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'Bio－Green' Functional Water Supply Influences Mineral Uptake and Fruit Quality in Tsugaru Apples

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'바이오 그린' 機能水 處理가 사과 쓰가루 品種의 無機成分 吸收와 果實品質에 미치는 影響

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Abstract

Commercial Bio－Green(B.G.) functional water was manufactured through a series of processes ; water → ultra－purification → adding catalysts → energy imprinting fermenting with energized water + zeolite and others + photosynthetic bacteria in fermenter → filtering. Control(0), 5 or 10 liters per plant of B.G. functional water were supplied to the orchard soil under canopy of 10 year－old 'Tsugaru'/M26 apple trees on March 20, May 20 and June 20, 1995, respectively. pH and content of Ca and Mg of orchard soil were increased by supply with B.G. functional water. However, P_2O_5, K, and B contents were not influenced by the treatment. At harvest time soluble solid content of flesh tissue and anthocyanin of fruit skin were increased by the treatment. B.G. functional water treatment showed higher root activities, and photosynthesis of leaves than that of control. Also B.G. functional water treatment enhanced Ca content in fruit skin and flesh tissues, whereas not affected N, K, and Mg contents. During storage at 4℃ cold room, the more volume of B.G. functional water supply showed lower bitter pit symptom. Respiration and ethylene evolution in fruit decreased, while fruit firmness increased by the treatment during storage.

주 제 어 : 사과, 기능수, 영양, 생리장해, 칼슘
Key words : *Malus domestica* B., functional water, nutriention, physiological disorder, calcium

Introduction

The productivity and the quality of fruit crops are mainly dominated by the three factors, i.e. variety choice, climate condition and agro－techniques in commercial orchards.

Although there were outstandingly improved and developed in the fields of new varieties and cultural techniques with agricultural mechanics in advance during last two to three decades, the environments of soils, water and air have suffered in terms of a pollutant which attributed from industrialization around all over the world. Agricultural environment may be unsatisfactory ; in weather condition of too cold or hot, too wet or dry, also in soil characteristics such as poor physical conditions, improper soil pH or saline soil. Man-made activities can cause problems such as too much pesticides, inorganic fertilizers and herbicides during cropping seasons (Bennett, 1993).

In recent years there have been some revolutionary research projects to solve the environmental problems, and to improve yield and quality by using new materials and ultra-functional substances in agriculture. In fact, they have been commercially applied in crop cultivation with Effective Microorganisms (EM) in Japan and Korea (Matsmoto, 1994), mineral complex of Spray-N-Grow in U.S.A. (Nightingale, 1994), electrolytic water in Japan and Korea (Miyaki, 1994), ultrasonic irradiated water in Japan and U.S.A. (Koda and Nomura, 1994), functional water in Japan (Masayo, 1994), pi (π) water in Japan (Makino, 1994), Open-All in U.S.A.(CMH Environmental Group, 1993), and B.G. functional water in Korea (Kim et al., 1995).

The objective of this investigation was to determine the functions and effects on the growth and development of 'Tsugaru' apples with the energized B.G. functional water.

Materials and Methods

Manufacturing of energized B.G. functional water; In order to produce B.G. functional water 4 steps were processed by Kyungwon Enterprise Co. (Fig. 1). Through the first step the energized water was obtained by micro-filtering with tap water, exposure to a limited magnetic fields, adding catalysts, and energy imprint in platinum columns. The second step was to produce the energized solid powder by maintaining high temperature with liquid catalyst + zeolite in iron belt, and adding photosynthetic bacteria. After mixing with energized water plus energized solid power, the third step was carried in the microbial fermenter at 25℃ for 15 day. The last step was filtering the ferment substances to separate to 2 phases of filtrated liquid and residues; the filtrated liquid, B.G. functional water used for irrigation to crops, as well as the residues for soil conditioner before planting crops.

Treatment of B.G. functional water; Ten year-old 'Tsugaru' apple trees grafted on M.26 rootstock were used in this experiment. Trees were trained to a vertical axe system at a spacing of 3.5m×6.0m (470 trees · Ha^{-1}). The experiment was designed as a randomized block design with three replications within two-trees plot for a total of 18 trees. After dispersing the energized B.G. powders under apple trees as much as 3kg · $tree^{-1}$ and then plowing soil surface, aqueous B.G. functional water of 5 or 10 was applied around the trunk of each tree in the soil line in Horticultural Research Institute, Suwon, Korea at three times monthly from April 20, 1995. In order to measure the soil pH and mineral elements of the orchard each soil was sampled under the tree canopy on July 10, 1995, and dried at 60℃ for 48 hours.

The concentrations of mineral element of soil and fruit skin were measured by Atomic

Absorption Spectrophotometer (Perkin−Elmer, 2380). Soluble solids were measured by randomly selecting apple fruit, grinding them in a Waring blender, and filtering the juice through cheesecloth onto a temperature compensated hand−held refractometer (0 to 32%; Atago N1, Japan). Root activity was measured by the test of triphenyltetrazolium chloride (TTC). In photosynthesis, leaf gas exchange was measured with a portable closed photosynthesis system (LI−6200; LI−COR) between 1:00 and 3:00 PM. Photosynthetic photon flux (PPF, 400~700nm), air and leaf temperature, and relative humidity inside the leaf chamber were measured concurrently with gas (CO_2) exchange.

Ethylene production and respiration rates were measured daily on fruit from selected treatments held at 20℃ after removal from storage (Saltveit, 1982). Five fruits per treatment were sealed individually in 1 liter containers, and after 1 hour, 1mℓ gas sample was measured by gas chromatography using flame−ionization detectors (Hitachi K−53).

Results

The treatment of B.G. functional water significantly increased soil pH, Ca and Mg content in orchard soils. Especially, the higher B.G. functional water supply showed the higher levels of soil pH and exchangeable cations of Ca and Mg from soil extraction. However, the levels of P_2O_5, K and B were not influenced by the treatment of B. G. functional water (Table 1).

In terms of fruit characteristics of 'Tsugaru' apples, soluble solids were increased as much as 12.6° Bx in the treatment of 10 liters of B.G. functional water in comparison to 11.0° Bx of control (Table 2.). In addition anthocyanin contents in fruit skin were increased by B.G. functional water supply. There were no significant differences in fruit weight, organic acidity, and fruit firmness among the treatments.

There was an overall increase in fruit skin and flesh Ca concentration (Table 3), but a decrease in N concentration by B.G. functional water treatments. Both K and Mg were not significantly changed in the apple skin and flesh.

Higher root activity was constantly measured as affected by B.G. functional water supply of 10 and 5 liters in 'Tsugaru' apple trees. Also net photosynthetic rates of leaves were remarkably stimulated by the treatment as much as 13.4 $\mu mol \cdot m^{-2} \cdot s^{-1}$ in comparison to 10.5 $\mu mol\ m^{-2} \cdot s^{-1}$ of control (Table 4).

During the storage at 5℃ bitter pit, a physiological disorder of 'Tsugaru' apples was significantly decreased by supply of 5 to 10 liters of B.G. functional water, although very high levels of bitter pit have observed in control without B.G. functional water. In addition, bitter rot(*Gloesporium fructigenum*) of the 'Tsugaru' apples fruit during preharvest period was dramatically reduced from the apple trees supplied with 10 liters of B. G. functional water (Table 5). Genetically 'Tsugaru' apples are susceptible to bitter pit as postharvest physiological disorder, and bitter rot as preharvest desease.

During the fruit storage at 4℃ the fruit treated with B.G. functional water showed distinguishable characteristics of fruit firmness, respiration, and ethylene evolution in comparison to control. By the supply of B.G. functional water fruit firmness was higher on 4 weeks after storage, while respiration rate and ethylene evolution were significantly lower than that of control (Table 6).

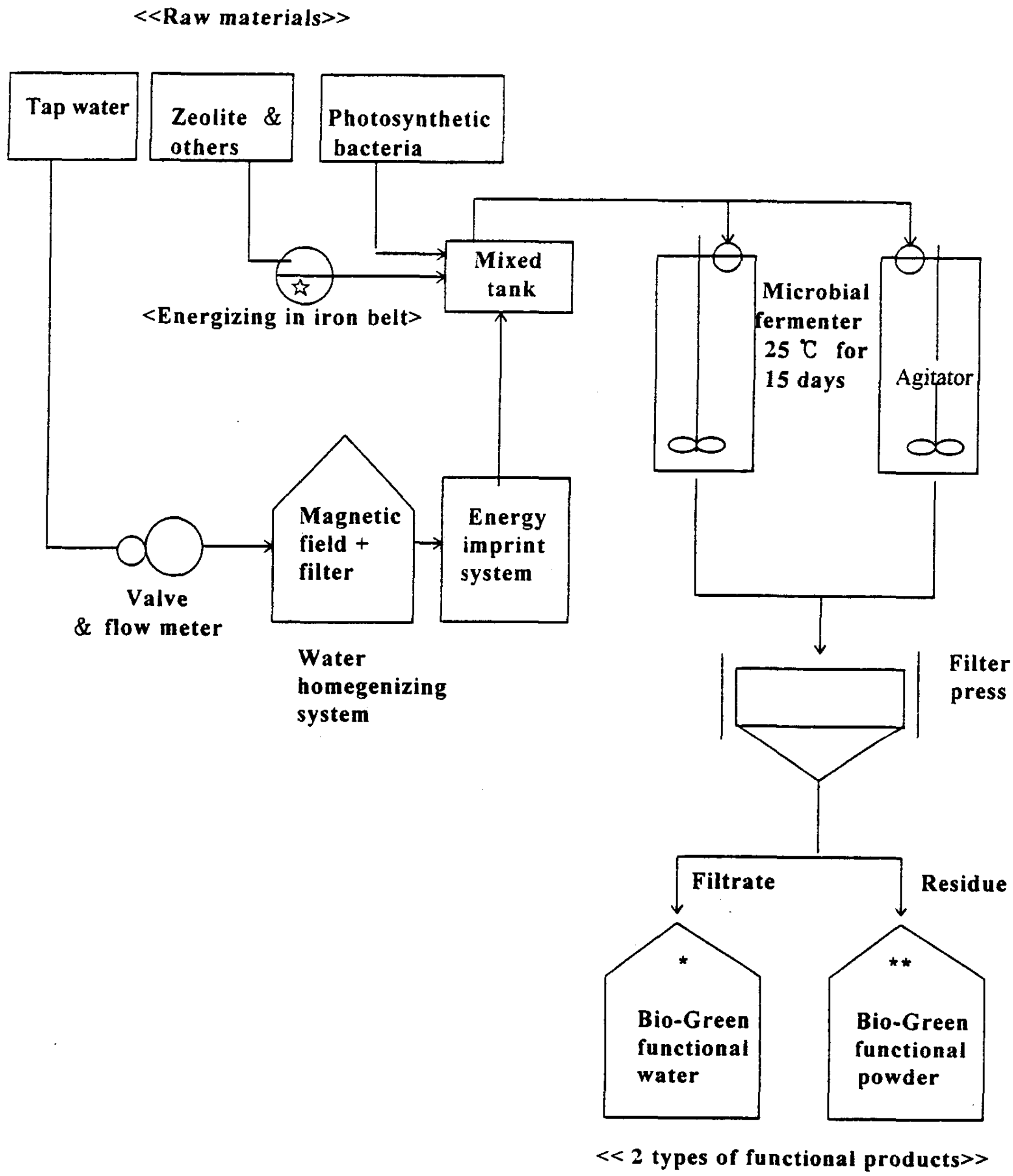

Fig. 1. Manufacturing process for the energized Bio-Green(B.G.) functional water.
The energized B.G. functional water(*) is to be supplied to orchard soils during plant growing season. Because the energized B.G. functional powder (**) is a soil conditioner as well as the supporter of the energized B.G. functional water, it must be supplied to orchard soils before plant growing season.

Table 1. Effect of B.G. functional water supply on the pH and mineral elements of the orchard soils in 'Tsugaru' apples. Soil was sampled on July 10, 1995.

Treatment[z]	pH (1:2.5)	P_2O_5 (ppm)	Exchangeable cation (me/100g) K	Ca	Mg	B (ppm)
Control	5.73b[y]	662a	0.50a	4.17c	1.17b	0.48a
5 ℓ B. G. functional water	6.31a	640a	0.53a	5.90b	1.39ab	0.46a
10 ℓ B. G. functional water	6.43a	657a	0.58a	6.21a	1.46a	0.41a

[z]B.G. functional water was supplied as much as 5 and 10 liters to the soils under the canopy of apple trees at 3 times monthly from April 20, 1995.

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

Table 2. Effect of B.G. functional water supply on the fruit characteristics of 'Tsugaru' apples.

Treatment[z]	Fruit wt (g)	Soluble solids (°Bx)	Organic acidity (%)	Firmness (kg/5mm)	Anthocyanin (mg/cm^2)
Control	252a[y]	11.0c	0.30a	0.57a	7.6b
5 ℓ B. G. functional water	253a	11.7b	0.25a	0.54a	9.3a
10 ℓ B. G. functional water	263a	12.6a	0.23a	0.69a	9.8a

[z]B.G. functional water was supplied as much as 5 and 10 liters to the soils under the canopy of apple trees at 3 time monthly from April 20, 1995.

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

Table 3. Effect of B.G. functional water supply on the mineral contents in fruit of 'Tsugaru' apples which harvested on August 30, 1995.

Treatment[z]	Skin (dry wt.) N (%)	K (%)	Ca (ppm)	Mg (ppm)	Flesh (dry wt.) N (%)	K (%)	Ca (ppm)	Mg (ppm)
Control	0.33a[y]	0.68a	302c	605a	0.24a	0.68a	145b	157a
5 ℓ B. G. functional water	0.27b	0.68a	374b	593a	0.23a	0.72a	156ab	158a
10 ℓ B. G. functional water	0.25b	0.70a	421a	610a	0.23a	0.74a	169a	162a

[z]B.G. functional water was supplied as much as 5 and 10 liters to the soils under the canopy of apple trees at 3 times monthly from April 20, 1995.

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

Table 4. Effect of B.G. functional water supply on the root activity and leaf photosynthesis of 'Tsugaru' apples. Roots and leaves were sampled to be measured their function on July 10, 1995.

Treatment[z]	Root activity (formazan $\mu g \cdot g^{-1} \cdot h^{-1}$)	Net photosynthetic rate ($\mu mol\ CO_2 \cdot m^{-2} \cdot s^{-1}$)
Control	172b[y]	10.5b
5 ℓ B.G. functional water	212a	12.1ab
10 ℓ B.G. functional water	239a	13.4a

[z]B.G. functional water was supplied as much as 5 and 10 liters to the soils under the canopy of apple trees at 3 time monthly from April 20, 1995.

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

Table 5. Effect of B.G. functional water supply on bitter pit and bitter rot of 'Tsugaru' apples.

Treatment[z]	Bitter pit[y] (%)	Bitter rot[x] (%)
Control	10.0a[w]	29.3a
5 ℓ B.G. functional water	5.7	10.0
10 ℓ B.G. functional water	2.1	7.9

[z]B.G. functional water was supplied as much as 5 and 10 liters to the soils under the canopy of apple trees at 3 times monthly from April 20, 1995.

[y]Bitter pit percentage during storage at 4℃ for 4 weeks.

[x]Bitter rot percentage during preharvest and postharvest at 4℃ for 4 weeks.

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

Table 6. Effect of B.G. functional water supply on fruit firmness, respiration and ethylene evolution of 'Tsugaru' apple fruit on 4 weeks after storage at 4℃.

Treatment[z]	Fruit firmness (kg/5mmφ)	Respiration rate (CO_2 mg $\cdot kg^{-1} \cdot h^{-1}$)	Ethylene ($\cdot kg^{-1} \cdot h^{-1}$)
Control	0.41b[y]	3.91a	4.65a
5 ℓ B.G. functional water	0.51ab	2.83b	3.78ab
10 ℓ B.G. functional water	0.63a	2.33b	3.27b

[z]B.G. functional water was supplied as mush as 5 and 10 liters to the soils under the canopy of apple trees at 3 times monthly from April 20, 1995.

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

Discussion

In 1990s several functional substances have been produced and used to improve the productivity and quality in cultivation of crops. Kim et al. (1995) suggested that the B.G. functional water have distinct functions of neutralizing agent for acid soil, increasing cations of Ca and Mg, and native micro-organisms in the farm lands, activating nutrient metabolism in plants, and disease resistance, etc. In this experiment the supply of B.G. functional water to the orchard soil of 'Tsugaru' apples significantly influenced to increase soil pH and Ca contents in soils and fruit, although there were not the same trends of Mg in soils and N in fruit. The result of the increased soluble solids content in apple fruit considered to relate to promotion of root activity and photosynthetic rate as affected by B.G. functional water supply. Yoo (1996) reported that the cherry tomato treated with B.G. functional water showed higher yield and soluble solids than that of control. A low level of exchangeable Ca in fruit tissues has also been related to more bitter pit in apple (Yamasaki et al. 1968 ; Kim, 1991 ; Ferguson and Watkins, 1983). It was very outstanding results that higher Ca and/or lower N in the fruit indicated lower bitter rot incidence during preharvest stages, lower bitter pit, respiration rate, and ethylene evolution during postharvest storage. By the 'Open-All' which is a soil and water conditioner, and manufactured by CMH Environmental Group(1993), soluble solids, berry set, and yields of grape were increased in vineyard of California, U.S.A. Many researchers reported that the increased Ca in the plant tissue reduced *Gloesporium perennans* in apples(Chapless and Johnson, 1977), *Rhizoctonia solani* in bean (Bateman and Lumsden, 1965), *Botrytis cinera* in lettuce (Krauss, 1971), and Fusarium wilt in tomato (Corden, 1965). On the other hand Makino (1994) found that the energized pi (π) water stimulated the seed germination, and resulted in higher yields of corn, radish and potato.

It (1995) reported that soluble solids, fruit weight in melon and cucumber were increased by spray of oxidative electrolytic water, while powdery mildew disease could be controlled without fungicides in the plastic film house. In these studies, the B.G. functional water supply resulted in orchard soil conditioning with increased pH, Ca and Mg content, and increased soluble solids and Ca content in 'Tsugaru' fruit, higher root activity and net photosynthetic rate of the leaves, and increased potential of fruit storage as lower respiration and ethylene evolution during storage. Especially, bitter rot of diseases and bitter pit of fruit physiological disorders were remarkablely reduced by supply of B.G. functional water.

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摘　　要

바이오 그린 기능수는 지하수 순수화→처리 촉매제 첨가→에너지 imprinting→여과 과정을 거쳐 제조되는 미약 에너지 발생 신소재로서 10년생 사과 쓰가루/M26 품종의 수관하부에 1995년 4월 20일, 5월 20일 및 6월 20일 '바이오 그린' 기능수를 주당 0, 5, 10ℓ씩 관주 처리하여 얻어진 결과는 다음과 같다.

사과원 토양의 화학적 특성에 있어서 무처리구의 pH 5.73에 비하여 기능수 처리구는 pH 6.31~6.43이었고, 기능수 처리에 의하여 치환성 Ca 및 Mg 함량이 증가되었다. 한편 P_2O_5, K 및 B 함량은 차이가 인정되지 않았다. 기능수 처리에 의하여 수확기 사과 과실의 당 함량과 과피의 안토시아닌 함량이 증가되었고, Ca 함량이 현저히 증가되었다. 그러나 N, K, Mg는 처리간에 차이가 없었다. 기능수가 처리된 사과의 수체특성에 있어서 뿌리활력과 잎의 광합성 능력이 향상되었다. 과실 저장중 (4℃) 기능수 처리구의 과실은 고두병 발생이 현저히 감소되었고, 호흡과 에틸렌 발생량이 상대적으로 적었으며, 높은 과실 경도를 나타냄으로써 과실 저장력이 향상되었다.