PHYSIOLOGICAL STUDIES ON CERTAIN HERBICIDES

THESIS

Submitted for Partial Fulfilment for the Degree of

MASTER OF SCIENCE

in

Botany

By

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B.Sc. (Hons.)

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1973

This dissertation has not previously been submitted for a degree at this or at any other university.

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ACKNOWLEDGMENTS

The author wishes to express his deep appreciation and thanks to Professor Dr. H.A. Foda, Botany Department, Faculty of Science, Ain Shams University for suggesting the point of research, supervision and constructive criticism throughout the work.

The author wishes also to express his thanks and gratitude to Dr. A.E. Dowidar, Assistant Prof., Natural History Dept., Faculty of Education, Ain Shams University and to Dr. A.S. El-Ghobashy, Lecturer in Botany Dept., Faculty of Science, Ain Shams University for their supervision and constructive criticism throughout the work.

The author wishes to express his gratitude to Prof. Dr. M. El-Shafey, Head of Botany Department, Faculty of Science, Ain Shams University, Prof. Dr. M.G.A. Hafez, Prof. Dr. M.S. Naim, and Prof. Dr. S.H. Elwan, Head of Botany Department, Faculty of Science, Al Azhar University for their facilities, valuable advices and suggestions.

The author is also grateful to his colleagues for their helps and advices.

(PART I)

INTRODUCTION

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INTRODUCTION

Herbicides are chemical compounds which are used to kill or to reduce the growth of herbs (Klingman, 1961). Some of them are total weed-killers while others are selective and only affect certain species leaving others unharmed. There are many different herbicides for selective use on waste areas, industrial sites, ... etc., and many more used at various stages of testing and development.

According to how they act on the plant there are 3 types of herbicides: contact, translocated and soil sterilants (Klingman, 1961).

1- Contact herbicides:

These are chemicals that kill the part of the plant which they come in contact. Generally, the effects are acute and the plant dies quickly or soon after treatment. Contact herbicides may be selective or non-selective. A selective herbicide kills or stunts some plants with little or no injury to others, e.g. 2,4 dinitro-6-sec butylphenol (DNBP); Van Overbeek, 1964. A non-selective herbicide is toxic to all plants. Living plant tissue has little or no resistance to non-selective herbicides e.g. pentachlorophenol (PCP); (Muzik, 1970).

2- Translocated herbicides:

These herbicides can be absorbed by either the roots or the above-ground parts and move, or translocated through the plant system. These chemicals upset the plant's growth and metabolic processes with chronic effect. They are selective herbicides. Among these chemicals, one may refer to 2,4-dichlorophenoxyacetic acid (2,4-D), methylchlorophenoxyacetic acid (MCPA) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) (Hamner & Tukey, 1944).

3- Soil sterilants:

Any chemical which prevents the growth of green plants when present in the soil is considered as a soil sterilant. Some of these herbicides resist chemical decomposition and leaching, while others are quickly decomposed or leached from the soil (Shaw, 1955).

According to the chemical structure of the herbicides, Brian (1964,a) suggested that they are divided broadly to 2 major categories: inorganic and organic herbicides.

I- Inorganic herbicides: The early use of herbicides was restricted to inorganic compounds. Bonnet (1896) observed the phytocidal effects of Bordeaux mixture (after Audus, 1964). Stender (1900) found that sodium nitrate, ammonium sulphate and certain potassium salts were just as effective as ferrous sulphate. Sodium arsenite was also studied as an inorganic herbicide (Bolley, 1901). Aslander (1926 & 1928) was perhaps the first to demonstrate that sodium chlorate was effective for killing deep rooted perennial weeds by soil applications. A full account of the use of both borates and chlorates up to 1942 was given by Robbins et al. (1942).

II- Organic herbicides: Among the organic herbicides, we can briefly refer to the following chemicals:

1- Phenols: The first use of organic chemicals for weed control is nitrophenols as a selective herbicide. Crafts (1946) studied a number of phenol derivatives and found that 4,6-dinitro-2-5-butylphenol was more active on certain plant species but less so on some economic crops such as peas.

2- Auxin herbicides: The first recognition of selective herbicidal properties of auxins was made in England by Slade et al. (1945). These workers observed that naphthaleneacetic acid(NAA)killed yellow charlock in oat fields without injuring the crop. The most important auxin herbicides are the chlorophenoxy compounds e.g. (2,4-D;MCPA) which were shown to be very effective against many broad-leaved dicotyledonous weeds, while the monocotyledonous crops e.g. cereals and grasses were found to be insensitive to these chemicals (Hamner & Tukey, 1944; Lush, 1956). The auxin herbicides are usually nontoxic to man, animal or fish and are nonflammable.

3- Benzoic and phenylacetic acids: Benzoic and phenylacetic acid derivatives were applied as herbicides e.g. 2,3,6-trichlorobenzoic acid (2,3,6-TBA) and its aldehyde were tested in the field as early as 1948. It is absorbed by plant leaves and roots and can persist in the soil for long periods (Bentley, 1950). Beatty (1958) reported that 2,3,6-TBA controls annual weeds and quackgrass (*Agropyron repens*) for an entire growing season.

4- Substituted ureas: Urea is a common fertilizer, but by replacing some of its hydrogen with other radicals, effective herbicides are produced. The four oldest substituted ureas are fenuron, (3-phenyl-1,1-dimethylurea) (Sharp *et al.*, 1953); monuron, 3-(p-chlorophenyl)-1,1-dimethylurea (Bucha and Todd, 1951); diuron, 3-(3,4-dichlorophenyl)-1,1-dimethylurea ; and neburon, 1-n-butyl-3-(3,4-dichlorophenyl)-1,1-dimethylurea. Newer substituted ureas, such as tenoram, cotoran and siduron have been used as active herbicides in a number of crops. Most of the substituted ureas may be used as soil sterilants at high rates and selectively at low rates. The substituted ureas are nonvolatile, nontoxic and nonflammable (Muzik, 1970).

5- Carbamates (urethanes): The carbamate herbicides are derived from carbamic acid (NH_2-COOH). The effect of carbamate was shown to retard the germination of oats and wheat resulting with abnormal growth (Friesen, 1929). Templeman and Sexton (1945) found that isopropyl N-phenylcarbamate (propham) and other aryl carbamic esters were toxic to monocotyledonous but not to dicotyledonous plants. Ethyl N,N-di-n-propylthiocarbamate (EPTC) can be used on number of crops which follow each other such as maize and beans with little danger of residual effect. Its use is quite safe to humans (Muzik, 1970).

6- Triazines: The triazene compounds control a wide variety of weeds but are most effective on seedlings.

A number of triazines was synthesized by Pearlman and Banks, 1948; Gysin, 1960. The triazines are nonflammable and nontoxic to animals. Selectivity is due to transformation of the molecule by resistant plants, partly by removal of chlorine atom (Eastin et al., 1964).

The triazines disappear in soil mainly by decomposition by microorganisms and by removal by crops and weeds. Some photodecomposition may occur (Comes and Timmons, 1964; Day and Clerx, 1964).

7- Bipyridylium quaternary salts: Two new chemicals have recently been introduced by I.C.I. These are now known as diquat (1,1-ethylene-2,2-dipyridilium dibromide) and paraquat (1,1-dimethyl-4,4-bipyridilium). These chemicals are water soluble, have a rapid contact action and are non-selective. Paraquat is useful as a spray on weeds around fruit trees and diquat may be used against aquatic weeds. These herbicides are neither volatile, flammable, nor toxic. A period of darkness following application enhances the effect of paraquat (Slade and Bell, 1966).

8- Miscellaneous chemicals: There are a number of herbicidal chemicals which are not members of a family marked generally by biological activity. The most important of these are 3-amino-1,2,4-triazole (amitrole), heptane, endothal, maleic hydrazide, amides (propanil or stam F-34) and toluidines (trifluralin or treflan). They has also proved effective as a pre-and post-emergence spray and as selective herbicide (Behrens, 1953).

Susceptibility and resistance to herbicides:

Attempts to correlate differences in absorption with differential susceptibility have been partially successful. This differential susceptibility may be attributed either to adsorption or detoxication or both (Veldstra and Booij, 1949).

Brian & Rideal (1952) and Brian (1958) found a broad correlation between the adsorption of MCPA on protein films prepared from extracts of different plants and the resistance of these plant species to this herbicide. In addition to such loss by adsorption, molecules of the herbicide may be prevented from reaching their site of action by association with enzyme surfaces where they become converted into compounds with little or no activity. Since plant species differ not only in their morphology but also in their chemistry, it is not surprising that they often respond differently to the same chemical treatment, thus providing a basis for herbicidal selectivity.

Fang et al., 1951; Holley, 1952; Weintraub et al., 1952 & 1954; Fang & Butts, 1954; Bach and Felling, 1961 demonstrated the detoxication of the universal herbicide 2,4-D by plants. There is evidence that this occurs to different extents in different species.

An example of selective detoxication is provided by the herbicide simazine. This chemical is apparently accumulated to toxic levels in susceptible plants, whereas corn is able to metabolize simazine fairly rapidly (Gysin and Knüsli, 1960). From such results Gysin and Knüsli (1960) concluded that the observed selectivity between species is mainly the result of differential breakdown of the herbicide. The mechanism of this breakdown has recently been studied and it has been shown that simazine is converted in maize seedlings and in vitro by maize extracts, into 2-hydroxy-4,6-bis (ethylamino) 1,3,5 triazine which is considered to be a detoxified form of herbicide (Hamilton and Moreland, 1962). The fact that 2,4,5-T is more toxic to cucumber plants than 2,4-D may be related to the inability of the plants to detoxify 2,4,5-T as rapidly as 2,4-D (Slife et al., 1962).