ZINC REQUIREMENTS OF TRANSPLANTED OILSEED RAPE

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TABLE OF CONTENTS

DECLARATION OF ORIGINALITY ii
ABSTRACT iii
ACKNOWLEDGEMENTS vii
TABLE OF CONTENTS ix
LIST OF TABLES xvii
LIST OF FIGURES xxi
LIST OF PLATES xxiii
LIST OF APPENDICES xxiv
ABBREVIATIONS xxv
GLOSSARY OF PLANT SPECIES xxvi

CHAPTER 1 : LITERATURE REVIEW AND THESIS AIMS 1

1.1. Introduction 2

1.2. Zinc in soils 3

1.2.1. Geographical distribution of low zinc soils 3

1.2.2 Zinc forms and behaviour in soils 4

1.2.3 Zinc sorption and desorption 6

1.2.4 Factors affecting the forms and availability of zinc 7

1.2.4.1 Soil pH 7

1.2.4.2 Soil organic matter 8

1.2.4.3 Clay minerals 9

1.2.4.4 Interaction with other elements 10

1.3. Zinc in plants 11
1.3.1. The functions of zinc

1.3.1.1. Morphological effects

1.3.1.2 Physiological and biochemical effects

a. Zinc in enzyme function

b. Zinc in carbohydrate metabolism

c. Zinc in protein metabolism

d. Zinc in membrane integrity

1.3.2. Mechanism of zinc uptake

1.3.3. Factors affecting zinc uptake by plants

1.3.3.1. Temperature

1.3.3.2. Soil water content

1.3.3.3. Light

1.3.4. Zinc distribution and redistribution

1.3.5. Soil-root interface

1.3.5.1. Change in rhizosphere pH and redox potential

1.3.5.2 Excretion of organic acids and chelators

1.3.5.3 Mycorrhizal symbiosis

1.3.6 Diagnosis and prognosis of zinc deficiency

1.3.6.1 Diagnosis

1.3.6.2. Prognosis

1.4. Transplanted crops

1.4.1 Physiology of transplanted crops

1.4.2 Nutrition of transplanted crops

1.4.3. Zinc requirement of transplanted crops
CHAPTER 2 : EFFECT OF TRANSPLANTING AND ROOT PRUNING ON EXTERNAL ZINC REQUIREMENTS OF OILSEED RAPE (Brassica napus L.)

2.1 Abstract

2.2 Introduction

2.3 Materials and methods

2.3.1 Zinc treatment

2.3.2 Plant culture

2.3.3 Harvest procedure

2.3.4 Plant and soil analysis

2.3.5 Data analysis

2.4 Results

2.4.1 Growth and symptom development

2.4.2 Root and shoot dry matter production

2.4.3 Root length

2.4.4 Relative growth rate and relative absorption rate

2.4.5 Zinc concentration in plants

2.4.6 Soil pH and zinc concentration

2.5 Discussion

2.5.1 External and Internal zinc requirements of transplanted oilseed rape

2.5.2 Mechanisms of increased external zinc requirement

2.5.3 Levels of root pruning
CHAPTER 3: RESPONSE OF DIRECT SOWN AND TRANSPLANTED OILSEED RAPE TO ZINC-HEDTA CONCENTRATION IN CHELATE-BUFFERED NUTRIENT SOLUTION

3.1. Abstract 78

3.2. Introduction 79

3.3. Materials and methods 81
   3.3.1. Treatment 81
   3.3.2. Plant culture 81
   3.3.3. Harvest procedure 83
   3.3.4. Analysis of plants and nutrient solution 83
   3.3.5. Data analysis 84

3.4. Results 84
   3.4.1. Growth and symptom development 84
   3.4.2. Shoot and root dry weights 85
   3.4.3. Shoot: root ratios, root length and root hairs 85
   3.4.4. Relative growth rates 87
   3.4.5. Shoot and root zinc concentrations 87
   3.4.6. Phosphorus concentrations and contents 88
   3.4.7. Nitrogen concentrations in solution 90

3.5. Discussion 93

3.6. Conclusion 97

CHAPTER 4: EFFECT OF SOLUTION Zn-HEDTA AND ROOT PRUNING ON GROWTH AND ZINC UPTAKE OF TRANSPLANTED OILSEED RAPE IN CHELATE-BUFFERED NUTRIENT SOLUTION
4.1. Abstract 100
4.2. Introduction 101
4.3. Materials and methods 103
  4.3.1. Treatment 103
  4.3.2. Plant culture 103
  4.3.3. Harvest procedure 104
  4.3.4. Plant analysis 105
  4.3.5. Data analysis 105
4.4. Results 106
  4.4.1. Growth and symptom development 106
  4.4.2. Shoot and root dry weights 106
  4.4.3. Relative growth rates 108
  4.4.4. Shoot : root ratio 111
  4.4.5. Root length and root hair density 111
  4.4.6. Nutrient concentration in plant parts 112
  4.4.7. Solution pH 116
4.5. Discussion 118
  4.5.1. Response of transplanted oilseed rape to external zinc 118
  4.5.2. Response of transplanted oilseed rape to root pruning 119
4.6. Conclusion 123

CHAPTER 5 : SEEDBED ZINC NUTRITION AFFECTS THE EARLY GROWTH OF TRANSPLANTED OILSEED RAPE IN CHELATE-BUFFERED NUTRIENT SOLUTION
CHAPTER 5: THE CHEMICAL CHANGES IN THE RHIZOSPHERE AND NON-RHIZOSPHERE SOIL OF OILSEED RAPE AND ITS RELATIONSHIP TO RECOVERY OF ROOT FUNCTION

5.1. Abstract 126

5.2. Introduction 127

5.3 Materials and methods 129

5.3.1. Treatment 129

5.3.2. Plant culture 129

5.3.3. Harvest procedure 130

5.3.4. Plant analysis 131

5.3.5. Data analysis 131

5.4. Results 131

5.4.1. Plant in the seedbed 131

5.4.2. Post-transplanting growth response 132

5.4.3. Root length and root hairs density 133

5.4.4. Nutrient concentrations in plant parts 136

5.5. Discussion 138

5.5.1. Effect of seedbed zinc concentration 138

5.5.2 Effect of root pruning 141

5.6. Conclusion 144

CHAPTER 6: THE CHEMICAL CHANGES IN THE RHIZOSPHERE AND NON-RHIZOSPHERE SOIL OF OILSEED RAPE AND ITS RELATIONSHIP TO RECOVERY OF ROOT FUNCTION

6.1. Abstract 146

6.2. Introduction 147

6.3. Materials and methods 149
6.3.1. Treatment 149
6.3.2. Plant culture 149
6.3.3. Harvest procedure 150
6.3.4. Plant and soil analysis 151
6.3.5. Organic acids determination 151
6.3.6. Data analysis 152

6.4. Results 153
6.4.1. Symptoms and growth 153
6.4.2. Root and shoot dry matter 153
6.4.3. Shoot : root ratio 155
6.4.4. Root tips 155
6.4.5. Root length 156
6.4.6. Zinc concentration in plant parts 158
6.4.7. Organic acids in soil 159
6.4.8. Rhizosphere and non-rhizosphere soil pH 165
6.4.9. Zinc in soil 165

6.5. Discussion 167
6.5.1. Effect of zinc supply and root pruning on plant growth 167
6.5.2. Changes in rhizosphere pH 172
6.5.3. Organic acids in rhizosphere and non-rhizosphere soil 173
6.5.4. Zinc concentration in rhizosphere and non-rhizosphere soil 174

6.6. Conclusion 175
CHAPTER 7 : GENERAL DISCUSSION

7.1. Effect of zinc application and root pruning on plant growth 178

7.2. Zinc requirement of transplanted crops 183

7.3. Mechanisms of increased external zinc requirement 184
   7.3.1. The temporary increases in shoot : root ratio 184
   7.3.2. The time taken for the recovery of root function 185
   7.3.3. Rhizosphere modification 186
   7.3.4. Agronomic consequences 187

7.4. Concluding remarks 188

REFERENCES 192

APPENDICES 219
DECLARATION OF ORIGINALITY

I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for a higher degree at any Tertiary education institution.

Mulyati.
ABSTRACT

Transplanting is a common practice for many horticultural crops and some field crops. Recently, transplanted oilseed rape (*Brassica napus* L.) crops have been reported to be sensitive to zinc (Zn) deficiency. However, Zn nutrition in transplanted field crops has not been investigated in detail. The objectives of this present research were to investigate whether transplanting increases external Zn requirements of transplanted oilseed rape, and the mechanisms of root function, growth and Zn uptake after transplanting including rhizosphere modification capacity by plant roots. The second objective was to examine the relative effects of root pruning and transplanting on Zn responses of oilseed rape, and the third objective was to determine external and internal Zn requirements of transplanted oilseed rape for diagnosing and predicting Zn deficiency.

An experiment on a low Zn sand (DTPA extractable Zn 0.14 mg kg\(^{-1}\)) was set up to determine whether transplanted oilseed rape had a higher Zn requirement than that of direct-sown plants. Low Zn supply depressed shoot dry weight, however, root growth was relatively more strongly suppressed than shoots. Maximum root dry weight required much higher external Zn for transplanted plants compared to direct-sown plants, whilst shoot dry weight required a similarly low external Zn supply. In addition, transplanted plants were sensitive to zinc deficiency during the early post-transplanting growth, and the response weakened as the plants recovered from root injury or transplanting stress. However, the transplanted plants also experienced root
pruning before transplanting and so in this experiment the higher Zn requirement could have been due to root pruning or transplanting or both.

A further experiment was undertaken to determine the comparative external Zn requirements of direct-sown and transplanted plants in well-stirred chelate-buffered solution culture where a rhizosphere effect on plant availability of Zn forms is absent and the effects of poor root-soil contact on post-transplanting growth are minimized. In solution culture at the same level of Zn supplied, direct-sown plants produced higher shoot and root dry matter and greater root length than those of transplanted plants. However, since a higher external Zn requirement was found for transplanted plants in buffered solution culture than for direct-sown plants, it was concluded that the higher Zn requirement was not related to decreased rhizosphere modification, to greater demand for Zn or to poor root-solution contact, but rather to the time required for transplanted plants to recover from transplanting and root injury. The recovery of root function in solution culture was more rapid than that in soil culture and expressed as a higher Zn requirement for shoot as well as root growth. It suggested that the delay in root recovery in soil culture was due to slower absorption of Zn from the soil after transplanting than was the case in solution culture.

Chelate-buffered nutrient solution culture and harvesting plants successively at 5 day intervals until 25 days after transplanting was used to examine the mechanisms of the recovery of root growth and function. In this experiment, the external Zn requirement of transplanted plants was investigated with unpruned or pruned root systems. Plants with unpruned root system and sufficient Zn supply
exhibited faster recovery from transplanting than those with pruned root system plants. The results suggest that root pruning impaired Zn uptake by plant roots and slowed down the root and shoot growth after transplanting. Increased solution Zn partly alleviated the effects of root pruning and presumably this is a major reason why transplanted oilseed rape had a high external Zn requirement. However, root pruning also appeared to impair water uptake, and may have suppressed shoot growth through sequestering carbon for new root growth and through decreased phytohormone production by roots.

Since rapid root recovery of transplanted plants is essential for successful of growth in the field, Zn application to the nursery bed was explored as a starter fertilizer to stimulate root growth after transplanting. The objective of this experiment was to determine whether increasing the seedbed Zn would stimulate new root growth of transplanted oilseed rape, and therefore would alleviate the need for increased external Zn for post-transplanting growth. Results showed that adequate Zn concentration in the seedbed promoted the post-transplanting growth by stimulating the new root growth especially increased root length, and also hastened the recovery of root systems. However, high Zn concentration at transplanting still had a more dominant effect in stimulating the new root growth of oilseed rape after transplanting.

The final experiment was set up using rhizobags with three rates of Zn supply and unpruned or pruned root systems. The purpose of this study was to investigate the chemical change in the rhizosphere and non-rhizosphere or bulk soil and its relationship to the recovery of root function after transplanting, and also to identify
and quantify the organic acids in soil extracts of direct-sown and transplanted plants. The rhizosphere soil pH was lower than that of non-rhizosphere soil, and the decrease of soil pH was suggested as the mechanism of the increase of Zn availability and mobility in the rhizosphere soil. Direct-sown plants were more efficient in utilizing Zn than those of transplanted plants especially compared to those of plants with pruned root system. Zinc deficient plants excreted higher concentration of organic acids particularly citric acid, suggesting this was a mechanism of Zn mobilization and Zn uptake by roots of oilseed rape.

The main implications of the present study for the management of Zn nutrition of transplanted crops were: the need to increase the Zn application to crops in the nursery and at transplanting compared to direct-sown plants; the possibility that external requirements of other nutrients will be greater in transplanted crops also requires further consideration; and in cropping systems where transplanting is practised, greater attention should be given to the avoidance of root damage during the transplanting.
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LIST OF TABLES

<table>
<thead>
<tr>
<th>Table No.</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1.1</td>
<td>Effects of Zn status on exudation of low-molecular-weight compounds by cotton roots during a 6 hr period in solution (Cakmak and Marschner, 1988).</td>
<td>17</td>
</tr>
<tr>
<td>Table 1.2</td>
<td>Effects of Zn supply to wheat plants on root exudates and Zn mobilization from calcareous soils (Adapted from Marschner et al., 1987).</td>
<td>29</td>
</tr>
<tr>
<td>Table 1.3</td>
<td>The critical Zn concentrations (mg Zn kg⁻¹ dry matter) for diagnosing of Zn deficiency in canola (Adapted from Rashid et al., 1994).</td>
<td>33</td>
</tr>
<tr>
<td>Table 1.4</td>
<td>Critical concentrations of Zn in soil for several crops and soil types in Australia from pot and field experiments (Adapted from Armour et al., 1990).</td>
<td>35</td>
</tr>
<tr>
<td>Table 2.1</td>
<td>Effect of Zn supply on shoot : root ratio of direct-sown and transplanted plants of oilseed rape at 7 and 10-leaf stages.</td>
<td>62</td>
</tr>
<tr>
<td>Table 2.2</td>
<td>Effect of Zn supply on root length (m plant⁻¹) of direct-sown and transplanted seedlings of oilseed rape at 7- and 10-leaf stages.</td>
<td>63</td>
</tr>
<tr>
<td>Table 2.3</td>
<td>Effects of Zn supply on relative growth rates (RGR: g 100 g⁻¹ day⁻¹) of shoot and root and Zn absorption rate (RAR: μg g⁻¹ fresh root day⁻¹) of direct-sown and transplanted plants between 7- and 10-leaf stages.</td>
<td>63</td>
</tr>
<tr>
<td>Table 2.4</td>
<td>Effect of Zn supply on Zn concentration in the youngest mature leaf (mg kg⁻¹ dry matter) of direct-sown and transplanted oilseed rape at 7- and 10-leaf stages</td>
<td>67</td>
</tr>
<tr>
<td>Table 2.5</td>
<td>Effect of Zn supply on shoot Zn content (μg plant⁻¹) of direct-sown and transplanted plants at 7- and 10-leaf stages.</td>
<td>68</td>
</tr>
<tr>
<td>Table 2.6</td>
<td>Effect of Zn supply on soil pH (water 1:5) and DTPA-extractable Zn (μg kg⁻¹ soil) of soil supporting direct-sown and transplanted plants at 7- and 10-leaf stages.</td>
<td>69</td>
</tr>
</tbody>
</table>
Table 2.7. Critical external Zn concentrations (µg Zn kg⁻¹) for shoot and root dry weights and root length of direct-sown and transplanted oilseed rape at 7- and 10-leaf stages.

Table 3.1. Effect of Zn-HEDTA supply on shoot: root ratios, root length (m plant⁻¹) and root hair density (number g⁻¹ fresh root) of direct-sown and transplanted plants at 7-leaf stage.

Table 3.2. Effect of Zn-HEDTA supply on shoot and root zinc concentration (mg kg⁻¹ dry matter) of direct-sown and transplanted plants at 7-leaf stage.

Table 3.3. Effect of zinc-HEDTA supply on P concentration (mg kg⁻¹ dry matter) and P content (mg plant⁻¹) in the old leaves of direct-sown and transplanted plants.

Table 3.4. Effect of Zn-HEDTA on NH₄-N and NO₃-N concentration (mg N.L⁻¹) changes in solutions supporting direct-sown and transplanted plants at 7 days and at final harvest.

Table 4.1. Effect of solution Zn-HEDTA concentration and root pruning on shoot and root dry weights (g plant⁻¹) of transplanted oilseed rape at 5, 10, 15, 20 and 25 days after transplanting (DAT) in chelate-buffered nutrient solution.

Table 4.2. Effect of solution Zn-HEDTA concentration and root pruning on shoot: root ratio of transplanted oilseed rape at 5, 10, 15, 20 and 25 days after transplanting (DAT) in chelate-buffered nutrient solution.

Table 4.3. Effect of solution Zn-HEDTA concentration and root pruning on root length (m plant⁻¹) and root hair density (number g⁻¹ root fresh weight) of transplanted oilseed rape at 5, 10, 15, 20 and 25 days after transplanting (DAT) in chelate-buffered nutrient solution.

Table 4.4. Effect of solution Zn-HEDTA concentration and root pruning on Zn concentration (mg kg⁻¹) in shoots and roots of transplanted oilseed rape at 5, 10, 15, 20 and 25 days after transplanting (DAT) in chelate-buffered nutrient solution.

Table 4.5. Effect of solution Zn-HEDTA concentration and root pruning on Zn absorption rate (mg kg⁻¹ root fresh weight day⁻¹) by transplanted oilseed rape at 5, 10, 15, 20 and 25 days after transplanting (DAT) in chelate-buffered nutrient solution.
Table 4.6. Effect of solution Zn-HEDTA concentration and root pruning on phosphorus (P) concentration in the two oldest leaves (g kg\(^{-1}\)) of transplanted oilseed rape at 5, 10, 15, 20 and 25 day after transplanting (DAT) in chelate-buffered nutrient solution.

Table 5.1. Effect of seedbed Zn, Zn supply in solution and root pruning on shoot and root dry weights (g plant\(^{-1}\)) of transplanted oilseed rape at 20 days after transplanting.

Table 5.2. Effect of seedbed Zn, Zn supply in solution and root pruning on root length (m plant\(^{-1}\)), specific root length (m g\(^{-1}\) root fresh weight) and root hair density (number g\(^{-1}\) root fresh weight) of transplanted oilseed rape at 20 days after transplanting.

Table 5.3. Effect of seedbed Zn, Zn supply in solution and root pruning on shoot and root Zn concentrations (mg kg\(^{-1}\) dry weight) of transplanted oilseed rape at 20 days after transplanting.

Table 6.1. Effect of Zn supply and root pruning on root and shoot dry matter (g plant\(^{-1}\)) of transplanted and direct-sown oilseed rape at 5 and 7-leaf stages.

Table 6.2. Effect of Zn supply and root pruning on shoot : root ratio of transplanted and direct-sown oilseed rape at 5 and 7-leaf stages.

Table 6.3. Effect of Zn supply and root pruning on number of root tips (number plant\(^{-1}\)) and root length (m plant\(^{-1}\)) of transplanted and direct-sown oilseed rape at 5 and 7-leaf stages.

Table 6.4. Effect of Zn supply and root pruning on zinc concentration in old leaf (OL) and youngest mature leaf (YML) (mg kg\(^{-1}\)) of transplanted and direct-sown oilseed rape at 5- and 7-leaf stages.

Table 6.5. Effect of Zn supply and root pruning on zinc concentration in shoots and roots (mg kg\(^{-1}\) dry matter) of transplanted and direct-sown oilseed rape at 5- and 7-leaf stages.

Table 6.6. Effect of Zn supply on organic acids (µg L\(^{-1}\)) in rhizosphere soil of direct sown oilseed rape at 5 and 7-leaf stages. Organic acids were presented according to the time retention.
Table 6.7. Effect of Zn supply and root pruning on organic acids (µg L⁻¹) in non-rhizosphere soil of direct-sown oilseed rape at 5- and 7-leaf stages. Organic acids were presented according to the time retention.

Table 6.8. Effect of Zn supply with root had not been pruned on organic acids (µg L⁻¹) in rhizosphere soil of transplanted oilseed rape at 5- and 7-leaf stages. Organic acids were presented according to the time retention.

Table 6.9. Effect of Zn supply and root pruning on rhizosphere and non-rhizosphere soil pH-H₂O and pH-CaCl₂ of transplanted and direct-sown oilseed rape at 5-leaf stages.

Table 6.10. Effect of Zn supply and root pruning on rhizosphere and non-rhizosphere soil pH-H₂O and pH-CaCl₂ of transplanted and direct-sown oilseed rape at 7-leaf stages.

Table 6.11. Effect of Zn supply and root pruning on rhizosphere and non-rhizosphere soil zinc concentration (µg Zn kg⁻¹ air dry soil) of direct-sown and transplanted oilseed rape at 5-leaf stages.

Table 6.12. Effect of Zn supply and root pruning on rhizosphere and non-rhizosphere soil zinc concentration (µg Zn kg⁻¹) of transplanted and direct-sown oilseed rape at 7-leaf stages.
**LIST OF FIGURES**

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1.1.</td>
<td>Relationship between plant growth and nutrient concentration in the plant for diagnosing or predicting nutrient deficiency and toxicity (Adapted from Smith and Loneragan, 1997).</td>
<td>31</td>
</tr>
<tr>
<td>Figure 2.1.</td>
<td>Effect of Zn supply on root dry matter of direct-sown and transplanted plants at 7-leaf stage. The critical value at 90% of maximum root dry matter was 90 µg Zn kg(^{-1}) soil (a) and 240 µg Zn kg(^{-1}) soil (b).</td>
<td>57</td>
</tr>
<tr>
<td>Figure 2.2.</td>
<td>Effect of Zn supply on root dry matter of direct-sown and transplanted plants at 10-leaf stage. The critical value at 90% of maximum root dry matter was 107 µg Zn kg(^{-1}) soil (c) and 114 µg Zn kg(^{-1}) soil (d).</td>
<td>58</td>
</tr>
<tr>
<td>Figure 2.3.</td>
<td>Effect of Zn supply on shoot dry matter of direct-sown and transplanted plants at 7-leaf stage. The critical value at 90% of maximum shoot dry matter was 70 µg Zn kg(^{-1}) soil (a) and 80 µg Zn kg(^{-1}) soil (b).</td>
<td>59</td>
</tr>
<tr>
<td>Figure 2.4.</td>
<td>Effect of Zn supply on shoot dry matter of direct-sown and transplanted plants at 10-leaf stage. The critical value at 90% of maximum shoot dry matter was 107 µg Zn kg(^{-1}) soil (c) and 110 µg Zn kg(^{-1}) soil (d).</td>
<td>60</td>
</tr>
<tr>
<td>Figure 2.5.</td>
<td>The relationships between shoot dry matter (g plant(^{-1})) and Zn concentrations (mg Zn kg(^{-1}) dry matter) in youngest mature leaf of direct-sown oilseed rape at 7- and 10-leaf stages.</td>
<td>65</td>
</tr>
<tr>
<td>Figure 2.6.</td>
<td>The relationships between shoot dry matter (g plant(^{-1})) and Zn concentrations (mg Zn kg(^{-1}) dry matter) in youngest mature leaf of transplanted oilseed rape at 7- and 10-leaf stages.</td>
<td>66</td>
</tr>
<tr>
<td>Figure 3.1.</td>
<td>Effect of Zn-HEDTA supply on shoot (a) and root (b) dry weights of direct-sown (DS) and transplanted (TR) plants in chelate-buffered nutrient solution at 7-leaf stage.</td>
<td>86</td>
</tr>
<tr>
<td>Figure 3.2.</td>
<td>Effects of Zn-HEDTA supply on relative growth rates of shoot (a) and root (b) of direct-sown (DS) plants at 18 DAS and transplanted (TR) oilseed rape at 9 DAT, respectively.</td>
<td>89</td>
</tr>
<tr>
<td>Figure 3.3.</td>
<td>Effect of Zn-HEDTA supply on temporal changes in pH of nutrient solutions in which direct-sown (DS) and transplanted</td>
<td>92</td>
</tr>
</tbody>
</table>
(TR) plants of oilseed rape were grown for 18 and 9 days, respectively.

Figure 3.4. Effect of Zn-HEDTA supply on root length (m) per unit mass of direct-sown (DS) and transplanted (TR) plants. (a). on a root fresh weight basis (m g^{-1} root fresh weight) and (b). on a root dry weight basis (m g^{-1} root dry weight).

Figure 4.1. Effect of solution Zn-HEDTA concentration and root pruning on relative growth rates of roots (g 100 g^{-1} day^{-1}) of transplanted oilseed rape, harvested successively on day 5, 10, 15, 20 and 25.

Figure 4.2. Effect of solution Zn-HEDTA concentration and root pruning on relative growth rates of shoots (g 100 g^{-1} day^{-1}) of transplanted oilseed rape, harvested successively on day 5, 10, 15, 20 and 25.

Figure 4.3. Effect of solution Zn-HEDTA concentration on pH change after growing oilseed rape for up to day 25 after transplanting.

Figure 5.1. Effect of seedbed zinc concentration, zinc level and root pruning on relative growth rates of shoots and roots of transplanted oilseed rape for the 20 day post-transplanting growth period.
## LIST OF PLATES

<table>
<thead>
<tr>
<th>Plate</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Direct-sown oilseed rape cv. Hyola 42 plant grown with a low Zn supply for 15 days: (a) purpling pigmentation developed in the youngest leaf; (b) brown spots developed in the older leaves and leaf tips developed necrotic patches.</td>
<td>54</td>
</tr>
<tr>
<td>2.2</td>
<td>Symptoms of Zn deficiency in oilseed rape cv. Hyola 42 grown for 15 days with 10 μg Zn kg⁻¹ soil: (a) Younger leaf displaying chlorosis and the development of light brown spots; (b) Older leaves displaying discolouration at the margins and between the main veins.</td>
<td>55</td>
</tr>
</tbody>
</table>
# LIST OF APPENDICES

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix 2.1</td>
<td>The soil chemical properties of Lancelin sand</td>
<td>220</td>
</tr>
<tr>
<td>Appendix 2.2</td>
<td>Effect of Zn supply on Zn uptake (mg kg⁻¹ root dry matter) of direct-sown and transplanted plants at 7- and 10-leaf stages.</td>
<td>221</td>
</tr>
<tr>
<td>Appendix 3.1</td>
<td>Effect of Zn-HEDTA supply on shoot and root fresh weights of direct-sown and transplanted plants.</td>
<td>222</td>
</tr>
<tr>
<td>Appendix 4.1</td>
<td>Effect of solution Zn-HEDTA concentration and root pruning on relative growth rate of shoots and roots (g 100 g⁻¹ day⁻¹) of transplanted oilseed rape at 5, 10, 15, 20 and 25 days after transplanting in chelate-buffered nutrient solution.</td>
<td>223</td>
</tr>
<tr>
<td>Appendix 4.2</td>
<td>Effect of solution Zn-HEDTA concentration and root pruning on Zn content (µg plant⁻¹) of transplanted oilseed rape at 5, 10, 15, 20 and 25 days after transplanting in chelate-buffered nutrient solution.</td>
<td>224</td>
</tr>
<tr>
<td>Appendix 5.1</td>
<td>Effect of seedbed Zn concentration on shoot and root fresh and dry weights (g pot⁻¹) in seedlings growth at 32 days after sowing.</td>
<td>225</td>
</tr>
<tr>
<td>Appendix 5.2</td>
<td>Effect of seedbed Zn, Zn supply in solution and root pruning on phosphorus concentration (%) dry matter and content (mg plant⁻¹) in older leaves of transplanted oilseed rape at 20 days after transplanting.</td>
<td>226</td>
</tr>
<tr>
<td>Appendix 5.3</td>
<td>Effect of seedbed Zn, Zn supply in solution and root pruning on shoot and root dry weights (g pot⁻¹) of transplanted oilseed rape at 20 days after transplanting.</td>
<td>227</td>
</tr>
<tr>
<td>Appendix 6.1</td>
<td>Effect of Zn supply and root pruning on root and shoot fresh weight (g plant⁻¹) of transplanted and direct-sown oilseed rape at 5- and 7-leaf stages.</td>
<td>228</td>
</tr>
<tr>
<td>Appendix 6.2</td>
<td>The retention times of each standard organic acid measured by high pressure liquid chromatography.</td>
<td>229</td>
</tr>
</tbody>
</table>
### ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>DAS</td>
<td>day after sowing</td>
</tr>
<tr>
<td>DAT</td>
<td>day after transplanting</td>
</tr>
<tr>
<td>DDI-H₂O</td>
<td>double deionised water</td>
</tr>
<tr>
<td>DM</td>
<td>dry matter</td>
</tr>
<tr>
<td>DNP</td>
<td>dinitrophenol</td>
</tr>
<tr>
<td>DS</td>
<td>direct-sown</td>
</tr>
<tr>
<td>DTPA</td>
<td>diethylene triamine pentaacetic acid</td>
</tr>
<tr>
<td>HEDTA</td>
<td>hydroxyethyl ethylenedinitroltriacetic acid</td>
</tr>
<tr>
<td>ICP</td>
<td>inductively couple plasma</td>
</tr>
<tr>
<td>RAR</td>
<td>relative absorption rate</td>
</tr>
<tr>
<td>RGR</td>
<td>relative growth rate</td>
</tr>
<tr>
<td>ROS</td>
<td>reactive oxygen species</td>
</tr>
<tr>
<td>SOD</td>
<td>superoxide dismutase</td>
</tr>
<tr>
<td>TDI-H₂O</td>
<td>triple deionised water</td>
</tr>
<tr>
<td>TR</td>
<td>transplanted</td>
</tr>
<tr>
<td>YEB</td>
<td>youngest emerged blade</td>
</tr>
<tr>
<td>YFEL</td>
<td>youngest fully expanded leaf</td>
</tr>
<tr>
<td>YML</td>
<td>youngest mature leaf</td>
</tr>
<tr>
<td>YOL</td>
<td>youngest opened leaf</td>
</tr>
</tbody>
</table>
## GLOSSARY OF PLANT SPECIES

<table>
<thead>
<tr>
<th>Common name</th>
<th>Botanical name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td><em>Malus domestica</em></td>
</tr>
<tr>
<td>Barley</td>
<td><em>Hordeum vulgare</em></td>
</tr>
<tr>
<td>Bean</td>
<td><em>Phaseolus vulgaris</em></td>
</tr>
<tr>
<td>Bell pepper</td>
<td><em>Capsicum annuum</em></td>
</tr>
<tr>
<td>Broccoli</td>
<td><em>Brassica oleracea var</em></td>
</tr>
<tr>
<td>Cabbage</td>
<td><em>Brassica oleracea var capitata</em></td>
</tr>
<tr>
<td>Canola</td>
<td><em>Brassica napus</em></td>
</tr>
<tr>
<td>Cauliflower</td>
<td><em>Brassica oleracea var. botrytis</em></td>
</tr>
<tr>
<td>Chickpea</td>
<td><em>Cicer arietinum</em></td>
</tr>
<tr>
<td>Cotton</td>
<td><em>Gossypium hirsutum</em></td>
</tr>
<tr>
<td>Cucumber</td>
<td><em>Cucumis sativus</em></td>
</tr>
<tr>
<td>Corn</td>
<td><em>Zea mays</em></td>
</tr>
<tr>
<td>Grape</td>
<td><em>Vitis vinifera</em></td>
</tr>
<tr>
<td>Muskmelon</td>
<td><em>Cucumis melo</em></td>
</tr>
<tr>
<td>Oilseed rape</td>
<td><em>Brassica napus</em></td>
</tr>
<tr>
<td>Orange</td>
<td><em>Citrus spp.</em></td>
</tr>
<tr>
<td>Peach</td>
<td><em>Prunus persica</em></td>
</tr>
<tr>
<td>Peanut</td>
<td><em>Arachis hypogaea</em></td>
</tr>
<tr>
<td>Pine</td>
<td><em>Pinus radiata</em></td>
</tr>
<tr>
<td>Rice</td>
<td><em>Oryza sativa</em></td>
</tr>
<tr>
<td>Crop</td>
<td>Scientific Name</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Rye</td>
<td><em>Secale cereale</em></td>
</tr>
<tr>
<td>Sorghum</td>
<td><em>Sorghum vulgare</em></td>
</tr>
<tr>
<td>Sub-clover</td>
<td><em>Trifolium subterranean</em></td>
</tr>
<tr>
<td>Sunflower</td>
<td><em>Helianthus annuus</em></td>
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<tr>
<td>Tobacco</td>
<td><em>Nicotiana tabacum</em></td>
</tr>
<tr>
<td>Tomato</td>
<td><em>Lycopersicum esculentum</em></td>
</tr>
<tr>
<td>Wheat</td>
<td><em>Triticum aestivum</em></td>
</tr>
<tr>
<td>White clover</td>
<td><em>Trifolium repens</em></td>
</tr>
<tr>
<td>White lupin</td>
<td><em>Lupinus albus</em></td>
</tr>
</tbody>
</table>