

# Effect of Surfactant Treatments on the Growth of Vegetables<sup>®</sup>

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In the present study we investigated the effect of a complex of surfactants in combination with liquid fertilizer on the growth of two vegetables. The complex of surfactant is a mixture of nonionic surfactant and a substance derived from a plant oil. The results showed that the complex of surfactants promoted the growth of tomato and spinach by accelerating photosynthetic rate and fertilizer absorption. They also increased the yield of strawberry. The complex of surfactants plus liquid fertilizer has been commercialized [called Perform<sup>®</sup> Soil (Kao Corp.)].

## INTRODUCTION

It is very important for farmers and plant propagators to grow seedlings of good quality in the early stage in order to produce stable yield and high quality. In agriculture surfactants are used for wetting and penetration of pesticides as a spreader or adjuvant (Kawashima and Takeno, 1982; Yokota et al., 1993). However, the utilization of surfactants in combination with a fertilizer application has received little research. In this study, we investigated the effects of surfactants in combination with liquid fertilizer on the growth of two vegetables and strawberry.

## MATERIALS AND METHOD

**Growth of Tomato and Spinach.** Tomato (*Lycopersicon esculentum* 'Zuiken') was used in this growth test. The seeds were sown in soil called 'Kureha engei baido' (Kureha chemical) containing N : P : K = 0.4 : 1.9 : 0.6 g kg<sup>-1</sup> in a greenhouse. Day 23 after sowing, each concentration of the complex of surfactants was irrigated with each dilution ratio of liquid fertilizer containing 17N : 9.5P : 18K at 7-day intervals. Control was irrigated only with the liquid fertilizer. On Day 44 after sowing, SPAD value, height, leaf area, shoot dry weight, and root dry weight of tomato were measured. On Day 61 after sowing, vitamin C and brix value were measured in tomato leaf tissue with RQ flex (Merk).

Spinach (*Spinacia oleracea* 'Esper') was also tested by similar methods.

**Photosynthetic Rate and Respiration Rate.** On Day 76 after sowing of 'Zuiken' tomato (*L. esculentum* 'Zuiken'), photosynthetic rate and respiration rate were measured with an infrared gas analyzer in a closed assimilation box (Nagaoka et al, 1984).

On Day 47 after sowing spinach, photosynthetic rate was measured with the portable photosynthesis apparatus (Model LI-6400, LICOR Inc.).

**Absorption of Fertilizer Component on Hydroponics.** 'Momotaro' tomato (*L. esculentum* 'Momotaro') seeds were sown in Kureha engei baido. On Day 17 (two true leaf stage) after sowing, the tomato seedlings were transplanted in a hydroponic

**Table 1.** Effect of the complex of surfactants with liquid fertilizer on the early growth of tomato 'Zuiken'.

Dilution ratio of liquid fertilizer*	Concentration of the complex of surfactants (ppm)	SPAD value	Height (cm)	Leaf area (cm <sup>2</sup> per plant)	Dry weight	
					of shoots (g per plant)	of roots (g per plant)
None	0	33.6	18.9	415.6	0.72	0.19
6000 times	0	34.3 (100)	19.6 (100)	434.8 (100)	0.94 (100)	0.21 (100)
6000 times	100	37.9 (110)	21.7 (111)	525.9 (121)	1.10 (117)	0.30 (143)
3000 times	0	34.9 (100)	20.8 (100)	474.9 (100)	0.96 (100)	0.25 (100)
3000 times	200	38.6 (111)	21.4 (103)	539.1 (114)	1.19 (124)	0.33 (131)
1500 times	0	36.0 (100)	20.4 (100)	487.6 (100)	0.88 (100)	0.28 (100)
1500 times	400	38.7 (108)	21.3 (104)	514.2 (105)	1.09 (123)	0.28 (100)

\*The component of liquid fertilizer N: P: K=17:9:5:18.

system containing a standard nutrient solution [Ohtsuka A solution (N : P : K = 260 : 120 : 405 ppm)] with or without the complex of surfactants.

On Day 12 after transplanting, the concentration of nitrate ion, phosphate ion, and potassium ion in each solution were measured. The absorption content of each fertilizer component by the plant was calculated from the concentration remaining in solution.

**Yield of Strawberry.** The transplants of strawberry, *Fragaria* 'Sagahonoka', which were planted in the field on 14 Sept. 1999, received an initial fertilizer treatment (N : P : K = 26 : 20 : 27 kg 10 acres<sup>-1</sup>). The complex of surfactants were irrigated with liquid fertilizer near the roots at 14-day intervals (total 16 times) from 14 Sept. 1999 to 14 April 2000. The yield of strawberry fruits was determined from Nov. 1999 to April 2000.

## RESULTS AND DISCUSSION

**Growth of Tomato and Spinach.** On Day 44 after the sowing of 'Zuiken' tomato, growth in the complex of surfactant treatments plus fertilizer increased 8% to 11% for the SPAD value, 5% to 21% for leaf area, 17% to 24% for shoot dry weight, and 0% to 43% for root dry-weight as compared with the same concentration of fertilizer (Table 1). The complex of surfactants remarkably promoted the increase in root dry weight. On Day 61 after sowing, the concentration of Vitamin C and brix value in tomato leaves increased each 18% to 49% and 0% to 7% of control (Table 2). There was a tendency for the best dilution ratio of liquid fertilizer to be 3000 to 4000 times and the best concentration of the surfactant complex to be 160 to 200 ppm (Table 1 and 2).

On Day 47 after sowing of 'Esper' spinach, the complex of surfactant treatments with fertilizer increased 10% to 14% for SPAD value, 8% to 12% for leaf area, 8% for shoot dry weight and 20% to 23% for root dry weight as compared with the same concentration of fertilizer. The result of the component analysis in leaf tissue showed an increase of Vitamin C and a reduction of NO<sub>3</sub>-ion.

**Table 2.** Effect of the complex of surfactants with or without liquid fertilizer on Vitamin C and Brix in tomato leaves.

Dilution ratio of liquid fertilizer*	Concentration of the complex of surfactants (ppm)	Concentration of vitamin C (ppm)	Brix value
None	0	2890(100)	8.2(100)
None	160	3398(118)	8.2(100)
8000 times	0	3116(100)	8.08(100)
8000 times	160	3766(121)	8.24(102)
4000 times	0	2718(100)	7.85(100)
4000 times	160	4059(149)	8.40(102)

\*The component of liquid fertilizer N : P : K=17 : 9.5 : 18

**Table 3.** Effect of the complex of surfactants with liquid fertilizer on photosynthetic rate and respiration rate of tomato.

Dilution ratio of liquid fertilizer*	Concentration of the complex of surfactants (ppm)	Photosynthetic rate (mg CO <sub>2</sub> dm <sup>-2</sup> h <sup>-1</sup> )	Respiration rate (mg CO <sub>2</sub> dm <sup>-2</sup> h <sup>-1</sup> )
None	0	12.8a**	2.2a
3000 times	0	13.0a	2.2a
3000 times	200	15.1b	3.4b

\*The component of liquid fertilizer N: P: K=17:9.5:18

\*\*Different letters within columns by Duncan's multiple range test, 5% level.

**Photosynthetic Rate and Respiration Rate.** Photosynthetic rate and respiration rate were investigated on Day 76 after sowing of tomato. Neither liquid fertilizer nor the control had a significant effect on photosynthetic or respiration rates (Table 3). However, the complex of surfactant treatments with fertilizer significantly promoted the photosynthetic rate and respiration rate when compared to the liquid fertilizer (Table 3). The complex of surfactants on spinach also increased the photosynthetic rate. These results show that the complex of surfactants may activate the metabolism of plant.

**Absorption of Fertilizer Component in Hydroponics.** Absorption content of fertilizer component in tomato seedlings was measured with or without the complex of surfactants in a hydroponic medium. Tomato seedlings treated with the complex of surfactants increased 63% for nitrate ion, 49% for phosphate ion, and 42% for potassium ion as compared with the standard medium (Table 4). Tomato seedlings treated with the complex of surfactants had more white roots and root hairs.

**Yield of Strawberry.** The strawberry yield was investigated with or without the complex of surfactants in the field. The strawberry plants treated with the complex of surfactants and liquid fertilizer remarkably increased number and dry weight of leaf and crown parts. Furthermore the complex of surfactants with liquid fertilizer increased both of the number of fruits and weight of a fruit. Finally, the yield of strawberry fruits increased 30% over control by the complex of surfactants (Table 5).

## SUMMARY

These data showed that the complex of surfactants increased the absorption of the fertilizer component and the photosynthetic rate, and promoted plant growth. However, the mechanism action of the complex of surfactants in plants has not been determined yet in detail.

The mixture of the complex of surfactants and fertilizer (N : P : K : Mg=6 : 2 : 5 : 1) is commercially available from KAO corporation in Japan, the product name is PERFORM<sup>®</sup> SOIL.

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**Table 4.** Effect of the complex of surfactants on the absorption of fertilizer component on hydroponics of tomato 'Momotaro'.

Concentration of the complex of surfactants (ppm)	Absorption content into plant (mg per plant)		
	Nitrate ion	Phosphate ion	Potassium ion
0	577.0(100)	61.0(100)	209.3(100)
200	940.8(163)	90.8(149)	297.3(142)

**Table 5.** Effect of the complex of surfactants with liquid fertilizer on yield of strawberry 'Sagahonoka'.

Test plot (number per 10 plants)	Number of fruits (g per fruit)	Weight of fruit (g per 10 plants)	Total yield of fruits
Control	417(100)	14.2(100)	5921(100)
The complex of surfactants with liquid fertilizer	491(117)	15.9(112)	7813(130)

**LITERATURE CITED**

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