

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

THE INFLUENCE OF GROWTH STAGE  
AND APPLICATION SITE ON MOVEMENT  
AND EFFECT OF GLYPHOSATE  
IN CIRSIUM ARVENSE (L) SCOP.

A thesis presented in partial  
fulfilment of the requirements for the degree  
of Master of Agricultural Science  
in Plant Science at  
Massey University

KERRY CHARLES HARRINGTON

1983  
08500-09

ABSTRACT

Glyphosate was applied at different rates to the upper parts of Cirsium arvense plants at various growth stages in a glasshouse experiment. Measurements and observations were made of the plants over a period of several months following treatment. In other experiments, glyphosate was applied to different parts of plants and to either side of leaves to determine the importance of herbicide placement on its subsequent effectiveness.

Complete death of plants, as signified by decomposition of the roots, generally occurred only where the maximum dose (100 mg ai/plant) was applied, and occurred consistently only for those plants treated at the post-flowering growth stage. However, plants treated on the lower parts of stems died in some cases after application of 25 mg.

The symptoms and damage resulting from glyphosate action are described and discussed. Extensive translocation of glyphosate appeared to occur, both symplastically and apoplastically, with greater translocation to the roots and untreated daughter stems occurring from treated tissue situated low on the stem. Stem tissue seemed as efficient at absorbing glyphosate as leaves, and likewise no difference in absorption rates by upper compared with lower leaf surfaces was detected.

Complete control of plants occurred only if all stems simultaneously wilted approximately 1 month after treatment, apparently due to disruption of the roots.

Plants varied considerably in response to treatment and no relationship could be established between degree of effect and plant size, plant sex or relative humidity at the time of treatment.

The results are discussed in relation to ropewick application of glyphosate to C. arvense plants.

ACKNOWLEDGEMENTS

I am deeply indebted to my supervisor, Dr G.W. Ivens, for his guidance, assistance and encouragement during the course of this study and the preparation of the manuscript.

I would also like to thank:

- Dr.J. Verity for her help during the initial planning of the project.
- Prof B.R. Watkin, Mr A.G. Robertson and other members of the Agronomy Department for their helpful advice and interest.
- Mr L.G. Cranfield and other staff members of the Plant Growth Unit for technical assistance given during the trial.
- the Scholarship Committee of the Agriculture and Horticulture Faculty and the NZ Weed and Pest Control Society for their financial support.
- the staff of the Computer Centre, Massey University, for their advice on computing problems.
- Mr G.C. Arnold (Mathematics Department) for assistance with the statistical analysis.
- Monsanto NZ Ltd for supplying the glyphosate.

## CONTENTS

TITLE.....	i
ABSTRACT.....	ii
ACKNOWLEDGEMENTS.....	iii
TABLE OF CONTENTS.....	iv
LIST OF TABLES.....	vii
LIST OF FIGURES.....	viii
LIST OF PLATES.....	ix
LIST OF APPENDICES.....	xi
LIST OF PESTICIDES.....	xii
INTRODUCTION.....	1
(1) <u>Cirsium arvense</u> .....	1
(a) Shoot development.....	1
(b) Root system.....	1
(c) Flowers and seeds.....	3
(d) Distribution.....	3
(e) Significance as a weed.....	4
(i) Effects.....	4
(ii) Causes.....	4
(2) Ropewick Applicators.....	5
(3) <u>Cirsium arvense</u> , Glyphosate and Ropewick Applicators.....	8
(a) Present situation.....	8
(b) Objectives of this work.....	9
LITERATURE REVIEW.....	10
(1) Glyphosate Absorption by Plants.....	10
(a) Characteristics.....	10
(b) Factors affecting absorption.....	11
(i) Relative humidity and rainfall.....	11
(ii) Water stress.....	11
(iii) Temperature.....	12
(iv) Light.....	13
(v) Age and position of treated tissue.....	13
(vi) Species and varietal differences.....	15
(vii) Adjuvants.....	16
(viii) Leaf surface features.....	16
(c) Absorption mechanism.....	17
(2) Translocation of Assimilates.....	19
(a) Direction of movement.....	19
(b) Sinks in <u>Cirsium arvense</u> .....	20
(c) Amino acid translocation.....	23
(3) Glyphosate Translocation.....	25
(a) Characteristics.....	25
(b) Factors affecting glyphosate translocation....	28
(i) Temperature.....	28
(ii) Water stress.....	29
(iii) Light.....	29
(iv) Age and position of treated tissues.....	30
(v) Species and varietal differences.....	33
(vi) Herbicide rate and concentration.....	33
(vii) Adjuvants.....	34
(4) Metabolism of Glyphosate.....	35
(5) Mode of Action.....	36
(6) Glyphosate Symptoms and Damage.....	36

(a) Effects.....	38
(i) Pigments.....	38
(ii) Necrosis.....	39
(iii) Wilting.....	40
(iv) Growth rate.....	41
(v) Axillary bud development.....	41
(vi) Regrowth.....	42
(vii) Other effects.....	43
(b) Translocation studies using symptom expression.....	43
(i) Lee and Cahoon (1981).....	44
(ii) Fernandez and Bayer (1976).....	44
(iii) Rioux, Bandeen and Anderson (1974).....	44
(iv) Claus and Behrens (1976).....	45
(v) Lutman (1979).....	45
(7) Sexual Dimorphism in <u>Cirsium arvense</u> .....	46
METHODS AND MATERIALS.....	47
(1) Propagation Methods.....	47
(2) Experimental Design.....	50
(a) Growth stage experiment.....	50
(i) Vegetative stage.....	50
(ii) Early bud stage.....	50
(iii) Late bud stage.....	50
(iv) Flowering stage.....	50
(v) Post-flowering stage.....	54
(b) Plant Part Experiment.....	54
(c) Leaf Side Experiment.....	55
(3) Measurements and Observations.....	55
(a) At treatment.....	55
(b) One week after treatment.....	55
(c) Four weeks after treatment.....	55
(d) Main harvest.....	56
(e) Second harvest.....	56
RESULTS.....	57
(1) Measures of Glyphosate Effectiveness.....	57
(a) Necrosis.....	57
(b) Scoring of damage.....	57
(c) Regrowth.....	57
(d) Root decomposition.....	59
(2) Growth Stage Experiment.....	64
(a) Symptoms.....	64
(i) Necrosis after 1 week.....	64
(ii) Chlorosis.....	64
(iii) Growth.....	68
(iv) Symptoms after 4 weeks.....	68
(v) Axillary growth.....	71
(vi) Flowers.....	74
(vii) Natural senescence.....	76
(viii) Plant death.....	76
(ix) Regrowth.....	79
(x) Overall effects.....	79
(3) Plant Parts Experiment.....	84
(a) Observations.....	84
(b) Root decomposition.....	88
(4) Leaf Side Experiment.....	90
(5) Variability Within Results.....	90

DISCUSSION.....	94
(1) Growth Stage Experiment.....	94
(2) Root Decomposition.....	95
(3) Plant Death.....	96
(4) Regrowth.....	97
(5) Symptoms.....	98
(6) Translocation.....	99
(a) Symplastic.....	99
(b) Apoplastic.....	100
(7) Translocation to Daughter Stems.....	101
(8) Plant Parts Experiment.....	102
(9) Leaf Side Experiment.....	104
(10) Variability Within Replicates.....	104
(11) Practical Implications.....	106
CONCLUSION.....	109
BIBLIOGRAPHY.....	111
APPENDICES.....	124

LIST OF TABLES

- I. Characteristics at time of treatment of plants used in the Growth Stage Experiment.....51
- II. The log shoot:root ratios of C.arvense plants treated with different doses of glyphosate at different stages of growth....81
- III. The log shoot:root ratios of individual plants treated with 100 mg of glyphosate.....82
- IV. The eight most affected plants from the Plant Parts Experiment with their log shoot:root ratios.....86
- V. Correlation coefficients, using results from treated plants in all three experiments, between the log shoot:root ratio and the factors listed.....92

LIST OF FIGURES

1. Structures of amino acid, glycine and glyphosate.....24
2. Outline of aromatic amino acid biosynthesis, indicating the sites of glyphosate action proposed by various workers.....37
3. Average regrowth dry weight and stem dry matter percentage of untreated plants plotted against time of harvest.....58
4. Average regrowth characteristics following stem removal of plants treated with glyphosate.....60
5. Average log shoot:root ratios of untreated control plants plotted against times of harvest.....62
6. Average log shoot dry weight and log root dry weight of untreated plants plotted against times of harvest.....63
7. The log shoot:root ratios of plants treated with glyphosate at different levels of maturity during the vegetative growth stage.....83
8. Average log shoot:root ratios of plants treated on different parts of the mother stem.....89
9. Average log shoot:root ratios of plants treated on either their upper or lower leaf surfaces.....91
10. Average shoot and root dry weights of plants treated on either their upper or lower leaf surfaces.....91

LIST OF PLATES

1. The 5-week-old seedlings immediately prior to transplanting into bags. (9th October).....48
2. The extent of the root development in seedlings 5 weeks after germination. (9th October).....48
3. The bags were kept on wet felt mats on trolleys while the plants were young. The white paper around the bags helped minimize heating of the bags by the sun. (24th October).....49
4. The plants were put on felt mats on the floor once they grew larger, and soak hoses ran under the mats. (11th November)....49
5. A stem at the early bud stage.....52
6. Male flowers and buds. From left to right the flowers would be termed old, young, senescent, old and young.....52
7. Female flowers and buds. The centre flower would be termed old and the other two as young.....53
8. Senescent female flowers.....53
9. Roots of a Cirsium arvense plant at the second harvest. Fibrous root material is still present at the upper part of this root system.....65
10. Healthy regrowth 3 weeks after the main harvest.....65
11. Slightly distorted regrowth 3 weeks after the main harvest....66
12. Severely distorted regrowth.....66
13. A treated leaf in the process of turning necrotic. Note the healthy tissue beside the midrib and major veins.....67
14. Treated leaves which have turned completely necrotic.....67
15. A stem of an untreated C. arvense plant, showing the light-coloured ridges.....69
16. Necrosis of ridges on the stem of a treated plant.....69
17. Apical leaves of a vegetative mother stem yellowing 1 week after glyphosate application to the partially necrotic leaf shown in the bottom right-hand corner.....70
18. The stem on the left was treated with glyphosate, resulting in chlorosis of apical and axillary leaves of associated daughter stems.....70
19. The green net-like design that formed on less affected leaves. Note the green tissue beside major veins.....72
20. An affected leaf (right) several weeks after treatment beside an unaffected leaf. Note the green tips of lobes.....72

21. Necrosis of the treated portion of a stem several months after treatment.....73
22. Some distorted leaves showing the reduction in size and number of spines. The leaf on the far right is normal.....73
23. Typical bleached strap-like growth of young apical leaves affected by glyphosate.....75
24. From left to right are leaves taken from top to bottom from the affected portion of a stem which recovered from a dose of glyphosate.....75
25. A daughter stem affected by glyphosate. Internodes are short and leaves distorted on the upper portion of the main stem, and long axillary stems have formed with distorted leaves near their bases.....77
26. Distortion of C. arvense buds and flowers by glyphosate.....77
27. Glyphosate-induced browning of female florets.....78
28. Distortion of male flowers as seen at the main harvest. The flowers on the far right are normal.....78
29. Senescence of a C. arvense plant.....85
30. A vegetative stem of an untreated plant with flat leaves.....107
31. A stem similar in all respects to that in Plate 30 except in its leaf morphology, and thus presumably also in its genotype..107

LIST OF APPENDICES

1. Characteristics of plants at the time of treatment.....124
2. Measurements made of plants when harvested.....133
3. Analyses of variance for data cited in the text.....142
4. Correlation coefficients between the log shoot:root ratio  
and the factors listed for plants treated at the vegetative  
stage with 6.2, 25 and 100 mg of glyphosate.....148
5. Chi-square analysis of male:female ratio.....149

LIST OF PESTICIDES

The chemical names of pesticides appearing in this text are listed below:

acephate	OS-dimethyl acetylphosphoramidothioate
amitrole	3-amino-1,2,4-triazole
barban	4-chlorobut-2-ynyl N-(3-chlorophenyl)carbamate
bromoxynil	3,5-dibromo-4-hydroxybenzotrile
2,4-D	2,4-dichlorophenoxyacetic acid
dalapon	2,2-dichloropropionic acid
dicamba	3,6-dichloro-2-methoxybenzoic acid
dichlorvos	2,2-dichlorovinyl dimethyl phosphate
glyphosate	N-(phosphonomethyl)glycine
maleic hydrazide	1,2,3,6-tetrahydro-3,6-dioxopyridazine
MCPA	4-chloro-2-methylphenoxyacetic acid
picloram	4-amino-3,5,6-trichloropicolinic acid
terbutryne	6-t-butylamino-4-ethylamino-2-methylthio- 1,3 5-s-triazine
zineb	zinc ethylene-1,2-bisdithiocarbamate