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Maleic hydrazide: A plant growth regulator in agriculture and horticulture

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Abstract

Maleic hydrazide (MH) is a widely used plant growth regulator in agriculture and horticulture, primarily applied to control sprouting in storage crops like potatoes, onions, and garlic, and to regulate unwanted growth in tobacco, ornamental plants, and turf. It works by inhibiting cell division, thereby slowing or halting plant growth without killing the plant.

1. Introduction

Maleic hydrazide (MH) is a synthetic plant growth regulator belonging to the pyridazinone group, widely recognized for its ability to inhibit cell division and suppress unwanted vegetative growth. Since its introduction in the mid-20th century, MH has been employed in agriculture and horticulture to regulate plant development without destroying the crop. Its primary mode of action involves blocking mitosis, thereby reducing sprouting, sucker formation, and excessive elongation. This makes MH a valuable tool for improving crop storage, maintaining quality, and enhancing management practices in both field and ornamental systems.

In agriculture, MH is extensively applied to potatoes, onions, garlic, and carrots to prevent sprouting during storage, thereby extending shelf life and reducing post-harvest losses. It is also used in tobacco production to control sucker growth after topping, which improves leaf quality and yield. In horticulture, MH plays a role in maintaining compact growth in ornamental plants, shaping shrubs, and reducing mowing frequency in turfgrass management. These applications highlight its versatility as a cost-effective regulator, though its use requires

careful timing and adherence to residue regulations to ensure food safety and environmental sustainability.

2. Chemical Profile

Maleic hydrazide (MH), chemically known as *1,2-dihydropyridazine-3,6-dione*, is a pyridazinone derivative with the molecular formula $C_4H_4N_2O_2$ and a molecular weight of 112.09 g/mol (Figure 1). It is an odorless white crystalline solid, soluble in water, alcohol, and acetone, and stable under normal conditions but decomposes at high temperatures, releasing nitrogen oxides. Introduced in the 1950s, MH has been widely used as a plant growth regulator and selective herbicide. Its primary agricultural applications include sprout suppression in storage crops such as potatoes and onions, and sucker control in tobacco cultivation (PubChem, n.d.; Chemiis, 2026).

3. Mechanism of Action in Plants

The mechanism of MH is based on its ability to **inhibit mitosis (cell division)** in meristematic tissues. It interferes with DNA synthesis and spindle formation, thereby blocking cell division and suppressing vegetative growth. This inhibition results in prolonged dormancy in storage crops, reduced sucker formation in tobacco, and compact growth in ornamentals and turf. Unlike herbicides that kill plants, MH functions as a **growth depressant**, slowing elongation while allowing the plant to remain physiologically active. This makes it a valuable tool for post-harvest management, crop quality improvement, and horticultural shaping, though its use requires careful timing and monitoring of residues to ensure food safety (EPA, 1994; Chemiis, 2026).

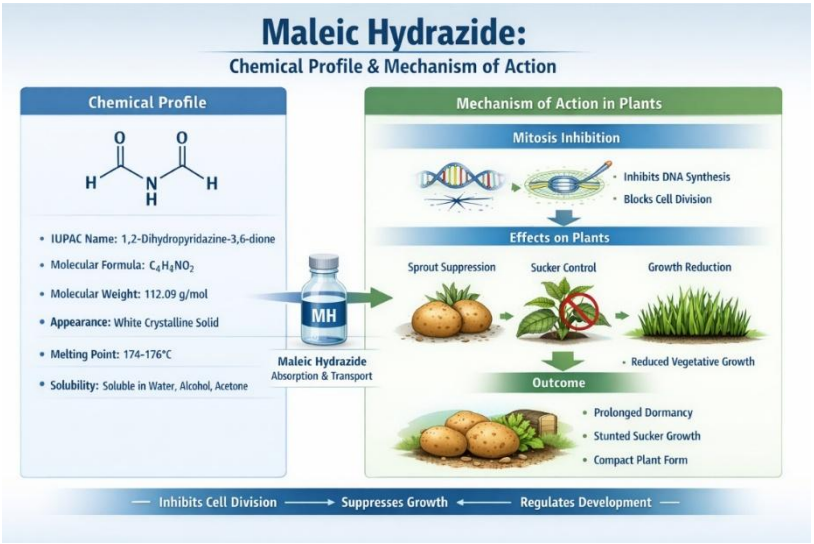

Figure 1: Chemical profile and mechanism of action of maleic hydrazide in plants

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4. Applications in Agriculture

Applications of maleic hydrazide in agriculture and horticulture are furnished in figure 2.

4.1 Sprout inhibitor

Maleic hydrazide (MH) is widely used as a sprout inhibitor in storage crops such as potatoes, onions, garlic, and carrots, where it effectively prolongs dormancy and prevents sprouting during long-term storage. By inhibiting mitosis in meristematic tissues, MH reduces cell division and suppresses the initiation of new shoots, thereby maintaining crop quality and minimizing post-harvest losses. Its application is typically carried out pre-harvest, allowing the compound to translocate into developing tissues and exert its inhibitory effect during storage. This makes MH a cost-effective alternative to refrigeration or controlled atmosphere storage, ensuring extended shelf life and reduced waste in commercial supply chains, though its use requires careful timing and monitoring of residues to comply with food safety regulations (PubChem, n.d.; Chemiis, 2026; U.S. EPA, 1994).

4.2 Tobacco industry

In the tobacco industry, maleic hydrazide (MH) is primarily applied as a sucker control agent to prevent the growth of axillary shoots that emerge after the plant is topped. These unwanted suckers compete with the main leaves for nutrients and water, reducing both yield and quality. MH, when sprayed at the appropriate stage, is absorbed and translocated within the plant, inhibiting cell division in meristematic tissues and thereby suppressing sucker development. This regulation ensures that the plant's resources are directed toward the maturation of the main leaves, resulting in improved leaf size, uniformity, and chemical composition, which are critical for curing and processing. The use of MH in tobacco cultivation is considered cost-effective and efficient compared to manual sucker removal, though its application requires careful timing to maximize effectiveness and minimize residue concerns (Chemiis, 2026; PubChem, n.d.; U.S. EPA, 1994).

4.3 Cereal and oilseed crops

In cereal and oilseed crops, maleic hydrazide (MH) is applied as a growth regulator to reduce excessive vegetative development and minimize lodging, a condition where plants fall over due to weak stems or over-elongation. By inhibiting mitosis in meristematic tissues, MH slows down cell division and elongation, resulting in sturdier plants with improved standability. This regulation is particularly beneficial in crops such as wheat, barley, and oilseeds, where lodging can significantly reduce yield and complicate harvesting. The use of MH thus contributes to better crop management, enhanced productivity, and more efficient mechanized harvesting, though its application must be carefully timed to avoid negative

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impacts on reproductive development and to comply with residue regulations (Chemiis, 2026; PubChem, n.d.; U.S. EPA, 1994).

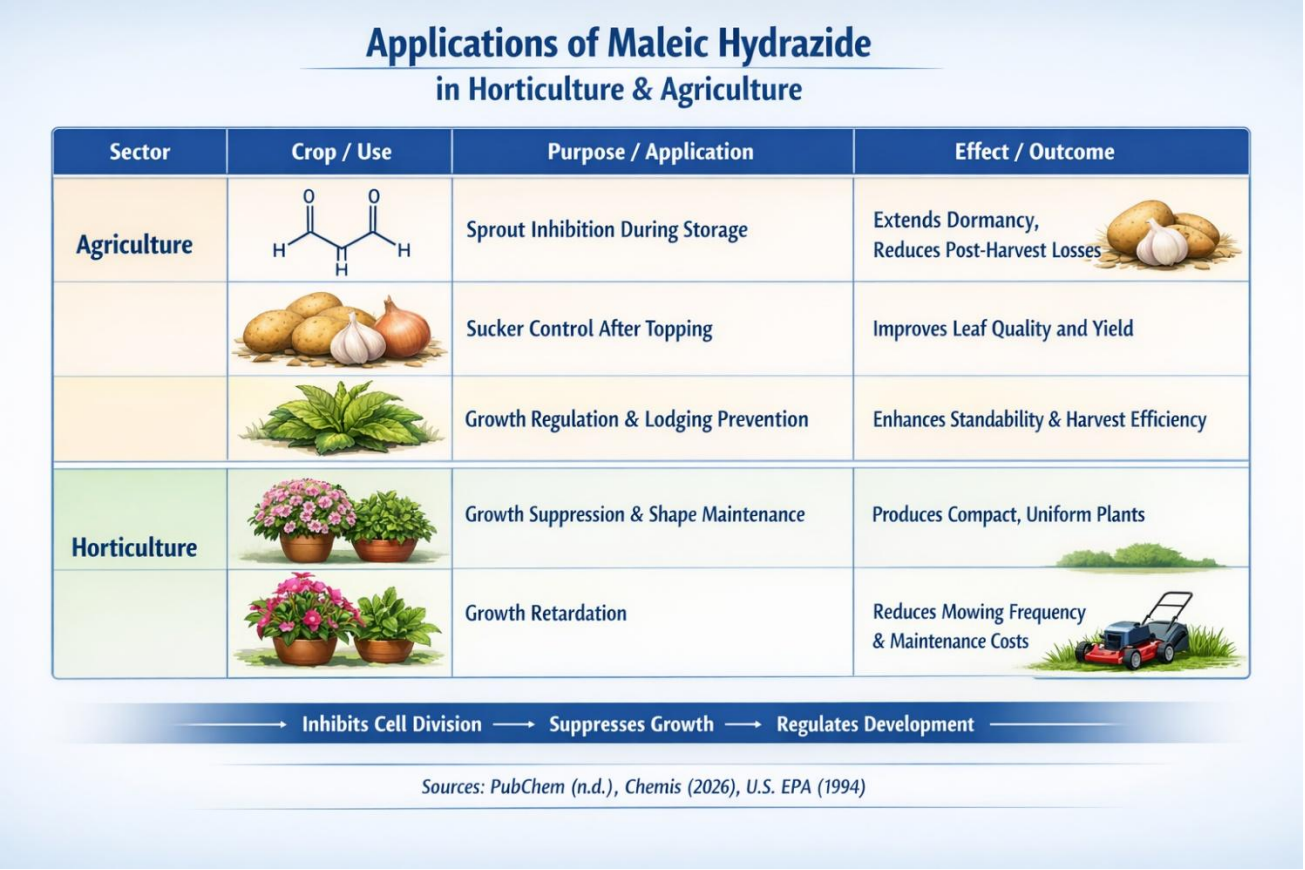

Figure 2: Applications of maleic hydrazide in agriculture and horticulture

5 Applications in Horticulture

5.1 Ornamental crops

In ornamental crops, maleic hydrazide (MH) is applied as a growth regulator to maintain compact plant architecture, control excessive elongation, and enhance aesthetic appeal. By inhibiting mitosis in meristematic tissues, MH suppresses vegetative growth, allowing ornamental plants such as flowering shrubs, potted foliage, and decorative turf to retain desirable shapes and sizes. This regulation reduces the need for frequent pruning or trimming, making MH particularly valuable in commercial landscaping and nursery management. Additionally, MH helps in producing uniform plants with improved market value, though its application must be carefully timed to avoid stunting flowering or negatively impacting ornamental quality. Overall, MH serves as a cost-effective tool for shaping and managing ornamental crops while ensuring resource efficiency in horticultural systems (Chemiis, 2026; PubChem, n.d.; U.S. EPA, 1994).

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5.2 Turf and lawns

In turf and lawns, maleic hydrazide (MH) is applied as a growth suppressant to reduce the frequency of mowing and maintain a more uniform, compact turf structure. By inhibiting mitosis in meristematic tissues, MH slows down cell division and elongation, thereby decreasing the rate of grass growth without damaging the turf. This regulation is particularly beneficial in public parks, golf courses, and residential lawns, where it helps lower maintenance costs, conserve labor, and improve aesthetic appeal. Additionally, MH contributes to resource efficiency by reducing the need for repeated trimming and minimizing fuel use in lawn care equipment. However, its application must be carefully managed to avoid uneven growth patterns and to comply with residue and environmental safety regulations (Chemiis, 2026; PubChem, n.d.; U.S. EPA, 1994).

6. Limitations and risk management

Maleic hydrazide (MH), despite its widespread use as a plant growth regulator, presents several limitations and risks that must be carefully managed. One of the primary concerns is the persistence of MH residues in treated crops, which necessitates strict monitoring to comply with food safety regulations. Its effectiveness is highly dependent on timing of application—if applied too early or too late, sprout inhibition or sucker control may be inconsistent. Overuse or misapplication can also lead to phytotoxic effects, such as stunted growth or reduced flowering in sensitive crops. Additionally, MH may impact soil microflora and non-target plants, raising environmental concerns. Regulatory agencies, including the U.S. Environmental Protection Agency (EPA), have emphasized the need for controlled use due to potential residue and ecological risks, while industry guidelines highlight that MH should be applied only under recommended conditions to balance its benefits with sustainability (Chemiis, 2026; PubChem, n.d.; U.S. EPA, 1994).

Table 1: application area, purpose, benefit and limitations

Application Area	Purpose	Benefit	Limitation
Storage crops	Sprout inhibition	Longer shelf life, reduced waste	Residue monitoring required
Tobacco	Sucker control	Better leaf quality	Timing critical
Ornamentals	Growth regulation	Compact, aesthetic plants	Overuse may stunt flowering

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Application Area	Purpose	Benefit	Limitation
Turf/Lawns	Growth suppression	Reduced mowing frequency	Possible uneven growth

7. Future prospects

Looking ahead, the future prospects of maleic hydrazide (MH) in agriculture and horticulture lie in its continued role as a cost-effective growth regulator, but with greater emphasis on sustainability, precision application, and integration into modern crop management systems. Advances in formulation technology and application methods are expected to improve its efficiency, reduce residue concerns, and enhance environmental safety. In agriculture, MH will likely remain important for sprout inhibition in storage crops and sucker control in tobacco, while in horticulture and turf management, its use may expand with demand for low-maintenance, aesthetically uniform landscapes. Moreover, research into combining MH with other bioregulators or eco-friendly practices could broaden its utility in integrated pest and growth management strategies. As regulatory frameworks tighten, future applications will depend on balancing its proven benefits with food safety, ecological impact, and consumer acceptance (Chemiis, 2026; PubChem, n.d.; U.S. EPA, 1994).

Conclusion

In conclusion, maleic hydrazide (MH) has established itself as a versatile and cost-effective plant growth regulator with wide-ranging applications in both agriculture and horticulture. Its ability to inhibit mitosis makes it particularly valuable for sprout suppression in storage crops such as potatoes and onions, sucker control in tobacco, and growth regulation in cereals, oilseeds, ornamentals, and turf. These uses contribute to improved crop quality, extended shelf life, reduced labor costs, and enhanced aesthetic value in managed landscapes. However, its effectiveness depends on precise timing of application, and concerns about residues and environmental impact necessitate careful monitoring and adherence to regulatory guidelines. Looking forward, MH's role will likely evolve with advances in sustainable crop management practices, ensuring that its benefits are maximized while minimizing risks to food safety and ecosystems (Chemiis, 2026; PubChem, n.d.; U.S. EPA, 1994).

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