

Modifying poppy growth and alkaloid yield with plant growth regulators

by

Geoffrey J. Dean

B. Agr. Sc. (Hons)

Submitted in fulfilment of the requirements

for the degree of

Master of Agricultural Science

University of Tasmania

Hobart

June 2011

I, Geoffrey Johnson Dean, declare that this thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duly acknowledged in the thesis, and to the best of my knowledge and belief, no material previously published or written by another person except where due acknowledgement is made in the text of the thesis, nor does the thesis contain any material that infringes copyright.

Signed:

Date:

This thesis may be made available for loan and limited copying in accordance with the *Copyright Act 1968*.

Signed:

Date:

ABSTRACT

Poppies (*Papaver somniferum* L.) are a major crop in Tasmanian broad-acre cropping rotations. Morphine has been the major alkaloid produced but now approximately half of the State's production is derived from thebaine-producing poppies. Yield potential in poppies is enhanced with earlier sowing, however this commonly results in excess vegetative growth and crop lodging. The effects of a range of plant growth regulators on plant growth and alkaloid yield of thebaine poppies were evaluated in three preliminary field trials conducted in northern Tasmania from 2002 - 04. Application of Slow Grow (maleic hydrazide) reduced seed weight in most trials and this result is potentially beneficial to industry as thebaine poppy seed is of limited commercial value due to thebaine residues. Application of Moddus (trinexapac) and Sunny (uniconazole) showed the greatest potential by altering alkaloid profile and reducing plant height respectively.

In a subsequent field trial with morphine poppies, single and split applications of Sunny across three growth stages were compared and while plant height was reduced, effects on plant lodging were inconsistent. Whereas lodging was decreased with the split application, the single application increased lodging, perhaps a result of the large height difference between main stem and lateral capsules. The split application of Sunny also resulted in a greater capsule yield compared with single and nil treatments through increased capsules/m². Despite a reduction in individual seed weight, seed yield from Sunny treatments was also greater due to a large increase in the number of seeds per capsule. It is proposed that the reduction in plant height and lodging with application of Sunny leads to reallocation of assimilates to yield components. Alkaloid content, in particular morphine, was also increased with application of Sunny and this is likely to be a result of extended alkaloid biosynthesis through delayed maturity.

The alkaloid, thebaine, is of higher value than oripavine and application of Moddus in three additional rate and timing trials consistently increased thebaine content. Associated with this, oripavine content decreased and this effect was rate responsive. In contrast with Sunny, Moddus had little effect on plant height or maturity. Instead, seed yield was reduced and straw yield tended to increase and combined with alkaloid effects, this consistently increased thebaine yield around 25%. Multiple and split

applications of Moddus tended to further increase thebaine content. As total alkaloid did not vary with single applications, it was postulated that Moddus inhibits the biosynthesis of oripavine from thebaine.

Results from this study and further trials conducted by industry have led to the registration of Moddus on poppy crops and close to 100% adoption rates by thebaine poppy growers. The potential of Sunny as a plant growth regulator (now marketed as Sumagic) has also been verified and in addition the benefit of split applications of both Sunny and Moddus demonstrated.

ACKNOWLEDGEMENTS

There are a number of people who I wish to sincerely thank for helping complete this thesis.

In particular I thank my more recent supervisors, Tina Acuna and Meixue Zhou for their persistence and good humour over the last year and also Neville Mendham for travelling the long haul where others couldn't see the light. I also thank Sergey Shabala for his assistance in dealing with administrative issues. Tony Fist has provided me with invaluable support and comment on poppy matters as have other staff at Tas Alkaloids.

Fellow higher degree students have been helpful in bouncing ideas and providing suggestions, advice on thesis writing and with formatting, in particular Angela Merry. I also thank Simon Munford and Brett Davey for technical assistance with field trials and Anne Lucadou-Wells and Margaret Quill for their library support.

Thank you to Horticulture Australia Limited and Tasmanian Alkaloids for the funding and thus enabling me to work in an interesting area. My gratitude also to the growers on whose properties these trials were conducted.

In many ways this was an example of how not to do a higher degree: start later in life; attempt to do it while actively working and completely change topics after 5 years! However after a number of years this stage of my life is completed and no one will be more happy than my wonderful wife Jo (who I thank for her understanding and my reduced household chores) and my two lovely boys Jack and Laurie who will see more of their father and who may find they can now be noisier before bedtime.

CONTENTS

ABSTRACT	III
ACKNOWLEDGEMENTS.....	V
CHAPTER 1. INTRODUCTION.....	ERROR! BOOKMARK NOT DEFINED.
CHAPTER 2. LITERATURE REVIEW	ERROR! BOOKMARK NOT DEFINED.
2.1 Poppy production and alkaloid biosynthesis	Error! Bookmark not defined.
2.1.1 Introduction.....	Error! Bookmark not defined.
2.1.2 Cultural requirements	Error! Bookmark not defined.
2.1.3 Poppy alkaloids and biosynthesis	Error! Bookmark not defined.
2.2 Crop lodging	Error! Bookmark not defined.
2.2.1 Introduction.....	Error! Bookmark not defined.
2.2.2 Crop losses from lodging	Error! Bookmark not defined.
2.2.3 Plant characteristics associated with reduced lodging.....	Error! Bookmark not defined.
2.2.3.1 Stem characteristics.....	Error! Bookmark not defined.
2.2.3.2 Root characteristics	Error! Bookmark not defined.
2.2.4 Lodging and crop management.....	Error! Bookmark not defined.
2.3 Use and effects of plant growth regulators	Error! Bookmark not defined.
2.3.1 Introduction.....	Error! Bookmark not defined.
2.3.2 Effects of plant growth regulators on plant hormones and secondary metabolites	Error!
Bookmark not defined.	
2.3.2.1 Gibberellic acid metabolism	Error! Bookmark not defined.
2.3.2.2 Absciscic acid metabolism	Error! Bookmark not defined.
2.3.2.3 Ethylene metabolism	Error! Bookmark not defined.
2.3.2.4 Cytokinin metabolism	Error! Bookmark not defined.
2.3.2.5 Flavonoid metabolism	Error! Bookmark not defined.
2.3.3 Effects of plant growth regulators on plant morphology and development	Error! Bookmark not defined.
defined.	
2.3.3.1 Stem characteristics.....	Error! Bookmark not defined.
2.3.3.2 Root characteristics	Error! Bookmark not defined.
2.3.3.3 Maturity	Error! Bookmark not defined.
2.3.4 Variability in effects of plant growth regulators.....	Error! Bookmark not defined.
2.3.4.1 Plant species and variety	Error! Bookmark not defined.

2.3.4.2 Crop stage of development/timing of application.....	Error! Bookmark not defined.
2.3.4.3 Chemical uptake, activation and duration of activity.....	Error! Bookmark not defined.
2.3.4.4 Rate of chemical applied	Error! Bookmark not defined.
2.3.4.5 Weather and growing conditions	Error! Bookmark not defined.
2.3.4.6 Crop management	Error! Bookmark not defined.
2.3.5 The role of canopy size in PGR function	Error! Bookmark not defined.
2.3.6 Summary and scope of thesis.....	Error! Bookmark not defined.

CHAPTER 3. SCREENING OF PLANT GROWTH REGULATORS TO REDUCE LODGING IN POPPIES..... ERROR! BOOKMARK NOT DEFINED.

3.1 Introduction Error! Bookmark not defined.

3.2 Materials and methods Error! Bookmark not defined.

3.2.1 Field trial design and treatments.....	Error! Bookmark not defined.
3.2.2 Cultural details.....	Error! Bookmark not defined.
3.2.3 Trial measurements and harvest procedure	Error! Bookmark not defined.
3.2.4 Sample analysis	Error! Bookmark not defined.
3.2.5 Statistical analysis.....	Error! Bookmark not defined.

3.3 Results..... Error! Bookmark not defined.

3.3.1 Preliminary PGR screening trial: Cressy 2002-03	Error! Bookmark not defined.
3.3.1.1 The effect of PGR application on plant growth and yield components	Error! Bookmark not defined.
3.3.1.2 The effect of PGR application on alkaloid.....	Error! Bookmark not defined.
3.3.2 PGR screening trial: Symmons, 2003-04.....	Error! Bookmark not defined.
3.3.3 PGR screening trial: Hagley, 2004-05	Error! Bookmark not defined.
3.3.3.1 The effect of PGR application on plant growth and yield components	Error! Bookmark not defined.
3.3.3.2 The effect of PGR application on alkaloid.....	Error! Bookmark not defined.

3.4 Discussion Error! Bookmark not defined.

3.4.1 The effect of PGR application on plant growth	Error! Bookmark not defined.
3.4.2 The effect of PGR application on yield components	Error! Bookmark not defined.
3.4.3 The effect of PGR application on alkaloid	Error! Bookmark not defined.

CHAPTER 4. THE EFFECT OF APPLICATION RATE AND TIMING OF THE PLANT GROWTH REGULATOR MODDUS ON POPPIESERROR! BOOKMARK NOT DEFINED.

4.1 Introduction	Error! Bookmark not defined.
4.2 Materials and Methods	Error! Bookmark not defined.
4.2.1 Trial design and treatments.....	Error! Bookmark not defined.
4.2.2 Cultural details, measurements and processing	Error! Bookmark not defined.
4.2.3 Statistical analysis.....	Error! Bookmark not defined.
4.3 Results.....	Error! Bookmark not defined.
4.3.1 Trial at Symmons, 2003-04	Error! Bookmark not defined.
4.3.1.1 The effect of Moddus application on growth and yield components	Error! Bookmark not defined.
4.3.1.2 The effect of Moddus application on alkaloid	Error! Bookmark not defined.
4.3.2 Trial at Hagley, 2004-05	Error! Bookmark not defined.
4.3.2.1 The effect of Moddus application on growth and yield components	Error! Bookmark not defined.
4.3.2.2 The effect of Moddus application on alkaloid	Error! Bookmark not defined.
4.3.3 Trial at Symmons, 2004-05	Error! Bookmark not defined.
4.4 Discussion	Error! Bookmark not defined.
4.4.1 The effect of Moddus application on growth and yield components	Error! Bookmark not defined.
4.4.2 The effect of Moddus application on alkaloid	Error! Bookmark not defined.
 CHAPTER 5. THE EFFECT OF SOWING RATE AND SPLIT APPLICATION OF SUNNY ON MORPHINE POPPIES	
ERROR! BOOKMARK NOT DEFINED.	
5.1 Introduction	Error! Bookmark not defined.
5.2 Materials and methods	Error! Bookmark not defined.
5.2.1 Field trial design and treatments.....	Error! Bookmark not defined.
5.2.2 Cultural details, measurements and processing	Error! Bookmark not defined.
5.2.3 Statistical analysis.....	Error! Bookmark not defined.
5.3 Results.....	Error! Bookmark not defined.
5.3.1 The effect of sowing rate and Sunny application on plant growth ..	Error! Bookmark not defined.
5.3.2 The effect of sowing rate and Sunny application on yield components	Error! Bookmark not defined.
5.3.3 The effect of sowing rate and Sunny application on alkaloid content	Error! Bookmark not defined.
5.4 Discussion	Error! Bookmark not defined.

5.4.1 The effect of sowing rate on growth, yield and alkaloid	Error! Bookmark not defined.
5.4.2 The effect of Sunny application on growth, yield and alkaloid	Error! Bookmark not defined.

CHAPTER 6. GENERAL CONCLUSIONS AND RECOMMENDATIONS.....	ERROR!
BOOKMARK NOT DEFINED.	

REFERENCES.....	ERROR! BOOKMARK NOT DEFINED.
------------------------	-------------------------------------

APPENDIX 1	ERROR! BOOKMARK NOT DEFINED.
-------------------------	-------------------------------------