ZINC REQUIREMENTS OF TRANSPLANTED OILSEED RAPE

Mulyati
B.Sc. (Hons) (Agronomy)
M.Sc. (Soil Science)

This thesis is submitted for the degree of
Doctor of Philosophy

School of Environmental Science
Division of Science and Engineering

MURDOCH UNIVERSITY

2004

TABLE OF CONTENTS

CHAPTER 7 : GENERAL DISCUSSION

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.

ACKNOWLEDGEMENTS

It is with pleasure that I wish to acknowledge the help of a number of people who gave their assistance to the completion of this thesis.

I wish to express my sincere gratitude and thanks to my supervisor Associate Professor Richard W. Bell not only for his guidance, patience, and encouragement, but also for the opportunity to work with and learn from him. I would also like to thank Dr. Longbin Huang for his helpful advice. I am grateful to Dr. Pauline Grierson and Ms. Carol Worth who gave their assistance for the organic acids analysis, and to Mr. Frank Farrow for his help on laboratory work (using ICP). Many thanks to Max, Kim and Ian in the glasshouse work. And also thank to Richard and Mark for their help in collecting soil at Lancelin. Thanks also must go to the members of the Land Management and Plant Nutrition especially Trace Element Groups for sharing their expertise, friendship and for all the help that I have received.

The Australian Development Assistance Bureau is gratefully acknowledged for financial support for this study. My sincere thanks is extended to Murdoch University for providing the facilities for completion of this thesis, and also to The University of Mataram for giving me the opportunity to continue my study.

A very special thank you to my parents who always pray for me with love. Finally, and also to my husband and my children Vera, Venny and Vemy for their support, patience and understanding at all times through the difficult stage during my study in Australia.

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

ABBREVIATIONS

DAS	day after sowing
DAT	day after transplanting
DDI-H_2O	double deionised water
DM	dry matter
DNP	dinitrophenol
DS	direct-sown
DTPA	diethylene triamine pentaacetic acid
HEDTA	hydroxyethyl ethylenedinitrolotriacetic acid
ICP	inductively couple plasma
RAR	relative absorption rate
RGR	relative growth rate
ROS	reactive oxygen species
SOD	superoxide dismutase
TDI-H_2O	triple deionised water
TR	transplanted
YEB	youngest emerged blade
YFEL	youngest fully expanded leaf
YML	youngest mature leaf
YOL	youngest opened leaf

GLOSSARY OF PLANT SPECIES

Common name	Botanical name
Apple	*Malus domestica*
Barley	*Hordeum vulgare*
Bean	*Phaseolus vulgaris*
Bell pepper	*Capsicum annuum*
Broccoli	*Brassica oleracea var*
Cabbage	*Brassica oleracea var capitata*
Canola	*Brassica napus*
Cauliflower	*Brassica oleracea var. botrytis*
Chickpea	*Cicer arientinum*
Cotton	*Gossypium hirsutum*
Cucumber	*Cucumis sativus*
Corn	*Zea mays*
Grape	*Vitis vinifera*
Muskmelon	*Cucumis melo*
Oilseed rape	*Brassica napus*
Orange	*Citrus* spp.
Peach	*Prunus persica*
Peanut	*Arachis hypogaea*
Pine	*Pinus radiata*
Rice	*Oryza sativa*

Rye	*Secale cereale*
Sorghum	*Sorghum vulgare*
Sub-clover	*Trifolium subterranean*
Sunflower	*Helianthus annuus*
Tobacco	*Nicotiana tabacum*
Tomato	*Lycopersicum esculentum*
Wheat	*Triticum aestivum*
White clover	*Trifolium repens*
White lupin	*Lupinus albus*