# THE CHOICE OF NITROGEN SOURCES BY THE CUCUMBERS

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**Abstract**: The cucumbers were grown in three kinds of nutrient' 150 ppm $NO_3^-$-N, 150 ppm $NH_4^+$-N, and the mixture of 75 ppm $NO_3^-$-N and 75 ppm $NH_4^+$-N, separately for seven days. The best and the worst growth were in the nutrient of $NO_3^-$-N and $NH_4^+$-N, respectively. Although they took the same amounts of combined nitrogen from each nutrient, the better assimilation of $NO_3^-$-N than $NH_4^+$-N in the cucumbers resulted in heavier dry weights, higher contents of total nitrogen, and higher soluble proteins contents in the leaves of cucumbers that grown in higher concentration of $NO_3^-$-N. The compostions of soluble proteins in the leaves of cucumbers were also influenced by nitrogen sources by showing their discrete electrophoretic patterns.

## INTRODUCTION

The promotory or the inhibitory effects of $NO_3^-$-N and $NH_4^+$-N on the growth and the development of plants were depended on the plant kinds and their metabolic status. Such as the rice seedlings grown in $NH_4^+$-N has higher total soluble protein and free amino nitrogen levels (Marwaha & Juliano, 1976), the pine seedlings grown in $NH_4^+$-N has lighter dry weights than those in $NO_3^-$-N (Lotocki & Andrzei, 1978), the development of detached wheat grains in terms of dry weight, nitrogen and protein were increased with the increasing concentrations of $NH_4^+$-N in the culture media (Bonovan & Lee, 1978), the uptake of combined nitrogen by cultured tobacco cells were increased the concentration of $NH_4^+$-N in the media, and the growth rates of cells had a peak at 0.83 of $NH_4^+$-N to $NO_3^-$-N rotio in the media (Kohno *et al.*, 1977), the proper amount of $NH_4^+$-N speeded up the growth and the development of rose cells cultured in $NO_3^-$-N media (Mohanty *et al.*, 1978).

The dry weights of cucumbers, that were separately grown in various nutrients with several concentrations of combined nitrogen, were heaviest and proportionally with the increasing concentration of $NO_3^-$-N for those grown in $NO_3^-$-N, and lightest and unproportionally with the increasing concetraton of $HN_4^+$-N for those grown in $NH_4^+$-N, and also higer with the higher ratio of $NO_3^-$-N to $NH_4^+$-N for those grown in the mixture of $NO_3^-$-N and $NH_4^+$-N (Wu, 1974). Therefore, in this study, The amounts of combined nitrogen uptakes in relate to the dry weights of cucumbers, and to the total nitrogen contents of cucumber leaves, and to the soluble proteins contents of cucumber leaves would be determined. And the influences of combined nitrogen sources on the compositions of soluble proteins in the cucumber leaves would also be determined.

## MATERIALS AND METHODS

Seeds of the pickling cucumber (*Cucumis sativus* $F_1$ hybrid S-612, 1978 from Taichung, Taiwan) were used. The seeds were soaked in the running tap water to remove germination inhibitors for overnight before they were germinated in the moistened woodendust for one

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week. Then twelve seedlings were transferred to a blue plastic pot which contained three liters of aerating modified Hoagland's nutrient. Potassium nitrate, ammonium sulfate and ammonium nitrate were the nitrogen sources of 150 ppm $NO_3^-$-N, 150 ppm $NH_4^+$-N, and the mixture of 75 ppm $NO_3^-$-N and 75 ppm $NH_4^+$-N, respectively. The pH value (6.5-7.0) and the volume of nutrients were kept constant. Each nutrient was replicated two times in a completely randomized arrangement. The external appearances of the cucumbers were observed, and dry weights of root, hypocotyl, stem and leaf, the amounts of combined nitrogen uptake, the amounts of total nitrogen and soluble proteins in leaves, the electrophoretic patterns of soluble leaf protein were determined after one week of growth in the nutrients.

The combined nitrogen contents of the nutrients were determined by steam-distillation (Bremner & kerney, 1965). The contents of total nitrogen in the leaves of cucumbers were determined by standard Kjeldahl method (Peterson & Chester, 1964). The contents of soluble leaf protein were determined by Folin-Ciocalter method (Lowry *et al.*, 1951), and their electrophoretic patterns were determined by using gel electrophoresis (Davis, 1964).

## RESULTS AND DISCUSSION

Both of cucumbers growth in 150 ppm $NO_3^-$-N and the mixture of 75 ppm $NO_3^-$-N and 75 ppm $NH_4^+$-N were healthy and about equal in plant size, and had abundant root systems in white color. On the contrary, the cucumbers grown in 150 ppm $NH_4^+$-N were severely stunted and had poor root systems in brown color, some of them were dead and had necrotic spots on stems and leaves. This showed that the $NO_3^-$ ion would promote the growth of cucumbers although this promotory effect was not so critical on the concentration of $NO_3^-$ ion. On the other hand, this also showed that the $NH_4^+$ ion would inhibit the growth of cucumbers and this inhibitory effect, which might be attributed by the accumulation of $NH_4^+$ ion in the cucumber cells, would only happen at higher concentration of $NH_4^+$ ion. Since the color of cucumber leaves was darker green with higher concentration of $NH_4^+$-N, the chlorophyll and other pigments might be also affected by $NH_4^+$ ion.

The amounts of combined nitrogen in the nutrients and the amounts of combined nitrogen uptake by the cucumbers were shown in Table 1. After seven days of transferring, plenty of combined nitrogen still remained in the nutrients. Regardless the kinds of nutrient, same amounts of toal combined nitrogen level were uptaken from the nutrients in the seven days of growth. This showed that the cucumbers were supplied with sufficient nitrogen sources in the nutrients and did not have any preference on the uptake of nitrogen sources.

The dry weights of various parts in the cucumbers grown in the nutrients were shown in Table 2. After seven days of growth, the dry weights of cucumber and its leaves increased six times and ten times, respectively in $NO_3^-$-N, four times and ten times, respectively in the mixture of $NO_3^-$-N and $NH_4^+$-N, three times and six times, respectively in the $NH_4^+$-N. In

Table 1. The amounts of combined nitrogen in the nutrients (in mg N per nutrients), and the amounts of combined nitrogen uptake (in mg N per cucumber) by the cucumbers grown in the various nutrients for seven days.

| nutrients | 150 ppm $NH_3^-$-N | | 150 ppm $NH_4^+$-N | | 75 ppm $NO_3^-$-N and 75 ppm $NH_4^+$-N | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | $NO_3^-$-N | | $NH_4^+$-N | |
| growth period (days) | 0 | 7 | 0 | 7 | 0 | 7 | 0 | 7 |
| mg N per nutrient | 354 | 168 | 330 | 159 | 173 | 72 | 173 | 83 |
| mg N uptake per cucumber | | 16 | | 16 | | 8 | | 8 |

Table 2. The dry weights (in g per cucumber) of various parts of the cucumbers grown in the various nutrients for seven days.

| nutrients | | 150 ppm $NO_3^-$-N | 150 ppm $NH_4^+$-N | 75 ppm $NO_3^-$-N and 75 ppm $NH_4^+$-N |
|---|---|---|---|---|
| growth period (days) | 0 | 7 | 7 | 7 |
| root | 0.01 | 0.05 | 0.02 | 0.04 |
| hypocotyl | 0.02 | 0.05 | 0.04 | 0.04 |
| stem | | 0.04 | | 0.01 |
| leaves | 0.01 | 0.10 | 0.06 | 0.10 |
| total | 0.04 | 0.24 | 0.12 | 0.19 |

short, the dry weights of cucumbers and leaves were heaviest and lightest in the nutrient of $NO_3^-$-N and $NH_4^+$-N, respectively.

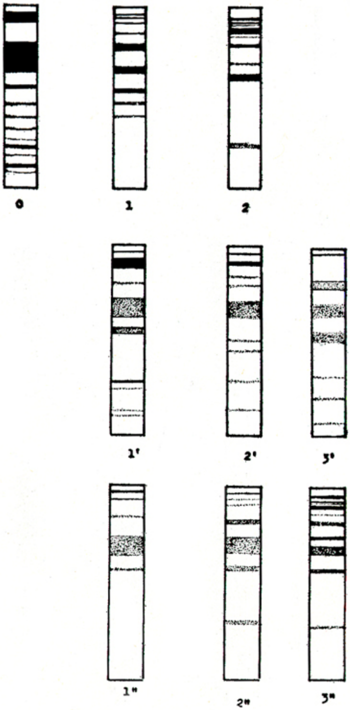
The total nitrogen contents of cucumbers and the soluble proteins contents of cncumber leaves were shown in Table 3 and Table 4, respectively. They were increasing with the growth of cucumbers. Again, both contents were highest and lowest in the nutrient of $NO_3^-$-N and $NH_4^+$-N, respectively. Hence, it was inferred that the assimilation of $NO_3^-$-N into nitro genous components and soluble proteins was better than that of $NH_4^+$-N in the cucumbers.

Table 3. The contents (in $\mu$g N per cucumber and percentage of dry wt.) of total nitrogen in the leaves of cucumbers grown in the various nutrients for seven days.

| nutrients | | 150 ppm $NO_3^-$-N | 150 ppm $NH_4^+$-N | 75 ppm $NO_3^-$-N and 75 ppm $NH_4^+$-N |
|---|---|---|---|---|
| growth period (days) | 0 | 7 | 7 | 7 |
| $\mu$g N per cucumber | 3.08 | 12.24 | 4.21 | 10.04 |
| percentage of dry wt. | 3.08 | 12.24 | 7.01 | 10.04 |

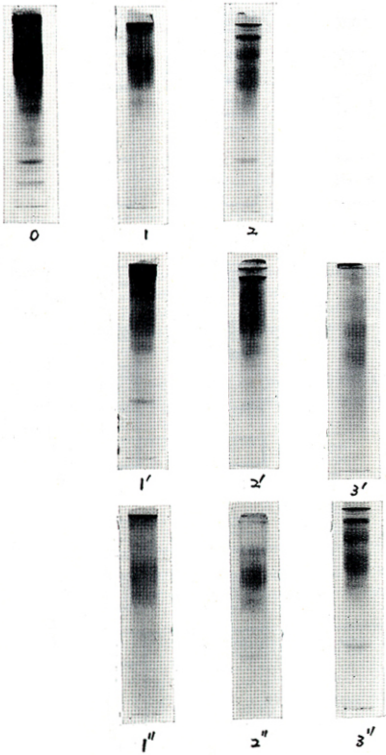
Table 4. The content (in $\mu$g as eff albumin and percentage of dry wt.) of soluble proteins in the leaves of cucumbers grown in the various nutrients for seven days.

| nutrients | | | 150 ppm $NO_3^-$-N | 150 ppm $NH_4^+$-N | 75 ppm $NO_3^-$-Nand 75 ppm $NH_4^+$- N |
|---|---|---|---|---|---|
| growth poriod (days) | | 0 | 7 | 7 | 7 |
| cotyledons | $\mu$g per pair cot. | 3.38 | 4.20 | 0.94 | 2.39 |
| | percentage of dry wt. | 0.54 | 0.11 | 0.03 | 0.10 |
| first leaves | $\mu$g per leaf | | 7.53 | 3.14 | 6.28 |
| | percentage of dry wt. | | 0.11 | 0.05 | 0.10 |
| second leaves | $\mu$g per leaf | | 4.52 | | 2.90 |
| | percentage of dry wt. | | 0.15 | | 0.10 |
| total | $\mu$g per cucumber | 3.38 | 16.25 | 4.08 | 11.57 |
| | percentage of dry wt. | 0.54 | 0.37 | 0.08 | 0.30 |




A: Schematic drawings

Fig. 1. The electrophoretic patterns of soluble proteins in the leaves of cucumbers grown in the various nutrients for seven days.
0-0 day cotyledon, 1-cotyledon in $NH_4^+$-N, 2-first leaf in $NH_4^+$-N.
1′-cotyledon in $NO_3^-$-N, 2′-first leaf in $NO_3^-$-N, 3′-second leaf in $NO_3^-$-N.
1″-cotyledon in $NO_3^-$-N and $NH_4^+$-N, 2″-first leaf in $NO_3^-$-N and $NH_4^+$-N,
3″-second leaf in $NO_3^-$-N and $NH_4^+$-N.




B: Photographic pictures

If so, those unassimilated $NH_4^+$ ions were accumulated and then gradually provoked the symptoms of ammonium toxicity on the cucumbers.

On the basis of dry weights, the total nitrogen contents of cucumbers and the soluble proteins contents of cucumber leaves were decreasing with the growth of cucumbers. This decline indicated that non-nitrogenous components were accumulated in the cucumbers, and their contents were highest and lowest in the nutrient of $NO_3^-$-N and $NH_4^+$-N, respectively. The highest contents of non-nitrogenous components and nitrogenous components summed up the heaviest dry weights in the cucumbers that grown in $NO_3^-$-N for seven days. In the same manner, the lightest dry weights were summed up in the cucumbers that grown in $NH_4^+$-N for seven days.

For each correspondent leaf, the soluble protein contents were also vary with the nitrogen sources on nutrient, and were highest and lowest in $NO_3^-$-N and $NH_4^+$-N, respectively. The compositions of soluble proteins in the leaves of cucumbers were shown in their electrophoretic patterns (Fig. 1). The number of bands in the patterns of cotyledons were decreasing with the growth of cucumbers, especially down to five bands in the mixture of $NO_3^-$-N and $NH_4^+$-N. The number of bands in the cotyledons of $NO_3^-$-N were the same as that of $NH_4^+$-N, but their distributions of bands were different. In first leaves, there were five heavy bands in $NH_4^+$-N, one heavy bands in $NO_3^-$-N, and no heavy bands in the mixture of $NO_3^-$-N and $NH_4^+$-N. In second leaves, there were more cathod towarded bands in the mixture of $NO_3^-$-N and $NH_4^+$-N. Hence, the electrophoretic patterns of soluble proteins in the cotyledons, the first leaves, and the second leaves of cucmbers were different with the nitrogen sources of the nutrient. The mechanisms for their influences on the compositions of soluble proteins should be further studied. Conclusively, the soluble proteins of cucumber leaves were influenced by the sources of combined nitrogen in the nutrient, not only in the quantitative contents but also in the quantitative compositions.

## REFERENCES

BREMNER, J. M. & D. R. KEENEY, 1965. Steam distillation methods for determinations of ammonium, nitrate and nitrite. Anal. Chem. Act. **32**: 485-495.

DAVIS, B. J. 1964. Disc electrophoresis. II. Method and application to human serum proteins. Ann. N. Y. Acad. Sci. **121**: 404-427.

DONOVAN, G. R. & J. W. LEE 1978. Effect of nitrogen source on grain development in detached wheat heads in liquid culture. Aust. J. Plant Physiol. **5**(1): 81-88.

KOHNO, HITOSHI, R. TANAKA, & F. YOSHIDA, 1976. Mineral nutrition of cultured chlorophyllous of tobacco: V. Effects of $NH_4/NO_3$ ratios in media on the cells. Bull. Fac. Agric. Tamagawa Univ. **16**: 10-15.

LOTOCKE, & ANDRZEI, 1977. Effect of root aeration ann form of nitrogen on photosynthetic productivity of Scotch pine. ACTA SOC BOT POL **46**(2): 303-316.

LOWRY, O. H., N. J. ROSEBROUGH, A. L. FARR & R. J. RANDALL, 1951. Protein measurement with Folin phenol reagent. J. Biol. Chem. **193**: 265-275.

MARWAHA, R. S. & B. O. JULIANO, 1976. Aspects of nitrogen metabolism in the rice seedling. Plant Physiol. **57**: 923-927.

MOHANTY, BIBEKANAKA & J. S. FLETCHER, 1978. Influence of ammonium on the growth and development of suspension culteures of Paul's scarlet rose. Physiol Plant **42**(2): 221-225.

PETERSON, L. A., & G. CHESTERS, 1964. A reliable total nitrogen determination on plant tissue accuulating nitrate nitrogen. Agr. J. **56**: 89-90.

WU, M. L. 1974. The effect of nitrogen from ammonium and nitrate on the growth of cucumbers. Taiwania **19**(2): 166-172.