JARQ 30, 181–188 (1996)

Effect of Combination of Reflective Film Mulching and Shading Treatments on the Growth of Carnation

Takashi YAMAGUCHI*[1], Akiko ITO*[2] and Masaji KOSHIOKA*[3]

Department of Floriculture, National Research Institute of Vegetables, Ornamental Plants and Tea (Ano, Age, Mie, 514-23 Japan)

Abstract

The purpose of this paper is to investigate the effect of a combination of reflective film mulching (RFM) and shading treatments on the growth of carnation at high temperatures. Combination of RFM and shading treatments increased plant height, length of primary and secondary branches of carnation seedling. Moreover RFM prolonged the harvest period by advancing flowering by approximately 1 month, which resulted in the increase of the cut flower yield. The number of cut flowers harvested in the first 3 months of the harvest period increased from 33 to 107% compared to the non-mulched plots (over 2 years), and total yield (harvested until May in the next year) increased by 15%. The optimum results were obtained when the shading period was limited to 2 months in midsummer, and a longer shading period decreased the yield as a result of reduced solar radiation. The beneficial effects of RFM on carnation growth were revealed, namely lowering of soil temperature in midsummer and supply of solar radiation to the low to middle leaves from the reflective surface.

Discipline: Horticulture
Additional key words: cut flower, high temperature, yield

Introduction

The optimum temperature for carnation growth is reported to range for 15 to 20°C which is relatively low among horticultural crops[1,11]. In the warmer part of the country like in southwestern Japan, the temperature inside greenhouses sometimes exceeds 40°C. To reduce the high temperature stress, seedlings were planted in early summer to grow throughout the hot season at the young and vigorous stage. Cooling system is also effective, but air conditioning is not practical due to the high cost. Shading can be used, and it has been reported to be effective in the cases of spinach[4] and bell pepper[6]. However, shading reduces the solar radiation which leads to light starvation inside the plant community, and decreases the number of lateral shoots[3] and cut flower yield[9] in carnation.

We considered to utilize reflective film mulching (RFM) to compensate for the light shortage caused by the shading treatment. RFM has been extensively studied for the control of diseases and insect pests in vegetable crops such as tomato[8], cucumber[7], pumpkin[7], lettuce[14,15], bean[2] and *Phaseolus*[12]. RFM also has been shown to lower the soil temperature and increase photosynthesis, resulting in high yields and high quality. In the case of cultivation of glasshouse rose during midwinter, covering of the northern wall with a reflective layer alleviated the decrease of cut flower yield due to the shortage of incident solar radiation. For carnation growing, Yamaguchi[13] reported that RFM increased the yield by 30% compared with bare soil.

Although no reports are available, several studies indicated the effectiveness of a combination of RFM and shading on carnation growth. The purpose of this paper is to investigate how the combination of RFM and shading treatments affects the yield and quality of carnation cultivated under standard practices in Japan.

Present address:
*[1] Fukkaen Nursery & Bulb CO., LTD. (2167 Kitayama, Misato, Yokkaichi, Mie, 510-11 Japan)
*[2] Department of Pomology, Fruit Tree Research Station (Tsukuba, Ibaraki, 305 Japan)
*[3] To whom correspondence should be addressed.

Materials and methods

The experiments were carried out in a greenhouse located at the National Research Institute of Vegetables, Ornamental Plants and Tea (longitude 135°E, latitude 35°N). The temperature inside the greenhouse was maintained above 15°C. Carnation rooted cuttings were planted in 90 cm wide benches filled with a mixture of soil and compost disinfected with dazomet in advance. Fertilizer was applied in the ratio of 3.5(N)-3.0(P)-3.5(K)-1.1(Mg) kg/100 m^2. Liquid fertilizer consisting of N at 100 ppm was applied once a week after planting. Plots consisted of 6 rows, and rows were 10 cm apart from each other, except for the middle 2 rows which were 30 cm apart. Plant spacing was 20 cm within the row (36.5 plants/m^2), unless otherwise stated. Plants were watered as required. Flowers were harvested 2 times weekly at the 10th node level from the neck at full bloom. Length, weight, stem diameter and drooping grade of stem[13] were determined, and the flowers were graded according to the commercial practice in Japan. Stem diameter was measured in the middle of the 5th internode from the neck node. In all the experiments, aluminized polyester film was used for mulching.

Experiment 1: Separate effect of RFM and shading treatments on carnation growth

Rooted cuttings of carnation cv. Tanga were planted on June 27, 1990 in 2.0 m^2 plots (1 replication). They were pinched at the 5th node and trained to hold 4 or 5 lateral shoots per plant. Subsequently vigorous branches were pinched again. Five treatments were included in the experiment: (1) no-mulching (bare soil) and no-shading; control, (2) mulching with RFM (PolyShine Cloth mulch, Hitachi condenser KK, Japan) and no-shading; RFM, (3) mulching with RFM (PolyShine Cloth mulch) and shading during the summer season; RFM + SDS, (4) mulching with RFM (PolyShine Cloth mulch) and shading throughout the experiment; RFM + S, and (5) no-mulching and shading throughout the experiment; NM + S. Shading was applied using a wooden frame (1.5 m(H) × 1.2 m(W) × 2.2 m(L)) covered with a cheese cloth (white cheese cloth #200, Kurare KK, Japan) whose permeability to photosynthetically active radiation (PAR) was 84%. Plants of plot 3 were shaded between July 26 and September 26 and those of plots 4 and 5 between July 26 and December 31.

Plant height, length and number of primary and secondary branches were recorded on August 26. Number and quality of the cut flowers were recorded from the onset of flowering until December 31 approximately for 3 months, while flowers on the primary branches were harvested according to standard cultural practices.

Experiment 2: Effect of reflective surface of mulch on expansion of plant community and growth at early stage

The purpose here was to determine how the reflective film affected carnation growth by modifying the environmental factors. We used a PolyShine Cloth (Hitachi condenser KK, Japan) as a reflective film for mulching and a white cheese cloth (cheese cloth #200, Kurare KK, Japan) for shading.

(1) Plant community at the beginning of flowering stage

Rooted cuttings of cv. Tanga were planted on July 18, 1987 in 4.9 m^2 plots (1 replication). They were pinched at the 5th node and trained to hold 4 or 5 lateral shoots per plant. Subsequently vigorous branches were pinched again. Two treatments were included in this experiment: (1) no-mulching (bare soil); control, and (2) mulching with the reflective film; RFM.

Number and cumulative length of primary branches longer than 30 cm were recorded on December 8 and the plant community was measured by the stratified clipping method[5] on December 9. Number of cut flowers was recorded from the onset of flowering until February 1, 1988 (for approximately 4 months).

(2) Daily soil temperature fluctuations under high air temperature

Rooted cuttings of cv. Scania were planted on July 18, 1987 in 4.9 m^2 plots (1 replication). They were pinched at the 5th node and trained to hold 4 or 5 lateral shoots per plant. Subsequently vigorous branches were pinched again. Two treatments were included in this experiment: (1) no-mulching (bare soil); control, and (2) mulching with the reflective film; RFM.

Soil temperature was monitored every 2 h at 0.5 cm and 5 cm depths between August 5 and August 14 for each treatment.

Experiment 3: Effect of planting density on carnation growth

The experiment was designed to determine the optimum planting density for RFM. Rooted cuttings of cv. Nora and cv. Barbara were planted on June 30, 1993 in 1.6 m^2 plots (1 replication) at the following densities in 4 treatments: (1) standard density (37.5 plants/m^2) without mulching; control, (2) standard density (37.5 plants/m^2) with reflective film mulching (PolyShine Cloth mulch, Hitachi condenser KK, Japan); SCD + RFM, (3) high planting density (44.4 plants/m^2) with RFM; CPD + RFM, and (4) low planting density (22.2 plants/m^2) + RFM; SPD + RFM. Then they were pinched at the 5th node and trained to hold 4 or 5 lateral shoots. Since this experiment was carried out during an unusually cool summer, shading treatments were omitted due to the low temperature and insufficient solar radiation. The average values of temperature between July 1 and August 10, daily integrated solar radiation and daily integrated period of sunshine were 23.4°C, 10.0 MJ/m^2 and 5.0 h in 1993, and 26.1°C, 16.2 MJ/m^2 and 8.2 h in 1992, respectively.

Plant height, number of unfolded leaves and cumulative length of primary and secondary branches were recorded on August 9 and on September 18. Yield and quality of the cut flowers were recorded from the first flowering until the end of the experiment (May 10, 1994).

Results

Experiment 1: Separate effect of RFM and shading treatments on carnation growth

Reflective film mulching clearly promoted carnation growth 1 month after the treatment (Table 1). In the RFM plots the plant height, length of primary branches, and length and number of secondary branches increased. Shading treatment combined with RFM during the hot season resulted in an additional beneficial effect on plant height, length of primary and secondary branches, whereas the number of secondary branches decreased .

Cut flower yield decreased in the order of RFM, RFM + SDS, RFM + S, control and NM + S plots (Table 2). Production in the RFM, RFM + SDS, RFM + S and NM + S plots was 2.51, 2.15, 2.11 and 0.62 times higher than that in the control, respectively. The difference in flower production was apparently due to the total amount of solar radiation. Cut flower weight seemed to be influenced in the same way as cut flower yield. Cut flower length

Table 1. Carnation growth response to combination of mulching with reflective film (RFM) and shading treatments in midsummer

Treatment	Plant height (cm)	Primary branch		Secondary branch	
		Length (cm)	Number (/m^2)	Length (cm)	Number (/m^2)
Control	42.5	34.5	53.8	11.9	151
RFM	58.3	49.6	90.0	14.7	229
RFM + SDS	65.5	52.3	85.1	16.2	189
RFM + S	65.5	52.3	85.1	16.2	189
NM + S	43.4	36.6	47.5	11.9	104

Data were collected on August 26, 1990.

Table 2. Effects of reflective film mulching (RFM) and shading treatments on yield and quality of carnation cut flowers

Treatment	Number of cut flowers (/m^2)	Percentage grade of flower weight[a)]			Percentage grade of flower length[b)]			Percentage grade of drooping[c)]		
		M	L	XL	M	L	XL	M	L	XL
Control	32.5	46.2	53.8	0	46.2	53.8	0	24.0	60.0	16.0
RFM	82.5	56.1	43.9	0	22.8	77.2	0	6.3	64.1	29.7
RFM + SDS	70.0	48.3	51.7	0	3.6	94.6	1.9	1.9	43.6	54.6
RFM + S	68.5	68.9	32.1	0	13.3	84.8	1.9	7.9	47.0	45.1
NM + S	20.1	43.8	56.2	0	–	–	–	18.9	62.2	18.9

Data were collected for the flowers harvested from the onset of flowering (early October) to December 31, 1990.
a): M (medium); less than 26 g, L (large); 26 to 35 g, XL (extra large); more than 35 g.
b): M (medium); less than 66 cm, L (large); 66 to 80 cm, XL (extra large); more than 80 cm.
c): EX (high quality); less than 11°, M (medium); 11° to 20°, IF (low quality); more than 20°.

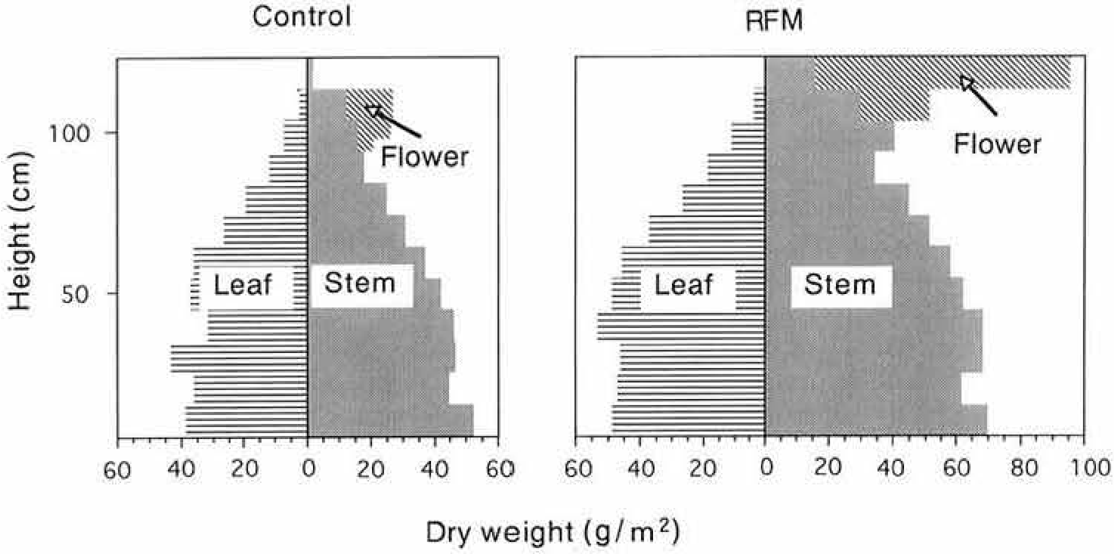

Fig. 1. Effect of reflective film mulching (RFM) on size of plant community of cv. Tanga at the onset of flowering
Measurement was conducted on December 9, 1987 by applying the stratified clipping method.

decreased in the order of RFM + SDS, RFM, RFM + S, control and NM + S plots. Classification by drooping grade was in the descending order of RFM, RFM + S, RFM + SDS, control and NM + S plots.

Experiment 2: Effect of reflective surface of mulch on the plant community and the initial stage of growth

(1) Plant community at the beginning of flowering stage

RFM promoted the early growth of carnation. Average number of primary branches was 5.2 in the control and 6.0 in RFM, and cumulative length of branches in RFM was 37% longer than that in the control (RFM, 560 ± 117; control, 408 ± 64 cm, respectively). Besides, since RFM subsequently promoted flowering, the cut flower yield in the RFM plots also increased by 68% (RFM, 162.5; the control, 97.0/m^2, respectively). Larger plant communities were obtained in the RFM plots (Fig. 1) on December 9. Leaf area index (LAI) and dry matter production in the RFM plots increased by 40.4% and 58.7% of the values of the control.

(2) Daily soil temperature fluctuations under high air temperature

As shown in Fig. 2, the soil temperature both at 0.5 cm and 5 cm depths under RFM was lower during daytime than that under bare soil whereas higher during the night. RFM mitigated the daily fluctuations of soil temperature and its effect was more appreciable near the surface.

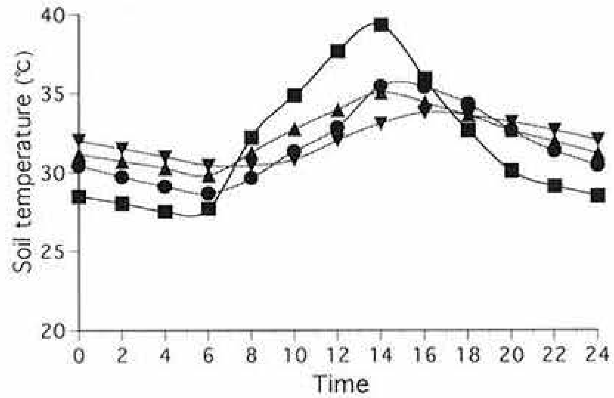

Fig. 2. Daily soil temperature fluctuations in summer season with (▲ ▼) or without (■ ●) reflective film mulching
Soil temperature was monitored every 2 h at 0.5 cm (■ ▲) and 5 cm (● ▼) between August 5 and 14, 1987.

Experiment 3: Effect of planting density on carnation growth

Cumulative length of the secondary branches of 'Nora' was influenced by the treatments (Table 3); at 71 days after planting the values were in the order of NM (control) < CPD + RFM < SPD + RFM = SCD + RFM plots. 'Barbara' was not affected by the treatments. No difference in any other characteristics was observed among the treatments. Fig. 3 shows the seasonal changes in the number of cut

Table 3. Effect of planting density and reflective film mulching (RFM) treatment on the early growth of carnation

Cultivar	Treatment	Plant height (cm)	Primary branch Length[a)] (cm)	Primary branch Number (/m^2)	Secondary branch Length[a)] (cm)
Nora	Control	42.1	103.0	10.4	3.3
	SCD + RFM	42.5	108.5	10.8	23.3
	CPD + RFM	46.9	123.2	10.7	10.5
	SPD + RFM	42.8	126.2	10.7	23.4
Barbara	Control	32.8	94.1	9.2	4.3
	SCD + RFM	32.9	104.0	9.5	13.7
	CPD + RFM	39.2	104.0	9.6	15.8
	SPD + RFM	32.7	109.3	9.7	14.9

Data were collected on September 18, 1993.
a): Cumulative length of branches per seedling.

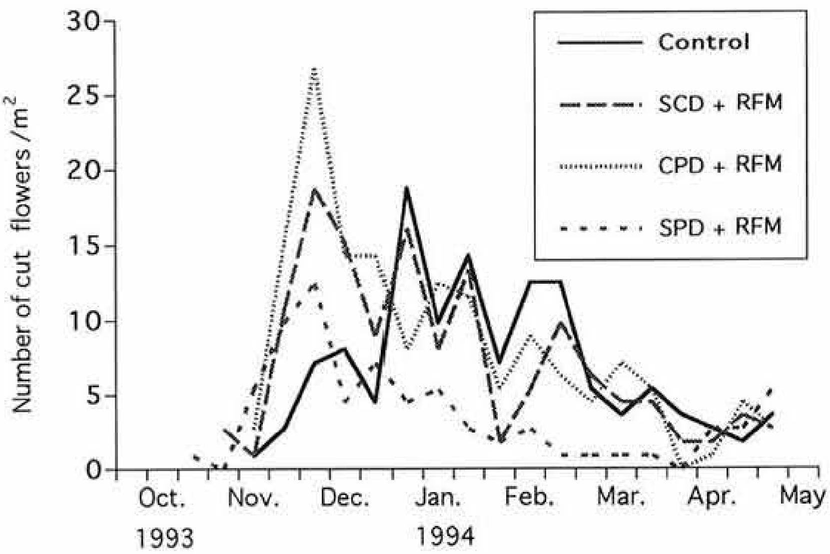

Fig. 3. Effect of planting density and reflective film mulching on the seasonal change of yield in carnation cv. Barbara
Plots were as follows: control (without mulching, 37.5 seedlings/m^2), SCD + RFM (mulching, 37.5 seedlings/m^2), CPD + RFM (mulching, 44.4 seedlings/m^2) and SPD + RFM (mulching, 22.2 seedlings/m^2). Data were collected from the onset of flowering in 1993 until May 10, 1994.

flowers of cv. Barbara summed up every 10 days from the onset of flowering until the end of the experiment. Seasonal patterns were different between the RFM plots and the control (no-mulching) for both cultivars; the highest points of 3 RFMs were observed at a similar position, almost 1 month earlier than in NM. Total yields increased in the order of NM (control), SPD + RFM, SCD + RFM and CPD + RFM plots (Table 4). On the other hand, cut flower yield values per plant in the NM, SPD + RFM, SCD + RFM and CPD + RFM plots were 3.45, 5.40, 3.57 and 4.14 in Nora and 3.44, 4.50, 3.45 and 3.44 in Barbara, respectively. The yield of the SPD + RFM plot was the highest and that of NM was the lowest for both cultivars. Cut flower number per seedling may be related to the total amount of solar radiation supplied to the seedlings although we did not grade the yield of the SCD + RFM and SPD + RFM plots in this order. The flowers were divided into 2 groups according to their harvest earliness; harvested 1) within or 2) out of the planted year. In both cultivars the crowded plot

Table 4. Effect of planting density and reflective film mulching (RFM) treatment on the yield and quality of carnation cut flowers

Harvest earliness	Cultivar	Treatment	Number of cut flowers (/m²)	Percentage grade of flower weight[a)]			Percentage grade of flower length[b)]			Percentage grade of drooping[c)]		
				M	L	XL	M	L	XL	M	L	XL
Early[d)]	Nora	Control	45.5	0	73.4	26.6	2.0	17.6	80.4	5.9	47.0	47.0
		SCD+RFM	74.2	6.5	80.7	12.8	4.9	21.7	73.5	0	45.8	54.2
		CPD+RFM	109.8	2.6	85.2	12.2	0.8	7.3	91.9	5.7	34.4	59.8
		SPD+RFM	54.1	3.9	54.9	41.2	0	21.1	78.9	9.6	42.3	48.1
	Barbara	Control	23.8	4.6	77.3	18.1	7.6	42.4	50.0	30.7	61.3	8.0
		SCD+RFM	61.6	21.3	73.7	5.0	25.0	68.7	6.3	23.9	71.4	4.7
		CPD+RFM	85.4	20.3	74.4	5.4	4.9	46.4	48.5	13.6	64.2	22.2
		SPD+RFM	56.3	14.7	75.5	9.8	2.3	53.3	44.4	33.4	53.3	13.3
Late[d)]	Nora	Control	83.9	1.1	27.8	71.2	2.1	16.0	81.9	45.8	44.7	9.5
		SCD+RFM	59.8	1.5	36.1	62.4	0	34.3	65.7	56.9	30.4	12.7
		CPD+RFM	74.1	2.4	69.8	27.8	0	21.7	78.3	30.2	62.8	7.0
		SPD+RFM	65.6	0	34.8	65.2	14.3	43.3	42.4	41.5	50.8	4.7
	Barbara	Control	105.2	0.8	14.1	85.2	5.2	53.9	40.9	53.4	43.1	3.5
		SCD+RFM	85.6	7.7	41.2	51.1	13.6	64.0	22.4	54.1	39.1	6.8
		CPD+RFM	90.6	2.9	45.0	52.1	10.4	58.6	31.0	48.8	46.6	4.6
		SPD+RFM	43.8	0	15.1	84.9	20.1	48.4	31.5	62.8	34.2	3.0

Data were collected for the flowers harvested from the onset of flowering (early October, 1993) to May 10, 1994.
Cut flowers were classified as follows:
a): M (medium); less than 26 g, L (large); 26 to 35 g, XL (extra large); more than 35 g.
b): M (medium); less than 61 cm, L (large); 61 to 70 cm, XL (extra large); more than 70 cm.
c): EX (high quality); less than 11°, M (medium); 11° to 20°, IF (low quality); more than 20°.
d): Flowers were divided according to the earliness at harvest in 1993 (early) or in 1994 (late), respectively.

tended to produce more drooping flowers, leading to the increase of flowers with low quality (Table 4). In the flowers of group 1 and cv. Nora drooping was more conspicuous than in those of group 2 and cv. Barbara, respectively. Furthermore, the CPD plot produced longer flowers than the other plots without weight increase, which indicated that the plants in the CPD plot grew as turions.

Discussion

The effect of the combination of RFM and shading treatments was evident in the increase of carnation yield. The number of flowers harvested in the first 3 months increased by RFM by 44 and 154% in Exp. 1 and Exp. 2(1), respectively, and by the combination of RFM and shading treatments by 33 and 115%, respectively compared with the control (no-mulching). However, the increase in the number of total flowers by RFM was only 15% compared with the no-mulching treatment throughout the experiment (Exp. 3). Exp. 3 also showed that the seasonal peaks of yield with RFM occurred approximately 1 month earlier than in the case of NM. These findings indicate that the increase in the yield of RFM (with or without shading) was mainly due to earlier flower development and subsequent earlier yield and prolonged harvest period.

Exp. 1 showed that the effect of RFM and shading on yield was opposite. The yield increased with RFM but decreased with shading. Yamaguchi[13] reported that RFM (without shading) increased the carnation yield by 30 to 40% while shading (without mulching) reduced it by 8 to 24% compared with the control (no-mulching and no-shading), and they suggested that the results may be due to the amount of available radiation. Stanhill et al.[10] stated that covering of the northern wall and paths between the rows with a highly reflecting layer (aluminized polyester) increased the yield of cut roses in a glasshouse during midwinter, and they indicated that the average radiation requirement was 10.88 MJ per bloom. Our results were in agreement with these 2 experiments and the number of flowers corresponded to the total amount of solar radiation.

The amount of solar radiation also affected the cut flower quality. The highest quality in Exp. 1 was observed in the RFM plot with shading but not in the RFM plot without shading. This phenomenon may be due to an another effect of the shading treatment comparable to a thinning effect on carnation at early vegetative growth. Vegetative growth and the size of the plant community showed that shading treatment during the summer season reduced the number and length of the secondary branches. Kageyama et al.[3] reported that 60% shading could delay markedly the development of lateral shoots. The reduced number of secondary branches of plots with a high plant density may be caused by light shortage (Exp. 3). Tanaka & Tanaka[11] reported that the sink activity of lateral shoots was high when the size of the shoots was small. This observation suggests that the reduction of the number of secondary branches had suppressed competition among the organs for the assimilates and nutrients. The higher quality in the summer shading plots may be due to both the decrease in temperature and the reduced competition among the organs for assimilates and nutrients.

Yamaguchi[13] reported that RFM increased the PAR between 0 and 20 cm above surface compared with the absence of mulching. The increased solar radiation was due to the amount of reflected light of RFM which promoted the carnation growth mainly through the function of light supply to the lower leaves. Relatively old leaves at a lower position display an adequate photosynthetic activity. Tanaka & Tanaka[11] reported that the photosynthetic rate of old (230- to 270-day-old age) carnation leaves at the light saturation level could reach a value half of that of young leaves (10- to 40-day-old age), which is a relatively higher value among the herbaceous plants. Moreover, the LAI of the lower part was greater than that of the upper part (Fig. 1). Therefore, supplemental light provided by RFM to lower leaves could appreciably affect carnation growth through the acceleration of assimilation.

RFM also alleviated the daily fluctuations of the soil temperature. Soil temperature under RFM was lower during daytime whereas higher during night than that of bare soil. Schalk & Robbins[8] examined the effects of RFM for 3 years on tomato plants and reported that aluminum mulching lowered soil temperatures by 5.1°C at the soil surface and 3.7°C at 7 cm depth compared with the absence of mulching in a year with the highest air temperature throughout the experiments, and that the difference in temperatures between mulching and the absence of mulching increased as the air temperature rose. There are several reports on the effect of RFM on the yield of vegetables. However the effects were inconsistent, presumably due to the soil temperature during the experiments. RFM was reported to increase the yield of cabbage[7], lettuce[14,15], bean[2], but to reduce the growth, height and yield of southern pea (*Vigna unguiculata*)[7]. The effect of RFM was inconsistent in tomato[8]. In general, RFM treatment during summer resulted in the increase of growth, height, plant vigor and yield but was no longer effective or even exerted a detrimental effect during winter, as the soil temperature attenuation of RFM is considered to be unfavorable in winter due to the low temperature. Schalk & Robbins[8] demonstrated that the optimum yield was obtained in the plot that was mulched during summer with a reflective film and with a black film during winter. Carnations, whose optimum temperature for growth was reported to range from 15 to 20°C[1,11], also need a lower temperature during summer. This report indicated that RFM was effective to achieve this objective.

RFM also enhanced the early vegetative growth and increased the number of early harvested flowers (harvested until the end of the year under standard cultural practice in Japan). However, the quality of the flowers harvested later became lower in RFM than in bare soil. This phenomenon was ascribed to the light starvation caused by subsequent strong shading to prevent overgrowth at early stages. Exp. 3 which was carried out to determine the optimum planting density showed that the quality of cut flowers harvested later decreased in the plot with dense planting compared with the bare soil plot. Conversely the yield increased with the increase of the number of seedlings/m^2. However, the plot with sparse planting produced a lower yield than the bare soil plot in spite of the higher quality of the flowers. Thus the optimum planting density for RFM was found to be 37.5 plants/m^2, which corresponds to the standard density in Japan.

References

1) Abou Dahab, A. M. (1967): Effects of light and temperature on growth and flowering of carnation (*Dianthus caryophyllus* L.). *Mededelingen Landbouwhogeschool Wageningen*, **67**(13), 1-76.
2) Cardona, C. et al. (1981): Effect of artifical mulches on *Empoasca karaemeri* Ross and Moore populations and dry bean yields. *Environ. Entomol.*, **10**, 705-707.
3) Kageyama, Y., Okamoto, N. & Konishi, K. (1985):

Effects of light, soil moisture and plant density on lateral shoot development in carnations. *Sci. Rep. Fac. Agric., Okayama Univ.*, **65**, 15-21 [In Japanese with English summary] .
4) Kurozumi, T. et al. (1988): An effect on summer spinach of minimizing rise in temperature by shading. *Bull. Nara Agric. Exp. Stn.*, **19**, 31-37 [In Japanese with English summary] .
5) Monsi, M. & Saeki, T. (1953): Üeber den Lichtfaktor in den Pflanzengesellschaften und seine Bedeutung für die Stoffproduktion. *Jpn. J. Bot.*, **14**, 22-52.
6) Roberts, B. W. & Anderson, J. A. (1994): Canopy shade and soil mulch affect yield and solar injury of bell pepper. *HortScience*, **29**, 258-260.
7) Schalk, J. M. et al. (1979): Reflective film mulches influence insect control and yield in vegetables. *J. Am. Soc. Hort. Sci.*, **104**, 759-762.
8) Schalk, J. M. & Robbins, M. L. (1987): Reflective mulches influence plant survival, production, and insect control in fall tomatoes. *HortScience*, **22**, 30-32.
9) Sherry, W. J. & Goldsberry, K. L. (1980): Carnation production responses to solar radiation transmitted through plastic greenhouse covers. *J. Am. Soc. Hort. Sci.*, **105**, 579-582.
10) Stanhill, G. et al. (1975): The effect of reflecting surfaces on the solar radiation regimes and carbon dioxide fixation of a greenhouse rose crop. *J. Am. Soc. Hort. Sci.*, **100**, 112-115.
11) Tanaka, M. & Tanaka, M. (1987): The technique of cultivation of Sim carnation in the Northern Kyushu. *Bull. Saga Agric. Exp. Stn.*, **24**, 1-82 [In Japaneses with English summary].
12) Wells, P. W., Dively, G. P. & Schalk, J. M. (1984): Resistance and reflective foil mulches as control measures for the potato leafhopper (Homoptera: Cicadellidae) on *Phaseolus* species. *J. Econ. Entomol.*, **77**, 1046-1051.
13) Yamaguchi, T. (1987): Stimulating effects of some chemical and physical treatments on the growth of carnation. *Acta Hort.*, **216**, 281-288.
14) Zalom, F. G. (1981): Effects of aluminum mulch on fecundity of apterous *Myzus persicae* on head lettuce in a field planting. *Ent. Exp. & Appl.*, **30**, 227-230.
15) Zalom, F. G. & Cranshaw, W. S. (1981): The influence of reflective mulches and lettuce types on the incidence of aster yellow and abundance of its vector, *Macrosteles fascifrons* (Homoptera: Cicadellidae), in Minnesota. *The Great Lakes Entomologist*, **14**, 145-150.

(Received for publication, November 2, 1995)