



**UNIVERSITI PUTRA MALAYSIA**

**IMPROVEMENT OF SEEDLING ESTABLISHMENT AND  
LODGING RESISTANCE IN SELECTED RICE CULTIVARS  
USING GROWTH REGULATORS**

**SRI WAHYUNI**

**FP 2002 30**

**IMPROVEMENT OF SEEDLING ESTABLISHMENT AND  
LODGING RESISTANCE IN SELECTED RICE CULTIVARS  
USING GROWTH REGULATORS**

**SRI WAHYUNI**

**Thesis Submitted to the School of Graduate Studies,  
Universiti Putra Malaysia, in Fulfillment of the Requirement  
for the Degree of Master of Agricultural Science**

**October 2002**



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Agricultural Science

**IMPROVEMENT OF SEEDLING ESTABLISHMENT AND  
LODGING RESISTANCE IN SELECTED RICE CULTIVARS  
USING GROWTH REGULATORS**

**By**

**SRI WAHYUNI**

**October 2002**

**Chairperson : Dr. Uma Rani Sinniah**

**Faculty : Agriculture**

Studies were conducted to investigate the possible use of growth regulators to improve seedling establishment and lodging resistance in wet seeded rice cultivars.

The first experiment was designed to evaluate the effect of growth regulators i.e. GA<sub>3</sub> and IBA as seed treatment on seedling establishment, growth and grain yield. Levels of GA<sub>3</sub> were 25, 50 and 100 mg/L and IBA were 10, 20 and 40 mg/L; and water was used as control. The treatments were tested on four rice cultivars i.e. Membramo and Widas (Indonesian cultivars), MR 219 and MR 84 (Malaysian cultivars). In the second experiment, growth retardants paclobutrazol and prohexadione calcium at 50, 100 and 200 mg/L as foliar application at panicle initiation were investigated for their effects on growth, lodging resistance and yield of four rice cultivars. A third experiment was conducted to evaluate selected



combinations of seed treatment and foliar spray on growth, lodging resistance and yield of two rice cultivars.

Results of the study showed that GA<sub>3</sub> as seed treatment induced favourable early emergence but shoot etiolation resulted in seedlings more prone to lodging during the vegetative phase. On the other hand, IBA treatments improved root growth by increasing the number of adventitious roots and contributed towards better establishment with seedlings having broader and greener leaves. IBA at all concentrations did not show any significant differences in all growth parameters measured and had no detrimental effects on grain yield. IBA at 10 mg/L was sufficient in providing the required improvement in the rice seedlings.

Cultivar response to GA<sub>3</sub> was similar, however response to IBA was different. Indonesian cultivars had shoot lengths comparable to the control, while the Malaysian cultivars had shorter shoots.

Foliar applied growth retardants inhibited plant growth, retarded internode and culm length but increased culm diameter. All treated plants had higher bending and stem breaking resistance compared to the control. The treatments also improved culm thickness, increased the amount of cellulose, hemicellulose and lignin content in culms. Histological studies showed greater compaction of parenchyma cells and thickening of parenchyma cell walls. The higher bending and breaking resistance and hence improved lodging resistance was largely attributed to these changes in culms treated with the growth retardants.

Treatments with 100 and 200 mg/L paclobutrazol and prohexadione gave significant retardation of internodes, reduced culm length by 20% and gave higher stem breaking resistance compared to those at 50 mg/L, but did not affect yield. High concentration of retardant can suppress effective panicle exertion, as such 100 mg/L paclobutrazol is recommended as paclobutrazol is more cost-effective compared to prohexadione calcium.

Cultivar response to growth retardants was similar. The differences amongst cultivars in parameters observed are attributed to their genetic differences. In general, Malaysian cultivars had larger culm diameter with higher bending and stem breaking resistance compared to Indonesian cultivars. Indonesian cultivars had shorter plant height and higher tiller numbers compared to Malaysian cultivars.

Combinations of seed treatment with IBA and foliar application of paclobutrazol at panicle initiation gave similar response as with individual chemicals. IBA improved rooting ability at the early stage and paclobutrazol retarded internodes and improved stem breaking resistance. Plants treated with 100 and 200 mg/L paclobutrazol alone or in combination with 10 mg/L IBA had significantly higher stem breaking resistance and pulling down resistance compared to the control or IBA alone. There were no significant differences in grain yield.

The results indicate that seed treatment with IBA followed by paclobutrazol at panicle initiation significantly improved lodging resistance without any detrimental effects on tillering, photosynthetic rate, yield components or grain

yield. With significant reductions in yield losses due to lodging, the direct benefit to farmers is the increase in harvestable yields.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk ijazah Master Sains Pertanian

**PENINGKATAN KEUPAYAAN ANAK BENIH DAN KETAHANAN  
REBAH PADA KULTIVAR PADI TERPILIH DENGAN  
MENGUNAKAN PENGAWALATUR TUMBESARAN**

**SRI WAHYUNI**

**Oktober 2002**

**Pengerusi : Dr. Uma Rani Sinniah**

**Fakulti : Pertanian**

Kajian telah dijalankan untuk mengetahui kesan penggunaan pengawalatur tumbesaran untuk meningkatkan keupayaan anak benih dan ketahanan terhadap kerebahan tanaman padi menggunakan sistem tabur terus.

Eksperimen pertama mengkaji kesan pengawalatur tumbesaran iaitu GA<sub>3</sub> dan IBA menggunakan kaedah rawatan biji benih ke atas perkembangan anak benih, tumbesaran dan hasil padi. Kepekatan GA<sub>3</sub> yang digunakan ialah 25, 50 dan 100 mg/L dan IBA pada 10, 20 dan 40 mg/L dengan air sebagai rawatan kawalan. Empat kultivar padi iaitu Membramo dan Widas (kultivar dari Indonesia), MR 219 dan MR 84 (kultivar dari Malaysia) digunakan dalam kajian ini. Ekperimen kedua pula dijalankan untuk mengkaji kesan perencat tumbesaran paclobutrazol dan prohexadione calcium pada kadar 50, 100 dan 200 mg/L ke atas tumbesaran, ketahanan terhadap rebah dan hasil padi. Empat kultivar seperti yang digunakan dalam eksperimen satu diuji dan aplikasi adalah secara semburan daun semasa

pembentukan panikal. Eksperimen ketiga dijalankan untuk mengkaji kesan kombinasi rawatan biji benih dan semburan daun ke atas tumbesaran, ketahanan terhadap rebah dan hasil padi. Rawatan melibatkan kombinasi terpilih dari eksperimen satu dan dua dan dikaji pada dua kultivar padi.

Rawatan GA<sub>3</sub> mempercepatkan kemunculan anak benih, akan tetapi pucuknya mengalami etiolasi dan mengakibatkan anak benih mudah rebah semasa perkembangan vegetatif. Sebaliknya, rawatan IBA menggalakkan pengakaran dengan meningkatkan jumlah akar adventitus dan menyumbang terhadap tumbesaran anak benih yang lebih sihat dengan daun yang lebih lebar dan hijau. Kepekatan IBA yang berbeza tidak memberikan kesan yang bererti ke atas parameter pertumbuhan dan tiada kesan negatif ke atas hasil. IBA pada kepekatan 10 mg/L adalah cukup untuk memberikan kesan positif ke atas anak benih padi.

Kesan kultivar ke atas aplikasi GA<sub>3</sub> adalah sama, tetapi kesan IBA berbeza, dimana pemanjangan pucuk kultivar dari Indonesia adalah setanding dengan kawalan, manakala kultivar dari Malaysia mempunyai pucuk yang lebih pendek.

Perencat tumbesaran pula merencat perkembangan pokok, internod dan batang padi tetapi meningkatkan garispusat batang. Semua pokok padi yang dirawat dengan perencat tumbesaran mempunyai ketahanan rebah yang lebih tinggi berbanding dengan kawalan. Ketebalan batang, kandungan total selulosa, hemiselulosa dan lignin pada batang padi juga meningkat. Kajian histologi menunjukkan pepadatan pada sel parenkima dan peningkatan ketebalan dinding



sel parenkima. Peningkatan pada struktur batang ini memberikan peningkatan terhadap ketahanan rebah.

Rawatan paclobutrazol dan prohexadione calcium pada kepekatan 100 dan 200 mg/L menunjukkan kesan pemendekan yang bererti pada internod dimana pemendekan batang sebanyak 20% diperolehi dan juga meningkatkan ketahanan rebah tanpa mempengaruhi hasil berbanding dengan rawatan pada kepekatan 50 mg/L. Kepekatan perencat yang tinggi boleh mempengaruhi kebolehan padi untuk terbit, jadi paclobutrazol pada kepekatan 100 mg/L disyorkan berbanding dengan prohexadione calcium memandangkan paclobutrazol adalah lebih murah.

Kesan kultivar keatas perencat tumbesaran adalah sama tetapi wujud perbezaan antara kultivar yang kemungkinannya disebabkan oleh perbezaan genetik. Secara amnya, kultivar dari Malaysia mempunyai garispusat batang yang lebih besar dengan ketahanan rebah yang lebih tinggi berbanding dengan kultivar dari Indonesia. Sedangkan kultivar dari Indonesia mempunyai batang yang lebih pendek dan jumlah anak pokok yang lebih banyak.

Kombinasi rawatan IBA dan paclobutrazol memberikan kesan yang sama seperti yang diperolehi apabila rawatan diberikan secara berasingan. IBA menggalakkan pengakaran pada peringkat awal tumbesaran dan paclobutrazol merencat internod dan meningkatkan ketahanan terhadap rebah tanpa memberi sebarang kesan yang bererti ke atas hasil padi. Padi yang diberi rawatan dengan 100 mg/L paclobutrazol sahaja atau dengan kombinasi 10 mg/L IBA mempunyai ketahanan

terhadap kerebahan yang lebih tinggi berbanding dengan kawalan atau rawatan dengan IBA sahaja.

Keputusan menunjukkan bahawa rawatan biji benih dengan IBA diikuti dengan paclobutrazol semasa pembentukan panikal meningkatkan ketahanan terhadap rebah tanpa sebarang kesan yang negatif ke atas jumlah anak pokok, kadar fotosintesis, komponen hasil dan hasil padi. Pengurangan kehilangan hasil akibat peningkatan ketahanan rebah akan secara langsung meningkatkan hasil tuaian petani.

## ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Dr. Uma Rani Sinniah for her supervision, constructive criticisms and her invaluable guidance and encouragement throughout my study and preparation of this manuscript.

My sincere thanks also go to my supervisory committee members Associate Prof. Dr. Mohd. Khanif Yusop and Associate Prof. Dr. Rajan Amarthalingam for their invaluable advice and encouragement during my study and preparation of this manuscript.

I am grateful to the Project Director of Participatory Development of Agricultural Technology Project (PAATP), Agency for Agricultural Research and Development (AARD), and the Ministry of Agriculture, Government of Indonesia for the scholarship and the opportunity to pursue a postgraduate program at Universiti Putra Malaysia.

I would also like to express my deepest thanks to my husband Iwan M. Purwanto and my sons Muhammad Ihsan Nursyahid and Dwiputra Ahmad Ramdani for their encouragement, patience, and moral support during the period of study. Finally, my sincere appreciations to my friends and colleagues for their assistance during my study. Above all, ALLAH SWT the Most Gracious and Merciful who gave me strength to successfully complete my studies.



This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfillment of the requirement for the degree of Master of Agricultural Science. The members of the Supervisory Committee are as follows:

**Uma Rani Sinniah, Ph.D.**  
Faculty of Agriculture,  
Universiti Putra Malaysia.  
(Chairperson)

**Mohd. Khanif Yusop, Ph.D.**  
Associate Professor/ Dean,  
Faculty of Agriculture,  
Universiti Putra Malaysia.  
(Member)

**Rajan Amarthalingam, Ph.D.**  
Associate Professor,  
Faculty of Agriculture,  
Universiti Putra Malaysia.  
(Member)

---

**AINI IDERIS, Ph.D.**  
Professor /Dean,  
School of Graduate Studies,  
Universiti Putra Malaysia.

Date :

## TABLE OF CONTENTS

		<b>Page</b>
ABSTRACT		ii
ABSTRAK		vi
ACKNOWLEDGEMENTS		x
APPROVAL		xi
DECLARATION		xiii
LIST OF TABLES		xvii
LIST OF FIGURES		xxi
LIST OF PLATES		xxiii
LIST OF ABBREVIATIONS/ NOTATIONS		xxv
CHAPTER		
1	GENERAL INTRODUCTION	1
	1.1 Background	1
	1.2 Objectives	4
2	LITERATURE REVIEW	5
	2.1 Growth and Development of The Rice Plant	5
	2.2.1 Vegetative Stage	5
	2.2.2 Reproductive Stage	6
	2.2.3 Ripening Stage	7
	2.1 Rice Crop Establishment Practices	9
	2.2 Lodging	11
	2.3.1 Types of Lodging and Damage	11
	2.3.2 Factors Affecting Lodging	13
	2.3.3 Methods for Evaluating Lodging Resistance	14
	2.4 Stand Establishment	15
	2.5 Plant Growth Substances	17
	2.5.1 Auxins	18
	2.5.2 Gibberellic Acids (GAs)	20
	2.5.3 Plant Growth Retardants	24
3	THE EFFECT OF GA <sub>3</sub> AND IBA AS SEED TREATMENT ON SEEDLING ESTABLISHMENT, GROWTH AND YIELD OF FOUR WET SEEDED RICE ( <i>Oryza sativa</i> L.) CULTIVARS	31
	3.1 Introduction	31
	3.2 Materials and Methods	32
	3.2.1 Location	32
	3.2.2 Crop Establishment	32
	3.2.3 Treatment, Experimental Design and Layout of the Experiment	33
	3.2.4 Crop Management	35
	3.2.5 Parameters Evaluated	35
	3.2.6 Statistical Analyses	39



3.3	Results and Discussion	40
3.3.1	The Effect of Treatments on Shoot Growth	40
3.3.2	The Effect of Treatments on Root Growth	60
3.3.3	The Effect of Treatments on Mature Plant	74
3.4	Overall Discussion	77
4	THE EFFECT OF PACLOBUTRAZOL AND PROHEXADIONE CALCIUM AS FOLIAR SPRAY ON GROWTH, LODGING RESISTANCE AND YIELD OF FOUR WET SEEDED RICE ( <i>Oryza sativa</i> L.) CULTIVARS	79
4.1	Introduction	79
4.2	Materials and Methods	80
4.2.1	Location	80
4.2.2	Crop Establishment	81
4.2.3	Treatment, Experimental Design and Layout of the Experiment	81
4.2.4	Crop Management	82
4.2.5	Parameters Evaluated	83
4.2.6	Statistical Analyses	91
4.3	Results and Discussion	92
4.3.1	The effect of Treatments on Physical Characteristics	92
4.3.2	The Effect of Treatments on Lodging Resistance	103
4.3.3	The Effect of Treatments on Cell Wall Substances	107
4.3.4	Histological Study	110
4.3.5	The Effect of Treatments on Chlorophyll Content, Photosynthetic Rate and Flag Leaf Area	120
4.3.6	The Effect of Treatments on Yield Components and Grain Yield	123
4.4.	Overall Discussion	125
5	THE EFFECT OF COMBINED APPLICATION OF GROWTH REGULATORS AS SEED TREATMENT AND FOLIAR SPRAY ON GROWTH, LODGING RESISTANCE AND YIELD OF TWO WET SEEDED RICE ( <i>Oryza sativa</i> L) CULTIVARS	128
5.1	Introduction	128
5.2	Materials and Methods	129
5.2.1	Location of Experiment and Crop Establishment	129
5.2.2	Treatment, Experimental Design and Layout of the Experiment	129
5.2.3	Parameters Evaluated	130
5.2.4	Statistical Analyses	131
5.3	Results and Discussion	133
5.3.1	The Effect of Treatments on Root Growth	133
5.3.2	The Effect of Treatments on Physical Characteristics	138
5.3.3	The Effect of Treatments on Lodging Resistance	147
5.3.4	The Effect of Treatments on Flag Leaf Characteristics, Chlorophyll Content and Photosynthetic Rate	149



5.3.5	The Effect of Treatments on Yield Components and Grain Yield	154
5.4	Overall Discussion	155
6	GENERAL DISCUSSION AND CONCLUSIONS	157
	REFERENCES	162
	APPENDICES	174
	BIODATA OF THE AUTHOR	205



## LIST OF TABLES

<b>Table</b>		<b>Page</b>
3.1	The treatment combinations used as seed treatment	34
3.2	The effect of growth regulators on shoot length at one to three weeks after sowing (cm)	47
3.3	The interaction effect between growth regulators and cultivars on shoot length at one week after sowing (cm)	50
3.4	The interaction effect between growth regulators and cultivars on shoot length at three weeks after sowing (cm)	51
3.5	The effect of growth regulators on shoot dry weight at one to three weeks after sowing (g/seedling)	52
3.6	The interaction effect between growth regulators and cultivars on shoot dry weight at one week after sowing (g/seedling)	53
3.7	The effect of growth regulators on leaf area at one week after sowing (cm <sup>2</sup> / 3 leaves)	54
3.8	The interaction effect between growth regulators and cultivars on leaf area at two weeks after sowing (cm <sup>2</sup> / 3 leaves)	55
3.9	The interaction effect between growth regulators and cultivars on leaf area at three weeks after sowing (cm <sup>2</sup> / 3 leaves)	56
3.10	The effect of growth regulators on leaf chlorophyll content at one to three weeks after sowing (mg cm <sup>-2</sup> )	57
3.11	Cultivar differences in leaf chlorophyll content at one to three weeks after sowing (mg cm <sup>-2</sup> )	58
3.12	The effect of growth regulators on number of adventitious roots of rice seedlings (no./seedling)	66
3.13	Cultivar differences in production of adventitious roots	67
3.14	The effect of growth regulators on root length at one week after sowing (cm)	68





3.15	The interaction effect between growth regulators and cultivars on root length of rice seedlings at two weeks after sowing (cm)	69
3.16	The interaction effect between growth regulators and cultivars on root length of rice seedlings at three weeks after sowing (cm)	70
3.17	The effect of growth regulators on root dry weight of rice seedlings at one to three weeks after sowing (mg/seedling)	71
3.18	Cultivar differences in root dry weight of rice seedlings at one to three weeks after sowing (mg/seedling)	71
3.19	The effect of growth regulators on root dry weight of rice seedlings of cultivar MR 219 at one and two weeks after sowing (mg/seedling)	72
3.20	Cultivar differences in plant height and tiller numbers	74
3.21	Cultivar differences in diameter of culm base, culm length and culm index at harvest	75
3.22	Cultivar differences in grain yield and yield components	76
3.23	The effect of growth regulators on grain yield and yield components	77
4.1	The treatment combinations used as foliar spray	82
4.2	The effect of growth retardants on plant height (cm)	93
4.3	Cultivar differences in plant height (cm)	95
4.4	The effect of growth retardants on internode length (cm)	96
4.5	Cultivar differences in internode length (cm)	97
4.6	The interaction effect between growth retardants and cultivars on the second internode length (cm)	98
4.7	The effect of growth retardants on culm diameter (mm)	101
4.8	Cultivar differences in culm diameter (mm)	101
4.9	The effect of growth retardants on bending resistance of stem (g)	103
4.10	Cultivar differences in stem bending resistance (g)	104



4.11	The effect of growth retardants on stem breaking resistance (g)	105
4.12	Cultivar differences in stem breaking resistance (g)	105
4.13	The effect of growth retardants on hemicellulose, lignin and cellulose content in stems (g/100 g stem)	108
4.14	Cultivar differences in hemicellulose, lignin and cellulose content in stems (g/100 g stem)	108
4.15	The effect of growth retardants on outer and inner culm diameter (mm) and culm thickness ( $\mu\text{m}$ ) of rice plants	111
4.16	The effect of growth retardants on number of large and small vascular bundles	112
4.17	The effect of growth retardants on wall thickness, widest and narrowest diameter of parenchyma cells	114
4.18	The effect of growth retardants on chlorophyll content, flag leaf area, total chlorophyll content per leaf and photosynthetic rate	122
4.19	Cultivar differences in chlorophyll content, flag leaf area, total chlorophyll content per leaf and photosynthetic rate	123
4.20	The effect of growth retardants on grain yield and yield components	124
4.21	Cultivar differences in grain yield and yield components	125
5.1	Treatment combinations used as seed treatment and foliar spray	130
5.2	The effect of seed treatments on root dry weight of cultivar Widas and MR 219 (mg/seedling)	135
5.3	The effect of treatments on plant height of cultivar Widas and MR 219 (cm)	139
5.4	The effect of treatment combinations on plant height of Widas at one week after spraying and at harvest (cm)	139
5.5	The effect of treatment combinations on plant height of MR 219 at one week after spraying and at harvest (cm)	140
5.6	The effect of treatments on internode length of cultivar Widas at harvest (cm)	142



5.7	The effect of treatments on internode length of cultivar MR 219 at harvest (cm)	142
5.8	The effect of treatments on culm diameter of cultivar Widas at harvest (mm)	146
5.9	The effect of treatments on culm diameter of cultivar MR 219 at harvest (mm)	147
5.10	The effect of treatments on pulling down resistance and stem breaking resistance of cultivar Widas at harvest	148
5.11	The effect of treatments on pulling down resistance and stem breaking resistance of cultivar MR 219 at harvest	149
5.12	The effect of treatments on flag leaf characteristics of cultivar Widas	150
5.13	The effect of treatments on flag leaf characteristics of cultivar MR 219	151
5.14	The effect of treatments on leaf chlorophyll content and photosynthetic rate of cultivar Widas	153
5.15	The effect of treatments on leaf chlorophyll content and photosynthetic rate of cultivar MR 219	153
5.16	The effect of treatments on yield components and grain yield of cultivar Widas	154
5.17	The effect of treatments on yield components and grain yield of cultivar MR 219	155

## LIST OF FIGURES

Figure		Page
2.1	The chemical structure of Indole-3 butyric acid	20
2.2	The chemical structure of Gibberellic acid-3	21
2.3	The chemical structure of Paclobutrazol	26
2.4	Sites of action for paclobutrazol and prohexadione calcium in the inhibition of gibberellic acid biosynthesis	26
2.5	The chemical structure of Prohexadione-calcium	28
3.1	The effect of growth regulators on shoot length of Memberamo seedlings	42
3.2	The effect of growth regulators on shoot length of Widas seedlings	42
3.3	The effect of growth regulators on shoot length of MR 219 seedlings	43
3.4	The effect of growth regulators on shoot length of MR84 seedlings	43
3.5	Recovery of Widas rice seedlings from the effect of GA <sub>3</sub>	59
3.6	The effect of growth regulators on root length of Memberamo seedlings	61
3.7	The effect of growth regulators on root length of Widas seedlings	62
3.8	The effect of growth regulators on root length of MR 219 seedlings	63
3.9	The effect of growth regulators on root length of MR 84 seedlings	64
4.1	The effect of growth retardants on culm length	99
4.2	Cultivar differences in culm length	99



5.1	Root length of treated and untreated plants of cultivar Widas	134
5.2	Root length of treated and untreated plants of cultivar MR 219	134
5.3	The effect of treatments on culm length of cultivar Widas	144
5.4	The effect of treatments on culm length of cultivar MR 219	145



## LIST OF PLATES

<b>Plate</b>		<b>Page</b>
2.1	Detection of panicle initiation by dissection	8
2.2	Detection of panicle initiation by sheath removal	8
3.1	Normal, GA <sub>3</sub> effected and recovered shoots	37
3.2	The effect of growth regulators on MR 219 seedlings at two days after sowing	44
3.3	The effect of growth regulators on MR 219 seedlings at five days after sowing	45
3.4	The effect of growth regulators on shoot growth of MR 219 seedlings at one week after sowing	48
3.5	The effect of growth regulators on shoot growth of MR 219 seedlings at two weeks after sowing	49
3.6	The effect of growth regulators on adventitious roots of MR 219 seedlings at three days after sowing	65
3.7	The effect of growth regulators on adventitious roots of MR 219 seedlings at five days after sowing	65
4.1	Instron apparatus for measuring stem bending resistance	85
4.2	Method for measuring stem breaking resistance	85
4.3	Determination of outer and inner diameter of rice culm	91
4.4	Differences in foliage growth in treated and untreated MR 219 plants at one week after treatment	94
4.5	Effect of growth retardants on the third internode length of MR 219 at harvest	96
4.6	Cross section of normal rice culm and enlarged view of small and large vascular bundles	115
4.7	Cross section of the third internode of untreated and treated plants	116



4.8	Large vascular bundles in culms of untreated and treated plants	117
4.9	Small vascular bundles in culms of untreated and treated plants	118
4.10	Culm parenchyma cells of untreated and treated plants	119
5.1	Method for measuring pulling down resistance	132
5.2	Shoot and root development in untreated and IBA treated rice seedlings at two weeks after sowing	136
5.3	Shoot and root development in untreated and IBA treated rice seedlings at three weeks after sowing	137
5.4	Retardation in the second internode of treated MR 219 plants at harvest	143
5.5	Flag leaves of treated and untreated plants of cultivar Widas	151
5.6	Flag leaves of treated and untreated plants of cultivar MR 219	152

