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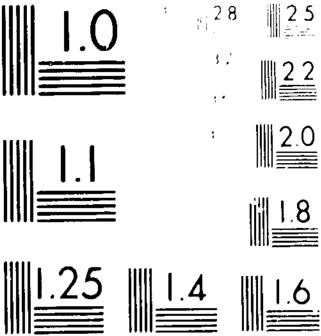
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THE CURRENT SITUATION OF APPLICATIONS OF PLASTICS IN HORTICULTURE IN JAPAN (THE LATEST DEVELOPMENT AND THE TRENDS)*

by

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Abstract

Approximately thirty years have passed since plastic films were introduced to Japan. During this period, A protected cultivation has much contributed towards rearing of leading farmers while bringing varieties in peoples' daily lives.

An annual increase rate of protected cultivation areas before the so-called "oil shock" in 1973 was on remarkable two figures. Even after the "oil shock", it still was on increase although such increase became little slack.

According to the statistics for the year 1979, total areas of glasshouses and plastic houses reached 32,000 ha. As for the kinds of crops grown, vegetables occupied 25,000 ha or 78%, flowers did 3,000 ha which are 9%, and fruit trees 4,000 ha which are 13% of a little acreage. In the last one or two years, an increase of protected cultivation areas for fruit trees has become very noticeable.

Two "oil shock" occurred in 1973 and 1980 triggered a move to save oil as heating fuel and also accelerated a development of substitutive fuel, both are the most important subjects of the study in protected cultivation. It contains usage of natural energies, seeking of substitutive energies, an alteration of growing period, a sharing of cultivation areas, an expansion of kinds of the crops etc. Among of them, particularly for an expansion of kinds in case of vegetables, an introduction of hardy vegetables is worth considering.

A protected cultivation which currently occupies about 30% and 70% respectively of the total production of vegetables and flowers would pay an important roll still further an increase, of a protected cultivation areas, even though it may be slight, can be attained.

Introduction

As shown in Table 1, the total areas of the glasshouses and the plastic houses in 1979 were 31,730 ha. 30,229 ha, equivalent to 95% of the total is for the plastic houses, and during the last 15 years, the glasshouses increased by 2.9 times while the plastic houses increased as much as 6.9 times. Looking it from a classification of kinds of crops, vegetables are by 6.2 times, flowers 4.9 times and fruit trees 10.2 times. Mentioning further, kinds of crops cultivated in the plastic houses are consisted of vegetables which are 82%, flowers which are 7% and fruit trees which are 11%.

In our country, majority of the covering material for the plastic houses are made of polyvinyl chloride film and not much polyethylene film. Recent increase of the plastic houses is especially remarkable for a growth of fruit trees, particularly of mandarine oranges. Secondly, in 1979 tunnel covered areas were 55,115 ha, of which 53,374 ha were for vegetables, 542 ha for flowers, 557 ha for sweet potatoes and 660 ha for potatoes. Also mulched areas were 105,223 ha in total, of which 22,902 ha were located inside of glasshouses and plastic houses, 35,971 ha were inside of tunnels and 46,360 ha were in the open fields (Tables 2 and 3).

A protected cultivation in Japan that are developed under such a background faces both saving of oil and establishment of oilless cultivation rather urgently. Therefore, I would like to explain the future problems focusing on these aspects.

Energy saving methods

The problems may be classified as follows:
Basically this matter is devided into two categories--one is a oilless method and another is an oil-saving method. These divisions are made on which has the heavier weight on possibilities. Therefore, even if the method is classified into an oil-saving category, it can be treated as a oilless category depending on the application of methods.

1. Oilless heating
   - A utilization of natural energy(subterranean heat, hot spring etc)
   - A research for substitutional combustibles(waste oil, saw dust, rice-hulls etc)
   - A utilization of exhaust heat from factories and power plants
   - A utilization of dispositional heat from urban wastes
   - An alteration of growing period
   - An introduction of hardy crops
2. Saving of fuel oil
   - An adoption of multi-layered covering method
   - An adoption of fixed double layer covering method
   - A method of thermal exchange in soil
   - A collection of solar energy
   - A control of atomospheric temperature during night time
   - An improvement on efficiency of boilers
   - An alteration of growing period
   - An introduction of hardy crops

Among above methods, a utilization of subterranean heat and hot springs is being under development. It is necessary to consider removal of harmful minerals contained in, otherwise they might contaminate neighbouring fields. This means that harmful minerals contained in warm water used in heating up glasshouses and plastic houses which is discharged out may be deposited in the fields. As for a utilization of waste feat generated in factories and power plants, it appears to have remote possibilities to operate a protected cultivation right next to such factories and power plants, because acquiring spaces is rather difficult in our country. There are a few attempts for the utilization of dispositional heat from waste oil and urban wastes, but it will not last unless constant supplies of materials are guranteed to be secured.

At below some additional explanation shall be described on some methods of possibilities in our country.

a. Multi-layered covering method

There are many cases of installation with a double layered thermal screen. Materials used for these covers are made of, starting with polyvinyl chloride film, polyethelene film. As a chief material, but non-woven mesh and polyvinyl chloride agricultural film blended with aluminium are also used. For the utilization of this method, it does not require too much of a cost, but creates shortcomings such as reducing penetrative sun rays and making interiors over-humidified, because of multi-layered covers.

b. Fixed double layer covering

This method is to stretch a covering material on outer surface and at the same time fix a covering material inside of glasshouses and plastic houses, thus creating an insulation layer in between in order to prevent from loosing heat.

c. Thermal exchange in soil

Air warmed up in glasshouses and plastic houses can be stored in plastic pipes which are buried in the ground, which can be recirculated within glasshouses and plastic houses to prevent temperature in houses from dropping down when they start to cool off during night time. When sunshine becomes less in winter seasons whereby a suitable temperature for the growth of the crops is unattainable, it cannot be helped but to use hot air heater to raise temperature for hardy crops such as strawberries, a suitable growth temperature during winter seasons can be maintained by this method without burning oil. Also a method used for maintaining temperature for a cultivation of mandarine orange in houses adopts variation of this system.

When this method was introduced at first, it was feared that it may become over-humidified in the housing facilities. But it became clear that this can be prevented by forcing ventilation in the mornings. A shortcoming of this method is; first--high cost for the materials and secondary --because a construction work is rather extensive, it is advisable to perform an installation work at the time of initial construction of glasshouses and plastic houses.

The tested example in the central Japan (Kanagawa prefecture) shows that, if a cost of hot air heating is set as 100, a cost of this method is only 22.3%.

d. Controlling atomospheric temperature during night time

This method is to control interior temperature of the housing for a cultivation of fruit vegetables. Based on the result of the test, it is advisable to lower a temperature in a latter half of a night than the one in a first half of a night, in order to make assimilated substances produced current during night time.

e. Alteration of growing period

With this method, it is aimed to save a consumption of fuel by shortening a heating period and avoiding heating during peak of the severest cold seasons. Table 3 shows a calculating of heating degree-hour for the growing of cucumbers and tomatoes, classified by locations, growing periods, heating periods, and designated degrees of night temperature. According to this table, the period which requires most consumption of fuel is, natural to say, for a forced heating during the coldest season. Compared with this, a growing to Autumn requires 60%, and, if a semi-forcing is used it requires merely 20% to 40%. Thus, if there is not much problem exists from the point of profitability, switching from a forced heating to a semi-forced heating or an alteration of a growing period to a growing in Autumn becomes an effective counter-measure to the saving of fuel.

In fact, in southern Japan (Miyazaki prefecture) a forced growing for tomatoes are much reduced and a combination of Autumn cucumbers and a semi-forced growing of tomatoes are replacing it.

f. Introduction of hardy crops

In cultivation of flowers, there are example such as switching from carnations to sweet peas which has more resistibility to lower temperature, or cultivation of potted flowers after cyclamen.

Here I would like to discuss possibilities of such methods in case of vegetables.

It must be studied carefully about its profitability, when some new hardy vegetables are to be cultivated in plastic houses for shipment to the markets.

Gross profits for various vegetables grown by a protected cultivation are shown in Table 4. From this Table, lettuces show the least amount of gross sales amount which is ¥48,100 per a. With tomatoes, aubergines and cucumbers gross sales amount are ¥210,000 which differ greatly from the same of lettuces. This means lettuces do not require as much production cost as fruit vegetables because lettuces are hardy vegetables.

From this aspect of economical efficiency, crops which are not currently grown in plastic houses but could be introduced as crops to be cultivated in plastic houses in future are onions, young corns, edible podded peas, garlics, garland chrysanthemums, garden peas, young broad beans and a kind of Welsh onions(Allium fistulosum L. var.caespitosum Makino) .

It needs to be checked on profitabilities in actual production, however. Above mentioned vegetables have had a rarher small areas for growing till now. If the areas are expanded, marketing quantities will be naturally increased, and the prices for them will certainly be dropped accordingly. And also a consumption structure of areas where such vegetables are to be sold needs to be checked, because if they do not agree with consumers' diet taste, enlargement of consumption can not be expected. From the aspect of cultivation, requirement of labour for production is to be checked also, because if it requires extraordinary amount of labour, productivity per labour will drop no matter how high a profitability is.

Sharing of production areas

Due to a steep rise of oil prices, produced crops from a subtropical zone such as Okinawa where heating is not totally required are shipped to the mainland of Japan, and a cultivation of crops in the mainland becomes economically unstable.

An average temperature in Okinawa during winter season is approximately 18 degrees centigrade, and requires no fuel for heating. Thus, a cultivation of crops is much profitable and this is the very present situation.

Some kinds of vegetables are forbidden from transshipping to other areas due to existence of vermin, but if a perfect extermination or preventive methods for such vermin are performed and products are freely shipped to the mainland, there will be bound to yield crops that are not financially paid to grow in the mainland.

Therefore, it is quite feasible to say that phenomene of alloting production areas may occur.

Conclusion

Comparing a consumption amount of vegetables for one day by each countries in 1975, according to the statistics by FAO, Italy ranks at the top by consuming 427g, and Portugal comes the second with 358g, Spain is the third with 353g, New Zealand the fourth with 351g, and Japan is the fifth with 348g. It showa Japan as one of the leading vegetable consumers in the world, however, an annual consumption amount per one person in Japan was at its peak in 1968 with 124.9 Kg and gradually on decrease ever since. Therefore, it is very unlikely that the consumption of vegetables will suddenly increase in our country.

However, as Japan extends latitudinally long from North to South, she can introduce various types of cultivational methods and considering remarkable technological developments both for kinds of crops and techniques of cultivation that she is making, it may be considered possible that the continuous supplies of horticultural crops through out the year without interruption plus demands for new kinds of their crops might enlarge consumptions.

Therefore, the horticulture in a plastic house would pay an important roll further.

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Table 1 Recent evolution of protected cultivation for horticurtural crops production (1979) 1 (unit:ha)

Crops	Glsshouses			Plastic houses			Total		
	Area	1979/ 1965 ratio	'79/ '77 ratio	Area	'79/ '65 ratio	'79/ '77 ratio	Area	'79/ '65 ratio	'79 '77 ratio
Vegetables	635.8	344	133	24,201.0	630	114	24,836.8	617	114
Flowers	672.7	334	106	2,097.4	582	118	2,770.1	493	115
Fruits	191.9	143	114	3,930.8	1,151	142	4,122.7	1,018	140
Sweet potatoes	-	-	-	-	-	-	-	-	-
Pota oes	-	-	-	-	-	-	-	-	-
Total	1,500.4			30,229.2			31,729.6		

Table 2 Recent evolution of protected cultivation for horticultural crops production (1979) [1] (unit:ha)

Crops	Tunnels					Mulches				
	in glass-houses and plastic houses	in the fields	Total	1979/ 1965 ratio	'79/ '77 ratio	in glass-houses	in tunnels	in the fields	Total	'79 '77 ratio
Vegetables	9,996	43,378	53,374	217	104	22,878	33,686	33,684	90,248	101
Flowers	237	287	524	246	120	-	-	*	-	-
Fruits	-	-	-	-	-	-	-	-	-	-
Sweet potatoes	1	556	557	-	-	14	1,606	8,536	10,156	125
Potatoes	1	659	660	-	-	10	679	4,140	4,829	114
Total	10,235	44,880	55,115			22,902	35,971	46,360	105,233	

Table 3 Heating degree-hour at the cultivation period in cucumbers and tomatoes (Kobayashi, 1980)

Crops	Locality	Cultivation period	Harvesting season	Heating season	Heating* degree-hour 10^3°C·hr	Ratio** %
Cucumbers	Central of Japan	Forcing	Mar.—June	Jan.—May	14.4	100
		Semi-forcing	Apr.—June	Mar.—May	5.1	35.5
	Southern	Autumn	Nov.—Jan.	Nov.—Jan.	7.2	55.9
		Forcing	Jan.—May	Nov.—Apr.	12.8	100
		Semi-forcing	Mar.—May	Feb.—Apr.	5.7	44.1
Tomatoes	Central	Forcing	Jan.—June	Nov.—Apr.	14.7	100
		Semi-forcing	May—July	Mar.—Apr.	3.2	21.6
	Southern	Autumn	Oct.—Jan.	Nov.—Jan.	5.8	58.8
		Forcing	Feb.—May	Nov.—Apr.	9.9	100
		Semi-forcing	Mar.—May	Feb.—Apr.	4.1	41.[illegible]

Note * Night temperature of cucumbers growing was set at 13°C, that of tomatoes was set at 10°C

** Comparison of degree-hour ratio in cultivation period as 100 forcing growing at the same place

Table 4 Possibility of introduction of hardy vegetables to glasshouses and plastic houses(Oda and Kageyama,1980)

Crops	Prices in winter market ¥/Kg	Yield per a Kg/a	Gross sales amount ¥ 10/a	Factors			Com-patibility	
				Productivity	Min. temp. for growth	Opt. temp. for growth		
Radish	46	541.8	25.1	-	*	**	-	
Cabbage	72	522.6	37.8	-	**	**	-	
Chinese cabbage	27	602.4	16.4	-	*	**	-	
Water melon	481	317.1	152.5	**	-	-	-	
Taro	170	194.7	33.1	-	**	-	-	
Onion	92	543.0	50.1	*	**	**	*	#
Young corn	419	164.7	69.0	*	*	*	*	#
Cucumber	279	805.1	224.6	**	*	*	*	
Welsh onion	125	339.3	42.4	-	**	**	-	
Carrot	70	331.2	23.3	-	*	**	-	
Spinach	154	222.7	34.3	-	**	**	-	
Aubergine	294	740.1	217.6	**	-	-	*	
Tomato	275	719.1	197.8	**	**	*	*	
Lettuce	250	792.4	48.1	*	**	**	*	
Pumpkin	282	394.8	111.3	**	**	*	*	
Edible burdock	162	258.0	41.8	-	*	*	-	
Strawberry	1,139	185.6	211.4	**	*	*	*	
Young kidney bean	868	116.3	100.9	**	*	**	*	
Edible podded pea	718	119.0	85.4	**	**	**	**	#
Turnip	61	391.2	23.9	-	*	**	-	
Garden asparagus	1,408	72.8	103.0	**	*	**	*	
Cauliflower	134	276.9	37.1	-	*	*	-	
Pimento	376	935.2	351.6	**	*	-	-	
Garlic	553	136.5	75.5	**	**	**	**	#
Garland chrysanthemum	229	244.7	56.0	*	**	**	*	#
Garden pea	550	106.7	58.3	*	**	**	*	#
Young broad bean	1,758	117.9	207.3	**	**	**	**	#
Allium fistulosum L.var.caespitosum Makino	239	249.9	59.7	*	**	**	*	#

Note: Productivity ** 70 10 ¥/a, * 48 10 -69.9 10 ¥/a, - 47.9 10 ¥/a

Min.temp.for growth ** 5 C, * 5-10 C, - 10 C

Opt.temp.for growth ** 15-20 C, * 20-25 C, - 25-30 C

Possibility of introduction # : Crops which are not currently grown in plastic houses but could be introduced as crops to be cultivated in plastic houses in future