低温処理の有無が中性イチゴ4品種の生育に及ぼす影響

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Growth and Development of Four Day-neutral Strawberries under Hydroponic System with or without Chilling

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Summary

Variations in vegetative and reproductive growth patterns in response to chilling treatment were evaluated in four day-neutral strawberries (*Fragaria* × *ananassa* Duch. cvs. 'Miyoshi', 'Summerberry', 'Enrai' and 'Everberry') under the NFT (nutrient film technique) system in plastic house. The results indicated that vegetative and reproductive growth of all cultivars responded to chilling. Apparently, the petiole length and leaf area responded to chilling after planting until early June, while the chilling had little effect on leaf production until April. Chilling also promoted flower production of the four cultivars so that it appears to be the dominant factor governing yield. 'Everberry' and 'Enrai' evidently have low yields and adaptability, and cannot be manipulated satisfactorily under the NFT system whereas 'Summerberry' was intermidiate and responded favorably to manipulation. We conclude from our findings that 'Miyoshi' grew and yielded better under the NFT system than did the other three cultivars with or without chilling.

Introduction

The day-neutral cultivars that bloom and fruit throughout the growing season have been incorporated into commercial strawberry production (Mass, 1984). Baumann et al. (1993) found that day-neutral cultivars in the raised beds system produced higher yield and longer periods than June-bearing cultivars during 1990 and 1991. These observations are of interest to horticulturists and geneticists because if chilling affects growth and development of day-neutral cultivars, the response offers an insight into the physiological processes that are important in breeding and cultural management schemes.

Thailand is in the tropical region at 5° ~ 21° north latitude, where temperature-zone crops do not receive adequate winter chilling. Of the strawberry cultivars introduced and tested for their adaptability in the northern highland area, only the June-bearing 'Tioga' was adaptable but its yield and fruit quality is unsatisfactory. The objective of this experiment was to study the adaptability of four chilled and unchilled day-neutral strawberry cultivars to tropical condition based on their vegetative and reproductive growth patterns.

The present work was undertaken to compare the growth patterns on four day-neutral strawberry cultivars with or without chilling grown under the NFT system (nutrient film technique) in a plastic house equipped with water curtain device.

Materials and Methods

The strawberry plants used in this study were four day-neutral cultivars, 'Everberry', 'Summerberry', 'Miyoshi', and 'Enrai', which were bred in Japan. On the plot without chilling, thirty runner plants of each cultivar were transplanted under the NFT system in a plastic house maintained at 23°~28°/7°~10°C (day/night) under a 24 hr (by cyclic lighting) daylength from outdoor on 21 October 1991. In the chilled plot, 30 comparable plants were grown outdoors and subjected to the sufficient chilling below 7°C until 17 February 1992. They were then transplanted in the above system. Strawberry plants of both plots were grown under the natural conditions after with or without chilling treatments after April. The experiment was designed as a randomized block with

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3 replications of 10 plants unit. Insecticides and fungicides were applied at 3～4 week intervals.

Total number of leaves per plant, mean petiole length and mean leaf index (length×breadth of the middle leaflet) to estimate leaf area (Darrow, 1932) of the third to fifth unfolded leaves (counting from the youngest leaf), were recorded at 10-day intervals beginning 50 days after transplanting. Days from transplanting to the first bloom and the number of flowers per plant were also recorded. Fruits were harvested at 5-day intervals during the growing season, graded, counted, and weighed. Runners and old leaves of all plants were removed constantly during the experiment.

Results

In the non-chilled plots, the percentages of plants that died by the end of the experiment were; 'Everberry', 40; 'Enrai', 20; 'Summerberry', 13, and 'Miyoshi', 0. In the chilled plots, 50, 47, 17, and 20% of the plants did not survive (data not shown).

On non-chilled plants, the petioles and leaves grew poorly from December 1991 to early April 1992 (Figs. 1 and 2). Subsequently, the petiole length and leaf area increased more rapidly in 'Miyoshi' and 'Everberry' than did those of 'Summerberry' and 'Enrai' until June when growth decreased gradually. The petiole length and leaf area of chilled plants grew more rapidly than did those of non-chilled plants from April to June. After June, their growth decreased similarly to that of the non-chilled plants.

There were no differences in leaf production between chilled and non-chilled plants of four cultivars from April till end of June, however, seemed to occur little differences in the end of growing season (Fig. 3). In August, non-chilled plants of 'Everberry', 'Miyoshi', and 'Summerberry' produced more leaves than did the chilled plants but not in 'Enrai'; 'Miyoshi' produced more leaves per plant than did the other cultivars.

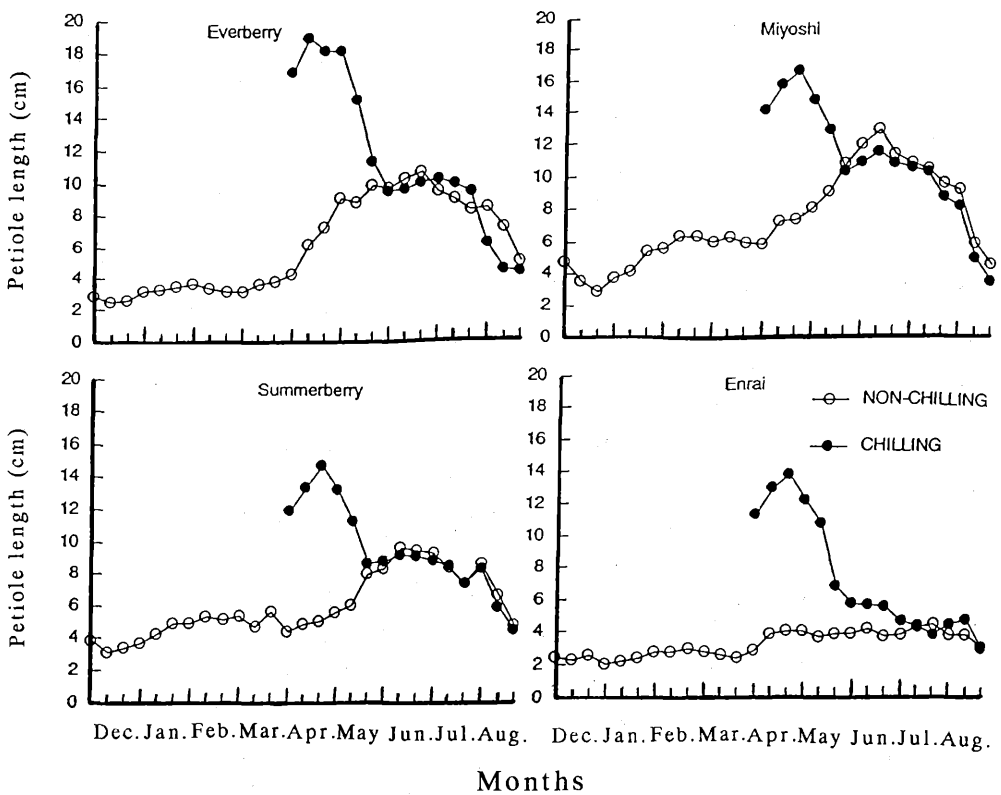

Fig. 1. Mean petiole lengths of non-chilled and chilled plant of four day-neutral strawberries.

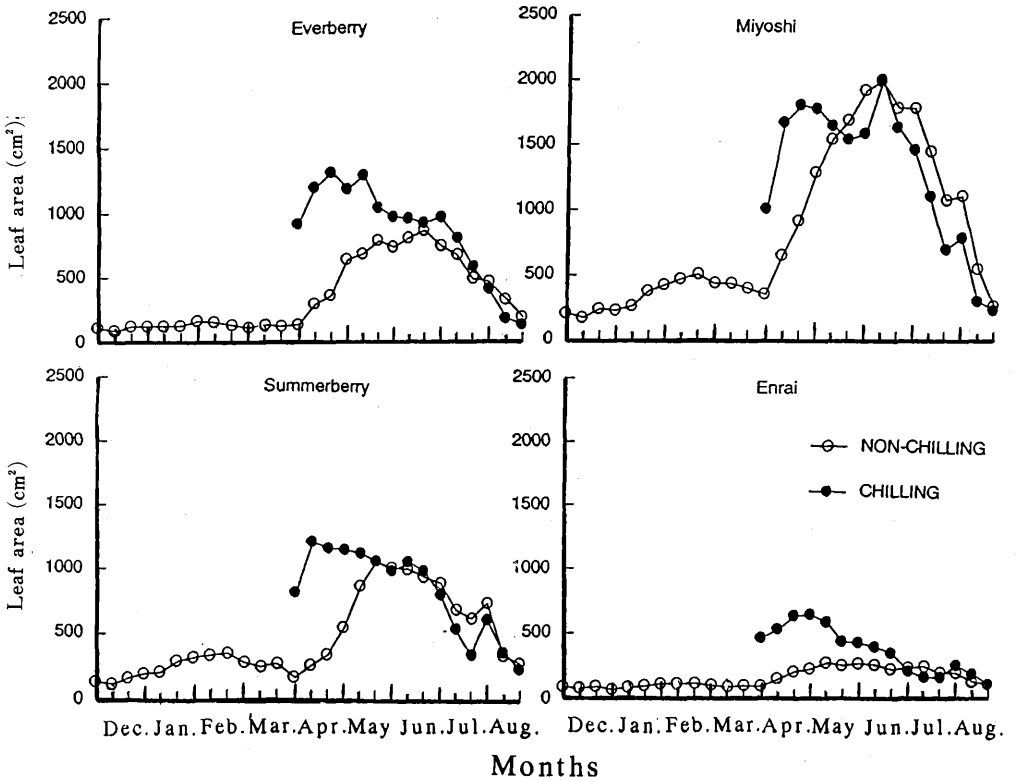

Fig. 2. Mean of total leaf area of non-chilled and chilled plant of four day-neutral strawberries.

All chilled plants had the first flowering within about one month after planting, while non-chilled plants required 70 or more days after planting (Table 1). In the chilled plants, 'Miyoshi', and 'Enrai', the first flowering appeared on 25 days after planting, whereas in 'Everberry' and 'Summerberry' bloom appeared on 28 and 32 days, respectively. In the non-chilled 'Enrai' plants, the first flowering appeared one to two weeks before those of the other three cultivars.

During the growing season, three peaks of flowering in the non-chilled plants and two peaks in the chilled plants were recognized (Fig. 4). Chill ed plants of all cultivars produced 2 ~ 3 times more flowers than did the non-chilled ones until late June (Fig. 4). After June, flower counts on non-chilled plants surpassed those of chilled plants.

The data on number of fruits and yields per plant of non-chilled and chilled strawberries (Figs. 5 and 6) reveal that by August, non-chilled 'Summerberry' and 'Miyoshi' plants were more productive than were comparable chilled plants. There were no differences in yields between 'Everberry' and 'Enrai'.

Both chilled and non-chilled 'Miyoshi' plants produced more fruits and greater yields per plant than did those of the other cultivars (Table 2). Within the non-chilled plots, about 50% of fruits of 'Enrai' were unmarketable (< 6 g), whereas 70% or more of the fruits in the other three cultivars were marketable (>6 g). 'Miyoshi', 'Summerberry', and 'Everberry' produced 33, 24, and 17 fruits weighing 197, 162, and 126 g, respectively. Within the chilled plots, the unmarketable fruits in four cultivars amounted to less than 30%. The yield of 'Enrai' was the smallest; e.g. 'Miyoshi', 'Summerberry', 'Everberry', and 'Enrai' produced 40, 28, 23, and 18 fruits weighing a total of 256, 206, 219, and 128 g per plant, respectively.

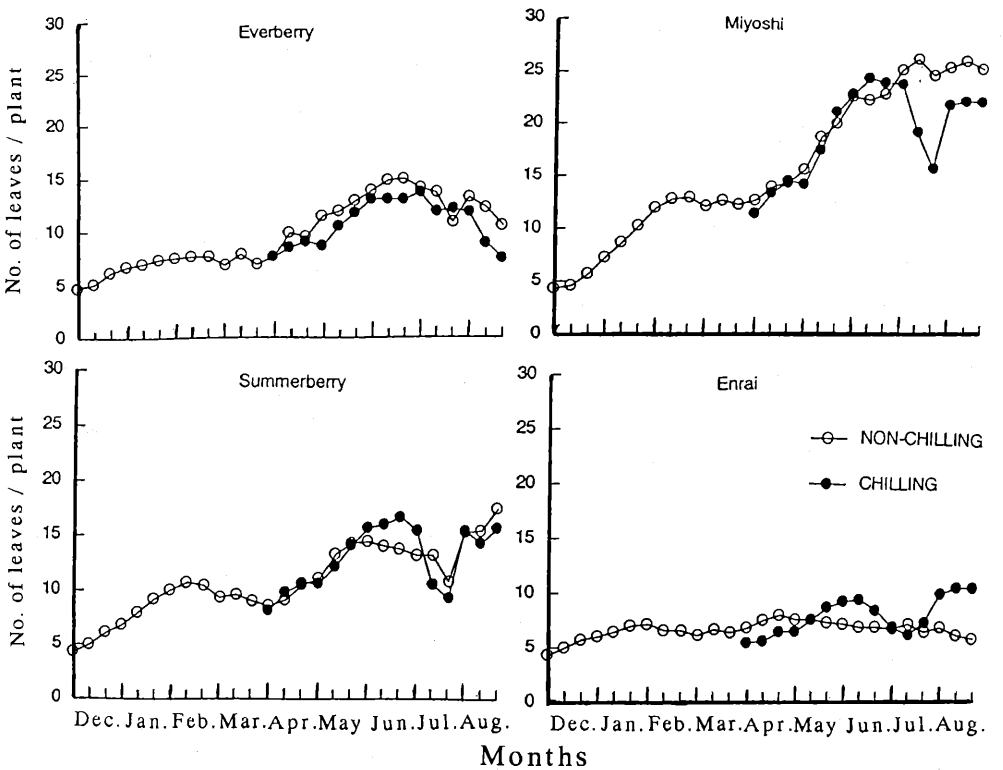

Fig. 3. Average number of leaves of non-chilled and chilled plant of four day-neutral strawberries.

Table 1. Average number of days from transplanting to the first flowering in non-chilled and chilled four day-neutral strawberry cultivars.

Cultivars	non-chilled plants	chilled plants
Everberry	76.1bc[z]	27.9b
Summerberry	89.7a	31.6a
Miyoshi	80.2b	25.3c
Enrai	71.7c	25.5c

[z] Mean separation within columns by Duncan' s multiple range test, at P=0.05.

Discussion

Petioles and leaf blades of plants that were dug in the fall before receiving any chilling and transplanted into the plastic house under the NFT system grew very little until early April. But petioles and leaves of plants dug in mid-February and subjected to the same conditions grew vigorously after their establishment. This increase in length of petiole and leaf size was observed until early June and after that time there were no differences until the end of experiment. Thus, the growth promotion of the day-neutral strawberries is a response to chilling. Apparently there is a high rate of petiole and leaf growth after winter chilling. This result is in agreement with the conclusion of Bailey and Rossi (1964) that the increase in length of petioles and size of leaves appears to be the best measure of response to chilling. This response to chilling was also observed by Arney (1956), Bringhurst et al. (1960), Guttridge (1958, 1960), and Voth and Bringhurst (1958).

The evidence relating to the effect of chilling on the leaf production of strawberry has been known. Bailey and Rossi (1964) found that the number of leaves on the June-bearing strawberry cultivar 'Catskill' was positively correlated with hours of chilling under long days at high temperature and under short days at both high and low temperatures. On transplanting date (17/2/1992), the chilled plants of four cultivars had 3 ~ 4 leaves

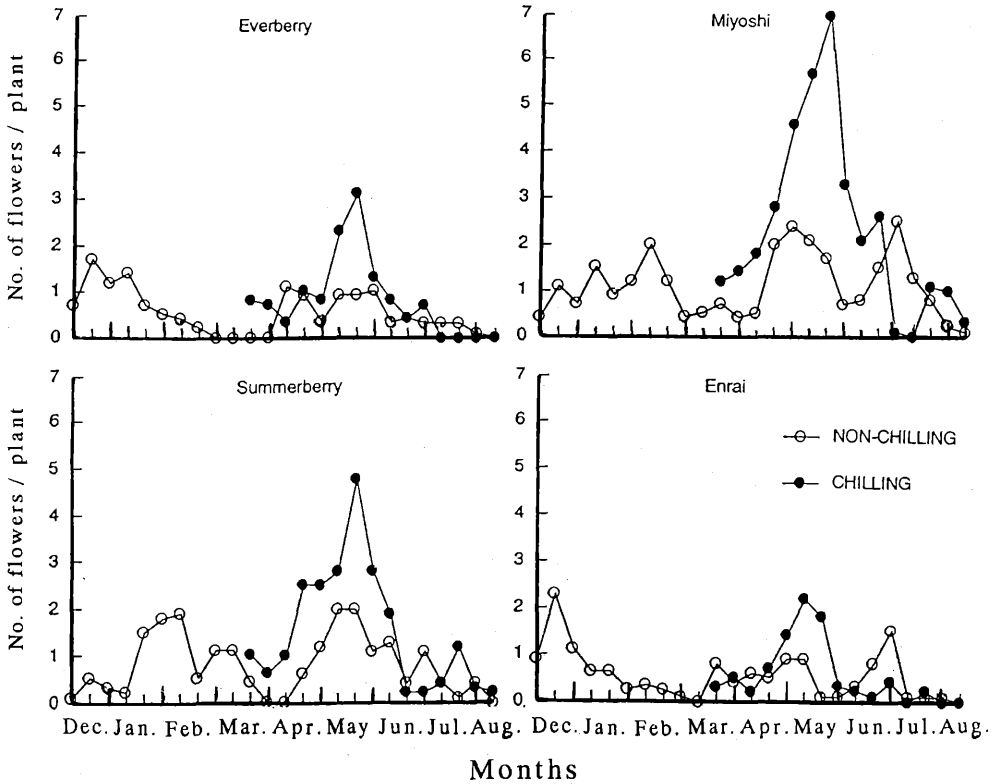

Fig. 4. Average number of flowers of non-chilled and chilled plant of four day-neutral strawberries.

per plant that increased rapidly until April. The present results indicated that initial increase of leaf number on chilled plants may be caused by chilling, and then being subjected to a long photoperiod at high temperatures. There were no differences between the number of leaves on chilled and non-chilled plants from April (Fig. 3). Thus, leaf production of non-chilled plants is stimulated by long days at high temperature. An effect of a long photoperiod on leaf production of strawberry was reported by Guttridge (1959) and Vince-Pure and Guttridge (1973).

Day-neutral strawberry clones (often referred to as everbearing), in contrast to June-bearing clones, initiated flowers under both long- and short-day conditions and bloom during the season of planting, if growing conditions are favorable (Downs and Piringer, 1955; Lawrence, 1981). In this study, 'Summerberry' plants bloomed the latest after transplanting compared with the other three cultivars (Table 1). The four cultivars responded to chilling by producing more flowers per plant than the unchilled plants (Fig. 4). However, chilled plants nearly ceased initiating flowers in July, whereas non-chilled ones continued to do so. Day-neutral plants in the field produced fewer flowers from midsummer until early fall (Durner et al., 1984). Smeets (1979) suggested that above 26°C, flowering in everbearing cultivars might be inhibited. This inability to flower by chilled plants in late summer may be caused by low plant vigor resulting after high fruit production and excessively high temperatures. It has long been recognized that fruiting and vegetative growth in strawberry are antagonistic (Galletta and Bringhurst, 1990).

We found that all four cultivars produced higher yields when chilled (Figs. 5 and 6) which is attributed to a promotion of flower initiation, and is in agreement with the findings of Durner and Poling (1987). Among the non-chilled plants, cultivars varied greatly in marketable and unmarketable yields, but not so in chilled plants (Table 2).

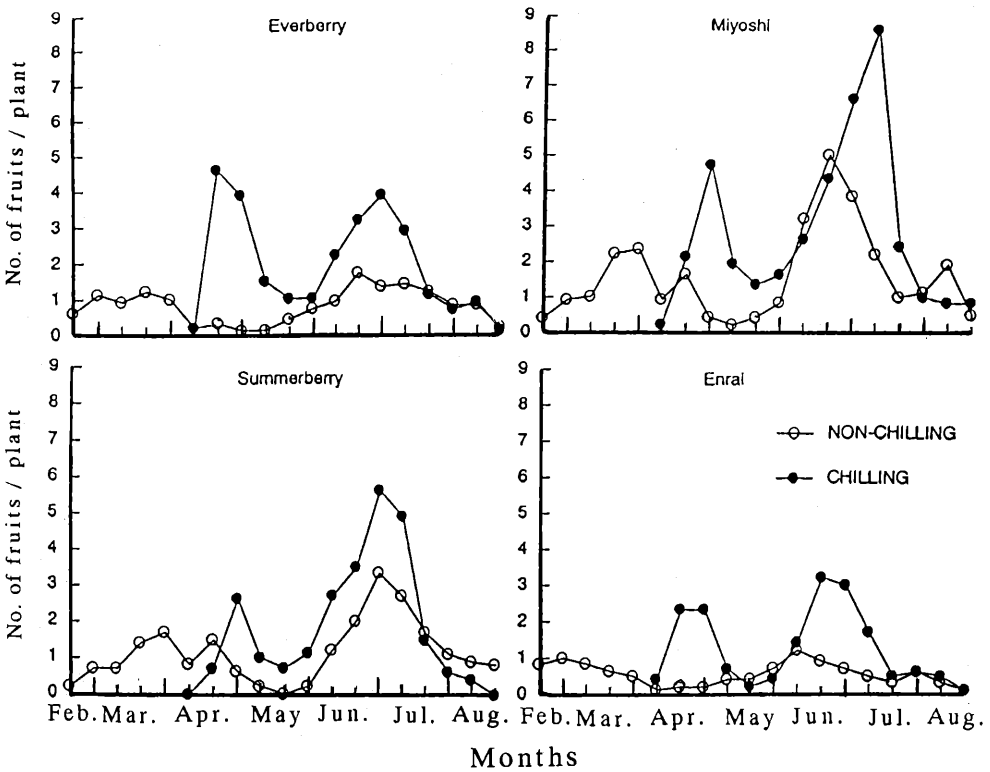

Fig. 5. Average number of harvested fruits of non-chilled and chilled plant of four day-neutral strawberries.

'Miyoshi' produced more total number of fruits and yields on both non-chilled and chilled plants than those of the other cultivars, while 'Enrai' produced the least.

After fruiting, many everbearing types appeared to be low in vigor (Galletta et al., 1981). The percentage of plants that failed to survive was smaller in 'Miyoshi' and 'Summerberry' compared to 'Enrai' and 'Everberry'. The yield and growth responses by the day-neutral cultivars to chilling reveal that the petioles and leaves expanded rapidly initially but they did not persist. Our results indicate that among the four day-neutral cultivars under the NFT system, 'Miyoshi' seems to be well adapted for vigor and yield with or without winter chilling and may be able to adapt for the highland conditions of northern Thailand.

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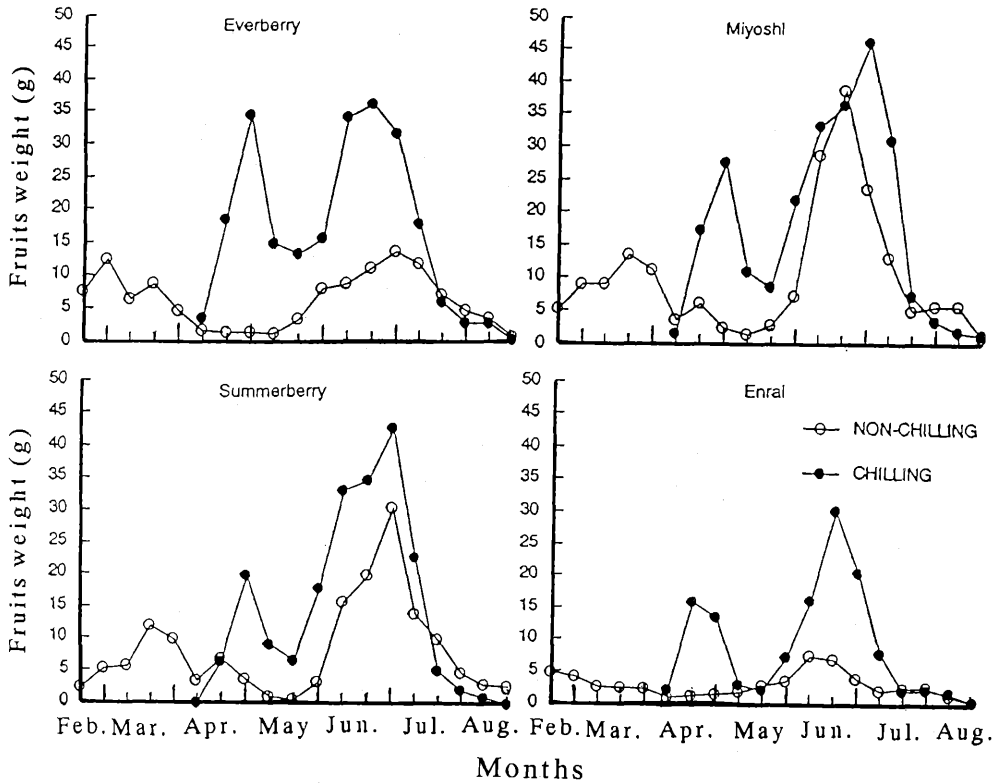

Fig. 6. Mean of yield per plant of non-chilled and chilled four day-neutral strawberries.

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Table 2. Total number of fruits, fruit weight and percentages of yield of marketable (>6g) and unmarketable (<6g) yields per plant on non-chilled and chilled day-neutral strawberries.

Cultivars	Marketable						Unmarketable		Total number of fruits	Total yield (g)
	>12 g		>8 g		>6 g		<6 g			
	no. of fruits	wt	no. of fruits	wt	no. of fruits	wt	no. of fruits	wt		
Non-chilled (10 Dec. 1991～30 Aug. 1992)										
Everberry	3.1a	46.1a (36.6%)	3.2b	33.2b (26.3%)	2.1ab	14.2ab (11.3%)	8.9bc	32.5b (25.8%)	17.3c	126.0bc[z]
Summerberry	3.0a	48.5a (29.9%)	4.0ab	39.6b (24.4%)	4.1ab	30.0ab (18.5%)	12.4b	43.9ab (27.1%)	23.5b	162.0ab
Miyoshi	3.4a	49.7a (25.2%)	6.9a	54.5a (27.6%)	5.1a	35.6a (18.0%)	17.3a	57.6a (29.2%)	32.7a	197.4a
Enrai	0.3b	3.8b (7.6%)	1.1c	10.9c (21.7%)	1.6b	11.4c (22.7%)	7.0c	24.2b (48.1%)	10.0c	50.3c
Chilled (10 Apr.～30 Aug. 1992)										
Everberry	6.1a	113.0a (51.5%)	4.9a	50.0a (22.8%)	3.6a	25.8a (11.8%)	8.7b	30.5b (13.9%)	23.3b	219.3a
Summerberry	5.1a	78.3a (38.0%)	4.7a	47.3a (22.9%)	6.5a	38.8a (18.8%)	11.6b	41.9b (20.3%)	27.9ab	206.3a
Miyoshi	5.2a	78.2a (30.5%)	4.8a	47.5a (18.5%)	6.7a	50.2a (19.6%)	23.1a	80.5a (31.4%)	39.8a	256.4a
Enrai	2.5a	39.6a (30.9%)	3.3a	31.9a (24.9%)	3.2a	22.5a (17.6%)	9.3b	34.1b (26.6%)	18.3b	128.1b

[z] Mean separation within columns by Duncan's multiple range test, at P=0.05.

低温処理の有無が中性イチゴ4品種の生育に及ぼす影響

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摘　要

4つの中性イチゴ（*Fragaria ×ananassa* Duch.）品種'みよし'，'サマーベリー'，'エバーベリー'および'円雷'において，栄養および生殖生長パターンの低温処理に対する変化について，温室内NFTシステムで評価した．結果はすべての品種の栄養および生殖生長が低温処理に反応することを示した．明らかに，葉柄長と葉の大きさは移植後から6月上旬まで低温処理に反応した．低温処理によって葉の生産は移植後50日までは促進されたが，その後は影響されなかった．低温処理は花数にも影響を及ぼした．すべての品種において，低温が収量を決定する主要な要因であると考えられた．生長と収量から低温処理の有無にかかわらず'みよし'が他の品種よりもNFTに適していると結論された．'エバーベリー'と'円雷'はNFTでは収量と適応性が低く，十分な市場性は望めないが，'サマーベリー'は中程度の反応を示し，市場性があると考えられた．