Selective Action of Root-Treated Oxyfluorfen and Chlomethoxynil

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根部處理 Oxyfluorfen과 Chlomethoxynil의 選擇作用性

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ABSTRACT

Selective action of root-treated oxyfluorfen [(2-chloro-4-thrifluoromethylphenyl)-3′-ethoxy-4′-nitrophenyl ether] and chlomethoxynil [2, 4-dichlorophenyl-3′-methoxy-4′-nitrophenyl ether] were investigated. Oxyfluorfen showed greater activity to all plant species than chlomethoxynil. ^{14}C-oxyfluorfen was little metabolized in roots of the plant species and more slowly absorbed than ^{14}C-chlomethoxynil. These results suggest that herbicidal activity of oxyfluorfen at the site of action is higher than chlomethoxynil. In the tested plants, rice, barnyardgrass, sorghum, and corn were absorbed less of the oxyfluorfen and chlomethoxynil than the broad leaf plant species. However, no clear relationship was observed between a degree of tolerance and absorption and metabolism of both herbicides by the plant species.

Key words : selective action, root treatment, diphenyl ethers, oxyfluorfen, chlomethoxynil

Introduction

Diphenyl ether herbicides are absorbed readily by plant roots, but rarely translocated from roots to shoots[1,3,4]. The previous study[1] indicated that root-applied diphenyl ether herbicides showed no phytotoxic activity. However, after relatively long-term exposure of roots to the herbicides, phytotoxic symptom in some plant species was found. Because little information is available on the selectivity mechanisn of root-applied diphenyl ether herbicides, herbicidal activity of root-applied oxyfluorfen and chlomethoxynil was compared, and their absorption, translocation and metabolism among various plant species were studied.

Materials and Methods

Plant materials and herbicides application

Four gramineous plant species ; rice(*Oryza sativa* L.), barnyardgrass(*Echinochloa oryzicola* Vasing.), sorghum(*Sorghum bicolar* Moench) and corn(*Zea mays* L.) and five broad leaf plants species ; tomato(*Lycopersicon esculentum* Mill), cabbage(*Brassica oleracea* L.), radish(*Raphanus sativus* L.), cucumber (*Cucumis sativus* L.) and buckwheat

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(*Fiagopyrum esculentum* Moench) were grown in a growth chamber with light intensity of 450 μEm^{-2} sec^{-1} as previously described[2]. Roots of the gramineous plants at the 2-leaf stage and the broadleaf plants at the fully developed cotyledon stage were soaked in 1μM of the herbicides solution for 24 hours in darkness. The herbicides were dissolved in Kasugai's nutrient solution and they contained 0.1% of acetone as a solvent. After the treatment, roots of the plants were washed and grown for 1, 3 or 6 days by a herbicide-free nutrient solution. The experiment was carried out with four replications and repeated.

Absorption and translocation

Roots of the plants were soaked to the 1μM ^{14}C-labeled oxyfluorfen or chlomethoxynil solution in darknes. The herbicide solution were contained same radioactivity sampled and radioactivity in the roots was determined by a combustion method[2]. The experiments were conducted with 3 replication. Translocation of the herbicides from roots were studied by autoradiography.

Metabolism

Roots of the plants were treated equally with the absorption study. After the treatment, followed by washing the roots, the plants were transferred to the herbicides-free nutrient solution and exposed to light. The plants were sampled at several time intervals after exposure to light. Metabolic rate of the herbicides were determined by the same procedure described elsewhere[2].

Results and Discussion

Selective herbicidial activity

Oxyfluorfen showed greater phytotoxic to all plants species than chlomethoxynil(Fig. 1).

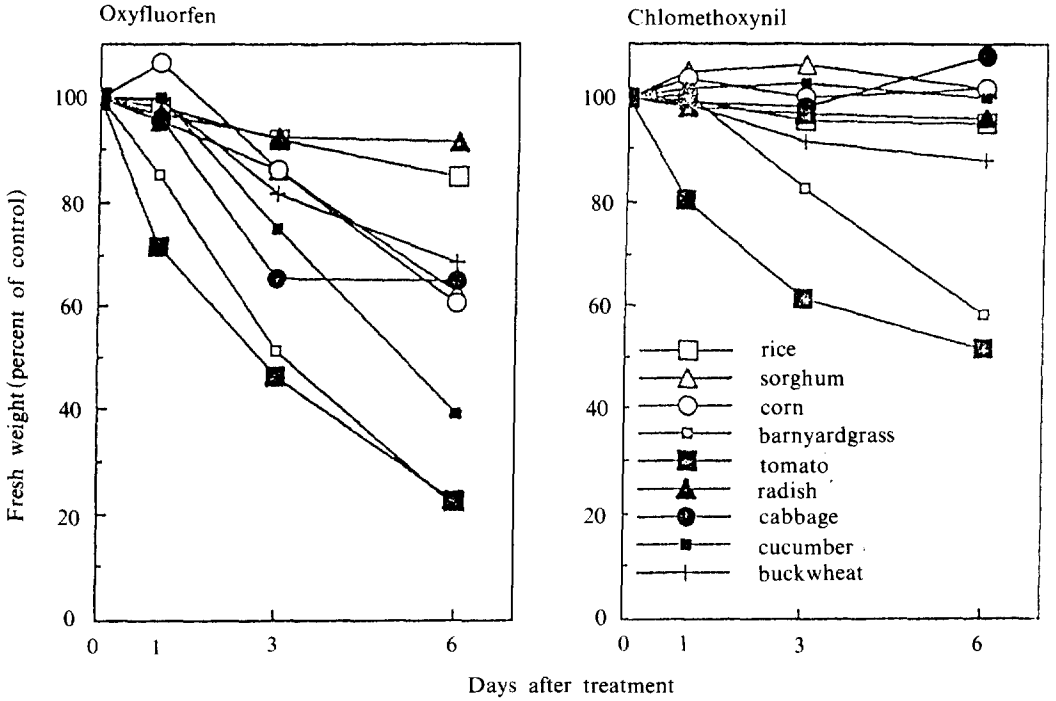

Fig. 1. Effects of oxyfluorfen and chlomethoxynil on growth of plants. The herbicides were applied to roots in darkness for 24hr.

Among the tested plants rice and radish were tolerant, and barnyardgrass and tomato were susceptible to the herbicide. Fresh weights of the suseptible plants decreased within 1 days after the treatment. In chlomethoxynil treatment, the plants except barnyardgrass and tomato showed little damage, but the two species were injured by the herbicides. The data indicate that the diphenyl ether applied to roots were phytotoxic to some plant species although longer period of absorption was required for the herbicidal activity compared with shoot application. Injury of roots or root hairs and wilting of leaves were main symptoms in the susceptible plants. Wilting of the leaves may be casued by reduction of water absorption by injured roots.

Absorption and translocation

Absorption rate of ^{14}C-chlomethoxynil from roots was higher than of ^{14}C-chlomethoxynil (Fig. 2). This suggest that absorption is not a factor of greater herbicidal activity of oxyfluorfen. Broad leaf plants absorbed both herbicide more rapidly than gramineous plants. However, no relationship between tolerance to each herbicide and the rate of absorption was observed. Autoradiography of root-applied ^{14}C-oxyfluorfen and ^{14}C-chlomethoxynil indicated that little translocation occurred from roots (data not shown).

Metabolism

Radoactivity of root-treated ^{14}C-oxyfluorfen was mostly recovered from a n-hexane fraction (Fig. 3). Thin-layer chlomatography (TLC) indicated that oxyfluorfen was hardly degradative in the plants, almost all radioactivity in the fraction were originated from the parent oxyfluorfen (data not shown).

^{14}C-chlomethoxynil was metabolized to a water-soluble metabolite(s) and to an insoluble residue slightly faster than oxyfluorfen (Fig. 3).

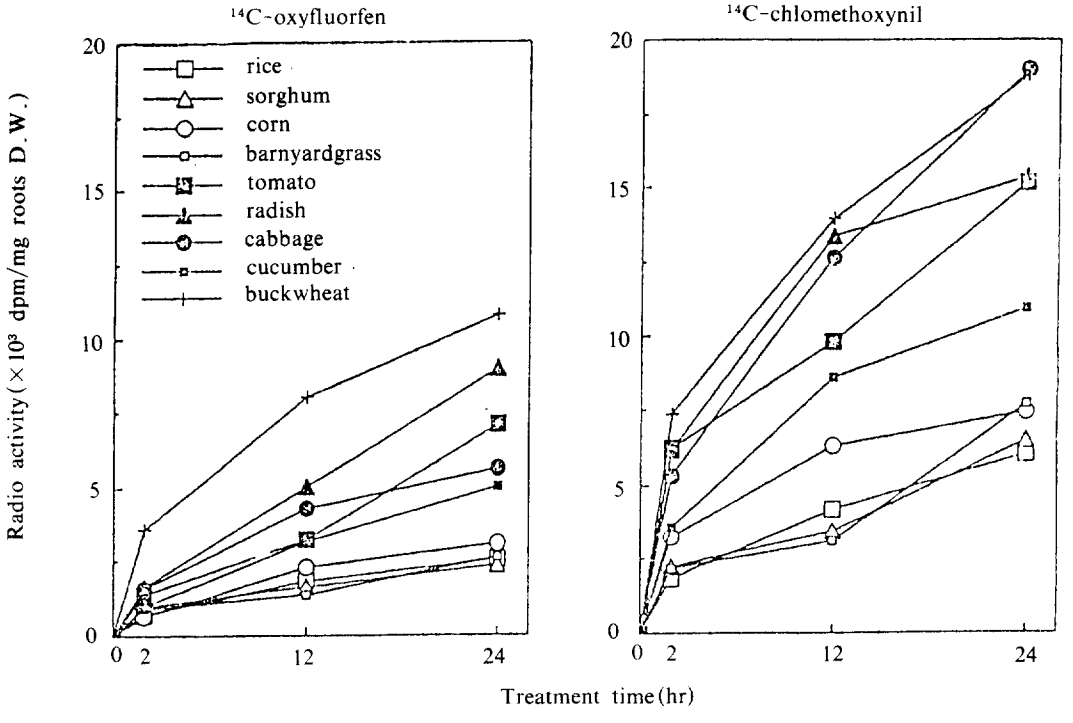

Fig. 2. Absorption of 10^{-6}M of ^{14}C-oxyfluorfen and ^{14}C-chlomethoxynil by roots in darkness.

However, 60-80% of absorbed radioactivity were still remained n-hexane fraction at 24hr. TLC of the fraction showed that almost all radioactivity was also originated from the parent compounds (data not shown). Glucose conjugate and several other unknown metabolites were found in the water soluble fraction. Although rice and radish rapidly degraded shoot-applied chlomethoxynil in their shoots compared with the other plants[2], and degradation of the chemical in roots was not greater than the others.

In the experiments, higher concentration of the parent compound in roots was formed in chlomethoxynil treatment because of its greater absorption. However, oxyfluorfen showed stronger phytotoxic activity to the plants than chlomethoxynil. This may be casued by higher herbicidal activity of oxyfluorfen at the site of action. The data also showed that both herbicides were quite selective after root application. However, no clear relationship was observed between a degree of tolerance and its absorption and metabolism. The other factors may involved in the selectivity mechanism of the herbicides. Thus, mode of action of the herbicides after root-treatment and their action site in roots should be understood.

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摘 要

Oxyfluorfen과 chlomethoxynil의 根部處理에 있어서 각 植物 種間의 選擇性 機構를 밝히기 위

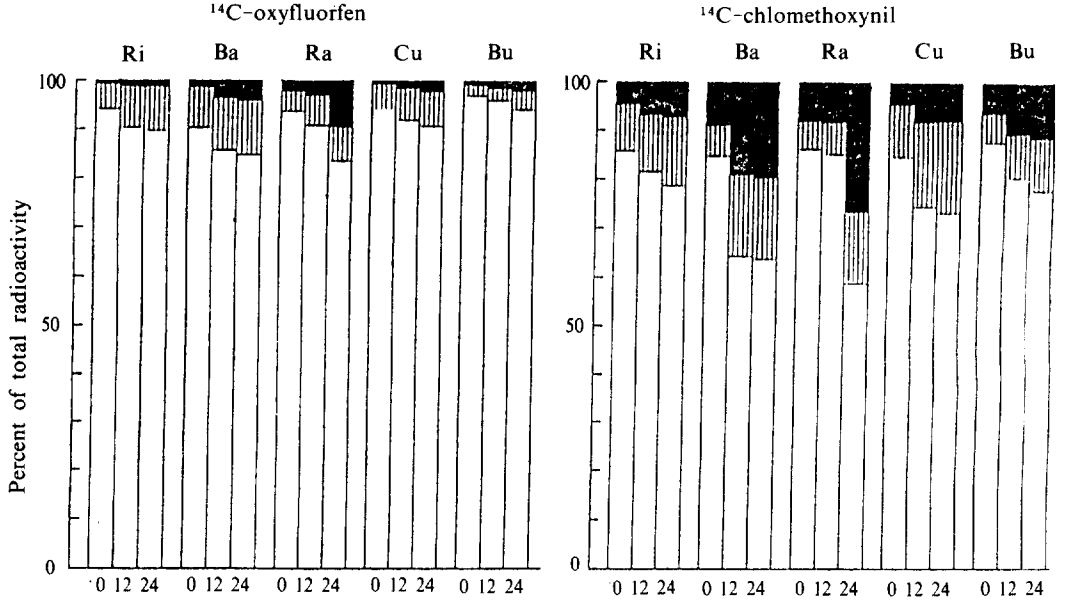

Fig. 3. Metabolism of root applied ^{14}C-oxyfluorfen and ^{14}C-chlomethoxynil in roots. The herbicides were treated in the dark for 24 hours before irradiation.
Ri : Rice, BA : Barnyardgrass, Ra : Radish, Cu : Cucumber, Bu : Buckwheat
■ : Insoluble residue, □ : Water, □ : n-Hexane

해 각 植物에서 藥劑의 殺草作用과 吸收, 移行 및 代謝 등의 關係를 調査하였다. 供試植物은 禾本科 植物로서 벼, 피, 수수와 옥수수를, 廣葉植物로서 토마토, 양배추, 무, 오이와 메밀을 利用하였다.

Oxyfluorfen은 각 植物에 대하여 chlomethoxynil보다 강한 殺草 活性을 나타내었다. Oxyfluorfen은 chlomethoxynil에 비하여 代謝速度가 다소 늦었지만 吸收量이 보다 적었기 때문에, 根部內의 作用點에서 Oxyfluorfen의 作用活性은 chlomethoxynil보다 큰 것으로 推察되었다.

Oxyfluorfen에 대하여 禾本科 植物은 廣葉植物보다 吸收量이 적었다. 禾本科인 피는 벼에 비하여 oxyfluorfen 吸收量의 差異는 거의 없었지만, 벼보다 큰 感受性을 나타내었으며, 또한 廣葉植物인 토마토와 오이는 메밀이나 무보다 吸收量이 적었음에도 불구하고 큰 感受性을 나타내었다. 각 植物이 吸收한 ^{14}C-oxyfluorfen은 대부분이 代謝되지 않고 未變化의 形態로 存在하였으며 抵抗性 植物과 感受性 植物과의 代謝率의 差異는 보이지 않았다. 또 water fraction을 調査한 결과, 각 植物에서 oxyfluorfen은 glucose를 包含한 植物成分과 少量의 抱合體를 形成하는 것으로 나타났다.

Chlomethoxynil 處理에 있어서도, 禾本科 植物은 oxyfluorfen 處理와 同樣으로 廣葉植物에 비하여 藥劑의 吸收量이 적었다. 피는 禾本科 植物중에서 藥劑處理 24시간 후에 吸收率이 가장 낮았고, 또한, 토마토는 양배추나 메밀보다 吸收率이 낮았음에도 불구하고 피와 토마토만이 큰 感受性을 보였다. 각 植物에 의해 吸收된 ^{14}C-chlomethoxynil의 放射能 중 60-80%는 n-hexane 중에 存在하였으며, 그 대부분은 chlomethoxynil로 부터의 것이었지만, n-hexane fraction의 TLC를 행한 결과, 벼에서 少量의 脫methyl體가 代謝産物로서 檢出되었다. 또한, 각 植物에서 oxyfluorfen과 同樣으로 少量의 chlomethoxynil이 glucose나 다른 成分과 抱合體를 形成하였다.

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