Graduation Project Report:

Agricultural Chemicals

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Benha university.

Presented by:

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4th year (Special Chemistry)

Under the Supervision of:

Prof. Dr. M. H. Arief

(2025)

Acknowledgment

Always in begin, in the Name of Allah, The Most Beneficent, The Most Merciful, and praise be to Allah who is help all success and me for him and I am especially grateful to my parents, who supported me emotionally and financially. I always knew that you believed in me and wanted the best for me. Thank you for teaching me that my job in life was to learn, to be happy, and to know and understand myself; only then, could I know and understand others. Then, with all my deep thanks, and my sincere appreciation to:

Prof. Dr. M. H. Arief

For his valuable and constructive suggestion during the planning and development of this research work. This willingness to give his time so generously has been very much appreciated.

نموذج تقييم مادة البحث والمقال

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عنوان البحث: **Agricultural Chemicals**

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درجات المشرف	تقيم اللجنة	المجموع
(50)	اللقاء (25) / المناقشة (25)	100
مجموع الدرجات بالحروف:		

توقيع المشرف والدرجات:

م	الاسم	التوقيع
1		
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رئيس قسم الكيمياء

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1. OVERVIEW .

Global population growth is about 1.3 % every year, and the population is expected to reach seven billion by 2015 and nine billion by 2050 [1]. In the time it takes to read this sentence, another 20 people will have been added to the world's population [2]. The number of malnourished people in the world has been estimated at 852 million. Each year, hunger and malnutrition are responsible for the deaths of six million children. In want of food, people plow forests and the world annually loses 9.4 million hectares of forests [3]. "Pesticides" is a general term and includes substances that kill weeds (herbicides), insects (insecticides) and fungus (fungicides). Although the terms might be "bad words" in some circles, it is only because of the use of these agricultural chemicals that the problem of food supply and deforestation is not worse. Six multinational companies: Syngenta, Bayer, Monsanto, DuPont, BAS ,And Dow are major players in the agrochemical industry [4]. Each has annual crop protection chemical sales in excess of $3 billion and together they have about 70 % of the market [5]. China is emerging as first in world pesticide production and second in usage with about 2,800 manufacturers and more than 400 million small-scale farmers [6]. There is great variety among pesticides. For example, in Canada there are over 7,000 pesticide products and over 500 active ingredients are registered [7]. More than 80 % of the pesticides used in Canada are herbicides [8].

2. FERTILIZER.

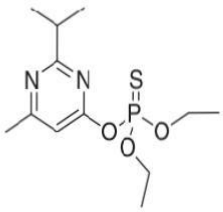
Fertilizers are compounds given to plants to improve growth [9]. Plants require elemental nutrients in diffrent amounts, which different according to species, genotype, soil, and environmental factors [10]. For grain crops, as seed is produced and removed from the field, nutrients are lost every season and must be replaced. Fertilizers are used for this purpose. Nitrogen, phosphorus, And potassium are primary nutrients. Primary nutrients are required in large amounts and are quickly depleted from the soil. Retail fertilizers for homeowners typically have a three-number designation such as 10-6-4. These numbers designate the weight percent of nitrogen, phosphorus, and potassium. The first number is the weight percent nitrogen in the fertilizer,10 % in this example. The second number is for phosphorus and represents the amount on a phosphate basis. In this example, there is 6% P2O5. Recognize that the phosphorus is not present as phosphorus pentoxide; this is a way of reporting the number. The third number is for potassium on a potash or potassium oxide basis. Fertilizer having the designation of 10-6-4 has the amount of potassium equivalent to 4 % K_2O. In addition to these three elements, many other elements are also needed for proper plant growth albeit often in smaller quantities.

Nitrogen is usually the most limiting nutrient in crop protection, partly because large amounts are required by plants and partly because it migrates from the soil [11]. Common nitrogen fertilizers are ammonia and derivatives of ammonia such as urea, ammonium nitrate, and ammonium phosphate. To understand the role of fertilizers, it might be helpful to think about soybean. Soybean is the world’s most important source of protein and accounts for nearly 70 % of the protein meal consumption and nearly 30 % of vegetable oil consumption [12]. Nitrogen, phosphorus, and potassium (in that order) are removed in soybean seed and need to be replenished. Soybean is a source of protein and protein is about 16 % nitrogen [13]. Phosphorus is used in essential components such as adenosine triphosphate (ATP), which is used in photosynthesis. Potassium serves as an important cation for many plant processes and is required for plant growth. Nitrogen, phosphorus, and potassium are sometimes called macronutrients. Other elements required include sulfur, calcium, And magnesium; sometimes these are called secondary macronutrients. Many other elements are also required but in smaller quantities and these are called Micronutrients [14].

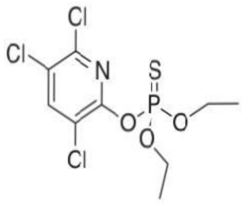
3. INSECTICIDES.

The Insecticide Resistance Action Committee (IRAC) was formed in 1984 to promote the development of insecticide resistance management strategies with the ultimate goal of sustainable agriculture and improved public health [15]. IRAC has classified insecticides based upon their mode of action (MoA) in 30 groups (28 groups plus a group for unknown action and another group for non-specific action).

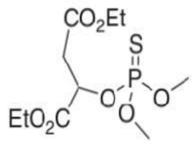
Organophosphates and carbamates are in group 1, acetylcholinesterase inhibitors. Organophosphate insecticides are powerful and effective anti-cholinergic agents and represent the largest class of insecticides Sold worldwide [16]. Most organophosphates are not persistent and do not bioaccumulate [17]. Through their inhibition of acetylcholinesterase, the Enzyme. responsible for catalyzing the breakdown of the neurotransmitter acetylcholine, the organophosphates are highly toxic to insects. This chemical class includes over 200 pesticides and includes diazinon, chlorpyrifos, And malathion [18]. Malathion is the most common organophosphate Insecticide applied in the United States [19]. Diazinon and chlopyrifos are not approved for household use in the United States. Chlorpyrifos demand is growing in Asia, especially in China where it is replacing more toxic organophosphates [20].



Diazinon

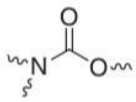


Chlorpyrifos

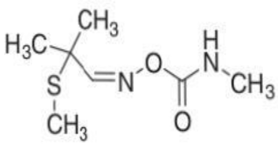


Malathion

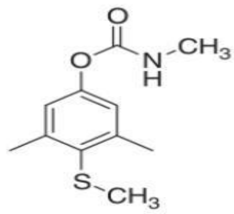
Carbamates include aldicarb, methiocarb, methomyl and carbofuran . Although they are broad-spectrum insecticides, with moderate toxicity and persistence, they rarely bioaccumulate or cause major environmental impacts [21].



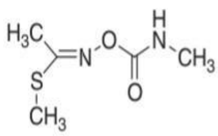
Carbamate linkage



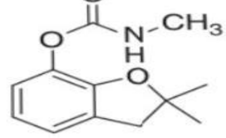
Aldicarb



Methiocarb



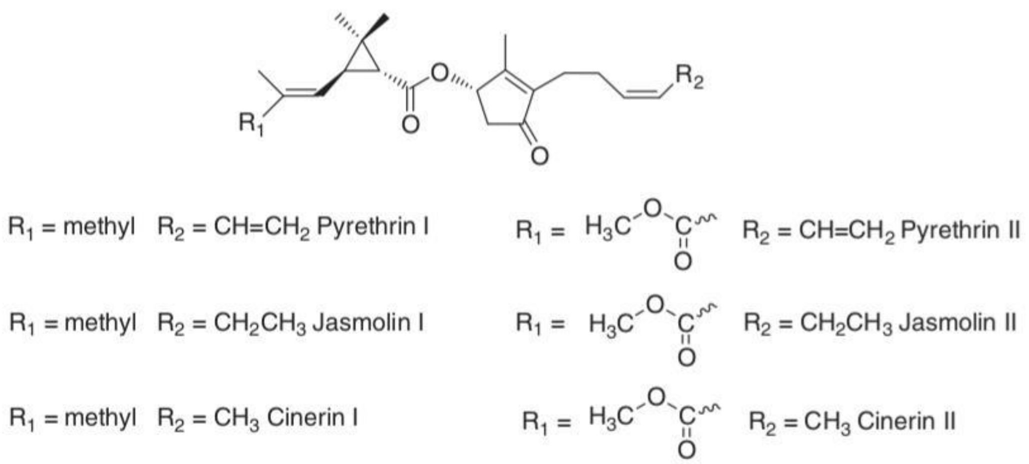
Methomyl



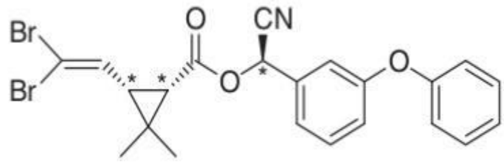
Carbofuran

Pyrethroid insecticides are widely used because of their high activity as an insecticide and low mammalian toxicity. Pyrethroids are in group 3, sodium Channel modulators. The pyrethroids have a highly nonpolar nature, low water solubility, and high affinity to soil and sediment particulate matter. Natural pyrethrin is extracted from the flowers of Chrysanthemum spp., and its use was already known in China in the first century A.D. Pyrethroids, synthetic analogues of pyrethrin, have been produced since 1940 [22].

The six pyrethrins, Pyrethrin I, Jasmolin I, Cinerin I, Pyrethrin II, Jasmolin II, and Cinerin II were found to be present in the leaf extract of the chrysanthemum cinerariaefolium seedlings. Pyrethrins are thought to act as defense mechanisms that prevent insects from feeding on the plant [23].The pyrethrins repel insects and also paralyze flying insects, thereby exhibiting a “knock-down” effect. The active components occur to a small extent in all parts of the plant, but especially in the flower heads [24].

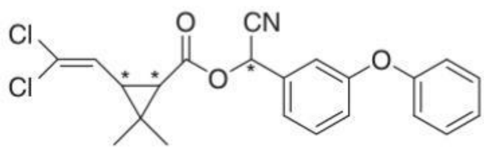


Pyrethroids often have two, three or more chiral centers and therefore can have four, eight, or more stereoisomers. Sometimes they are sold as single isomers, such as deltamethrin, useful for more than 150 crops including vegetables, fruits, cereals, oil seed rape, rice, soybeans, and corn. This pyrethroid has eight possible stereoisomers. The chiral carbons are marked with an asterisk in the structure shown. The commercial product has R configuration at each of the chiral cyclopropyl carbons and S at the cyanobenzylic carbon. Deltamethrin is highly toxic to insects. Compared with pyrethrin I, it is 1400 times as toxic to the housefly [25].

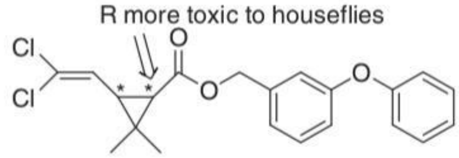


Deltamethrin

Cypermethrin has eight possible stereoisomers; it is used as a mixture of stereoisomers but only two of the eight are active. Typically the R configuration at the cyclopropyl carbon alpha to the carbonyl of the ester is more active than the S configuration; for example in permethrin it is 25 times more toxic to houseflies than the R configuration [26].

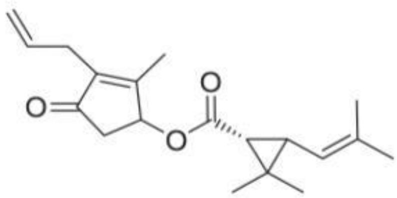


Cypermethrin

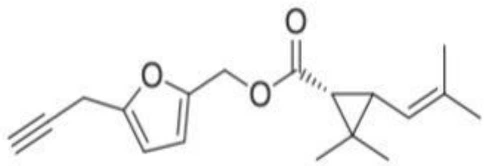


Permethrin

Most mosquito devices such as coils, mats, or vaporizers contain pyrethroids because mosquitoes are rapidly paralyzed and cannot suck blood, and because of the low mammalian toxicity of the pyrethroids. The pyrethroids are characterized as having a cyclopropane carboxylic acid ester functionality. Some commercial pyrethroids that are used in mosquito-control devices include d-allethrin, and furamethrin [27].

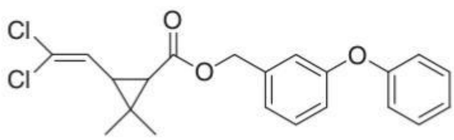


d-allethrin

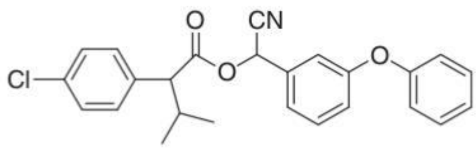


Furamethrin

By synthesizing hundreds of structural analogs and with several structure activity relationship (SAR) studies, there has been an expansion in the number of synthetic pyrethroids on the market.Type I pyrethroids, for example, permethrin cause hyperactivity and incoordination in the insect [28]. Type II pyrethroids do not have the cyclopropane ring and contain an alpha-cyanobenzyl ester. Fenvalerate is an example. The Type II pyrethroids induce paralysis. Fenvalerate has two asymmetric carbons at the two benzyl positions so there are four possible stereoisomers.It is sold as a mixture of the four stereoisomers and also as the most active, SS stereoisomer, which is called esfenvalerate.

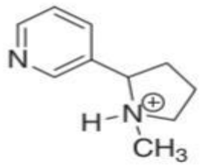


Permethrin

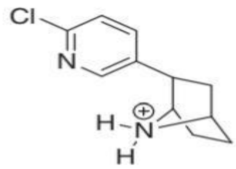


Fenvalerate

Another biological target for many insecticides is the nervous system of the insect because this can result in selective toxicity. The neonicotinoids in group 4, work by this mechanism and act on insect nicotinic acetylcholine receptors (nAChR). Nicotine, the namesake of the nAChR has been used for pest control since the 17th century [29]. However nicotine is dangerous to people and has limited effectiveness as an insecticide. Nicotine and its analog epibatidine, isolated from a tropical poisonous frog, exist mainly in the protonated form at physiological pH. They are examples of the nicotinoid family and are toxic to mammals.

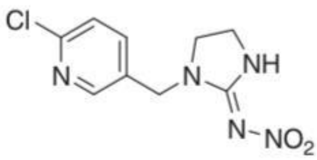


Protonated nicotine

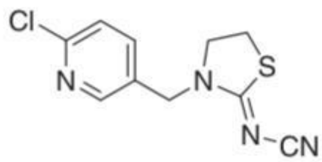


Protonated epibatidine

In contrast, the neonicotinoids are not protonated and so bind differently, resulting in greater activity on insects than mammals. It is this selectiveb toxicity that has led to extensive use of the neonicotinoids and they represent about 20 % of the global insecticide market [30]. Imidacloprid and thiacloprid are examples of neonicotinoid insecticides.

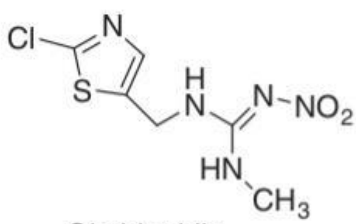


Imidacloprid



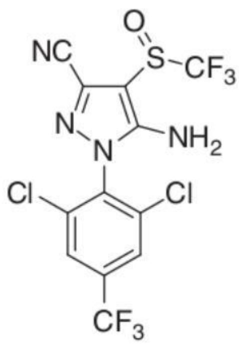
Thiacloprid

Another neonicotinoid example is clothianidin, which is used in the treatment of seeds. Clothianidin is used for canola, cereals, sunflowers, sugar beet, and corn, including 90 % of the United States corn crop [31].



Clothianidin

Another class of chemicals in group 3 is the phenylpyrazoles. Fipronil is a member of this class. Fipronil blocks chloride channels gated by the inhibitory neurotransmitter gamma-aminobutyric acid (GABA) and also those gated by glutamate [32]. Fipronil is also widely used as a household and veterinary insecticide for the control of insects such as termites, cockroaches, and ants. As with some neonicitinoid pesticides, there is a concern with the effect of fipronil on honeybees. The European Union has voted in favor of restricting the use of fipronil on seeds to only seeds sown in greenhouses [33].



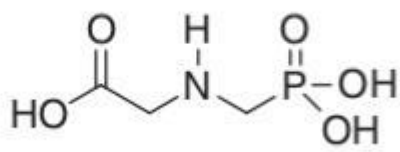
Fipronil

4. HERBICIDES.

On a globel basis, about 250 species of plants annoying enough to be called weeds, It represent 0.1 % of the world's plants [34]. Weeds reduce crop yield and so result in a need to plant larger space for the same crop production. Weeds can also reduce crop quality. Herbicides are "weed-killers" and are used to control unwanted plants that hinders the growth of the crop.

Weeds can develop resistance to herbicides. so, herbicides are often changed from season to season. When users switch herbicides, they can switch to one with a different mode of action. The weed Science Society of America (WSSA) has divided them into groups and assigned numbers from 1–27 for each group [35]. For example, group 1 herbicides inhibit acetyl CoA carboxylase. The international Herbicide Resistance action Committee (HRAC) has a similar classification system using letters and letter–number combinations. In the HRAC system, group 1 herbicides are labeled as group A. They are not all in the same order. Group 3, inhibitors of microtubule assemble, is group K1 in the HRAC system.

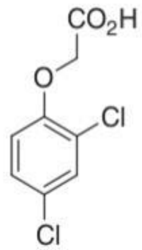
The shikimate pathway involves the biosynthesis of aromatic amino acids such as tryptophan and phenylalanine. The shikimate pathway is found in plants and microorganisms, never in animals. One important enzyme in the shikimate pathway is 5-enolpyruvyl shikimate 3-phosphase synthase(EPSPS). Glyphosate (Roundup™) is water soluble and can be sprayed upon plant leaves. It is absorbed and then inhibits EPSPS. Glyphosate exhibits little to no toxicity in mammals, birds, and fish because they do not have EPSPS [36].



Glyphosate

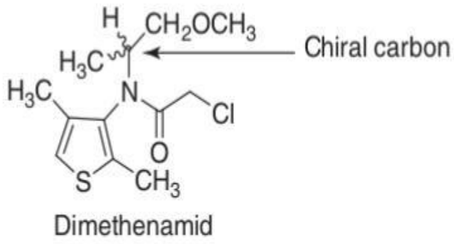
One relatively new herbicide is a pyrimidine-based chemical, salflufenacil(Kixor®, BASF) [37]. This herbicide inhibits chlorophyll biosynthesis. In particular it inhibits protoporphyrinogen IX oxidase (PPO) in the tetrapyrrole biosynthetic pathway. Protoporphyrin IX is the heterocylic ring system surrounding the magnesium cation in chlorophyll. There are several herbicides that operate by this mechanism. They are in group 14 (WSSA).

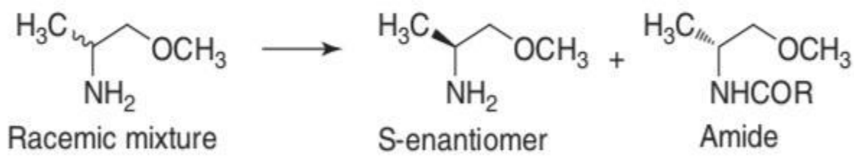
One herbicide that has been used since the 1940s is 2,4-dichlorophenoxyacetic acid (2,4-D). It is currently found in about 600 products registered for agricultural, residential, industrial, and aquatic uses [38].



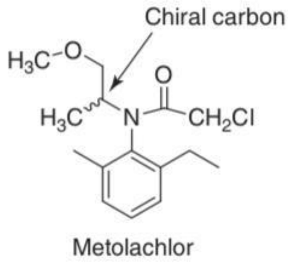
2,4-dichlorophenoxyacetic acid

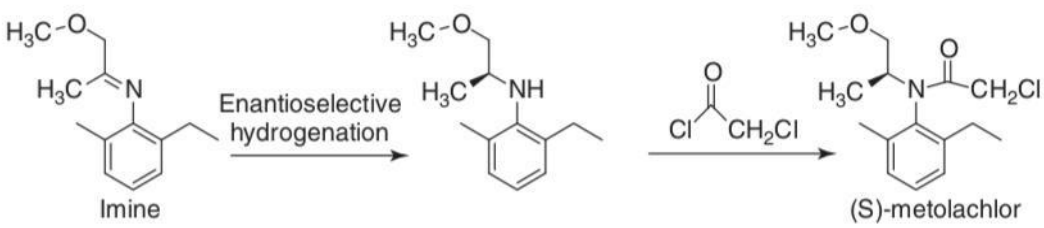
Chirality plays a critical role in pharmaceuticals and agrochemicals, influencing the biological activity of various compounds. In herbicides, this effect can significantly impact their effectiveness. Dimethenamid (marketed as Frontier® by BASF) is an herbicide classified under group 15, which inhibits the synthesis of very long-chain fatty acids. It is used to control annual grasses and broadleaf weeds in corn cultivation. The molecule contains two chiral elements: a chiral axis due to restricted rotation around a bond between the thiophene ring and nitrogen, and a chiral center at the methine carbon attached to nitrogen. As a result, it has four possible stereoisomers. The active form, (1S,aRS), can be synthesized through enzymatic acylation using S-methoxyisopropylamine. This process selectively acylates only the desired enantiomer, which is then isolated. Field trials have shown that the (1S,aRS) isomer is three to four times more effective than the racemic mixture[39]. BASF markets this active diastereomer under the trade name Outlook® .





Another herbicide where chirality is essential is Metolachlor, marketed by Syngenta as Dual®. Similar to Dimethenamid, it contains two chiral elements: a chiral axis and a chiral center. Originally introduced as a mixture of four stereoisomers, it was later discovered that 95% of the herbicidal activity comes from the isomer where the methine carbon has S configuration[40]. This insight led to the development of S-metolachlor, produced via enantioselective hydrogenation of an imine intermediate. This process marked one of the most significant industrial-scale enantioselective syntheses, with production exceeding 10,000 tons annually. The purified S-enantiomer is now marketed as Dual Gold® and Dual Magnum® in the U.S.

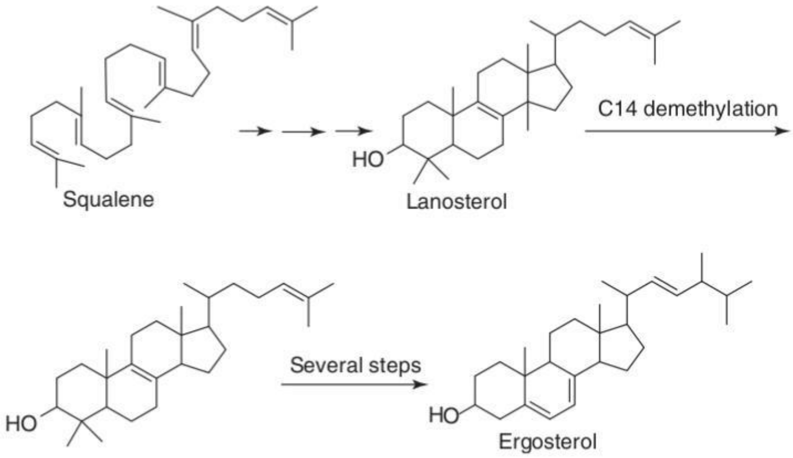




This product also contains a safener, benoxacor. Safener is a name for compounds that protect crops from herbicide injury without replacing herbicide activity in targeted weeds. Various chemicals have been developed to act as safeners for crops such as corn, grains, and rice. Safeners have been used for decades. They increase the activity of detoxification enzymes [41].

5. FUNGICIDES .

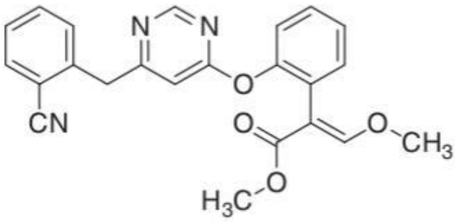
Fungicides are used to prevent mold and mildew in crops and seeds. They have been classified by the Fungicide Resistance Action Committee (FRAC) based upon 46 different fungicide and bactericide modes of action. Two of the major groups, based upon percent sales are the DMI fungicides in group G1 and the QoI fungicides in group C3 [42]. The DMI fungicides inhibit sterol biosynthesis. Ergosterol is the predominant sterol and is biosynthesized in several steps involving 11 enzymes from squalene. One of those steps involves removal of a methyl group at the C 14 carbon of the steroid. The group G1 fungicides inhibit this demethylation step and hence are called demethylation inhibitors (DMI) [43].

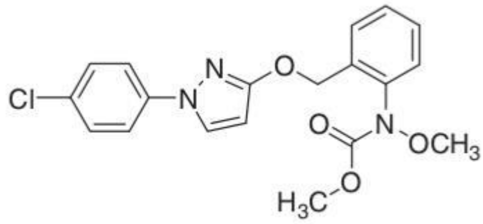


There are different chemical classes used but DMI fungicides with the triazole ring structure dominate. Examples of DMI fungicides containing the triazole ring example tebuconazole. The carbon bearing the hydroxy group in tebuconazole is chiral; the herbicide is used as a mixture of enantiomers.

Tebuconazole

QoI (quinone outside inhibitors) fungicides act at the Quinol outer binding site of the cytochrome bc1 complex thereby inhibiting respiration and causing death of the fungus. Strobilurins such as azoxystrobin and pyraclostrobin dominate this class of fungicides.





REFERENCES.

1. Hideo Ohkawa, Hisahi Miyagawa, Philip Lee. Pesticide Chemistry. New York:Wiley-VCH; 2007:4.
2. Andrew H Cobb, John PH Reade. Herbicides and Plant Physiology. 2nd Ed. NewYork: Wiley-Blackwell; 2010:p. viii.
3. Hideo Ohkawa, Hisahi Miyagawa, Philip Lee. Pesticide Chemistry. New York:Wiley-VCH; 2007:44.
4. Andrew H Cobb, John PH Reade. Herbicides and Plant Physiology. 2nd Ed. NewYork: Wiley-Blackwell; 2010:p. viii.
5. Ann Thayer. Chemical and Engineering News 2013; 91(21):13.
6. Hideo Ohkawa, Hisahi Miyagawa, Philip Lee. Pesticide Chemistry. New York:Wiley-VCH; 2007:23.
7. Y Yao, et al. Environmental Science and Technology 2008, 42:5931–5937.
8. R Dalton, C Boutin. Environmental Toxicology and Chemistry 2010,29:2304–2315.
9. Langdon Elsworth, Walter Paley. Fertilizers: Properties, Applications, and Effects. Nova Science Publishers, Inc., Hauppauge, NY; 2009:p. vii.

10. Langdon Elsworth, Walter Paley, editors. Fertilizers: Properties, Applications,And Effects. Nova Science Publishers, Inc., Hauppauge, NY; 2009:30.
11. Langdon Elsworth, Walter Paley, editors. Fertilizers: Properties, Applications, And Effects. Nova Science Publishers, Inc., Hauppauge, NY; 2009:34.
12. Langdon Elsworth, Walter Paley, editors. Fertilizers: Properties, Applications, And Effects. Nova Science Publishers, Inc., Hauppauge, NY; 2009:29.
13. Langdon Elsworth, Walter Paley, editors. Fertilizers: Properties, Applications, And Effects. Nova Science Publishers, Inc., Hauppauge, NY; 2009:34.
14. Langdon Elsworth, Walter Paley, editors. Fertilizers: Properties, Applications, And Effects. Nova Science Publishers, Inc., Hauppauge, NY; 2009:38–39.
15. W Kramer, U Schirmer, editors. Modern Crop Protection Compounds. Vol. 3.New York: Wiley-VCH; 2007:753.
16. Martins S Odetokun, M Angela Montesano, Gayanga Weerasekera, Ralph D Whitehead Jr., Larry L Needham, Dana Boyd Barr. Journal of Chromatography B 2010; 878(27):2567–2574.
17. Anindita Mitra, Chandranath Chatterjee, Fatik B Mandal. Research Journal of Environmental Toxicology 2011; 5:81–96.
18. Renata Raina, Lina Sun. Journal of Environmental Science and Health Part B 2008; 43:323–332.
19. Matthew R Bonner, Joseph Coble, Aaron Blair, Laura E Beane Freeman, Jane A Hoppin, Dale P Sandler, Michael C R Alavanja Am. J. Epidemiol. 2007; 166:1023–1034.
20. Michael McCoy. Chemical and Engineering News 2011; 89(11):13.

21. Anindita Mitra, Chandranath Chatterjee, Fatik B Mandal. Research Journal of Environmental Toxicology 2011; 5:81–96.
22. Irma Kakko, Tarja Toimela, Hanna Tähti. Environmental Toxicology and Pharmacology 2004; 15(2–3):95–102.
23. Kazuhiko Matsudaa, Yukio Kikutaa, Atsushi Habaa, Koji Nakayamab, Yoshio Katsudab, Akikazu Hatanakac, Koichiro Komai. Phytochemistry 2005; 66(13):1529–1535.
24. Leslie Crombie. Pestic. Sci. 1980; 11:102–118.
25. David Pulman. J Agric. Food Chem. 2011; 59:2770–2772.
26. Virginia Perez-Fernandez, Maria Angeles Garcia, Maria Luisa Marina. Journal Of Chromatography A 2010; 1217:968–989.
27. Hideo Ohkawa, Hisahi Miyagawa, Philip Lee. Pesticide Chemistry. New York: Wiley-VCH; 2007:149–150.
28. W Kramer, U Schirmer, editors. Modern Crop Protection Compounds. Vol. 3, New York: Wiley-VCH 2007:767.
29. Motohiro Tomizawa, Todd T Talley, David Maltby, Kathleen A Durkin, Katalin F Medzihradszky, Alma L Burlingame, Palmer Taylor, John E Casida, PNAS 2007; 104:9075–9080.
30. Motohiro Tomizawa, John E Casida. Accounts of Chemical Research 2009; 42:260–269.
31. Glenn Hess. Chemical and Engineering News 2012; 90(31):36.
32. W Kramer, U Schirmer, editors. Modern Crop Protection Compounds. Vol. 3.New York: Wiley-VCH; 2007:1049.
33. Britt Erickson. Chemical and Engineering News 2013; 91(29):21.
34. Andrew H Cobb, John PH Reade. Herbicides and Plant Physiology. 2nd Ed. New York: Wiley-Blackwell; 2010:1.
35. Carol Mallory-Smith, E James Retzinger. Weed Technology 2003; 17:605–619.

36. W Kramer, U Schirmer, editors. Modern Crop Protection Compounds. Vol. 1.New York: Wiley-VCH; 2007:291.
37. Melody Bomgardner. Chemical and Engineering News 2011; 89(16):14.
38. Britt Erickson. Chemical and Engineering News 2012; 90(16):33.
39. Karl Seckinger, et al. U.S. Pat. No. 5,457,085. 1995.
40. H Blaser, et al. Acc. Chem. Res. 2007; 40:1240–1250.
41. D Riechers, K Kreuz, Q Zhang. Plant Physiology 2010; 153:3–13.
42. W Kramer, U Schirmer, editors. Modern Crop Protection Compounds. Vol. 2.New York: Wiley-VCH 2007:417.
43. W Kramer, U Schirmer, editors. Modern Crop Protection Compounds. Vol. 2.New York: Wiley-VCH 2007:609.