

Special Feature: Case Studies Showcasing Nissan Chemical's Strengths

The Development Story of VERDAD® Herbicide for Paddy Rice

VERDAD®, a herbicide for paddy rice, was registered in August 2024.

Backed by the Group's unique strengths in both R&D capabilities and marketing abilities, we successfully created an innovative herbicide that improves farmers' work efficiency while also addressing key social challenges.



In recent years, prolonged high temperatures resulting from global warming have accelerated weed growth. In particular, weeds such as bulrush and cyperaceous perennial weeds in rice paddies not only deprive rice plants of nutrients, leading to reduced yields and quality, but also entangle harvesters such as combines during harvesting, reducing work efficiency and causing hardship for farmers. Effective weed-control technologies are therefore essential for ensuring stable rice yields and improving work efficiency.

To date, Nissan Chemical has developed and launched ALS inhibitor herbicides such as SIRIUS® (pyrazosulfuron-ethyl) and ALTAIR® (metazosulfuron) as core agents for herbicides for paddy rice. While ALS inhibitors have the advantage of controlling a

broad spectrum of weeds at low application rates, they are also up against the emergence of resistant weeds.

Meanwhile, market analysis conducted in collaboration with the Agricultural Chemicals Division revealed that while five to ten active ingredients have been commercialized for core agents such as ALS inhibitors and for barnyard grass targeted herbicides, there are still only three to four active ingredients available for controlling rock bulrush. Moreover, it became clear that control of cyperaceous perennial weeds relies heavily on ALS inhibitors.

Accordingly, we began research to create a new active ingredient capable of simultaneously controlling rock bulrush and cyperaceous perennial weeds based around the concept of providing more options to both producers using our product as well as other manufacturers creating mixed formulations.

Our research focused on trifluoromethanesulfonanilide-type compounds, which possess a mechanism of action known as "very-long-chain fatty acid biosynthesis inhibition," a mode less prone to the emergence of resistant weeds. Plants protect themselves from ultraviolet radiation and drying by forming a wax layer known as the cuticle, with its raw material being very-long-chain fatty acids. Trifluoromethanesulfonanilide-type compounds can inhibit the production of these essential materials, preventing normal plant growth and ultimately causing the plant to die. This pathway is specific to plants and does not exist in animals; this also gives it the advantage of low toxicity to humans, livestock,



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and environmental organisms.

Leveraging this mechanism of action led to the creation of our proprietary herbicide for paddy rice "Dimesulfazet," launched under the brand name VERDAD®.

The discovery and selection of VERDAD® involved numerous challenges. One example was designing a compound exhibiting high herbicidal efficacy against cyperaceous weeds while also avoiding phytotoxicity to rice. Through a collaboration between highly precise "biological evaluation" by the Biological Research Laboratories and "fine organic synthesis" by the Chemical Research Laboratories, we jointly analyzed and discussed structures, activity, and selectivity, leading to the discovery of a "four-membered lactam structure" design not found in existing pesticides. This novel molecular design—unbound by conventional knowledge—was the key to achieving VERDAD®'s consistently high herbicidal efficacy and crop selectivity, ultimately paving the way for its successful commercialization.

Key Features of VERDAD®

The most distinctive feature of VERDAD® is its outstanding efficacy against rock bulrush, a problematic weed often difficult to control with existing herbicides. Although active ingredients effective against rock bulrush have existed, there have been cases in which weeds persist in rice paddies, such as the emergence of herbicide-resistant weed populations, reduced efficacy due to temperature, water, and soil conditions, and diminished effectiveness against advanced growth weeds. VERDAD® provides consistent herbicidal efficacy, less susceptible to such environmental fluctuations. This also boasts high efficacy against cyperaceous perennial weeds such as perennial sedges, which are notoriously difficult to control given their long growth periods. The low application rate in rice paddies is 15 g a.i./10a, achieving a reduction of one half to one sixth of conventional rock bulrush herbicides. Furthermore, it has low toxicity to non-target environmental organisms, significantly reducing the chemical environmental impact.



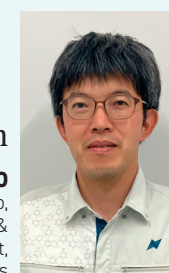
VERDAD®-containing herbicides "ZEARTH®" and "GINGAα"

The Success of VERDAD® Driven by the Synergy of R&D Capability and Marketing Ability

"Developing Herbicides Unlike Any Before" — Completion of Development Through Persistent Research

MIYAZAKI Takao

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Among rice herbicides, one-shot processing agents are required to control various weeds at once, and therefore products are created by combining multiple active ingredients. Accordingly, during development, it was necessary to consider combinations that could take advantage of VERDAD®'s excellent effectiveness against cyperaceous weeds while supplementing its effects against barnyard grass and broadleaf weeds. With so many options available, selection was one of the most challenging points. In addition, herbicides for paddy rice are used in different environments across various locations and seasons, and the types of weeds that emerge differ by region. Therefore, the product needed to demonstrate stable herbicidal activity under diverse rice paddy conditions. Extensive field trials were conducted across Japan, from Hokkaido in the north to Okinawa in the south, under conditions of low and high temperatures, different soil properties, and resistant weeds. As a result of this nationwide data collection, we successfully developed ZEARTH® and GINGAα.

Early Market Penetration Through Collaboration with Other Companies, Aiming for Total Sales of 6 Billion Yen.

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Marketing Group, Sales Department, Agricultural
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Among weeds in rice cultivation, the control of cyperaceous weeds is particularly important due to their long emergence period and the presence of herbicide-resistant weed populations. VERDAD® is a new active ingredient with a novel mode of action for controlling rock bulrush, and our aim was to promote its rapid adoption in the field not only through our own products but also its adoption by other manufacturers. Therefore, even before obtaining registration, we proposed collaboration to competing companies. The efficacy of the active ingredient was highly evaluated, advancing the development of their mixed formulations. As a result, products containing VERDAD® —ZEARTH® and GINGAα— which obtained registration in August 2024, and two other companies received approval for their respective products around the same time. Furthermore, additional products are planned for registration and launch within the next two to three years. We aim for total sales of VERDAD® through both our in-house products and external partnerships, to reach 6 billion yen at peak levels.