

## Table of Contents

|  | Page |
|--|------|
| ACKNOWLEDGEMENT                                | i    |
| ABSTRACT                                       | ii   |
| TABLE OF CONTENTS                              | vi   |
| LIST OF TABLES                                 | ix   |
| LIST OF FIGURES                                | xiii |
| Chapter 1 INTRODUCTION                         | 1    |
| Chapter 2 LITERATURE REVIEW                    | 3    |
| 2.1 The role of boron in plant growth          | 3    |
| 2.1.1 Development of reproductive organs       | 5    |
| 2.1.2 Pollen germination and fertilization     | 7    |
| 2.1.3 Filling of seeds                         | 10   |
| 2.2 Genotypic variation                        | 11   |
| 2.2.1 Boron uptake and requirement             | 11   |
| 2.2.2 Distribution and redistribution of boron | 13   |
| Chapter 3 MATERIALS AND METHODS                | 14   |
| 3.1 Field experiment                           | 14   |
| 3.1.1 Site, treatments and sowing              | 14   |
| 3.1.2 Sampling                                 | 15   |
| 3.1.2.1 Tissue boron analysis                  | 15   |
| 3.1.2.2 Anther and pollen                      | 16   |
| 3.1.2.3 Sterility counts                       | 16   |
| 3.1.2.4 Grain yield                            | 16   |
| 3.2 Pot experiment                             | 17   |
| 3.2.1 Site, treatments and sowing              | 17   |
| 3.2.2 Sampling                                 | 18   |
| 3.2.2.1 Tissue boron analysis                  | 18   |
| 3.2.2.2 Anther and pollen                      | 18   |
| 3.2.2.3 Sterility counts and 1000 grain weight | 19   |
| 3.3 Chemical analysis                          | 20   |
| 3.4 Data analysis                              | 20   |

## Chapter 4 RESULTS

21

|   |    |
|---|----|
| 4.1 Field experiment                        | 21 |
| 4.1.1 Environment conditions                | 21 |
| 4.1.2 Vegetative growth                     | 21 |
| 4.1.3 Development of anther and pollen      | 23 |
| 4.1.3.1 Anther length                       | 23 |
| 4.1.4.2 Pollen reaction to iodine           | 23 |
| 4.1.4 Grain set                             | 25 |
| 4.1.4.1 Basal floret fertility              | 25 |
| 4.1.4.2 Percentage of fertile florets       | 26 |
| 4.1.5 Yield components                      | 27 |
| 4.1.5.1 Spikelets per ear                   | 27 |
| 4.1.5.2 Grains per ear                      | 27 |
| 4.1.5.3 1000 grain weight                   | 28 |
| 4.1.6 Grain yield                           | 29 |
| 4.1.7 Boron concentration in tissue         | 29 |
| 4.1.7.1 Whole tops at double ridge stage    | 29 |
| 4.1.7.2 Flag leaf at booting stage          | 30 |
| 4.1.7.3 Developing ear at booting stage     | 30 |
| 4.1.8 Correlations among various characters | 32 |
| 4.2 Pot experiment                          | 33 |
| 4.2.1 Environmental conditions              | 33 |
| 4.2.2 Development of anther and pollen      | 34 |
| 4.2.2.1 Anther Length                       | 34 |
| 4.2.2.2 The number of pollen                | 37 |
| 4.2.2.3 Reaction of pollen to iodine        | 38 |
| 4.2.3 Pollen germination <i>in vitro</i>    | 40 |
| 4.2.3.1 Effects of B treatments             | 40 |
| 4.2.3.2 Effects of sowing dates             | 45 |
| 4.2.3.3 Effects of temperature treatments   | 48 |
| 4.2.4 Pollen tube growth                    | 51 |
| 4.2.4.1 Effects of B treatments             | 51 |
| 4.2.4.2 Effects of sowing dates             | 51 |
| 4.2.4.3 Effects of temperature treatments   | 53 |
| 4.2.5 Grain set                             | 54 |
| 4.2.5.1 Basal floret fertility              | 54 |
| 4.2.5.1 Percentage of fertile florets       | 54 |
| 4.2.6 Yield components                      | 56 |
| 4.2.6.1 Spikelets per ear                   | 56 |
| 4.2.6.2 Grains per ear                      | 57 |
| 4.2.6.3 1000 grain weight                   | 58 |
| 4.2.7 B concentration in tissue             | 60 |
| 4.2.7.1 Whole tops at tillering stage       | 60 |
| 4.2.7.2 Whole tops at double ridge stage    | 60 |
| 4.2.7.3 Flag leaf at booting stage          | 62 |
| 4.2.7.4 Developing ear at booting stage     | 62 |

|   |     |
|---|-----|
| <b>Chapter 5 DISCUSSION</b>                         | 64  |
| 5.1 Relationship between B supply and grain set     | 64  |
| 5.2 Development of anther and pollen                | 67  |
| 5.3 Pollen germination and fertilization            | 69  |
| 5.4 Relationship between tissue [B] and grain set   | 74  |
| 5.5 Weakness and further studies                    | 77  |
| <b>Chapter 6 CONCLUSION</b>                         | 78  |
| <b>REFERENCES</b>                                   | 80  |
| <b>APPENDIX</b>                                     | 84  |
| Appendix A Layout of experiment design              | 85  |
| Appendix B Analysis of variance of field experiment | 87  |
| Appendix C Analysis of variance of pot experiments  | 90  |
| Appendix D Analysis of [B] in tissue                | 97  |
| <b>CURRICULUM VITAE</b>                             | 100 |

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่  
 Copyright© by Chiang Mai University  
 All rights reserved

## List of Tables

| Table |  | Page |
|-------|--|------|
| 1.    | Boron content of the leaf tissue of plant species from the same location                       | 11   |
| 2.    | Ranks of genotypes in response to boron deficiency   | 14   |
| 3.    | Composition of basal nutrients   | 17   |
| 4.    | Effects of soil B treatments on days from emergence to double ridge stage of 9 wheat genotypes | 23   |
| 5.    | Effects of soil B treatments on anther length (cm) of 9 wheat genotypes                        | 24   |
| 6.    | Effects of soil B treatments on the percentage of positive reaction to iodine of 9 genotypes   | 24   |
| 7.    | Effects of soil B treatments on fertile florets of 10 wheat genotypes                          | 26   |
| 8.    | Effects of soil B treatments on spikelets per ear of 10 wheat genotypes                        | 27   |
| 9.    | Effects of soil B treatments on grains per ear of 10 wheat genotypes                           | 28   |
| 10.   | Effects of soil B treatments on 1000 grain weight of 9 wheat genotypes                         | 28   |
| 11.   | Effects of soil B treatments on grains yield of 1 m <sup>2</sup> field of wheat 9 genotypes    | 29   |
| 12.   | Effects of soil B treatments on [B] in whole tops double ridge stage of 9 wheat genotypes      | 30   |
| 13.   | Effects of soil B treatments on [B] in flag leaf at booting stage of 10 wheat genotypes        | 31   |
| 14.   | Effects of soil B treatments on [B] in developing ear at booting stage of 10 wheat genotypes   | 31   |

|     |  |    |
|-----|--|----|
| 15. | Matrix of correlations (Pearson) among various characters in B0 plants for 9 wheat genotypes   | 32 |
| 16. | Monthly maximum, minimum and mean air temperature (°C) recorded in the experimental station of the Multiple Cropping Center during October, 1991 - April, 1992 | 33 |
| 17. | Effects of plant B treatments on anther length (cm) of two genotypes for both sowing dates   | 37 |
| 18. | Effects of plant B treatments on the number of pollen per anther of two genotypes for both sowing dates  | 38 |
| 19. | Effects of media B treatments on germinated pollen (%) among various B supply plants of two genotypes at sowing date 2   | 43 |
| 20. | Effects of media B treatments on burst pollen (%) among various B supply plants of two genotypes at sowing date 2  | 44 |
| 21. | Effects of media B treatments on ungerminated pollen (%) among various B supply plants of two genotypes at sowing date 2                                       | 44 |
| 22. | Effects of sowing dates on burst pollen (%) of two genotypes at M20 and M100   | 47 |
| 23. | Effects of sowing dates on ungerminated pollen (%) of two genotypes at M20 and M100  | 47 |
| 24. | Effect of temperature on ungerminated pollen (%) of two genotypes at sowing date 2   | 50 |
| 25. | Effects of plant B treatments on spikelets per ear of two genotypes at both sowing dates   | 56 |

## Appendix

|     |   |    |
|-----|---|----|
| B-1 | ANOVA for days of reaching double ridge stage of 8 genotypes (excluding Sonora 64 and NL 460)   | 87 |
| B-2 | ANOVA of anther length and the percentage of positive pollen reaction to iodine of 9 genotypes (excluding NL 640)   | 87 |
| B-3 | ANOVA of basal floret fertility and the percentage of fertile florets of 10 genotypes   | 87 |
| B-4 | ANOVA of yield and yield components of 10 genotypes   | 88 |
| B-5 | ANOVA of [B] in tissue of 10 genotypes  | 88 |
| B-6 | Matrix of correlation among various characters in B0 plants of 9 genotypes  | 89 |
| B-7 | Matrix of correlation among various characters in B3 plants of 9 genotypes  | 89 |
| C-2 | Combined analysis for anther length, the number of pollen and the percentage of pollen positive reaction to iodine among locations in ear for two genotypes at two sowing dates | 91 |
| C-3 | ANOVA of the pollen germination for two genotypes at sowing date 1  | 91 |
| C-4 | ANOVA of the pollen germination for two genotypes at sowing date 2  | 92 |
| C-5 | Combined analysis of the pollen germination at M20 and M100 for two genotypes at two sowing dates   | 92 |
| C-6 | ANOVA of pollen germination between field temperature and 30°C at M20 and M100 at sowing date 2   | 93 |
| C-7 | ANOVA of pollen tube length at M20 and M100 for two genotypes at sowing date 1  | 93 |
| C-8 | Combined analysis of pollen tube length at M100 for two genotypes at two sowing dates   | 94 |

|      |   |    |
|------|---|----|
| C-9  | ANOVA of pollen tube length under temperature treatments at M100 for two genotypes at sowing date 2                     | 94 |
| C-10 | Combined analysis of basal floret fertility and the percentage of fertile florets for two genotypes at two sowing dates | 95 |
| C-11 | Combined analysis of yield and yield components for two genotypes at two sowing dates                                   | 95 |
| C-12 | Combined analysis of [B] in tissue for two genotypes at two sowing dates  | 96 |
| C-13 | ANOVA of ears (mature and late) per pot of two genotypes for each sowing date   | 96 |
| C-14 | One way ANOVA of sowing dates for ears (mature and late) per pot  | 96 |

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่  
Copyright© by Chiang Mai University  
All rights reserved

## List of Figures

| Figure |   | Page |
|--------|---|------|
| 1.     | Effect of B supply on the production and distribution of dry matter in maize plant. (Based on Vaughan, 1977)  | 4    |
| 2.     | Scanning electron micrographs (a,b) and light micrographs (c,d) of wheat pollen towards anthesis  | 6    |
| 3.     | Effect of boric acid concentrations on lily ( <i>lilium longiflorum</i> L.) pollen germination, tube growth and leakage of sugar to the medium  | 7    |
| 4.     | a) Daily mean temperature (°C) and air humidity (%) was recorded in the Station of Multiple Cropping Center during Dec. 1990 - Jan. 1991; and b) duration of developing reproductive organs | 21   |
| 5.     | Effects of B on grains in the two basal florets (F1+2) central spikelets of ear for 10 wheat genotypes  | 24   |
| 6.     | a) Daily mean temperature (°C) and air humidity (%) was recorded in the Station of Multiple Cropping Center during Nov. 1991 - Dec. 1992; and b) duration of developing reproductive organs | 35   |
| 7.     | a) Daily mean temperature (°C) and air humidity (%) was recorded in the Station of Multiple Cropping Center during Feb. - March 1992; and b) duration of developing reproductive organs     | 36   |
| 8.     | Effects of plant B treatments on positive reaction of pollen to iodine of two genotypes for both sowing dates   | 39   |
| 9.     | Effects of medium B treatments on the percentage of germinated pollen among various B supply plants for Sonora 64 and SW 41 at sowing date 1  | 40   |



|     |   |    |
|-----|---|----|
| 10. | The relation between the percentage of germinated pollen and medium B treatment for all B level plants of two genotypes | 42 |
| 11. | Effects of sowing dates on the percentage of germinate pollen of two genotypes  | 46 |
| 12. | Effects of temperature treatments on the percentage of germinated pollen for both genotypes at M20 and M100             | 49 |
| 13. | Effects of temperature treatments on the percentage of burst pollen for both genotypes at M20 and M100                  | 49 |
| 14. | Effects of B treatments on pollen tube growth for two genotypes at M20 and M100   | 52 |
| 15. | Effects of sowing dates on pollen tube growth for two genotypes at M20 and M100   | 52 |
| 16. | Effects of temperature on pollen tube growth for both genotypes at M20 and M100   | 53 |
| 17. | Effects of plant B treatments on two basal floret fertility (F1+2) for two genotypes at both sowing dates               | 55 |
| 18. | Effects of plant B treatments on percentage of fertile florets for two genotypes at both genotypes                      | 55 |
| 19. | Effects of plant B treatments on grains per ear for two genotypes at both sowing dates                                  | 57 |
| 20. | Effects of plant B treatments on 1000 grain weight for two genotypes at both sowing dates                               | 59 |
| 21. | Effects of plant B treatments on ears per pot for two genotypes at both sowing dates                                    | 59 |
| 22. | Effects of plant B treatments on [B] in whole tops at tillering stage for two genotypes at both sowing dates            | 61 |

|     |   |    |
|-----|---|----|
| 23. | Effects of plant B treatments on [B] in whole tops at double ridge stage for two genotypes at both sowing dates | 61 |
| 24. | Effects of plant B treatments on [B] in flag leaf at booting stage for two genotypes at both sowing dates       | 63 |
| 25. | Effects of plant B treatments on [B] in developing ear at booting stage for two genotypes at both sowing dates  | 63 |

#### Appendix

|      |                            |    |
|------|----------------------------|----|
| A-1. | Layout of field experiment | 85 |
| A-2. | Layout of pot experiment   | 86 |

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่  
 Copyright© by Chiang Mai University  
 All rights reserved