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The Effect of Fertigation System on the Contents and Composition of Non-Protein-N, Carbohydrate and Crude Lipid of Sweet Pepper (*Capsicum annul* L.)

Fanggong SUI*, Yunhua WANG*, Makoto NAGATOMO**
Naoya CHISHAKI and Shunji INANAGA
(*Laboratory of Plant Nutrition and Fertilizer*)
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Introduction

Application of a large amount of nitrogen fertilizer has been performed as a common agricultural practice to obtain high vegetable yields. Originally the excessive use of nitrogen fertilizer to the high-valuable vegetables grown in greenhouse is economically motivated. However, such an agricultural practice has raised a lot of problems such as the groundwater pollution due to the leaching of excess nitrate-N and the nitrate accumulation in the eating portion of vegetables in greenhouse culture[1]. It is assuredly considered surreally that the leaching of nitrate-N is more negligible in the greenhouse culture than in the field culture because of less amount of leaching by the rain during the vegetable growing period. In fact, after the addition of the excessive nitrogen fertilizers executed during the vegetable growing period, the leaching of nitrate-N occurred through the period when the greenhouse was used, in the natural culture[2].

A large amount of nitrogen fertilizer has been also applied in the culture of the sweet pepper, one of the most is an important vegetables both in China and in Japan.

In the greenhouse culture in order to decrease the amount of nitrogen fertilizer applied to the soil and at the same time to increase the fruit yield of sweet pepper, the fertigation system developed recently by The Tochigi Prefecture National Agricultural Experiment Stations may be efficient[3].

In this study, attempt has been made to clarify the effect on the component in the sweet pepper, which was cultured, making use of the fertigation system.

Materials and Methods

The experiment was conducted in a greenhouse at Kagoshima Agricultural Experiment Stations. The initial characteristics of the soil in the experimental greenhouse are shown in Table 1. The soil acidity was adjusted to pH 6.0 and 196kg a^{-1} of the cattle feces compost containing 2.0 kg a^{-1} as N, 5.9 kg a^{-1} as P_2O_5, and 1.7 kg a^{-1} as K_2O were added to the greenhouse

*Huazhong Agricultural University, Wuhan. China
**Kagoshima Agricultural Experiment Stations.

Table 1. The initial characteristics of soil in greenhouse

Treatment	pH	EC	NH_4-N	NO_3-N	P_2O_5	CEC	K	Ca	Mg
	H_2O	Dsm^{-1}	$mgkg^{-1}$	$mgkg^{-1}$	$mgkg^{-1}$	$cmol(+)kg^{-1}$	$cmol(+)kg^{-1}$	$cmol(+)kg^{-1}$	$cmol(+)kg^{-1}$
Control	5.5	0.08	7.1	28.5	683	9.13	1.47	5.00	0.75
I	5.6	0.09	10.9	37.4	858	9.28	1.51	5.30	0.78
II	5.7	0.09	8.1	38.1	798	8.98	1.27	5.12	0.86
III	5.7	0.10	10.0	27.3	838	9.57	1.84	5.54	1.06

Table 2. The quantity and kinds of fertilizer applied in experiment (kga^{-1})

Treatment	Basic fertilizer			Top dressing			Total of fertilizer		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Control	4.0	4.0	4.0	2.0	2.0	2.0	6.0	6.0	6.0
I				6.0	6.0	6.0	6.0	6.0	6.0
II				4.2	4.2	4.2	4.2	4.2	4.2
III				3.0	3.0	3.0	3.0	3.0	3.0

soil before transplanting.

As shown in Table 2, the experimental design consisted of four treatments i.e. control, 6.4 kg a^{-1} as N (I treatment), 4.2 kg a^{-1} as N (II treatment), 3.0 kg a^{-1} as N (III treatment). The control treatment showed the nitrogen amount added in the usual method while the other three treatments showed those added in fertigation system. In the control treatment, compound of the CDU555 and BB48 fertilizers were used for basal and top dressing fertilizer, respectively. In the fertigation system treatments, the fertigation No.3 (commercial article containing $N-P_2O_5-K_2O=15-15-15$) were used as top dressing fertilizer. In fertigation system the fertilizer application methods previously described were applied[3].

The plot area of treatment was $7.2m^2$, where 8 plants of sweet pepper were planted and each of them was allowed to grow with 4 leader branches and many lateral branches. The beds have been covered with transparent poly multi from the 20 November to the 25 May of the next year. Through the sweet pepper growing period the temperature of night was maintained at 18℃ or more in the greenhouse.

The fruits were harvested from the 5 November to the 25 May but the vegetative part of plant and the fruits harvested in February and April were used for the determination of the component of the plant. The vegetative parts of the plant were divided into the leader and the lateral branch with leaves, respectively. The sampling plant was determined after oven-drying at 70℃. At the component, carbohydrate, lipid and amino acid were extracted and determined by the method as previously described (Inanaga 1993,1994)[4,5].

Results

1. Nitrate-and ammonium-nitrogen contents of the fruit

As shown in Fig. 1 and 2, among all treatments. there was no significant differences in nitrate-and ammonium-nitrogen (N) of the fruit harvested in Apr. However, in the fruit harvested in Feb. significant differences with nitrate and ammonium-N were found. In the

fertigation system, the NH_4-N and NO_3-N contents increased with the increasing of the N amount applied.

2. Amino acid contents

Total amino acid contents of the fruit were shown in Fig. 3, In Ⅱ treatment, the total amino acid contents of the fruits harvested in Feb. and Apr. were higher than those in the other treatments (Fig. 3). In every treatment total amino acid content was more in the fruit harvested in April than in that in February. In the lower N treatment it was lower than any

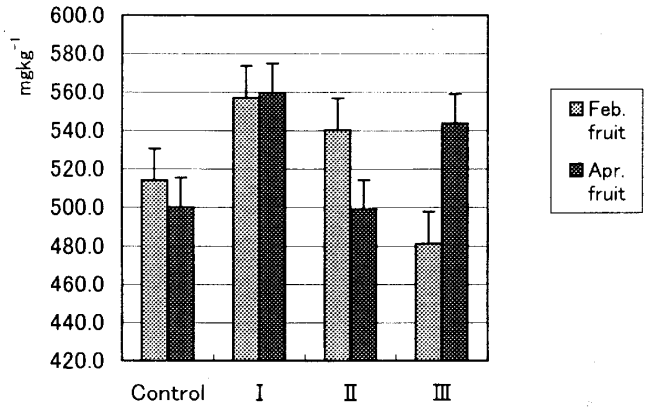

Fig. 1 Nitrate N content of fruit.

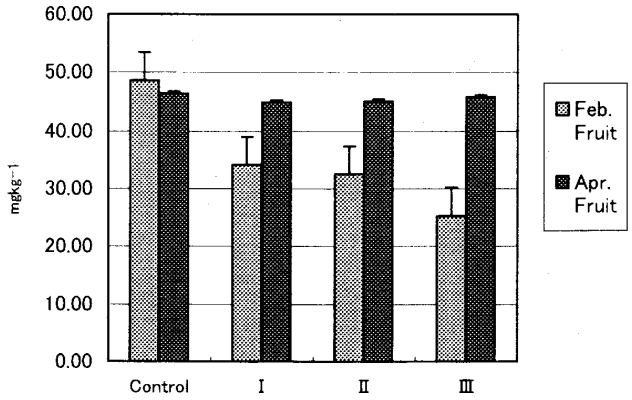

Fig. 2 Ammonium N content of fruit.

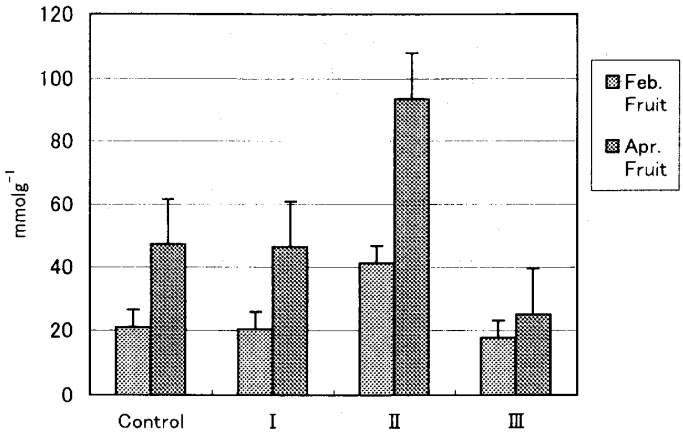

Fig. 3 Total amino acid content of fruit.

in all of the other treatments. Those of Ⅱ treatment were higher in both harvested in Feb. and in Apr. than those in the other treatments.

The composition of amino acid in the fruit harvested in Feb. was shown in Fig. 4. Main amino acid in the fruit of sweet pepper was prolin, glycin, alanin, leucin and isoleucin. However, differences were observed in the composition of amino acid among the N levels applied. In the fruit harvested in Feb. of the control and Ⅰ treatment in which N level was higher, prolin and arginin were hjgher than those in the Ⅱ and Ⅲ treatments. On the other hand, in the Ⅱ and Ⅲ treatments cystein and leucin became more compared with those of the higher N level treatment. While in the fruit harvested in April, prolin and cystein of the control were higher than those in the fertigation system treatments.

On the other hand, the percent of main amino acid to total amino acid was affected significantly by N level and the difference in the fruits harvested in the different season (Fig. 5).

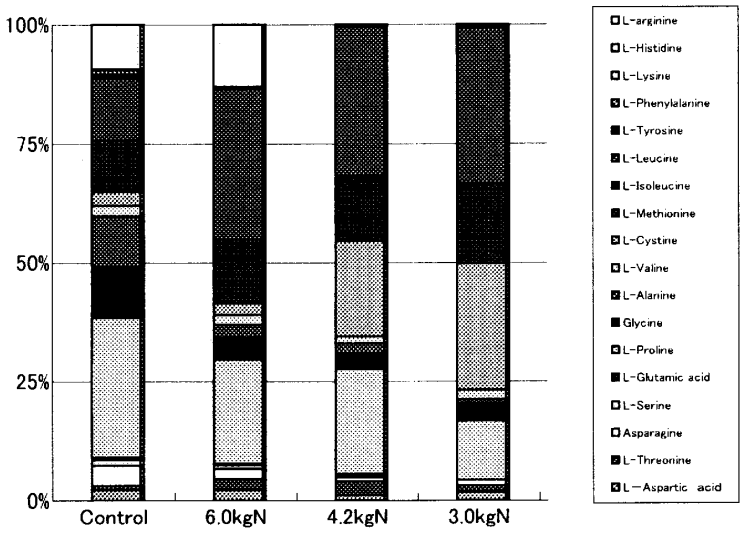

Fig. 4 Distrihution of amino acid in fruit harvested on Feb.

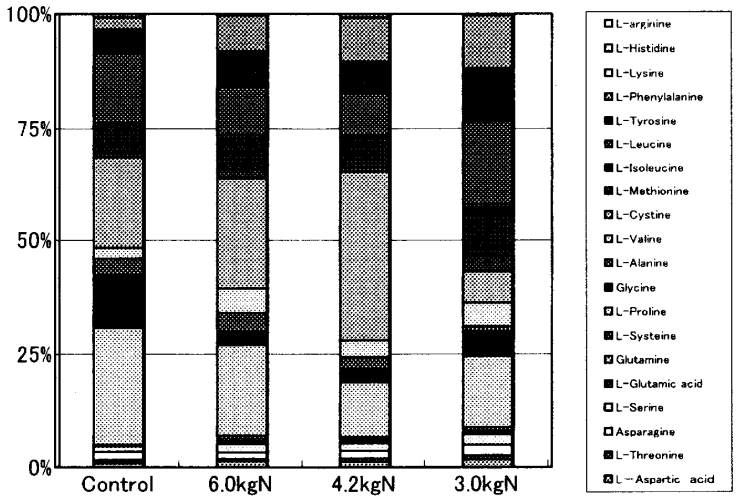

Fig. 5 Distrihution of amino acid in fruit havested on Apr.

3. Total sugar and main sugar contents

3.1 Total sugar content

As seen in Table 3, compared with the control treatment all the treatments in the fertigation system increased the total sugar contents of each organ. By decreasing the nitrogen amount applied from fertigation system, the total sugar contents of all organs increased. When the nitrogen amount applied by the fertigation system was decreased to half of the control treatment the total sugar contents of leader branch, fruits harvested in Feb. or in Apr. decreased remarkably excepting the lateral branch. There was more sugar in the fruit harvested in Feb. than that in Apr. and at the same time in the leader branch there was more than in the lateral branch in all the treatments.

3.2 Main sugar contents

As shown in Table 4, the kind of sugar of sweet pepper was mainly inositol, glucose, sucrose and fructose. In the fruit harvested in both months, fructose content was the highest among all the sugars, while in the leader branch the fructose content was lower than the other sugar contents, and in the lateral branch the inositol content was higher than the other sugar contents. There were differences with the each sugar content of the fruit between the control treatment and the fertigation system treatment, and among the fertigation system treatments.

In the lateral branch, the content of each sugar except fructose in the Ⅲ treatment was

Table 3. Total sugar content of sweet pepper (as sucrose%)

Treatment	Lateral branch	Leader branch	Feb. fuits	Apr. fuits
Control	1.62 c	1.77	28.95	39.45 b
Ⅰ	1.78 b	1.86	29.98	40.30 b
Ⅱ	1.62 c	2.46	37.01	45.48 a
Ⅲ	1.99 a	2.28	30.86	44.34 a
F Value	4.905*	NS	NS	6.403*

*; significant at 0.05 level. NS; no significant

Table 4. Contents of main sugar in branch and fruit of sweet pepper (%)

Treatment	Lateral branch				Leader branch			
	inositol	glucose	sucrose	fructose	inositol	glucose	sucrose	fructose
Control	0.500	0.209	0.095	0.167	0.228	0.511	0.466	0.111
Ⅰ	0.490	0.158	0.080	0.231	0.236	0.548	0.622	0.150
Ⅱ	0.504	0.149	0.094	0.295	0.270	0.533	0.816	0.138
Ⅲ	0.953	0.362	0.199	0.276	0.563	0.606	0.710	0.141
	· February fruit				April fruit			
	inositol	glucose	sucrose	fructose	inositol	glucose	sucrose	fructose
Control	0.865	3.549	1.394	6.871	0.747	6.084	1.442	6.469
Ⅰ	0.870	3.891	1.380	6.516	0.699	5.263	3.080	14.301
Ⅱ	0.664	4.101	0.992	5.221	0.719	5.172	3.101	14.468
Ⅲ	0.640	4.048	0.867	5.132	0.718	6.020	3.221	13.099

higher than in the other treatments, while in the leader branch the inositol and glucose in the Ⅲ treatment were higher than in the other treatments, and sucrose and glucose content were lower in the control treatment than those in the fertigation system treatment.

In the fruit harvested in Feb., the content of each sugar was higher in the control and Ⅱ treatment than that in the lower N treatment. On the other hand, in the fruit harvested in Apr., the sucrose and fructose content were remarkably lower in the control treatment than those in the fertigation system treatment. Furthermore in the fertigation system treatment, each sugar content excepting inositol became higher in the fruit harvested in Apr. than in that in Feb., while in the control treatment, the increasing of sugar content was not observed.

4. Starch content

Fig. 6 shows the crude starch contents in the branch and fruits of sweet pepper in different nitrogen treatments. Compared with fertigation system the control treatment increased the crude starch contents of lateral branch and the fruits harvested in April. By decreasing the amount of applied nitrogen in fertigation system, some effect could be observed in the branch and both fruits.

5. Crude lipid content

The crude lipid content in the fruit harvested in Feb. increased with the decreasing of N amount applied (Tab. 5). In the fruit harvested in Apr. there were no significant differences with lipid content among all the treatments. However in the higher N level it was higher in anaphase than in early fruit.

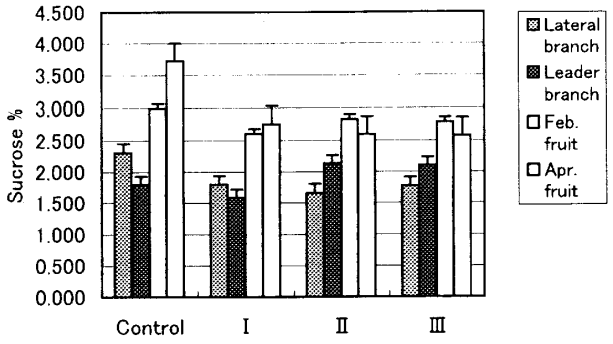

Fig. 6 Crude starch content of sweet pepper.

Table 5. Crude lipid content of fruit of sweet pepper (%)

Treatment	Feb. fruit	Apr. fruit
Control	2.09 b	2.44
I	2.18 b	2.65
Ⅱ	2.45 a	2.51
Ⅲ	2.65 a	2.54
F value	6.606*	NS

*; significant at 0.05 level. NS; no significant

Discussion

As previously reported[6], in the lower N level treatment, the growth of vegetative part and the yield of fruit were lower than in the other treatments, but decrease of those were obtained in the I and II treatments compared with the control treatment. While total N content of each organ became lower in the lower N level treatment.

As shown in Fig. 1, the NO_3-N content of the fruit increased with the increasing of the N amount applied, indicating that nitrogen affects the NO_3-N content not only in the vegetable leaf but also in fruit vegetable.

In case of the rice plant which absorbed a large amount of nitrogen at the maturing stage, the protein and free amino acid content increased, and of free amino acid, amide-N as glutamin and aspalagin was aroused. In the sweet pepper, as shown in Fig. 3, total amino acid in the fruit was the lowest in the lower N level, while it was the highest in the middle N level. The free amino acid in the fruit of sweet pepper, as shown in Fig. 4 and Fig. 5, was mainly prolin, leucin and alanin, being different with rice seed and peanut seed of which glutamin and asparagin were more. In the fruit harvested in Feb., in which total amino acid content was different, more arginin was observed in the fruit to which more nitrogen applied, but not in the fruit harvested in April. Those amino acid compositions may be characteristic of the sweet pepper and excess nitrogen may be accumulated in the fruit of sweet pepper as arginin. It is well known that in general crops, sugar in the leaf contained more sucrose than other sugar, and that carbohydrates of storage organs were starch. However, as shown in Table 4 in the vegetative part harvested in Apr. sucrose content was not more than in other sugars, and in the fruit the fructose content was the highest among carbohydrates, suggesting that in the fruit of sweet pepper fructose is a storage form but not starch, being different from other crops. The reason why in the vegetative part sucrose was less might be translocated to the fruit. The result that sugar content of the fruit harvested in Apr. increased compared with that on Feb. may be due to the increasing of temperature.

Difference between usual culture method and the fertigation system was observed in the carbohydrate in the fruit. In the fruit cultured in fertigation system, the sugar content, especially, fructose content was higher than that in the habitual method. From the fact that starch content was lower in the fruit of fertigation system, it was assumed that in the fertigation system starch synthesis from sugar translocated to fruit might be depressed. It is well known that sugar increased in the tomato fruit growing under water stress condition, but in fertigation system water stress condition is almost not present. The reason of this is far from clear.

In the fruit harvested in Feb. the crude lipid containing chlorophyll increased with the decreasing of the N amount applied, but in that in Apr. this was not observed.

To increase the sugar, total amino acid and cystein content of thefruit in the II treatment, this technique may be desirable.

Summary

The effects of fertigation system on non-protein-N, carbohydrate and crude lipid of sweet pepper were investigated, by comparison with habitual method. The results obtained are as follows:

The amount of NO_3-N in the fruit containing about 500 gkg-1 in the habitual method decreased with the decreasing of N applied in the fertigation system.

The total amino acid in the fruit was the lowest in the lower N level, while it was the highest in the middle N level. The free amino acid in the fruit of sweet pepper was mainly prolin, glycin, alanin, leucin and isoleucin. However, the composition of amino acid was affected with the N level applied.

The sucrose and fructose contents of fruit harvested in Feb. was lower both in the lower N level, and in the higher N level, while those of fruit harvested in Apr. in the fertigation system treatment remarkably became higher compared with those in the habitual method.

Compared with fertigation system the control treatment increased the crude starch contents of lateral branch and the fruits harvested in April. By decreasing the amount of nitrogen applied in fertigation system, some effect could be observed in the branch and both fruits.

The crude lipid content in the fruit harvested in Feb. increased with the decreasing of N amount applied on Apr. but there were no significant differences. In the high N level it was higher in anaphase than in early fruit.

To increase the sugar, total amino acid and cystein content of the fruit in sweet pepper, fertigation system may be desirable.

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