Absorption, Translocation and Metabolism of CNP, a Diphenyl Ether Herbicide, and its Amino Derivative in Rice Plants

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(Received February 17, 1978)

The absorption, translocation, and metabolism of CNP, a diphenyl ether herbicide, and its amino derivative (CNP-NH₂) which is a major degradation product of CNP in soils were investigated in rice plants, by using ¹⁴C-CNP and ¹⁴C-CNP-NH₂ labeled uniformly at the nitro- and amino- phenyl rings, respectively. CNP and CNP-NH₂ were absorbed rapidly through the roots, but were hardly translocated to the foliage, especially in CNP-NH₂. The amounts of CNP and CNP-NH₂ absorbed from soil culture were far less than those absorbed from water culture. CNP was scarcely metabolized in the rice plant, while CNP-NH₂ was rapidly metabolized.

The metabolism of CNP in the rice plant gave rise to three major metabolites, and two of them were identified as 2,4,6-trichlorophenyl 4'-formylaminophenyl ether and 2,4,6-trichlorophenyl 4'-hydroxyphenyl ether. CNP-NH₂ and its N-glucoside were also detected. CNP-NH₂ absorbed by the rice plant from water culture decreased rapidly and produced two major metabolites and a number of minor ones.

INTRODUCTION

CNP (MO® 2,4,6-trichlorophenyl 4'-nitrophenyl ether) is widely used as a preemergence herbicide for controlling various weeds in rice (*Oryza sativa* L.) cultivation in Japan. Several researches have been conducted on the absorption and metabolism of diphenyl ether herbicides in plants. For example, nitrofen (3,4-dichlorophenyl *p*-nitrophenyl ether)¹⁾, fluordifen (*p*-nitrophenyl α,α,α -trifluoro-2-nitro-*p*-tolyl ether)^{2,3)} and chlomethoxynil (2,4-dichlorophenyl 3'-methoxy-4'-nitrophenyl ether)⁴⁾ were absorbed by plants, but their translocation in plants was limited. Cleavage of the ether linkage and reduction of the nitro substituent occurred in plants,^{2,3)} but chlomethoxynil provided no phenolic derivatives in plants.⁴⁾

Radioactive nitrofen was absorbed and degraded thoroughly in rice and wheat, and the ¹⁴C from nitrofen was reincorporated into glucose in grains and into lignin in stems and leaves.^{5,6)}

In our previous study⁷⁻¹⁰⁾ the degradation of CNP in soils resulted in a fair amount of soil-bound residue which was attributed to CNP-NH₂. In rice field surveys,¹¹⁻¹³⁾ a small amount of the free CNP-NH₂ and a fair amount of the bound CNP-NH₂ were detected in soil, but neither CNP nor CNP-NH₂ were detected in rice grains.

In the present work, the absorption, translocation, and metabolism of CNP and CNP-NH₂ in rice plants were studied by using ¹⁴C-ring labeled compounds.

MATERIALS AND METHODS

1. ¹⁴C-labeled and Non-labeled Chemicals

The procedure for synthesizing nitrophenyl ring-labeled CNP will be reported elsewhere.¹⁰⁾ The specific activity of CNP was 2.20 μ Ci/mg,

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and its radio-purity was 99.9%.

2,4,6-Trichlorophenyl 4'-amino- ^{14}C -phenyl ether was synthesized according to the following procedure. 320 mg of nitrophenyl ring labeled ^{14}C -CNP (specific activity, $1.10\ \mu\text{Ci}/\text{mg}$), 1.0 g of SnCl_2 , 3 ml of ethanol, and 1 ml of conc. HCl in a round-bottom flask was refluxed for 2 hr. The reaction mixture was concentrated *in vacuo*. To the residue, 5N- NaOH was added. After partition with benzene, the benzene solution was dehydrated with anhydrous sodium sulfate, concentrated to a suitable volume and purified by silicic acid column chromatography developed with benzene. The resulting compound had a specific activity of $1.22\ \mu\text{Ci}/\text{mg}$, and a radio-purity of 99.0%.

$\text{N}-[4-(2,4,6\text{-Trichlorophenoxy})\text{phenyl}]-\text{D-glucosylamine}$ was synthesized from a mixture of 7.0 g of $\beta\text{-D-glucose}$ and 5.7 g of CNP-NH_2 in 160 ml of 95% aqueous ethanol, which was refluxed for 3 hr. After cooling, the precipitate was filtered, washed with ethanol, and recrystallized from 90% ethanol. mp. 138–139.5°C, Calcd.: N, 3.11%, Cl, 23.60%, Found: N, 3.11%, Cl, 22.99%.

2. Rice Plant

Seeds of rice (*Oryza sativa* L., cv. Nihonbare) were germinated and allowed to grow in Kasugai's nutrient solution in a greenhouse. Seedlings at the three-leaf stage were harvested and treated with ^{14}C -CNP or ^{14}C -CNP- NH_2 according to the procedure which will be described later.

3. Soil Sample

A diluvial soil sample was collected in winter from the arable layer of a rice field at the Paddy Field Experimental Farm, Aichiken Agricultural Research Center in Anjo, Aichi Prefecture. Its properties were as follows: texture, light clay; water holding capacity, 53.5%, pH 6.15; total carbon, 1.75%; total nitrogen, 0.15%; cation exchange capacity, 9.99 meq/100 g; clay mineral, kaoline; clay content, 45.2%. The sample was crushed and passed through a 2 mm sieve.

4. Absorption and Translocation of ^{14}C -Chemicals

Seedlings of rice plant at the three-leaf stage

were transferred into Kasugai's cultivating solution (100 ml) containing 5 ppm of ^{14}C -CNP (2.42×10^6 dpm) or ^{14}C -CNP- NH_2 (1.19×10^6 dpm). In the same manner, rice seedlings at the three-leaf stage were also transplanted into 100 g (dry weight basis) of soil in a 200-ml beaker. Before the transplantation, this soil was mixed with ^{14}C -CNP (4.84×10^6 dpm) or ^{14}C -CNP- NH_2 (2.38×10^6 dpm) at 10 ppm (dry soil basis) and submerged 1 cm deep, and allowed to stand for three days. These plants were allowed to grow under artificial light at 8,000–10,000 lux., for a 15-hr photoperiod at 20 to 30°C. In water culture, the initial level of the nutrient solution was maintained by adding water periodically. The plant was harvested after designated intervals, washed successively with water and benzene to remove soil particles and radioactive chemicals adhering to the plant surface. The plant was divided into roots and foliage and the total radioactivity of each plant part was measured by the wet combustion method according to Kametani.¹⁴⁾

5. Radioautogram

Harvested plants washed according to the procedure described above were blotted with filter paper to remove excess benzene, spread out between two sheets of filter paper and pressed with hot iron. A X-ray film (Fuji Kx Medical, Fuji Photo Film Co., Ltd.) was exposed to the pressed plants for several weeks, and the resulting film was developed.

6. Extraction and Fractionation

Rice plants harvested at various intervals were washed by the same procedure as above and divided into foliage and roots. These samples were homogenized with 80% aqueous acetone and filtered. The fibrous residues were washed several times with 80% aqueous acetone. Then the filtrates were combined and diluted with acetone up to 100 ml. The radioactivity in the unextracted fibrous residue was determined by the wet combustion method.¹⁴⁾

The combined filtrate was concentrated *in vacuo* to remove the solvent. The remaining aqueous phase was extracted with a total volume of 100 ml of ether three times. The ether extracts were dried with anhydrous

Table 1 *R_f* values of CNP, CNP-NH₂ and related compounds on silica gel thin layer chromatography.

Compounds	Solvent system				
	A	B	C	D	E
CNP	0.53	0.86	0.89	—	—
CNP-NH ₂	0.05	0.38	0.53	0.80	0.47
Compound I	0.00	0.12	0.28	0.73	0.12
Compound II	0.00	0.56	0.69	0.83	0.12
Compound III	0.03	0.44	0.55	0.70	0.05
Compound IV	0.00	0.09	0.21	0.79	0.10
Unknown 1	0.62	—	—	—	—
Unknown 2	*	0.85	—	—	—
Unknown 3	*	0.90	—	—	—
Glucoside	0.00	0.00	0.00	0.60	0.00

Solvent system: A, *n*-hexane-toluene (3 : 2); B, *n*-hexane-ethyl acetate (5 : 3); C, benzene-chloroform-acetone (6 : 3 : 1); D, benzene-ethanol (2 : 1); E, benzene-Chloroform-diethylamine (25 : 25 : 1).

Compound I, 2,4,6-trichlorophenyl 4'-formylaminophenyl ether; Compound II, 2,4,6-trichlorophenyl 4'-hydroxyphenyl ether; Compound III, *p*-nitrophenol; Compound IV, 2,4,6-trichlorophenyl 4'-acetylaminophenyl ether; Glucoside, *N*-[4(2,4,6-trichlorophenoxy)phenyl]-D-glucosylamine.

* In this solvent system these compounds did not give clear spots because of tailing.

sodium sulfate, and reduced to a suitable volume *in vacuo*. Then thin layer chromatography was carried out on plates coated with silica gel F₂₅₄ (E. Merck, precoated, 0.25 mm thick). The chromatograms were developed with the solvent systems shown in Table 1. An X-ray film was exposed to these chromatograms and developed.

The fibrous residue left after acetone extraction was refluxed for one hr with 3 N HCl. The mixture was filtered and the filtrate was shaken with ether. The degradation products in the ether extracts were separated and determined by thin layer chromatography as described above.

7. Radioactivity Measurement

Radioactivity extracted with the solvent was measured as follows: A small aliquot of the solvent was placed in a counting vial which contains 15 ml of scintillation fluid (PPO 6 g, POPOP 0.275 g, and naphthalene 112 g in dioxane 1,000 ml).

The silica gel of each radioactive spot on the thin layer chromatogram was scraped into a counting vial containing the scintillation fluid.

The radioactivity of the fibrous residue left

after acetone extraction was determined by the combustion method according to Kame-tani.¹⁴⁾ The ¹⁴CO₂ evolved from the burnt residue was trapped in 18 ml of scintillation fluid [PPO 5 g, POPOP 0.3 g, 1,000 ml of ethanolamine : methylcellosolve : toluene (1 : 3 : 6)].

The radioactivity was measured using a Packard Model 3320-515 scintillation counter. All measurements were corrected for background and quenching. Counting efficiency for all samples was determined by the external standard technique.

RESULTS AND DISCUSSION

1. Absorption and Translocation of ¹⁴C-CNP and ¹⁴C-CNP-NH₂ in Rice Plants

The radioautograms of root-soaked rice plants indicated that the radioactivity in nutrient solution was absorbed into the roots, and was scarcely translocated to the upper parts, particularly in the case of CNP-NH₂ as shown in Fig. 1.

The distribution of radioactivity in the rice plant at various intervals after treating the roots with CNP and CNP-NH₂ is shown in Table 2. Absorption from water culture was apparently larger than from soil culture in all

Fig. 1 Radioautograms and mounted plants showing the distribution of ^{14}C -CNP (Left) and ^{14}C -CNP-NH₂ (Right) in rice seedlings treated from the roots for 5 days.

Table 2 Absorption and translocation of the radioactivity in rice seedlings treated with ^{14}C -CNP and ^{14}C -CNP-NH₂.

		CNP treatment		CNP-NH ₂ treatment	
		Soil culture	Water culture	Soil culture	Water culture
6 hr	Roots		10,540		8,830
	Foliage		880		185
24 hr	Roots		19,330		10,450
	Foliage		1,050		230
5 days	Roots	3,990	25,070	463	14,590
	Foliage	457	1,690	98	308
10 days	Roots	2,650	25,150	445	23,770
	Foliage	537	1,610	138	421
20 days	Roots	1,860	33,280	410	23,580
	Foliage	799	2,230	293	426
35 days	Roots	1,840		418	
	Foliage	860		360	

All numbers represent dpm per plant.

cases. The radioactivity in plants increased rapidly up to 24 hr after the treatment, but subsequently increased only slightly. In soil culture, however, the radioactivity in plants did not increase after 5 days.

In water culture, CNP-NH₂ was a little more hardly absorbed by the roots than CNP, but its translocation to upper parts of the plant

was markedly less than that of CNP. In soil culture, CNP-NH₂ was hardly absorbed by the plants. It seems because CNP-NH₂ is strongly adsorbed on soil particles.⁸⁾ The difference in the absorption of CNP and CNP-NH₂ by rice roots may be owing to the difference in water solubility of these chemicals (CNP 0.3 ppm, and CNP-NH₂ 2.7 ppm at

Table 3 Distribution of radioactivity in rice plants treated with ^{14}C -CNP.

	Days	Roots			Foliage		
		Ether extracts	Aqueous remainings	Fibrous residue	Ether extracts	Aqueous remainings	Fibrous residue
Soil culture	5	75.7	3.4	12.1	7.8	0.5	0.7
	10	63.8	2.2	12.8	12.6	1.6	1.0
	20	47.7	3.0	16.9	23.7	2.1	1.7
	35	41.4	3.4	31.8	19.7	1.5	1.2
Water culture	5	89.2	0.6	1.9	5.9	0.4	0.1
	10	86.5	2.0	3.7	4.6	0.6	0.2
	20	86.3	2.1	4.6	5.7	0.5	0.3

All numbers represent the percentage of radioactivity of each fraction based on the total radioactivity in plants.

Table 4 Distribution of radioactivity in rice plants treated with ^{14}C -CNP-NH₂.

	Days	Roots			Foliage		
		Ether extracts	Aqueous remainings	Fibrous residue	Ether extracts	Aqueous remainings	Fibrous residue
Soil culture	5	48.2	4.8	22.4	9.5	4.3	2.0
	10	39.7	10.2	27.1	8.7	9.9	2.2
	20	29.3	6.3	19.3	23.7	9.8	5.6
	35	34.6	9.5	24.7	19.1	4.9	6.0
Water culture	5	61.1	6.0	30.0	1.2	0.5	0.2
	10	68.5	3.1	23.0	1.2	0.3	0.1
	20	74.3	2.0	19.6	1.0	0.6	0.2

All numbers represent the percentage of radioactivity of each fraction based on the total radioactivity in plants.

26°C).

The aqueous acetone solution extracted from the plants was concentrated, and the radioactive substances were partitioned into ether and water. The distribution of the radioactivity in these fractions, for plants treated with CNP, is shown in Table 3. Most of the radioactivity absorbed by plants from water culture was extracted with aqueous acetone, and the unextractable radioactivity in fibrous residue gradually increased with the lapse of time. In soil culture, a large portion of the radioactivity absorbed by roots was unextractable with aqueous acetone. Most of the radioactivity in the aqueous acetone extracts was extractable with ether, particularly in the extracts from the roots.

The distribution of radioactivity in each fraction, for plants treated with CNP-NH₂, is shown in Table 4. In the case of water culture,

the radioactivity in the water fraction after partition with ether and in the fibrous residue obtained from CNP-NH₂ treated plants was in contrast with that from CNP-treated plants. In soil culture, a large part of the radioactivity in plants was unextractable, and the radioactivity in the aqueous acetone extracts was hardly extractable with ether.

In water culture, it is thought that CNP-NH₂ absorbed into roots was readily bound with tissue constituents such as lignin, and consequently the radioactivity in plants became hardly extractable with aqueous acetone and could not be partitioned with ether. On the other hand, CNP was hardly degraded in the plants but it may not be bound with these tissue constituents. This may be the reason why the radioactivity absorbed by roots was readily extracted with aqueous acetone. The rate of translocation of CNP-NH₂ to the upper

parts of plants was less than that of CNP. This tendency may be attributed to the formation of complexes with plant materials.

In soil culture, a portion of the degradation products of CNP formed in soil was absorbed by the roots, and a larger portion of unextractable radioactivity remained in the fibrous residue in soil culture than in water culture. These may also be because of the easy binding of CNP-NH₂ with tissue constituents of plants. A very small amount of the radioactivity was translocated to the upper parts, but the radioactivity corresponded with 10 to 40% of the absorbed amount. A large portion of this radioactivity may be attributed to the degradation products of CNP or CNP-NH₂ in soil which were absorbed by roots and translocated to the foliage.

2. Metabolism of ¹⁴C-CNP and ¹⁴C-CNP-NH₂ in Rice Plants

Metabolites in the ether fraction were identified by the radioautographic technique. Radioautograms of the ether extracts obtained from the roots treated with CNP revealed the presence of CNP, compound I (2,4,6-trichlorophenyl 4'-formylaminophenyl ether), compound II (2,4,6-trichlorophenyl 4'-hydroxyphenyl ether), and an unidentified compound (unknown I). However, the amounts of these metabolites were very small as shown in Table 5. No phenolic metabolite derived by cleavage of the ether linkage of CNP was

detected, in contrast to fluorodifen, a dephenyl ether herbicide.²⁾ In water culture, CNP was scarcely metabolized in rice plants, and 77.2 to 84.7% of the radioactivity absorbed by plants was recovered as CNP. A small amount of CNP-NH₂ conjugated with glucose, i.e., *N*-[4-(2,4,6-trichlorophenoxy)phenyl]-D-glucosylamine was found in the ether fraction by co-chromatography with the synthetic compound. A proposed metabolic pathway of CNP in rice plants is shown in Fig. 2. The compound I, *N*-formyl derivative of CNP-NH₂ was found, but CNP-NH₂ itself was not detected in the ether extracts. The hydrolysate of the fibrous residue revealed a small amount of CNP-NH₂.

In soil culture, the percentage of the unchanged CNP in the absorbed radioactivity was less than in water culture, and the relatively large amount of degradation products appeared in a aqueous acetone extracts. Some of these degradation products recovered from the plants under soil culture were not found in those under water culture. Therefore, it seemed that some of these degradation products were formed in these soil and taken up by the plants. These compounds were grouped under the heading "others" in Table 5. As CNP present in the soil was degraded, the amount of CNP in roots gradually decreased. About 10% of the added radioactivity was recovered as ¹⁴C-CNP from the soil 35 days after the treatment. The unchanged CNP in the roots

Table 5 CNP and its metabolites in the ether extracts.

Metabolites		Water culture			Soil culture			
		5	10	20 days	5	10	20	35 days
CNP	R	84.7	77.2	79.1	63.8	42.6	20.9	20.0
	F	5.8	4.2	5.3	7.6	11.9	21.7	17.9
Compounds I	R	0.6	1.6	1.3	1.4	4.0	4.6	2.2
	F	0.0	0.1	0.1	0.0	0.1	0.0	0.0
Compounds II	R	0.4	0.6	0.5	0.7	1.1	2.1	1.5
	F	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Unknown I	R	0.5	0.8	0.7	0.0	0.0	0.0	0.0
	F	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Original region	R	1.4	3.4	2.4	3.3	7.7	10.0	5.3
	F	0.1	0.2	0.2	0.1	0.4	1.6	0.6
Others	R	1.5	2.9	2.2	3.5	8.4	10.2	12.5
	F	0.0	0.1	0.1	0.0	0.1	0.4	0.9

All numbers represent the percentage of radioactivity of each metabolite based on the total radioactivity in plants. F, Foliage; R, Roots.

was 20% of the total radioactivity absorbed by the plants at this stage. The amount of unchanged CNP was 79% of the total radioactivity translocated to the foliage and 91% of the radioactivity in its ether extracts. CNP-NH₂, the main degradation product of CNP in soil, is strongly adsorbed on soil particles to form complexes with soil organic matter.⁹⁾ Therefore, most of these were hardly absorbed by the plants. CNP which is not adsorbed virtually by soil particles was absorbed by the plants.

When the fibrous residue of roots left after aqueous acetone extraction was hydrolyzed with hydrochloric acid, about 75 to 87% of the radioactivity in the residue was extracted with ether as shown in Table 7. CNP is not changed virtually under these conditions. A fair number of the degradation products appeared in the ether extracts of the hydrolysate. Fair amounts of compound I and an unknown compound were found, accompanied by small amounts of CNP and CNP-NH₂. Free CNP-NH₂ was not found in the ether extracts from roots but was found after hydrolysis. These compounds, for the most part, seemed to be bound with tissue constituents, mainly lignin, and are thus unextractable unless the tissue are hydrolyzed with hydrochloric acid.

CNP-NH₂ was readily absorbed by rice plants from water, but it was not translocated to the upper parts, as it was not detected in the foliage, as shown in Table 6. In water culture, CNP-NH₂ was readily metabolized by the rice plants in contrast to CNP, and only trace amounts of CNP-NH₂ was detected in the roots, and was not detected at all in the foliage. Most of these metabolites of CNP-NH₂ in rice plants have not been identified. The main metabolites were unknown 2 and unknown 3, which were formed one hour after treatment with CNP-NH₂. Compound I and compound II were present in small amounts. Unknown 2 and unknown 3 which were formed from CNP-NH₂ bound to the plant tissues, were presumed to be less polar compounds, based on their chromatographic behavior.

Hydrolysates of the fibrous residue of plants treated with CNP-NH₂ provided fair amounts of two hydrolytic products described as unknown in Table 7, but these were not identified. These products were similarly formed by refluxing of the CNP-NH₂ with rice plants in dil. hydrochloric acid, in the same manner as described above. Therefore, these unknown products may be artifacts arising from CNP-NH₂ bound to plant tissues.

These results are summarized as follows:

Table 6 CNP-NH₂ and its metabolites in the ether extracts.

Metabolites		Water culture			Soil culture			
		5	10	20 days	5	10	20	35 days
CNP-NH ₂	R	1.7	1.6	1.6	3.3	2.5	1.1	1.8
	F	0.0	0.0	0.0				
Compound I	R	8.9	3.1	2.1	5.2	5.8	2.7	2.0
	F	0.2	0.1	0.1				
Compound II	R	2.0	1.7	2.2	2.0	2.0	1.1	1.1
	F	0.1	0.0	0.0				
Unknown 2	R	7.0	19.3	22.1	0.0	0.0	0.0	0.0
	F	0.0	0.0	0.0				
Unknown 3	R	11.7	24.1	28.5	16.1	13.3	10.8	15.6
	F	0.7	0.8	0.5				
Unknown 4	R	0.0	0.0	0.0	2.7	3.3	2.1	1.1
	F	0.0	0.0	0.0				
Original region	R	17.2	9.0	8.2	9.9	10.9	5.9	6.0
	F	0.2	0.2	0.3				
Others	R	12.9	9.9	9.8	9.1	8.6	5.6	7.1
	F	0.1	0.1	0.1				

All numbers represent the percentage of radioactivity of each metabolite based on the total radioactivity in plants. F, Foliage; R, Roots.

Table 7 Ether-extractable metabolites in hydrolysate of the fibrous residue of roots with 3 N HCl.

CNP treatment				CNP-NH ₂ treatment			
Metabolites	5	10	20 days	Metabolites	5	10	20 days
CNP	2.8	0.6	0.7	CNP-NH ₂	1.3	2.0	4.6
CNP-NH ₂	1.9	3.0	2.0	Unknown	77.5	75.4	68.7
Compound I	5.8	15.8	13.0	Others	3.4	1.4	1.4
Unknown	21.1	10.9	6.4	Original	4.3	6.6	9.7
Others	36.7	23.8	21.5	Total	86.6	85.3	84.4
Original	7.4	32.4	34.7				
Total	75.8	36.6	78.4				

All numbers represent the percentage of radioactivity of each metabolite based on the total radioactivity of the fibrous residue.

Fig. 2 Proposed metabolic pathway of CNP in plant.

CNP and its amino derivative (CNP-NH₂) were absorbed into the roots of rice plants in water culture, but these compounds, especially CNP-NH₂ were hardly transferred to the upper parts of the plants. In soil culture, however, the absorption of CNP-NH₂ by the plants was extremely limited due to the strong adsorption on soil particles. In plants, CNP was slowly metabolized to form CNP-NH₂ and CNP-OH and their glycosides. The cleavage of ether linkage hardly occurred. These results may indicate that in paddy field rice plants absorb a small amount of CNP herbicide and almost no CNP-NH₂, although fair amounts of CNP-NH₂ are formed and retain for rather long period in flooded soil as the conjugate form.

ACKNOWLEDGEMENT

We are indebted to Mr. T. Yoshimoto, Research Center, Mitsui-Toatsu Chemicals Inc., for providing us with radioactive CNP and many authentic chemicals.

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要 約

CNP およびそのアミノ体のイネ体における吸収, 移行, 代謝

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ジフェニルエーテル系除草剤 CNP およびその土壤中における主生成物であるアミノ体 (CNP-NH₂) のイネ体における吸収, 移行, 代謝について, ペンゼン環標識 ¹⁴C 化合物を用い, 室内実験により研究した. 両化合物とも水耕液から速やかに根に吸収されるが, 地上部への移行はきわめて少なく, とくにアミノ体はほとんど移行

しなかった. 土壌からの吸収は水耕液からの吸収よりもはるかに少なかった. イネ体内における CNP の代謝はきわめて遅いが, CNP-NH₂ は速やかに代謝された. CNP の主代謝物として 3 種類の化合物が検出され, そのうちの 2 種類を CNP のニトロ基がホルミルアミノ基および水酸基に変換された化合物と同定した. そのほかに CNP-NH₂ およびその *N*-glucoside も検出された. 水耕液からイネ体内に吸収された CNP-NH₂ は速やかに減少し, 2 種類の主生成物のほかに多数の代謝物が検出された.