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Effect on Fruit Quality of 2-Year Compost Application in a Conventionally Managed Pear Orchard

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관행재배구의 유기질 비료의 시용이 배 과실 품질에 미치는 영향

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Abstract

'Niitaka' (*Pyrus pyriforia*) has been the major cultivar of the Asian pear since the 1970s, and yielded about 70% of pear production in South Korea in 2002. When Chuseok (Korean Thanksgiving Day) is earlier than the fruit maturation period, farmers seek to advance the harvesting date to keep pace with the increase in consumer demand caused by the holiday. However, unripened fruit is of suboptimal marketable value because the flesh has a low soluble solid content, the fruit color is not attractive, and stone volume is high. Compost treatment can enhance soil microbial activity and affect soil chemistry, which may accelerate fruit maturation and allow an earlier harvesting date. Therefore, we examined the effect of 2 years of compost application on the fruit quality of Asian pear trees grown under conventional management conditions. The Hunter "L" and "a" values were higher in compost-treated fruit, which also showed greater sweetness and lower acidity than did conventional fruit. The stone volume was reduced and fruit calcium concentration was increased by compost treatment. Therefore, compost treatment may advance fruit harvesting owing to the increased marketability afforded by attractive skin color, sweetness, and reduced stone volume.

Key words : compost, fruit quality, stone cell, Hunter value, calcium

Introduction

The increased consumer demand for organic fruit has brought about a transition into organically grown fruits from conventionally grown fruit. Although the high premium price of organic fruit attracts farmers to grow the fruit, little scientific information about the fruit quality makes a challenge to manage organic fruit. Therefore, the organic system is an alternative to the integrated farming system which uses chemical fertilizer plus organic fertilizer such as compost in South Korea.

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The ‘Niitaka’ pear fruit is the major cultivar in South Korea, which comprises about 70% of pear fruits(1). Although the pear fruit is usually harvested in the early October in the Southern Region of South Korea, farmers are trying to pick up and sell the unripened fruits in the fresh market if the Chuseok is in the early or mid-September. However, the early harvested fruits have usually not reached at the ripening fruit stage, which brings about less fruit color and soluble solid content as well as more stone cell contents of the fresh fruit.

Compost contains essential nutrients and effective microorganisms; therefore, the increased soil biological and chemical properties would improve nutrient status of the trees(2). The increased leaf nutrients could dramatically change the postharvest behavior of apples and may quicken fruit maturation. Organic fertilizer providing less nitrogen due to the slow mineralization rate may improve fruit quality because smaller fruit size has more [Ca] in fruit through the dilution effect of the fruit(3). The consistent trends of high fruit firmness, sugar, and quality were observed in the organic farming system(4). However, there are few differences in quality and sensory tests of fresh and stored organically and conventionally grown apples(5-6).

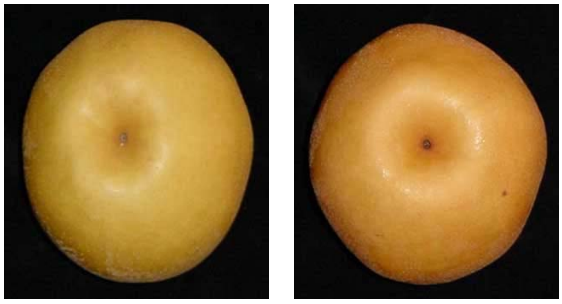
Stone cells reduce edibleness of the Asian pear(7). This symptom could be caused by peroxidase activity that is responsible for ripening of peach fruit(8). The stone cell of fruit grown under organic fertilizer could be reduced by enhancing fruit [Ca] because high fruit [Ca] maintains cell integrity and may delay ripening fruit process resulting in reducing stone cell content. Therefore, this study was established to investigate the effect of a two year compost application on fruit quality of Asian pear trees grown under conventional management.

Materials and Methods

The study was conducted with ten to fifteen-year-old 'Niitaka' pear trees conventionally grown under a private orchard in Kyung-San, Kyungnam, Korea in 2002. The study design was a completely randomized design with five replications of each treatment. The treated plot was applied by Sanwool® compost treatment that contained 8.5% of phosphate, 6.5% of potash, 21% of organic matter, and 3.1×10^{7} cfu. mg^{-1} of microorganism. The compost fertilizer was applied on May 15th and June 15th at rates of approximately 0.5 kg and 0.7 kg of compost per tree, respectively in 2001 and 2002. Compost and control plots were compared for fruit quality.

Fruit characteristics: The fruit skin color was graded by fruit hunter value with high grade spectrum color sensor (JS-555, Japan), and more positive values of L, a, and b stand for more lightness, redness, and yellowness, respectively. The fruit samples were approximately harvested at the size of 700 g per fruit. The fruit was measured with diameter(D) and length(L), and L to D ratio was calculated for the fruit type(Fig. 1). The fruit was peed out, and fruit firmness was observed with hand held penetrometer with 5 mm diameter plunger(Japan). For the soluble solid analysis, the fruit juice was measured by hand held refractometer(N1 Atago, Japan), and malic acidity(%) was reported by titrating a 10 mL juice aliquot with 0.1 N NaOH.

Stone cell: Ten g of pear fresh was homogenized for 35 minutes by 35 ml of CH_3OH(95%) and centrifuged for 10 minutes with 753×g. The sediment was homogenized for 25 minutes by 25 mL of CH_3OH(95%) and suspended for 15 minutes with 840×g. The sediment was shaking for 25 minutes by adding 25 ml of 1 N NaOH, and it was repeated again. The sediment was shacked by 25 mL of 1 N HCl, and it was dried for 80 ℃ in dry oven and the dry weight of the sediment was determined for the value of stone cell(7).



Conventional fruit Compost fruit

Fig. 1. Conventional and compost 'Niitaka' pear fruits in Kyungsan, Kyungbuk, 2002.

Fruit [N], [P], [K], [Ca], and [Mg]: After fruit characteristics were measured, the fruit samples were dried at 70°C for 3 days and ground to pass a 2 mm mesh screen. The 0.5 g ground fruit sample was extracted by 10 mL of H_2SO_4 at 250℃ in a grass flask in the flow hood until its color turned from green to white. If the sample was not completely extracted, two or three ml of H_2O_2 was added into the glass flask under 370℃. After the samples were completely extracted and cooled down, they were filtered through filter paper(Whatman NO. 6) and measured for phosphorous analysis at 470 nm on UV-visible spectrometer (Shimadzu UV-1601, Japan). Also, the filtered extraction was filled up to 100 mL with deionized water. The extracted aqueous was measured by atomic absorption spectrometer (Pye-unicam PV 9000) for the total nitrogen analysis, and it was diluted by 50 times and measured by Inductively Coupled Plasma Atomic Emission Spectrometer (Pye-unicam PU 9000, England) for the calcium, magnesium, and potassium analyses at the cooperative lab of college of agriculture in Chonnam National University.

Fruit texture; Texture analyzer(TA-XT2, Texture technologies Corp., USA) was used for the fruit texture characteristics such as cohesiveness, viscosity, springiness, adhesiveness, brittleness, and chewiness.

Results and Discussion

The fruit hunter value was used for indexing fruit skin color(Table 1). The more bright and red fruits were produced by the compost treated trees, and conventional fruit had high fruit b value, which is associated with the fruit yellowness color(Table 1 and Fig.1). The improved marketable fruit color indicates that the fruit harvesting date could be shortened due to the increased fruit hunter L and a values.

Table 1. Fruit color measured by hunter value as affected by compost treatment of 'Niitaka' pear orchard in Kyungsan, Kyunbuk, 2002

Treatment	Hunter value		
	L	a	b
Conventional	64.27±0.95	6.97±1.13	38.16±0.56
Compost	65.93±0.89	8.23±0.14	35.71±0.39

The fruit size was much heavier on the compost treated trees that had a slightly flatted type compared to the control(Table 2). The fruits grown under compost treatment had higher soluble solid content and lower acidity which resulted in high fruit sugar to acid ratio(Table 2). This would indicate that the compost application more had contributed for the fruit sweetness rather than fruit acidity. The fruit stone cell as a thick and muddy taste was reduced about 10% by compost treatment(Table 2). The stone cell formation would be prevented by enhancing fruit [Ca]. The improved fruit [Ca] will enhance cell membrane permeability and cell wall integrity as a component of pectin compound(9-10). The strong cell wall structure may delay fruit ripeness and reduce peroxidase activity which is associated with the formation of the stone cell in fruit(8).

Table 2. Fruit qualities as affected by compost treatment of 'Niitaka' pear orchard in Kyungsan, Kyungbuk, 2002

Treatment	Fruit wt. (g)	Shape index (L/D)	Soluble solid (A) (%)	Acidity (B) (%)	A/B	Stone cell (mg/FW g)
Conventional	685±76	0.92	11.2±0.12	0.71	15.77	17.5±3.0
Compost	757±37	0.89	11.9±0.26	0.66	18.03	16.3±4.0

The compost treated fruit had lower total [N] and [P] but higher [K] and [Ca] compared to the conventional fruit(Table 3). Larger fruit size has usually higher fruit [N] and lower [Ca] because the [Ca] is not kept pace with the rapid fruit expansion(11), but our experiment result showed that compost treated fruit had larger fruit size and high fruit [Ca] but low fruit [N]. Also, it was not observed that fruit K and Mg concentrations in fruit flesh of sweet persimmon showed a strong negative relationship with [Ca](12).

Table 3. Fruit nutrient concentrations as affected by compost treatment of 'Niitaka' pear orchard in Kyungsan, Kyungbuk, 2002

Treatment	Total N (%)	P_2O_5 (mg kg^{-1})	K (cmol$^+$ kg^{-1})	Ca (cmol$^+$ kg^{-1})	Mg (cmol$^+$ kg^{-1})
Conventional	3.75±0.50	93.3±23.4	5.89±1.07	2.11±0.38	2.89±0.62
Compost	3.13±0.23	86.3±33.0	7.50±1.52	2.62±0.53	2.82±0.78

Table 4 presents the fruit texture characteristics that were analyzed by fruit texture analyzer. No distinctive differences were found in all the treatments for the fruit springiness as an elasticity of fruit, cohesiveness as a unity of each fruit segment, and adhesiveness as a of the fruit segments in the mouth. Sensory panels found that there were no significant differences for the fruit texture, flavor, and tartness of conventional and integrated apple fruits(6). However, the chewiness, which is related to the fruit firmness, was lower with the compost treated fruits. This was also observed by low flesh firmness at the compost treated fruits. The high fruit [Ca] did not affect the fruit firmness in this experiment, but the reduced stone cell segments of the fruit by compost treatment would mostly affect the reduction of fruit firmness. In conclusion, the compost treated fruit had comparable fruit qualities compared to the conventional fruit. Especially, improved fruit skin color and fruit sweetness as well as lower fruit stone content were obtained by compost application, which would have allowed compost treated fruit to be sold earlier in the market season when Chuseok is earlier and prices are generally higher.

Table 4. Fruit texture as affected by compost treatment of 'Niitaka' pear orchard in Kyungsan, Kyungbuk, 2002

Treatment	Fruit texture (kg)				Fruit firmness (N)	
	Springiness	Cohesiveness	Adhesiveness	Chewiness	Peel	Flesh
Conventional	0.95±0.0	0.18±0.05	11.72±2.8	5.72±0.5	24.82±2.7	17.72±2.8
Compost	0.96±0.0	0.17±0.02	11.43±0.9	5.36±0.4	23.39±2.7	15.43±2.9

요 약

관행재배구의 유기질 비료의 시용이 배 과실 품질에 미치는 영향

1970년대부터 소비자의 선호도가 높은 신고 품종 재배가 급증하기 시작하였고, 2002년 현재 전체 배 재배면적의 70%를 차지하고 있다. 추석이 빠를 경우 성숙이 덜된 과일을 수확하여 시장에 출하함으로서 품질이 좋지 않은 과일로 인하여 소비가 둔화되고 가격이 떨어져 동양배를 재배하고 있는 농가의 수입을 감소시키는 요인으로 작용하고 있다. 따라서 본 실험은 미생물이 들어있는 유기질비료(compost)를 이용하여 추석에 조기 출하되는 신고배의 품질을 향상시킬 수 있는 방법을 제시하고자 실시하였다. 2년 동안의 compost 처리가 과일에 미치는 영향은 색차계를 이용하여 측정한 결과 Hunter L값과 a값이 높은 경향을 보여 사람의 눈으로 보기에 더 익은 것처럼 보였고, 더 당도가 상승하고 산도가 낮아지는 경향을 보여 과실의 조기 성숙이 이루어지고 있다고 판단하였다. 특히, 유기질 비료는 과실내 석세포 함량을 줄였고 칼슘함량을 높여서, 과실의 육질을 부드럽게 개선시킴으로써, 조기 출하되는 과실의 품질을 향상시킬 수 있는 방법으로 제안될 수 있다.

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