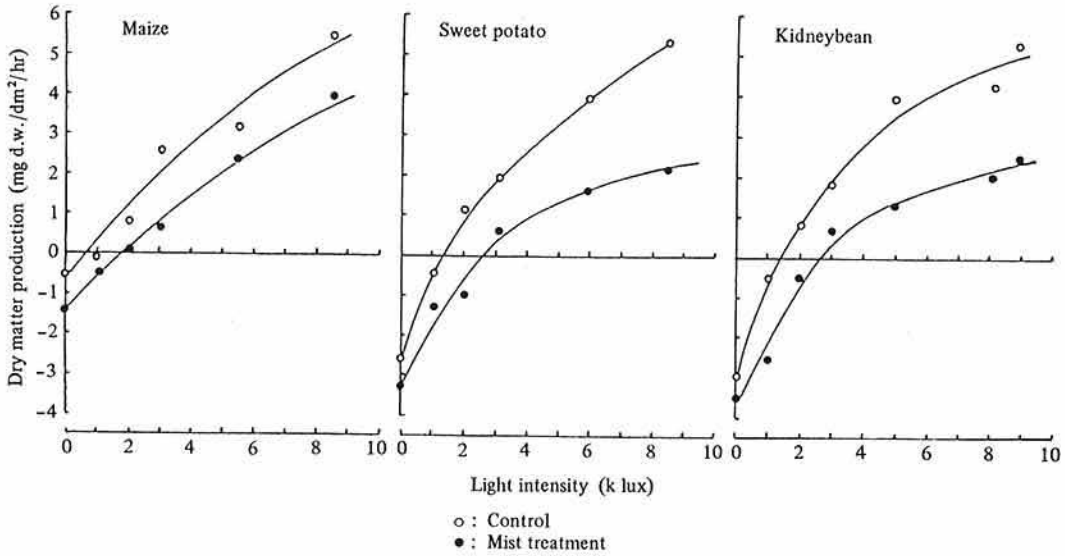

Fig. 1. Effect of mist treatment on dry matter production in a growth chamber[2]
Mist treatment was given for 6 hr and dry matter was measured at various light intensity.

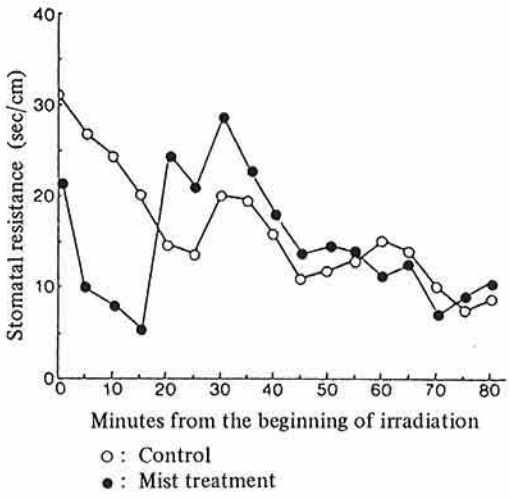

Fig. 2. Changes in stomatal resistance of primary leaves of kidney bean after the onset of irradiation
Plants were kept at 23°C under 6 klux illumination.

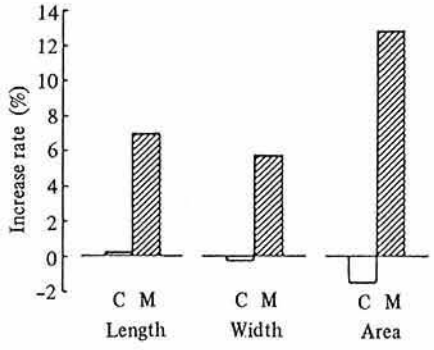

Fig. 3. Effect of mist on length, width and area of primary leaves in kidney bean in a greenhouse[3]
Plants were misted for 6 hr.
Increase rate: Percentage of increase during a 6-hr period
Air temperature: 30.5–34.5°C
Relative humidity: 52–66%
Solar radiation: 322 W/m²
C: Control M: Mist treatment

only from soil, but also from plant leaves. Kimura et al.[2] examined effect of rain on dry matter production, and found out, as given in Fig. 1, that a light-compensation point and a light-saturation point were influenced by mist treatment (10 mm/hr) in any crop. Particularly, the rate of dry matter production of kidney bean under the light intensity higher than the light compensation point was reduced to a level less than half of that of the untreated control. The reason for the reduced dry matter production by the mist treatment was attributed to (1) runoff of photosynthates by the water directly covering leaf surface, and (2) clogging of stomata by the water retarded photosynthesis. Kimura et al.[3] observed stomatal

movement under a rain treatment, and found out that stomata began to open immediately after the onset of illumination showing a greater stomatal aperture than that of the control plot, then closed after 20–30 min, and gradually recovered to the same level of aperture as that of the control plot after about 40 min (Fig. 2). It supports the above-mentioned theory of stomatal clogging by water. Thus, rain retards dry matter production, but it promotes leaf elongation (Fig. 3), i.e., leaves become lanky.[4]

Rain shelter houses make it possible to artificially regulate soil moisture because soils are not exposed to rain. Therefore, the occurrence of cracking fruit or blossom-end rot fruit was reduced in tomato and melon. In addition, good quality of products can be expected, because not only poor fruit bearing and inferior fruit are reduced, but also occurrence of sunscald fruit is prevented.

Problems in cultivation under rain shelters

The most important problem is to secure source of water supply. The cultivation under rain shelters often requires irrigation facilities, because crops sheltered from rain are cultivated during the season with relatively high temperature, so that they consume a large amount of water.

When water is not available sufficiently, the crops suffer from water shortage, and the merit of this type of cultivation is nullified. In securing water source, attention must be paid to the contamination of water with pathogenic microorganisms in the soil, because irrigation water contaminated with pathogens causes soil-born diseases. As a large amount of water is transpired by crops, watering is an important task. The method of watering, whether good or not, determines the result of the cultivation.

It is desirable to construct rain shelters at a cost as low as possible. Variations of rain shelters from quite simple structure (Plate 3) to relatively durable structure by the use of steel frames (Plate 4) are observed in Japan. In areas with strong wind, strong structure is needed. The higher the strength, the more the cost, so that it is important to determine the appropriate strength. On the other hand, surrounding the rain shelter houses with windbreak net is considerably effective in protecting the houses against strong wind.

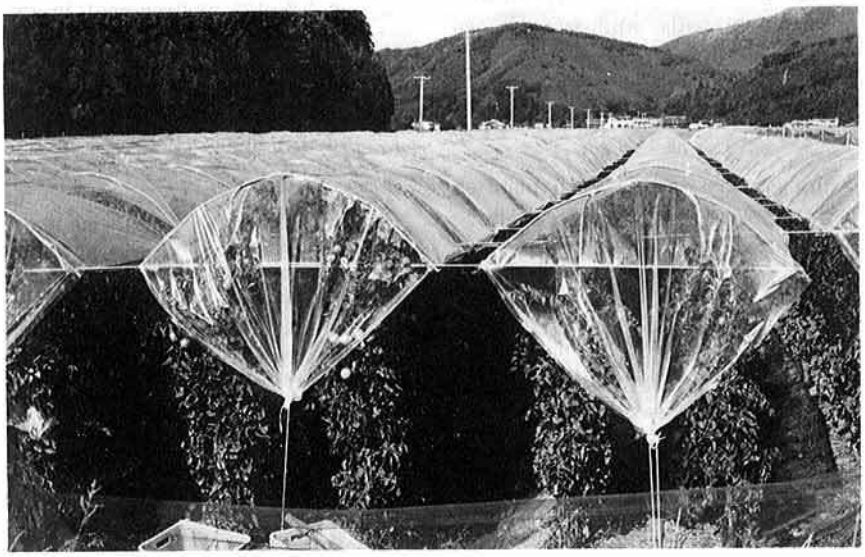

Plate 3. Simple rain shelters (Low cost, but not tolerant to wind)

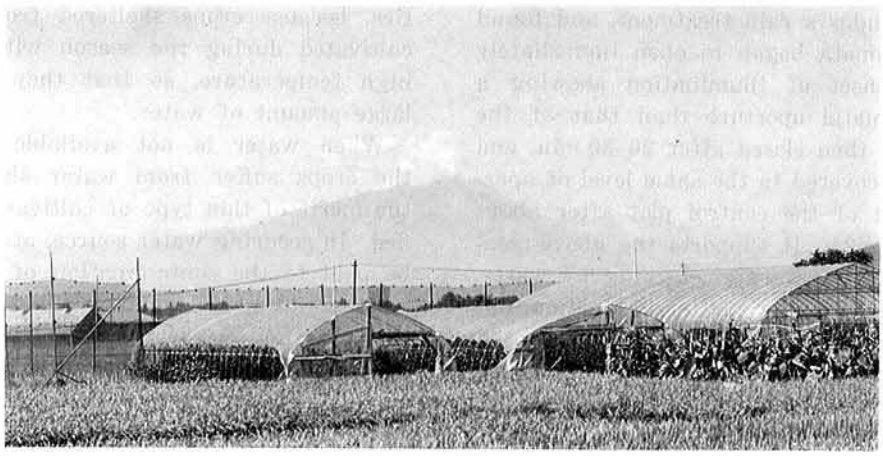

Plate 4. Rain shelter houses with pipe frame

The rain shelter houses are designed to achieve good ventilation in order to avoid temperature rise inside the houses. High temperature inside the houses causes troubles such as occurrence of poor fruit bearing or damaged fruit, particularly puffy fruit of tomato. Thus, in addition to the well-ventilating structure of the houses, attention must be paid to cultural management so as to prevent crop damage by high temperature.

Year-round culture is considered for efficient utilization of rain shelter houses. In such a case, accumulation of residual fertilizers is apt to occur in soils, and sometimes it causes crop damage by concentrated salts.

Summary

Rain shelter houses are roofed with plastic film and other waterproof materials to shelter crops from rain. The houses are effective in reducing crop damage caused by diseases and insect pests, in promoting crop growth, and in achieving stable production of high quality vegetables. Thus, the use of rain shelter houses is highly effective measures in vegetable production. Particularly in heavy rain areas, its effectiveness is quite high. However, the cultivation under rain shelter houses involves several problems. It induces higher cost of production as compared with the open-field cultivation, and the houses are liable to be damaged by strong wind. Furthermore, highly advanced techniques in watering and fertilizer application are required for the success of the cultivation under rain shelter houses.

References

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