Effects of Calcium Spray on the Quality of 'Nyoho' Strawberries Grown by Peat-Bag-Substrate Bench Culture

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ABSTRACT

The 200 ppm Ca²⁺ chelated with carboxylic acids (CALHARD®) was preharvesting sprayed to 'Nyoho' strawberries grown by peat-bag-substrate bench culture once a week between April and June, 1997 at the rate of 200 liter. 100m⁻². Remarkable increase fruit firmness was the main benefit of the Ca application. Although fruit firmness of all treatments decreased by the end of May, but Ca-applied strawberries were still firmer than control ones. Skin puncture force of Ca-applied berries was higher but the bundle zone puncture force, was not affected. Ca treatment increased ascorbic acid and Ca contents, and maintained fruit soundness by delaying decay caused by gray mold. Both Ca-applied and control strawberries grown on the south side of the bench tended to be higher in firmness and ascorbic acid content. Ca-applied strawberries on the south-side of bench had the highest Ca content and firmness. Ca treatment significantly decreased water soluble pectin (WSP) and increased hydrochloric acid soluble pectin (HSP). After storage at 20°C for 2 days, WSP increased whereas HSP decreased greatly especially in control berries from the north side. Monthly changes in titratable acidity and total soluble solids were not affected by the Ca treatment.

Key words: calcium application, peat-bag-substrate bench culture, strawberry

INTRODUCTION

In Japan, strawberries have been extensively grown under the plastic tunnel and plastic greenhouse by traditional soil culture. Recently, the "Rakuchin" peat-bag-substrate bench culture system has been widely promoted to the strawberry growers in Kagawa Pref because not only of increased fruit quality but also of increased yield and decreased labor cost as compared to the traditional soil culture. This system was especially advantageous for the old age growers since it is convenient for fruit picking and for plant management with very intensive cultural techniques such as automatic drip irrigation and nutrition management system, air heater, and CO₂ supplier. In addition, this system enables to give a higher yield with large high quality berries and less contamination from soil-born pathogens. A problem of strawberry production in Japan is its poor quality in the end of season from April to June due to the high temperature.

The beneficial effects of Ca on maintaining fruit quality are well documented by many re-

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searchers. Pre and postharvest application of Ca have been practised commercially in many fruits and vegetables for improving quality, delaying senescence, reducing postharvest decay and controlling the physiological disorder (Poovaiah, 1986; Conway et al., 1994). Foliar applications of Ca during the growing season have been reported to delay ripening and mold development in strawberries (Chéour et al., 1990; 1991; Chung et al., 1995).

In our previous study with 'Nyoho' strawberries grown by the traditional soil culture showed that the preharvest sprays of 200 ppm Ca-chelate during the fruit growth and development certainly increased fruit firmness and decreased rate of softening during storage for 2 days at 20°C (Na Phun et al., 1995; 1997).

The objective of this study was to examine the effects of preharvest Ca application on postharvest quality of 'Nyoho' strawberry grown by the peat-bag-substrate bench culture.

MATERIALS AND METHODS

Strawberries (Fragaria x ananaessa Duch. cv. 'Nyoho') were planted in PE bags contained mixed substrate (3 peat moss : 1 rockwool) on benches in a plastic house of the JA-Miki Nursery Center on September 20, 1996. Two hundred ppm Ca2+ chelated with carboxylic acids (CALHARD®, Otsuka Chem. Co. Ltd.) was weekly sprayed on the strawberries using a hand pressure sprayer at 200 liter. 100m⁻² from April to June, 1997. Control treatment was sprayed with water. Wetting agent Tween-20 was added to all treatments.

Strawberries at 90% maturation, after four times of Ca application, were harvested separately from the north and south areas of the bench culture row. Uniform berries with medium size, similar color and free of visual defects were selected to be tested. Fruit firmness was assessed with a 1 kg Universal Firmness Tester using a 5-mm diameter and 10-mm deep conical tip. Three positions per berry around the equator were measured. Skin and bundle zone puncture force were measured with a reometer using a 3 mm diameter cylindrical tip. Pectic substances were measured in alcohol insoluble solids (AIS) prepared from the flesh, and galacturonic acid concentration was measured using the carbazole method. Ca content was determined from seven in each treatment. Each berry was sliced into small portions which were separated into peel and core. Sliced portions were dried in an oven for subsequent Ca content determination with an atomic absorption spectrophotometer, and the data were demonstrated as percentage of dry weight. After storage at 20°C for 2 days quality of fruit was classified as sound, bruised and rotten fruit. L-ascorbic acid content was determined using the 2,4-dinitrophenyl hydrazine method. Juice samples were collected to determine the total soluble solids with a digital refractometer (PR-100; Atago Co. Ltd., Japan) and titratable acidity by titrating with 0.1 N NaOH to pH 8.1. Results were exhibited as percentage of citric acid. Analysis of variance was made. A 5% least significant difference (LSD) was used to determine differences among the means of the treatments.

RESULTS AND DISCUSSION

It appeared that preharvest Ca application to strawberries greatly increased fruit firmness at harvesting and significantly decreased the rate of fruit softening during storage at 20°C for 2 days (Fig1). It was interesting that strawberries grown on the south area of the bench had higher fruit firmness than those from the north. Therefore, Ca-applied strawberries harvested from the south area of the bench were most firm. In this study, strawberries were harvested once a week from 7 May to 25 June 1997. As the temperature increased
starting from the end May until the end of June, fruit firmness, in general, progressively decreased, however, Ca-applied strawberries were still firmer than the control ones. Preharvest foliar application of Ca was found effectively increasing fruit firmness of raspberries, apples, tomatoes and kiwifruits (Eaves et al., 1972; Bramlage, 1985; Garcia et al., 1995; Gerasopoulos et al., 1996).

The puncture force profile of strawberries measured with a reometer was shown in Fig. 2. Two peaks were observed in penetration through skin, cortex and bundle zone. The first peak is the skin puncture force and the second peak is the bundle zone puncture force. The skin puncture force of Ca-applied berries was higher than that of the control, however, the bundle puncture force was at the same level.

Pectic substances expressed as water soluble pectin (WSP), ammonium oxalate soluble pectin (ASP), and hydrochloric acid soluble pectin (HSP) were shown in Fig. 3. Ca-applied strawberries contained less WSP and higher HSP than the control berries. At harvesting HSP remained higher in the Ca-treated strawberries compared with the control. After 2 days storage at 20°C of strawberries, HSP generally decreased but of Ca-treated berries did not decrease as much as of control. Ca-applied strawberries contained less WSP than the control at harvesting. After storing at 20°C for 2 days the largest amount of WSP was observed in control berries grown in the north area and the smallest was in the Ca-applied ones grown in the south area of the bench. One of the reasons for delayed fruit softening by Ca spray may be due to inhibition of cell wall degrading enzymes. Conway et al. (1987) showed that Ca treatment decreased
the activity of polygalacturonase and cellulase.

Ca contents of both peel and core of strawberries are shown in Fig. 4. Preharvest Ca-applied berries had significantly higher Ca than those of control. The peel contained higher Ca than the core, and the peel of Ca-applied strawberries had significantly higher Ca content compared with the control. Comparing strawberries grown in the north and the south, the latter berries tended to contain more Ca. In consequence, the Ca applied strawberries grown at the south side had the highest Ca content. Ca uptake in the field depended on many environmental factors such as light, moisture, nutrition and salt concentration, temperature, and chemical sprays. In apple, high relative humidity (87%) was found to increase Ca uptake, while lower humidity (75-80%) was found to decrease rate of Ca uptake (Lidster et al., 1977). Light and temperature may also affect the uptake rate, potassium absorption in corn leaves was promoted by light (Rains, 1967). A large proportion of pectic material was found as Ca pectate in tomato leaves, wheat and corn plants applied with high levels of Ca during growth and grown under high light intensity (Kasztori, 1969). Increasing the duration and intensity of light enhanced the uptake and accumulation of Ca in roots, stems, petioles and leaves.

During storage at 20°C for 2 days, preharvest Ca treatment reduced the decay (Fig 5). This result was similar to those conducted by Chéour et al. (1990; 1991) in strawberries and by Lidster et al. (1979) in cherry. The berries harvested from the south area showed less decay than the berries harvested from the north area of the bench. Therefore treatment significantly decreased bruising.

Ascorbic acid contents of Ca-treated berries were higher than those of control (Fig. 6). Similar result was obtained by Poovaiah et al. (1986) that CaCl₂ increased ascorbic acid contents in apples. Titratable acidity and total soluble solids in 'Nyoho' strawberries were ranged between 0.9 %
Effects of calcium spraying on fruit quality appearance after storage at 20°C for 2 days of 'Nyoho' strawberries grown by peat-bag-substrate culture.

Effects of calcium spraying on ascorbic acid content at harvesting (A) and after storage at 20°C for 2 days (B) of 'Nyoho' strawberries grown by peat-bag-substrate culture. Error bars represent 5% LSD.

By the end of May, titratable acidity and total soluble solids gradually increased and then decreased. There was no effects of the Ca spray.

In conclusion, preharvest foliar application of Ca increased Ca content and fruit firmness, and improved fruit quality of strawberries towards the end of the growing season.

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Sociological Aspects of Peri-Urban Vegetable Production in the Areas around Bangkok

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ABSTRACT

In this paper, vegetable growers in the four provinces around Bangkok where the use of IPM has been promoted, were studied. Some sociological factors were employed to explain the growers' adoption of IPM practices: those that place constraints on the growers' ability to adopt, that shape their perceptions of profitability of various IPM practices, and the government agricultural policy. The main factors that were moderately associated with adoption included appropriateness of IPM technologies, source of technological information, government's subsidy scheme, awareness of the danger of hazardous substances, organizational membership and the growers' perceived benefits of the adoption of IPM technology.

Key words: integrated pest management, peri-urban vegetable production, sociological aspects

INTRODUCTION

Like other cities in developing countries, Bangkok is growing rapidly. Its population projection for the year 2000 is around 7.6 million (Population Institute). The increase in food production is undoubtedly needed. To ensure adequate micronutrient supply, consumption of vegetables is strongly encouraged. Vegetable intake in Thailand is approximately 40-50 kg. per person per year (Luksarard, 1997) which is lower than the intake recommended by FAO, i.e., 73 kg. per person per year (Gura, 1996). Today a larger number of Thais are conscious about the benefit of vegetables in the diet, especially for health reason. Increased vegetable production and consumption can contribute not only to better health but also to generate additional income of the growers.

There has been a growing concern about the environmental and health risks associated with modern agriculture or Green Revolution in Thailand. During the past decades, Thailand's agricultural development policy emphasized the growth of agricultural production and increasing income of farmers. The government has responded to the criticism of the modern agriculture with sustainable agriculture as stated in the Eighth National Economic and Social Development Plan (1996-2001).

Pesticide safety vegetable production program is one of the measurements for minimizing and correcting the use of agro-chemicals that damage the environment or harm the health of farmers and consumers. Technologies such as integrated pest management (IPM) is one of the alternatives. IPM is defined as "rational pesticide use, ecologi-
cally-based practices, better public health and larger harvests” (Bentley and Andrews, 1996).

A few Departments under the Ministry of Agriculture and Agricultural Cooperative (MOAC) in Thailand that promote the use of IPM in vegetable production are: the Department of Agriculture (DOA) and the Department of Agricultural Extension (DOAE), and the Department of Cooperatives (DOC). In addition to Hygienic Pesticide-Free Vegetable and Fruit Production Promotion and Development Program, DOA in cooperation with DOC has carried out the Hygienic Pesticide-Free Crops Production and Dissemination Program during Thailand’s Tourist Promotion Year (1998-1999; DOA and DOC, 1998). Due to the tourist promotion, there has been a greater demand of agricultural products, particularly vegetables, fruits and flowers for domestic consumption: in the hotels, restaurants, foodstalls and supermarkets. The program is to increase supply of pesticide safety vegetables and other crops.

DOAE, on the other hand, declared 1998 as The Campaign Year for Pesticide Safety Vegetable Production (DOAE, 1998). Twenty-four provinces were identified as having potentials for vegetable production and marketing. These included some provinces which are the periphery of Bangkok, such as Nakhon Pathom, Pathumthani, Chachoengsao and Pranakhonsri Ayuthaya. The 51 remaining provinces (excluding Bangkok) have been promoted, to grow pesticide safety vegetables mainly for local consumption.

Previous research on adoption of a wide range of innovations suggested three important factors affecting adoption. Firstly, the factors that shape farmers perceptions of profitability of various practices are to be identified. Secondly, the factors that place constraints on the farmers ability to adopt need to be taken into account. Lastly, the government agricultural policy can be examined whether or not it limits adoption of innovations (Sultiel et al., 1994)

MATERIALS AND METHODS

In this paper, the adoption of IPM in vegetable growing was examined using the sociological variables. The survey of 124 vegetable growers in four provinces Nakhon Pathom, Pathumthani, Chachoengsao and Pranakhonsri Ayuthaya was conducted in late 1997. Fifty-nine percent of the growers were males and 41 percent were females. Average age for these growers was 45, and about three-fourth had completed primary education. On the average the number of household members was 5. Size of land for vegetable growing varied and approximately one-third of the grower’s cultivated less than one rai\(^1\) (mean 3.4 rai). They have had long time experience in vegetable growing and the average was 11 years of experience. The vegetables grown in the study areas included water spinach, Chinese kale, yard long bean, Chinese cabbage (pakchoi), and cabbage.

The growers in Pathumthani and Pranakhonsri Ayuthaya took their products to two main wholesale markets in Bangkok. In Nakhon Pathom, private companies collected vegetables as ordered. Other growers brought products for sale in their town markets. The collectors from other provinces including Bangkok took the vegetables in Chachoengsao and delivered at hotels, restaurants and markets in their respective provinces and some growers took the vegetables to the wholesale market in town.

The dependent variables were operationalized by the growers’ responses to question asking whether they had adopted IPM in vegetable growing. The practices using the following materials

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\(^1\) Thailand measure 1 rai = 0.16 hectare (or 6.25 rai = 1 ha)
were identified by scientists as IPM.
1. Nylon net
2. Lime
3. Fermented fertilizer or livestock manure
4. Pest counting
5. Pest killing
6. Color sticky trap
7. Light trap
8. Neem sap
9. Nematode
10. Bacillus thuringiensis
11. Natural enemies

The independent variables included appropriateness of IPM technologies, source of technical knowledge, government subsidy scheme, awareness of the danger of hazardous substances, organizational membership and growers perceptions of benefits of adoption of innovations.

RESULTS

1. Appropriateness of IPM technologies
1.1 Nylon net

A majority of growers (73 percent) practiced IPM technologies. The adoption of each practice was examined. Among those who were IPM growers, 62 percent did not install nylon net house and 2.2 percent grow vegetables both in the net house and in the open air (Cramer’s V = 0.22 < .05). The reasons given were as the following.

a. High cost of investment

The larger the size of land, the greater the cost of investment for installation of the net house. Some of the growers obtained the nylon net for free. They had to buy other materials for installation themselves.

b. Strong wind

Some growers gave up using the net due to difficulties caused by strong wind. They avoided wasting of time to frequently repair the destroyed net and to fix the net house.

c. Strip land

An example was that in Pathumthani where the growers irrigated their strip land by boat, the net house is therefore not appropriate for the strip land.

d. Some growers learned from their own experience that it was humid in the net house that caused fungi. Despite the net house, a number of insects were still found.

e. Leafy vegetables that were grown in the net house did not look as good as those grown in the open air. Unless they lower the price, the products cannot be sold.

f. A few IPM growers cultivated leafy vegetables in the open air and vegetables that bear fruits in the net house, they learned that this was a practice resulted in good products.

1.2 Pest counting

Twenty nine percent of the IPM growers did not practice pest counting. A majority of them explained that they usually did not see the pests or if there were some insects, they had no time to count. Whereas 44 percent of the non-IPM growers mentioned that there were a number of pests and chemical spraying was the effective means to control them.

1.3 Pest killing

Similar to pest counting, 32 percent of the IPM growers and 62 percent of the non-IPM growers did not practice pest killing (Phi = -.27 p < .05). The reason given by the IPM growers was that they did not see the pest or if there were some insects they had no time to kill. The non-IPM growers, on the other hand, thought that chemical spraying is the effective means to get rid of a number of pests.

1.4 Color sticky trap

More than half of the IPM growers (59 percent) and almost all of the non-IPM growers did not apply the color sticky trap. (Phi = -.31 p < .05). Since vegetables are short-lived crop, there is no need to use it. The application of sticky trap con-
tributes to high cost. Furthermore it is rare or not available for sale. Whereas the non-IPM growers whose size of land was larger said that it was not effective to apply sticky trap. What they did was chemical spraying.

1.5 Light trap

About three-fourths of the IPM growers and all of the non-IPM growers did not use light trap. (Phi = -.28 p < .05). The main reasons were: the cultivated area was isolated and inaccessible to electricity service, some area had access to electricity service but the cultivated area was far away. The growers did not want to increase the cost of production by paying for all the expenditures to get access to electricity service. Some of them thought that the light trap is not necessary because vegetables are short-lived crops. It may not be effective.

1.6 Neem sap

Approximately one-third of the IPM growers and almost all of the non-IPM growers did not apply the neem sap (Phi = -.65 p < .05). The reasons given included: having no experience in using it, difficulty in using it, thinking that it may not be effective and finding no pest. The IPM growers who did not apply any pesticide usually grow water spinach because they found no pest with this kind of vegetable.

1.7 Nematode

Sixty percent of the IPM growers and almost all of the non-IPM growers did not apply the nematode (Phi = -.36 p < .05). Various reasons were given as: being unaware of its usefulness, being not available in the local market, difficulty in keeping it. However, some of the growers thought that the nematode destroys the crop roots.

1.8 Bacillus thuringiensis (BT)

Sixty four percent of the IPM growers and all of the non-IPM growers did not apply BT (Phi = -.36 p < .05). Some of them were not introduced BT and therefore were not aware of BT. However, those who were introduced BT have never tried using it because of the difficulty in its application. They were instructed to ferment BT with rice straw and manure. To the growers, rice straw is rare materials.

1.9 Natural enemies

Sixty-four percent of the IPM growers and 82 percent of the non-IPM growers did not pay attention to the natural enemies. They explained that it is not necessary to invest in the natural enemies because they already exist in nature. However, some of them were not interested in using the natural enemies because they thought that the practice may not be effective.

2. Source of technological information

Obtained technological information on IPM vegetable growing has moderate association with adoption of IPM practices (Phi = .25 p < 0.05). The most important source of information was the government agricultural extension staff (Phi = .27 p < .05). The respondents were asked “To whom they go to see first for consultation in case they have problems in vegetable growing.” Although the growers mentioned variety of sources, a number of IPM growers (42 percent) depended on the government agricultural extension staff (Cramer’s V = .39 p < .05).

3. Government’s subsidy scheme

In addition to dissemination of technological information on IPM, the government extension agency has provided the IPM growers with some subsidies, i.e. natural pesticide (neem sap) and nylon net. However, not all growers were provided with subsidies due to limited budget.

4. Awareness of the danger of hazardous substances

The growers’ awareness of the danger of hazardous substances had moderate association with the adoption of IPM practices. The IPM
vegetable growers perceived that misuse of chemical substance is dangerous to both the growers and the consumers (Cramer's V = .28 p < .05). A majority of them disagreed that farmers think more of the income from vegetable production than the danger of chemical pesticides (Cramer's V = .32 p < .05).

5. Organization membership

Organizational membership was associated with adoption of IPM technologies. A higher percentage of IPM growers belong to vegetable production group (Phi = .33 p < .05), and also other group or organization (Phi = .32 p < .05). Through the local organization, the agricultural extension staff approached the member growers and disseminated the IPM information.

6. Growers' perception of benefits of adoption of IPM technologies

Eighty two percent of the IPM growers were satisfied with their practices that contribute to better health of the grower and their family members. Seventy nine percent were satisfied because the consumers have no risk taking the chemical residues. About 67 percent were satisfied with additional income, this was due to low cost of production and many more marketing outlets.

The growers' perceptions of benefits has moderate association with the adoption of IPM practices. The smaller number of IPM vegetable growers reported high cost of expenses for inputs compared to the non-IPM growers (Phi = .22 p < .05). The larger number of IPM growers are satisfied with benefits, specified as contributing additional income (Phi = .28 p < .05) and being good for health of the growers and their family members (Phi = .21 p < .05).

The respondents were asked whether or not they wanted to continue IPM vegetable production. About three-fourths of the IPM growers and 50 percent of the non-IPM growers responded positively (Phi = .28 p < .05). However, more than half of the IPM growers (54 percent) did not want to expand the size of land for vegetable production. The various reasons given being included: having limited land and capital for investment, high wage rate, labor and water shortage. However, some of them grow rice as their major occupation. Some of them thought that larger quality of vegetable production can lead to poor quality (Phi = .28 p < .05).

DISCUSSION AND RECOMMENDATIONS

These findings suggested the importance of some factors needed to be considered in designing the programs aimed to expand the areas for IPM vegetable production.

Firstly, attention must be paid to particular IPM technologies that may be inappropriate for practice. Research and development on IPM should be promoted to find out site-specific technologies through grower-scientist collaboration.

Secondly, the government agricultural extension agency is a major source of IPM information. However, disseminating information about IPM has been limited to a certain extent. Some growers for example, had no understanding about biological control. Sufficient technical knowledge should be provided also by other avenues.

Thirdly, the government subsidy scheme has been operated under the demand system. Nevertheless, not all growers were provided with materials they requested and the materials such as nylon net were seldom delivered on time. Appropriate credit and subsidy scheme should be reconsidered.

Fourthly growing concern about the danger of hazardous substances has generated the growers interest in adopting IPM. More information about the effects of agriculture on the environment should be put out through the media such as T.V. and radio programs which are respectively widely watched.
and listened by the growers.

Fifthly, the vegetable growers should be encouraged to form a group which becomes another channel for delivering services and information.

Finally, the growers' perceived profitability in terms of low cost of production, additional income and better health has contributed to adoption of IPM. Encouraging adoption of IPM and supporting should be put forward for ensuring IPM is adopted more widely.

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