THE EFFECT OF NITROGEN FROM AMMONIUM AND NITRATE ON THE GROWTH OF CUCUMBERS

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Abstract: Cucumbers (*Cucumis sativus* cv. Pioneer) prefer NO_3-N uptake. The different combinations of NH_4-N and NO_3-N (NH_4-N ppm/NO_3-N ppm: 75/25, 50/50, 25/75.) did not interfere with NO_3-N uptake. However, the existence of NO_3-N in a solution with NH_4-N did significantly enhance the uptake of NH_4-N.

The cucumbers grown in NH_4-N had fewer leaves, shorter stems, lower fresh and dry weights than those grown at the same level in NO_3-N. The cucumbers grown in NO_3-N had about the same fresh and dry weights, stem length and leaf number as those grown in the combinations of NH_4-N and NO_3-N at the same level of nitrogen.

The pistillate flower differentiation of cucumbers was not promoted by the nitrogen from ammonium and or from nitrate in the nutrient solutions.

INTRODUCTION

For good cucumber production of once-over machine harvesting in the United States, both culture methods and choise of cultivars are important. The highest yield of pickling cucumbers was obtained by planting a seed blend of 90% gynoecious hybrid and 10% monoecious cultivars (Connor & Martin, 1971). The application of plant growth regulators to enhance pistillate flower differentiation, and subsequently to reduce the time of harvesting, was used in the production of monoecious cucumber cultivars.

The monoecious cucumber plants contained more endogenous gibberellin (GA)-like substances than the gynoecious cucumber plants (Atsmon, Land & Light, 1968). In the early stage of floral bud development, cucumbers have the potential of producing perfect flowers, but as the buds develop some become staminate, some become pistillate and others hermaphrodite flowers (Atsmon & Galun, 1960). Hormone environments affect their further development: gibberellin favoring the staminate flower formation and IAA favoring the pistillate flower formation (Galun, Jung & Lang, 1963). For example, gibberellic acid and naphthalene acetic acid were used to induce the staminate flower formation (Tayel, Moursi & Habbasha, 1967). Ethephon (2-chloroethylphosphoric acid) was used to induce pistillate flower formation (Cantliffe & Robinson, 1971). Other conditions affecting sex differentiation are: low temperature, red light and a short day promote pistillate flower differentiation in most cucumber varieties (Matsuo & Fukushima, 1970). Subsequent far-red light reversed the red light effect on cucumber flower sex differentiation. These phenomena suggest that the cucumber flower sex differentiation may be controlled by the phytochrome mechanism (McMarry & Miller, 1968).

The nutrition experiments were more concerned with the total yield of cucumber production (Bishop, Chipman & MacEachern, 1968), and less concerned the sex

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differentiation in cucumber flowers. Tayel *et al.* (1967) showed that the number of pistillate flowers per plant increased with increasing nitrogen fertilization. Therefore, the purpose of the present experiments were concerned with the effects of nitrogen from ammonium and or from nitrate on the growth and sex differentiation of cucumber flowers.

MATERIAL AND METHODS

Exp. 1. To determine the amount of NO_3–N uptake from different levels of NO_3–N in the nutrient solution.

Seeds of the pickling cucumber (*Cucumis sativus* cv. Pioneer Lot. No. 449–48, 1970 from Northrup, King) were used. The seeds were germinated in perlite for one week. One seedling was transferred to a two-liter black plastic container that had 1.9 liter of nutrient solution with modified Hoagland's formula. Concentrated nitric acid served as the nitrogen source in the nutrient solutions. There were six treatments with respect to the amount of nitrogen in the solution of NO_3–N: (1) 20 ppm, (2) 40 ppm, (3) 80 ppm, (4) 120 ppm, (5) 160 ppm, (6) 200 ppm. The nutrient solutions were adjusted to pH 5.5–6.0 by adding 24% H_2SO_4 or 10 N NaOH. The NO_3–N content in the nutrient solution was determined after 3, 7, 10, 14 and 21 days by using the steam-distillation method (Bremner & Keeney, 1965).

Exp. 2. The effects of different concentrations of ammonium, nitrate and their different combinations in the nutrient solutions on the nitrogen uptake and growth phenomena of cucumbers were studied.

Treatments were established by adding $(NH_4)_2SO_4$ and or HNO_3 to the nutrient solutions described above for the sources of nitrogen. The nine respective treatments of ppm NH_4–N/ppm NO_3–N were as follows: (1) 50/0, (2) 100/0, (3) 150/0, (4) 0/50, (5) 0/100, (6) 0/150, (7) 75/25, (8) 50/50, (9) 25/75. The nutrient solutions were also maintained at pH 5.5–6.0. Each treatment was replicated six times in a completely randomized design. After the first two weeks, the nutrient solutions were renewed weekly, 10 ml samples of the initial and terminal solutions taken from each container were analyzed for NO_3–N and NH_4–N by the steam-distillation method of Bremner and Keeney. The different amounts of NO_3–N and NH_4–N between the initial and terminal nutrient solutions were referred to as the amounts of NO_3–N and NH_4–N uptake. Three, four, and five weeks after transplanting the seedlings to the nutrient solutions, two plants were harvested for the determination of stem length, fresh weight, and flowering pattern, respectively.

RESULTS

There was no NO_3–N uptake by the cucumbers at 3 and 7 days in the nutrient solution. After 10 days in the nutrient solution, the cucumbers started to take up NO_3–N from the nutrient solutions of treatments 1 and 2. At the end of 21st day in the nutrient solution, the cucumbers that were grown at the higher levels of NO_3–N (teatments 3–6), took about 100 mg of NO_3–N from their nutrient solutions (table 1). The greatest amount of nitrate was taken up by the cucumbers that were grown at the highest concentration of NO_3–N.

Table 2 and table 3 showed the amounts of NH_4–N, NO_3–N, NH_4–N/NO_3–N in the initial and terminal nutrient solutions, respectively. The differences between

Table 1. The amount of NO_3-N uptake by the cucumbers from the nutrient solutions of Exp. 1
(mgm N/1.9 liter of the final nutrient solution)

Treatments (initial NO_3-N)		NO_3-N uptake days						Total NO_3-N uptake in 21 days
		3	7	10	14	17	21	
1	38.97	0	0	13.19	13.19	10.11	1.88	38.97
2	71.23	0	0	14.69	0	42.61	13.86	17.16
3	134.86	0	0	0	18.73	42.74	38.67	100.14
4	211.36	0	0	0	0	34.28	53.39	87.67
5	292.17	0	0	0	32.82	26.33	39.49	98.64
6	358.83	0	0	0	57.00	13.96	38.95	109.91

Table 2. The initial amount (beginning of week) of NH_4-N and NO_3-N in the solution of Exp. 2
(mgm N/1.9 liter of the final nutrient solution)

Treatments	14 days		21 days		28 days		35 days	
	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N
1	100.91		78.32		115.46		94.37	
2	196.27		178.85		197.71		185.29	
3	301.45		268.89		211.95		281.14	
4		105.09		47.94		96.43		96.27
5		203.34		96.67		190.87		172.43
6		308.90		148.96		284.05		269.72
7	144.93	46.47	133.31	23.54	166.61	44.50	139.00	41.49
8	103.74	94.92	98.65	42.33	102.27	82.59	99.39	86.11
9	51.36	132.98	57.09	65.66	55.90	129.68	53.94	123.44

Table 3. The terminal amount (end of week) of NH_4-N and NO_3-N in the solutions of Exp. 2
(mgm N/1.9 liter of the final nutrient solution)

Treatments	7 days		14 days		21 days		28 days		35 days	
	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N
1	95.65		68.06		51.97		78.01		66.39	
2	182.80		162.87		140.56		147.93		154.98	
3	274.89		240.26		209.15		210.79		242.54	
4		82.99		46.94		0		0		0
5		174.80		119.91		0		0		0
6		270.33		215.57		15.35		0		0
7	139.19	36.61	88.22	4.26	65.15	0	87.76	0	106.86	0
8	105.58	81.23	67.62	29.05	1.97	0	11.62	0	32.17	0
9	52.70	129.47	28.42	87.88	0.51	0	0	0	0	0

Table 4. The uptake amount of NH_4-N and NO_3-N by cucumbers from the solution of Exp. 2
(mgm N/1.9 liter final nutrient solution)

Treatment	7 days		14 days		21 days		28 days		35 days		Total uptake in 35 days	
	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N
1	5.26		27.59		26.53		37.45		27.98		124.18	
2	13.47		19.93		38.29		49.73		30.31		151.73	
3	26.56		34.63		59.74		1.06		38.61		160.60	
4		22.10		36.05		47.94		96.43		96.27		298.79
5		28.54		54.89		96.67		190.87		172.43		543.40
6		38.57		54.76		133.61		284.05		269.72		780.71
7	5.74	10.16	50.97	32.35	68.16	23.54	78.85	44.50	32.14	41.49	235.86	152.04
8	0	13.69	37.96	52.18	96.68	42.33	90.65	82.59	67.22	86.11	292.51	276.90
9	0	3.51	24.28	41.59	57.99	65.66	55.80	129.68	53.94	123.44	192.01	363.88

Table 5. Root growth of cucumbers grown for 21, 28 and 35 days with different sources and concentrations of nitrogen in the Exp. 2

Treatment	Fresh wt. (g/pot) days			Dry wt. (g/pot) days		
	21	28	35	21	28	35
1	2.5	5.0	5.0	0.39	0.45	0.45
2	1.5	4.0	9.0	0.28	0.40	0.58
3	2.0	5.0	10.0	0.30	0.46	0.50
4	26.0	33.5	54.5	1.16	1.02	2.05
5	35.5	49.0	74.0	1.19	1.60	3.00
6	32.5	57.0	91.0	1.45	2.09	3.12
7	12.5	25.0	22.0	0.75	1.00	1.20
8	14.5	33.3	31.0	0.80	1.44	1.48
9	15.0	28.7	42.0	0.79	1.00	2.38

Table 6. Shoot growth of cucumbers grown with different sources and concentrations of nitrogen in Exp. 2

Treatment	Fresh wt. (g/pot) days			Dry wt. (g/pot) days			Stem length (cm) days			No. of leaves larger than 2 cm days		
	21	28	35	21	28	35	21	28	35	21	28	35
1	10.0	22.5	17.5	1.11	2.05	2.60	13.3	38.0	51.5	6.0	8.0	9.5
2	10.5	22.0	24.0	1.26	2.27	2.80	17.5	38.0	36.0	7.0	9.0	10.0
3	11.0	22.0	29.0	1.27	2.22	3.40	15.7	23.0	43.5	7.0	8.0	11.0
4	28.5	58.0	95.0	3.37	5.00	9.65	25.8	67.3	110.5	8.5	13.0	18.0
5	42.5	100.0	184.0	4.24	7.91	29.00	39.0	72.0	129.0	10.5	14.0	19.0
6	89.0	122.0	151.0	6.15	10.90	27.40	53.8	85.0	105.0	11.5	15.0	19.0
7	33.5	57.0	64.5	3.56	5.11	9.35	37.0	62.5	85.5	10.0	12.5	15.5
8	42.0	79.3	96.0	4.20	6.97	22.10	45.0	76.5	103.5	11.0	13.3	17.0
9	52.5	68.9	163.0	5.70	7.10	20.50	46.3	69.5	157.0	11.0	13.3	20.0

data of table 2 and 3 at the same period showed the amounts of loss from the nutrient solutions by the uptaking of the cucumbers (table 4).

When compared to the uptake of NH_4-N in the cucumbers of treatments 1 to 6, the cucumbers preferred the uptake of NO_3-N, especially after 21 days in the nutrient solution. After 21 days, as shown in table 3, the cucumbers of treatments 4-6 took up all of the NO_3-N, while the cucumbers of treatments 1-3 only took up a part of the NH_4-N from their nutrient solutions. The different combinations of NH_4-N and NO_3-N did not interfere with the uptake of NO_3-N. However, NO_3-N did significantly enhance the uptake of NH_4-N.

Table 5 showed the roots of the cucumbers grown in NH_4-N (treatments 1-3) were brown in color and lighter in both fresh and dry weights. The roots of cucumbers grown at the same level of NO_3-N (treatments 4-6), however, were white in color and heavier in fresh and dry weights. The fresh and dry weights of roots that were grown in the combination of NH_4-N and NO_3-N (treatments 7-9), increased in proportion to the amount of NO_3-N in the nutrient solutions. The cucumbers grown in 100 ppm NO_3-N (treatment 5) had heavier roots, and the fresh and dry weights were more than those grown in the combinations of NH_4-N, NO_3-N at the same concentration of nitrogen (treatments 7-9).

Table 6 showed the cucumbers grown in NH_4-N (treatments 1-3) had fewer leaves, shorter stems, lower fresh and dry weights than those grown at the same level of NO_3-N (treatments 4-6). The cucumbers grown in 100 ppm NO_3-N (treatment 5) had about the same fresh and dry weights, stem length and leaf number as those grown in the combination of NH_4-N, NO_3-N at the same level of nitrogen (treatments 8 and 9).

No flower development could be observed at the first node of the cucumbers in any treatment. From the bases of the 5th or 6th node on, the cucumbers started to develop pistillate flowers at these two nodes. As shown in table 7, it is evident that different treatments had no significant effect on pistillate flower differentiation.

Table 7. Type of flower on each node at the 35 days in the nutrient solution in Exp. 2
(M: male, F: female, 0: no flower)

Treatment	1	2	3	4	5	6	7	8	9	10
1	0	M	M	M	M	M	M	F	F	F
2	0	M	M	M	M	M	F	F	F	F
3	0	M	M	M	M	M	F	M	M	M
4	0	M	M	M	M	M	F	F	F	M
5	0	M	M	M	M	M	M	F	F	F
6	0	M	M	M	F	F	F	F	F	F
7	0	M	M	M	M	F	F	F	F	M
8	0	M	M	M	M	M	M	F	F	F
0	0	M	M	M	M	M	F	F	F	F

DISCUSSION

It seems that treatments 1, 2 and 3 of Exp. 1 would deplete the NO_3-N in the nutrient solutions if the experiment had been prolonged. So to prevent the depletion of the nitrogen, the nutrient solutions were renewed every week in every treatment of Exp. 2.

The growth of cucumber roots and shoots were proportional to the uptaking of the total nitrogen as shown in tables 4, 5 and 6. It would have been of practical value if we had prolonged the period of the experiement to see the effect of the nitrogen level or different nitrogen sources on cucumber fruit development. These two experiments were done in the greenhouse of the Department of Horticulture at the University of Wisconsin at Madison in the summer of 1972. The cucumbers receiving the natural long day photoperiod did not favor pistillate flower differentiation. Temperature, photoperiod, light quality and hormone environment also affect cucumber flower sex differentiation, and it seems that the best way to control cucumber flower sex differentiation is try to discover the interactions among these factors.

ACKNOWLEDGMENTS

The author is very grateful to Drs. L. A. Peterson and B. E. Struckmeyer for their continual guidance and assistance in the undertaking of this study.

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