



รายงานวิจัยฉบับสมบูรณ์

โครงการ

การผลิตเมล็ดพันธุ์พืชอาหารสัตว์
เพื่อเพิ่มรายได้สำหรับเกษตรกรในหมู่บ้าน

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คณะเกษตรศาสตร์
มหาวิทยาลัยอุบลราชธานี

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บทสรุปสำหรับผู้บริหาร

โครงการวิจัยเรื่อง “การผลิตเมล็ดพันธุ์พืชอาหารสัตว์เพื่อเพิ่มรายได้สำหรับเกษตรกรในหมู่บ้าน” นี้ได้รับการสนับสนุนจากสำนักงานกองทุนสนับสนุนการวิจัย โดยดำเนินการที่คณะเกษตรศาสตร์ มหาวิทยาลัยอุบลราชธานี ตั้งแต่เดือนพฤศจิกายน 2548 ถึงเมษายน 2550

โปรแกรมการผลิตเมล็ดพันธุ์ที่มีคุณภาพสูงของหญ้ามูลาโท II หญ้าพาสพาล์มอุบล และถั่วสโตโลอุบล ในหมู่บ้านของโครงการประสบความสำเร็จเพียงบางส่วน มีเกษตรกรจำนวน 30 ราย ในหมู่บ้านหนึ่งของอำเภอวารินชำราบ จังหวัดอุบลราชธานี ซึ่งได้เข้าร่วมการผลิตเมล็ดพันธุ์สามารถผลิตเมล็ดพันธุ์หญ้าพาสพาล์มอุบล ได้ 6,600 กิโลกรัม และถั่วสโตโลอุบล 7,138 กิโลกรัม โดยเกษตรกรทั้ง 30 รายนี้ได้รับเงินสดจากโครงการรวม 1,241,800 บาท สำหรับเมล็ดพันธุ์ทั้งสองชนิด ในวันเดียวกับการรับซื้อเมล็ดพันธุ์

การผลิตเมล็ดพันธุ์หญ้ามูลาโท II ของโครงการประสบความสำเร็จไม่มากนัก เนื่องจากมีเกษตรกรเพียง 9% ที่เห็นสัญญาได้ผลิตเมล็ดพันธุ์ จำนวน 2,598 กิโลกรัม มาจำหน่าย เหตุผลหลักที่มีจำนวนเกษตรกรผลิตเมล็ดพันธุ์น้อยก็คือ โดยทั่วไป เกษตรกรในหลายหมู่บ้านในจังหวัดอุบลราชธานีมีความสนใจการผลิตข้าวมากกว่า อีกทั้งช่วงเวลาเก็บเกี่ยวข้าวก็เป็นช่วงเวลาเดียวกับการเก็บเกี่ยวเมล็ดพันธุ์หญ้ามูลาโท II นอกจากนี้ สภาพพื้นที่ลุ่มในจังหวัดอุบลราชธานีไม่ค่อยเหมาะกับการการผลิตเมล็ดพันธุ์หญ้ามูลาโท II ซึ่งเป็นหญ้าที่ต้องการดินดอนที่ระบายน้ำดี มีเพียงบางพื้นที่ในอำเภอนูนทริก วารินชำราบ และเขื่องใน ที่พบว่ามีความเหมาะสม และเกษตรกรมีความสนใจ

ในปี พ.ศ. 2550 มีเกษตรกรจำนวน 323 รายได้เห็นสัญญาเพื่อผลิตเมล็ดพันธุ์หญ้ามูลาโท II โดยเกษตรกรในกลุ่มนี้ จำนวน 112 รายอยู่ในจังหวัดอำนาจเจริญ และ 130 รายอยู่ในจังหวัดมุกดาหาร เกษตรกรกลุ่มดังกล่าวในสองจังหวัดนี้มีประสบการณ์อันยาวนานในการปลูกพืชอาหารสัตว์เพื่อผลิตเมล็ดพันธุ์ และส่วนใหญ่ก็เป็นเกษตรกรกลุ่มนี้เองที่ได้ทำสัญญาผลิตเมล็ดพันธุ์หญ้ามูลาโท II ในปี พ.ศ. 2550 โครงการจะดำเนินต่อเนื่องไปเรื่อยๆ ด้วยเงินสนับสนุนจากบริษัทเอกชน และโครงการจะยังคงพัฒนาและสนับสนุนอย่างต่อเนื่องเพื่อให้ภูมิภาคนี้เป็นศูนย์กลางความเป็นเลิศในการผลิตเมล็ดพันธุ์พืชอาหารสัตว์ต่อไป

จากการวิเคราะห์ผลตอบแทนทางเศรษฐกิจของการผลิตเมล็ดพันธุ์พืชอาหารสัตว์พบว่า การผลิตเมล็ดพันธุ์พืชอาหารสัตว์จะทำให้เกษตรกรมีรายได้ถึง 2-3 เท่าเมื่อเปรียบเทียบกับรายได้ที่เกษตรกรได้รับการผลิตพืชไร่อื่นๆ เช่น ข้าวโพด มันสำปะหลัง และอ้อย

สำหรับวิธีการเก็บเมล็ดพันธุ์หญ้ามูลาโท II พบว่าวิธีใช้ถุงในลอนสวมช่อดอกเพื่อเก็บเกี่ยวเมล็ดพันธุ์ เป็นวิธีที่ให้ผลผลิตเมล็ดพันธุ์หญ้าสูงสุด ส่วนในการศึกษาเกี่ยวกับการใช้สารควบคุมการเติบโตของพืชและสารพอลิเมอร์จากแป้ง พบว่าไม่ได้ช่วยเพิ่มผลผลิตเมล็ดพันธุ์หญ้าพาสพาล์มอุบล และมูลาโท II

บทคัดย่อ

โครงการวิจัยเรื่อง "การผลิตเมล็ดพันธุ์พืชอาหารสัตว์เพื่อเพิ่มรายได้สำหรับเกษตรกรในหมู่บ้าน" นี้ได้รับการสนับสนุนจากสำนักงานกองทุนสนับสนุนการวิจัย โดยดำเนินการที่คณะเกษตรศาสตร์ มหาวิทยาลัยอุบลราชธานี ตั้งแต่เดือนพฤศจิกายน 2548 ถึงเมษายน 2550

โปรแกรมการผลิตเมล็ดพันธุ์ที่มีคุณภาพสูงของหญ้ามูลาโท II หญ้าพาสพาล์มอุบล และถั่วสโตโลอุบล ในหมู่บ้านของโครงการประสบความสำเร็จเพียงบางส่วน มีเกษตรกรจำนวน 30 ราย ในหมู่บ้านหนึ่งของอำเภวารินชำราบ จังหวัดอุบลราชธานี ซึ่งได้เข้าร่วมการผลิตเมล็ดพันธุ์สามารถผลิตเมล็ดพันธุ์หญ้าพาสพาล์มอุบล ได้ 6,600 กิโลกรัม และถั่วสโตโลอุบล 7,138 กิโลกรัม โดยเกษตรกรทั้ง 30 รายนี้ได้รับเงินสดจากโครงการรวม 1,241,800 บาท สำหรับเมล็ดพันธุ์ทั้งสองชนิด ในวันเดียวกับการรับซื้อเมล็ดพันธุ์

การผลิตเมล็ดพันธุ์หญ้ามูลาโท II ของโครงการประสบความสำเร็จไม่มากนัก เนื่องจากมีเกษตรกรเพียง 9% ที่เห็นสัญญาได้ผลิตเมล็ดพันธุ์ จำนวน 2,598 กิโลกรัม มาจำหน่าย เหตุผลหลักที่มีจำนวนเกษตรกรผลิตเมล็ดพันธุ์น้อยก็คือ โดยทั่วไป เกษตรกรในหลายหมู่บ้านในจังหวัดอุบลราชธานีมีความสนใจการผลิตข้าวมากกว่า อีกทั้งช่วงเวลาเก็บเกี่ยวข้าวก็เป็นช่วงเวลาเดียวกับการเก็บเกี่ยวเมล็ดพันธุ์หญ้ามูลาโท II นอกจากนี้ สภาพพื้นที่ลุ่มในจังหวัดอุบลราชธานีไม่ค่อยเหมาะกับการการผลิตเมล็ดพันธุ์หญ้ามูลาโท II ซึ่งเป็นหญ้าที่ต้องการดินดอนที่ระบายน้ำดี มีเพียงบางพื้นที่ในอำเภอหนองრიง วารินชำราบ และเขื่องใน ที่พบว่ามีความเหมาะสม และเกษตรกรมีความสนใจ

โครงการได้พัฒนาตลาดส่งออกขนาดเล็กสำหรับเมล็ดพันธุ์หญ้าพาสพาล์มอุบล (5,000 กิโลกรัม) และถั่วสโตโลอุบล (4,000 กิโลกรัม) โครงการได้ส่งออกเมล็ดพันธุ์หญ้ามูลาโท II ไปยังประเทศวานูอาตู คอสตาริกา และลาว และได้เริ่มพัฒนาตลาดท้องถิ่นขนาดเล็กภายในประเทศไทยด้วย มีเกษตรกรบางรายเต็มใจที่จะจ่ายเงินซื้อเมล็ดพันธุ์หญ้ามูลาโท II ที่ผ่านการกักตุน (Scarfity) ด้วยกรดแล้ว ในราคา 500 บาท/กิโลกรัม

ในปี พ.ศ. 2550 มีเกษตรกรจำนวน 323 รายได้เห็นสัญญาเพื่อผลิตเมล็ดพันธุ์หญ้ามูลาโท II โดยเกษตรกรในกลุ่มนี้ จำนวน 112 รายอยู่ในจังหวัดอำนาจเจริญ และ 130 รายอยู่ในจังหวัดมุกดาหาร เกษตรกรกลุ่มดังกล่าวในสองจังหวัดนี้มีประสบการณ์อันยาวนานในการปลูกพืชอาหารสัตว์เพื่อผลิตเมล็ดพันธุ์ และส่วนใหญ่ก็เป็นเกษตรกรกลุ่มนี้เองที่ได้ทำสัญญาผลิตเมล็ดพันธุ์หญ้ามูลาโท II ในปี พ.ศ. 2550 โครงการจะดำเนินต่อเนื่องไปเรื่อยๆ ด้วยเงินสนับสนุนจากบริษัทเอกชน "Grupo Papalotla" และจากกองทุนหมุนเวียนเมล็ดพันธุ์ของโครงการเอง และโครงการจะยังคงพัฒนาและสนับสนุนอย่างต่อเนื่องเพื่อให้ภูมิภาคนี้เป็นศูนย์กลางความเป็นเลิศในการผลิตเมล็ดพันธุ์พืชอาหารสัตว์ต่อไป

จากการวิเคราะห์ผลตอบแทนทางเศรษฐกิจของการผลิตเมล็ดพันธุ์พืชอาหารสัตว์พบว่า การผลิตเมล็ดพันธุ์พืชอาหารสัตว์จะทำให้เกษตรกรมีรายได้ถึง 2-3 เท่าเมื่อเปรียบเทียบกับรายได้ที่

เกษตรกรได้รับจากการผลิตพืชไร่อื่นๆ เช่น ข้าวโพด มันสำปะหลัง และอ้อย กล่าวคือการผลิตเมล็ดพันธุ์พืชอาหารสัตว์เกษตรกรจะได้ผลตอบแทนสุทธิระหว่าง 5,000-9,800 บาท/ไร่ ในขณะที่ผลตอบแทนจากพืชไร่อื่นๆอยู่ระหว่าง 1,200-3,000 บาท/ไร่

สำหรับวิธีการเก็บเมล็ดพันธุ์หญ้ามูลาโท II พบว่าวิธีใช้ถุงไนลอนสวมช่อดอกเพื่อเก็บเกี่ยวเมล็ดพันธุ์ เป็นวิธีที่ให้ผลผลิตเมล็ดพันธุ์หญ้าสูงสุด ส่วนในการศึกษาเกี่ยวกับการใช้สารควบคุมการเติบโตของพืชและสารพอลิเมอร์จากแป้ง พบว่าไม่ได้ช่วยเพิ่มผลผลิตเมล็ดพันธุ์หญ้าพาสพาลัมอุบลและมูลาโท II

โครงการยังคงผลิตผลงานวิจัยคุณภาพสูงระดับนานาชาติไว้เช่นเดิมโดยได้เขียน และตีพิมพ์บทความจำนวนเก้าเรื่องในช่วงระยะเวลาของการดำเนินงานของโครงการเป็นเวลา 18 เดือนที่ผ่านมา

รายงานการวิจัยฉบับสมบูรณ์

เสนอต่อสำนักงานกองทุนสนับสนุนการวิจัย

1 โครงการ

การผลิตเมล็ดพันธุ์พืชอาหารสัตว์เพื่อเพิ่มรายได้สำหรับเกษตรกรในหมู่บ้าน

2 เจ้าหน้าที่โครงการ

หัวหน้าโครงการ

ศ.(พิเศษ) ดร. ไมเคิล แฮร์

ผู้ร่วมวิจัย

ดร.กังวาน ธรรมแสง

รศ.ดร.วรพงษ์ สุริยภัทร

รศ.ดร.กิตติ วงศ์พิเชษฐ

เจ้าหน้าที่วิจัย

นายกิตติพัฒน์ สายประเสริฐ

นางสาวอารีรัตน์ ลุนผา

3 ระยะเวลาโครงการ

1 พฤศจิกายน 2548 ถึง 30 เมษายน 2550

4 ผลงานวิจัยของโครงการ

4.1 การผลิตเมล็ดพันธุ์พืชอาหารสัตว์ในหมู่บ้าน

4.1.1 การผลิตเมล็ดพันธุ์หญ้ามูลาโท II

วัตถุประสงค์

วัตถุประสงค์หลักของงานวิจัยนี้คือ เพื่อแสดงให้เห็นว่าเกษตรกรรายย่อยสามารถประสบความสำเร็จในการผลิตเมล็ดพันธุ์หญ้ามูลาโท II

วิธีการ

ในปี พ.ศ. 2549 มีเกษตรกรจำนวน 1,438 รายได้เซ็นสัญญาโครงการเพื่อผลิตเมล็ดพันธุ์หญ้ามูลาโท II (ตารางที่ 1) ในช่วงระหว่างเดือนพฤศจิกายน 2548 ถึงเมษายน 2549 โครงการได้เยี่ยมเยียนเกษตรกรตามหมู่บ้านต่างๆที่มีความสนใจผลิตเมล็ดพันธุ์พืชอาหารสัตว์ พร้อมทั้งได้จัดการประชุมขึ้นในหมู่บ้านเหล่านั้น โครงการนี้ได้รับความช่วยเหลือและความร่วมมืออย่างมากจากสมาชิกสภาจังหวัดอุบลราชธานี(สจ.) และธนาคารเพื่อการเกษตรและสหกรณ์การเกษตร(ธกส.) จังหวัดอำนาจเจริญ สมาชิกสภาจังหวัดอุบลราชธานีได้ให้ความช่วยเหลือและร่วมมือกับโครงการเป็นอย่างดีในการติดต่อเกษตรกร ในการจัดหาสถานที่ประชุม และช่วยเหลือในการเซ็นสัญญา ซึ่งหากปราศจากความช่วยเหลือดังกล่าวแล้ว คงเป็นไปได้ที่จะมีเกษตรกรจำนวนมากถึง 1,438 รายมาเซ็นสัญญา

เกษตรกรซึ่งเห็นสัญญาเหล่านี้ได้รับการฝึกอบรมที่หมู่บ้านเกี่ยวกับการผลิตเมล็ดพันธุ์พืชอาหารสัตว์ โดยโครงการได้นำเสนอขั้นตอนและวิธีการผลิตเมล็ดพันธุ์โดยเกษตรกรในหมู่บ้านด้วยวิธีหัตถ์และพาเวอร์พอยท์ รวมทั้งได้แจกจ่ายแผ่นพับเกี่ยวกับวิธีปลูก การจัดการ และการผลิตเมล็ดพันธุ์พืชอาหารสัตว์ ในช่วงการเห็นสัญญา เกษตรกรแต่ละรายได้รับเมล็ดพันธุ์แบบให้เปล่าจำนวน 100 กรัม (สำหรับพื้นที่หนึ่งถึงสองไร่) หรือ 200 กรัม (สำหรับพื้นที่มากกว่าสองไร่) เพื่อนำไปเพาะต้นกล้า

เมล็ดพันธุ์หญ้ามูลาโท II ที่แจกจ่ายให้เกษตรกรนั้นได้ผ่านการกักตุนเมล็ดด้วยกรดกำมะถันเป็นเวลา 20 นาทีในเดือนมีนาคม 2549 เพื่อเพิ่มความงอกจาก 24% เป็น 89% สำหรับวิธีการกักตุนเมล็ดแต่ละครั้ง ใช้เมล็ดพันธุ์ประมาณ 70 กิโลกรัมเทลงไปในเครื่องผสมคอนกรีต แล้วผสมเข้ากับกรดกำมะถันเป็นเวลา 20 นาที หลังจากนั้น นำเมล็ดพันธุ์แช่ลงในน้ำผสมปูนขาวเพื่อทำให้มีสภาพเป็นกลาง เสร็จแล้วจึงนำเมล็ดหญ้าไปล้างในน้ำไหลและทำให้แห้ง ในของบรรจุขนาด 100 กรัมมีเมล็ดพันธุ์ประมาณ 13,000 เมล็ด

ช่วงเดือนพฤษภาคมถึงตุลาคม 2549 โครงการได้เยี่ยมเยียนหมู่บ้านต่างๆอย่างสม่ำเสมอ (ประมาณทุก 3-4 สัปดาห์) และมีการตรวจพืชในแปลงด้วย ฤดูปลูกที่ผ่านไประหว่างเดือนพฤษภาคมถึงกรกฎาคม ปริมาณฝนต่ำกว่าค่าเฉลี่ย และเกษตรกรจำนวนมากปลูกหญ้าช้ากว่าที่ควร ในขณะที่หญ้าบางแปลงที่ปลูกก่อนได้ตายในเดือนมิถุนายนเนื่องจากความแห้งแล้ง จึงต้องปลูกใหม่ ส่วนฝนที่ตกหนักในเดือนสิงหาคมและกันยายนทำให้มีน้ำท่วมขังในหลายแปลง และในบางแห่งเกิดน้ำท่วม จึงทำให้หญ้าตาย

เจ้าหน้าที่ของโครงการได้ปฏิบัติหน้าที่เป็นอย่างดีในการแนะนำเกษตรกรที่สนใจเกี่ยวกับวิธีเตรียมดินหญ้าเพื่อเก็บเกี่ยวเมล็ดพันธุ์ และได้แจกจ่ายแผ่นซีดีเกี่ยวกับการจัดการก่อนเก็บเกี่ยวเมล็ดพันธุ์ไปยังเกษตรกรทุกกลุ่ม เกษตรกรได้รวบรวมดินหญ้าให้ตั้งขึ้นในช่วงที่ช่อดอกกำลังโผล่ออกมา และในระยะออกดอก ได้ผูกช่อดอกรวมเป็นช่ออีกครั้งหนึ่ง (รูปที่ 1 และ 2) ดังนั้น จึงมีการรวบรวมหญารวมสองครั้ง

ในการเก็บเมล็ดพันธุ์เกษตรกรจะเคาะเมล็ดพันธุ์หญ้ามูลาโท II ที่ยังสดลงในกระด้งทุกวันในช่วงเก็บเกี่ยว (รูปที่ 3) นำเมล็ดพันธุ์ที่เก็บเกี่ยวมาทำให้แห้งอย่างช้าๆในร่มเป็นเวลาสามวัน และนำออกตากแดดในวันที่สี่

โครงการได้รับซื้อเมล็ดพันธุ์ในสองระดับราคา กล่าวคือ เกษตรกรที่เก็บเกี่ยวเมล็ดพันธุ์ได้มากกว่า 100 กิโลกรัม โครงการรับซื้อในราคา 200 บาท/กิโลกรัม ส่วนเกษตรกรที่ผลิตได้น้อยกว่า 100 กิโลกรัม โครงการรับซื้อในราคา 180 บาท/กิโลกรัม



รูปที่ 1 หญ้ามูลาโท II สำหรับผลิตเมล็ดพันธุ์ที่จังหวัดอำนาจเจริญ



รูปที่ 2 หญ้ามูลาโท II สำหรับผลิตเมล็ดพันธุ์ที่จังหวัดอำนาจเจริญ



รูปที่ 3 การเก็บเกี่ยวเมล็ดพันธุ์หญ้ามูลาโท II ที่จังหวัดอำนาจเจริญ

ตารางที่ 1 การผลิตเมล็ดพันธุ์หญ้ามูลาโท II โดยเกษตรกรในหมู่บ้าน ปี พ.ศ. 2549

จังหวัด	หมู่บ้าน	อำเภอ	จำนวน เกษตรกรที่ เซ็นสัญญา	จำนวน เกษตรกรที่ เก็บเกี่ยว เมล็ดพันธุ์	ผลผลิต เมล็ดพันธุ์ (กก.)
อุบลราชธานี					
1	ปากกุดหวาย	วารินชำราบ	30	30	462
2	ทางสาย	วารินชำราบ	13	-	-
3	ขามใหญ่	เมือง	131	4	30
4	ชีเหล็ก	เมือง	93	-	-
5	หัวเรือ	เมือง	108	-	-
6	ปะอาว	เมือง	138	-	-
7	สว่าง	สำโรง	7	1	11
8	ป่าช้า	สว่างวีระวงศ์	2	1	16
9	กุดประพาย	เดชอุดม	8	1	10
10	นาเยีย	นาเยีย	27	-	-
11	หนองบก	เหล่าเสือโก้ก	9	-	-

12	จิก	เหล้าเสือไก่	4	-	-
13	สร้างถ่อ	เหล้าเสือไก่	11	3	39
14	หาด	เหล้าเสือไก่	16	2	20
15	หาดน้อย	เหล้าเสือไก่	18	2	10
16	สว้าง	ดอนมดแดง	41	2	19
17	คำไฮใหญ่	ดอนมดแดง	16	-	-
18	สร้างมิ่ง	ม่วงสามสิบ	3	-	-
19	หนองหลัก,เหล้าบุก	ม่วงสามสิบ	156	-	-
20	ดุมใหญ่	ม่วงสามสิบ	21	-	-
21	ทุ่งมณี	ม่วงสามสิบ	61	3	40
22	วังมน	ม่วงสามสิบ	13	1	14
23	คำหว่า	ตาลชุม	29	-	-
24	ท่าค้อ	เขื่องใน	15	-	-
25	ยางขึ้น	เขื่องใน	77	11	120
26	โนนข่า	พิบูลมังสาหาร	17	-	-
27	อ่างศิลา	พิบูลมังสาหาร	19	-	-
28	เรียงแถวได้	สิรินธร	31	-	-
29	ข้าวปุ้น	กุดข้าวปุ้น	8	-	-
30	โนนใหญ่	โพธิ์ไทร	63	-	-
31	เก่ากลาง	บุญชริก	25	14	105
32	จุกการ	ศรีเมืองใหม่	9	-	-
33	คำเตย	ศรีเมืองใหม่	33	-	-
34	หนองแสงใหญ่	โขงเจียม	21	6	20
35	หนองผือน้อย	โขงเจียม	9	-	-
36	ปากแซง	นาตาล	8	-	-
อำนาจเจริญ					
37	นาแต่	เมือง	30	2	421
38	คำงเหลื่อม	เมือง	39	10	232
39	แก้งกรีน	เมือง	22	15	507
40	ปากอ	ขาม่วน	36	19	498
41	ไร่ชี	ลืออำนาจ	19	-	-

ยโสธร					
42	เที่ยงเพ็ง	ป่าดิว	1	-	-
ศรีสะเกษ					
43	นารังกา	กันทรลักษณ์	1	1	24
	รวม		1,438	128	2,598

ผลการวิจัย

ในเดือนธันวาคม 2549 โครงการได้รับซื้อเมล็ดพันธุ์หมูมูลาโท II ที่มีคุณภาพดี ปริมาณ 2,598 กิโลกรัม จากเกษตรกรจำนวน 128 ราย และได้จ่ายเงินสดจำนวน 484,760 บาท ให้เกษตรกร ในวันที่ได้รับซื้อเมล็ดพันธุ์ เมื่อนำเมล็ดพันธุ์กลับมายังมหาวิทยาลัย ได้กักตุนเมล็ดพันธุ์ด้วยกรด กำมะถัน และทำความสะอาดอีกครั้ง ได้ปริมาณเมล็ดพันธุ์หลังทำความสะอาดในขั้นตอนสุดท้าย จำนวน 2,000 กิโลกรัม

โครงการได้ส่งออกเมล็ดพันธุ์ 1,900 กิโลกรัม (ตารางที่ 2) ส่วนอีก 100 กิโลกรัม เก็บไว้จำหน่ายภายในประเทศ

ตารางที่ 2 การส่งออกเมล็ดพันธุ์หมูมูลาโท II ในปี พ.ศ. 2550

ประเทศ	ปริมาณ (กิโลกรัม)
วานูอาตู	1,800
ลาว	100

แม้ว่าจะมีเกษตรกรจำนวนมากถึง 1,438 รายได้เซ็นสัญญาเพื่อผลิตเมล็ดพันธุ์ แต่มีเพียง 128 รายเท่านั้น (9%) ที่ประสบความสำเร็จในการผลิตเมล็ดพันธุ์ ทั้งนี้ เนื่องจากเหตุผลดังต่อไปนี้:

- 1 แม้จะมีเกษตรกรรายใหม่จำนวนมากเข้าร่วมประชุม แต่ที่เกษตรกรเหล่านั้นเซ็นสัญญาเนื่องจากสมาชิกสภาจังหวัด(สจ.)ที่อยู่ในท้องถิ่นเป็นผู้บอกให้ทำ โดยที่เกษตรกรได้รับเบี้ยเลี้ยงที่เข้าร่วมการประชุม โดยที่ตามความเป็นจริงแล้วเกษตรกรที่เข้าร่วมประชุมส่วนใหญ่ไม่สนใจและไม่มีความต้องการที่จะปลูกหมูเพื่อผลิตเมล็ดพันธุ์ ซึ่งอาจจะกล่าวได้ว่า การเซ็นสัญญาเป็นเพียงเรื่องตลกหรือทำกันเล่นๆ ไม่ได้จริงจังอะไร และการประชุมที่ถูกจัดขึ้นก็เพื่อความมั่งหวัง ผลทางการเมืองเท่านั้น ในเกษตรกรหลายราย เมล็ดพันธุ์ที่รับไปยังคงเก็บไว้อยู่ในบ้าน ในขณะที่เกษตรกรบางรายได้ส่งคืนเมล็ดพันธุ์
- 2 เกษตรกรรายใหม่หลายรายได้เพาะต้นกล้า แต่ก็ไม่ได้ย้ายลงปลูกในแปลง เนื่องจากไม่มีพื้นที่เพาะปลูกเพียงพอ ซึ่งปัญหานี้เกษตรกรก็ไม่ได้แจ้งแก่ทางโครงการขณะเมื่อมีการประชุม

แต่เกษตรกรก็ยังคงเห็นสัญญา หรือแม้ว่าพื้นที่ของเกษตรกรไม่เหมาะสมที่จะปลูกหญ้าก็ตาม
 ทั้งนี้เพียงเพื่อให้สมาชิกสภาจังหวัดพอใจเท่านั้น

3 เกษตรกรบางรายย้ายต้นกล้าลงปลูกในพื้นที่ลุ่มมาก ซึ่งเกิดน้ำท่วมขังในช่วงเดือนสิงหาคม-
 กันยายน จึงทำให้หญ้ามูลาโท II ตาย โดยที่เกษตรกรเหล่านั้นคิดว่าพื้นที่ดังกล่าวไม่น่าจะถูก
 น้ำท่วมขัง

4 เกษตรกรบางรายปลูกหญ้ามูลาโท II ในดินทรายจัด หญ้าจึงมีจำนวนช่อดอกน้อยมาก

5 เกษตรกรบางรายปลูกหญ้ามูลาโท II เพื่อใช้เป็นอาหารสัตว์เลี้ยง โดยที่ไม่เคยมีความตั้งใจที่
 จะปลูกเพื่อผลิตเมล็ดพันธุ์เลย เกษตรกรบางรายตัดหญ้าเพื่อจำหน่ายเป็นหญ้าสด หรือตัด
 หญ้าให้สัตว์เลี้ยงของตนเอง

สำหรับในปี พ.ศ. 2550 มีเกษตรกรจำนวน 323 รายได้เซ็นสัญญาแล้วเพื่อผลิตเมล็ดพันธุ์หญ้า
 มูลาโท II (ตารางที่ 3) โดยวางแผนที่จะปลูกในพื้นที่รวม 1,141 ไร่ ซึ่งถ้าหากได้ผลผลิตเมล็ดพันธุ์
 เฉลี่ย 30 กิโลกรัม/ไร่ ผลผลิตเมล็ดพันธุ์รวมทั้งสิ้นจะได้ 34,000 กิโลกรัม โดยที่ราคาซื้อขายในสัญญา
 คือ ถ้าเกษตรกรที่ผลิตได้ต่ำกว่า 50 กิโลกรัม/ไร่ จะได้รับราคา 150 บาท/กิโลกรัม ถ้าผลิตได้ในช่วง
 50-100 กิโลกรัม/ไร่ จะได้รับราคา 175 บาท/กิโลกรัม และสูงกว่า 100 กิโลกรัม/ไร่ จะได้รับราคา
 200 บาท/กิโลกรัม

ปีนี้มีเกษตรกรรายใหม่จำนวนมากจากจังหวัดมุกดาหาร ที่เคยผลิตเมล็ดพันธุ์หญ้ากินนีสีม่วง
 ซึ่งมีปัญหาด้านการตลาดของเมล็ดพันธุ์ที่ผลิตได้ติดต่อโครงการ เพื่อจะผลิตเมล็ดพันธุ์หญ้ามูลาโท II
 ทางโครงการมีความยินดีมากที่ได้เกษตรกรกลุ่มนี้เข้ามาร่วมงาน เนื่องจากส่วนใหญ่เป็นผู้ที่มีประสบ
 การณ์ในการผลิตเมล็ดพันธุ์พืชอาหารสัตว์มาก่อน ในขณะเดียวกันมีกลุ่มเกษตรกรที่มีประสบการณ์
 เช่นกันจากอำเภอนาเยีย จังหวัดอำนาจเจริญ ได้เข้าร่วมงานกับโครงการในปี

ทางโครงการคาดหวังว่าจังหวัดมุกดาหารและอำนาจเจริญจะเป็นศูนย์กลางของการผลิตเมล็ด
 พันธุ์หญ้ามูลาโท II เนื่องจากพื้นที่ที่จะปลูกหญ้าเพื่อผลิตเมล็ดพันธุ์มีความเหมาะสมมาก เพราะเป็น
 ที่ดอน ดินระบายน้ำดี อีกทั้งเป็นพื้นที่ที่เคยปลูกหญ้ากินนีสีม่วงเพื่อผลิตเมล็ดพันธุ์ และพืชไร่ เช่น
 อ้อย และมันสำปะหลัง มาก่อน

เกษตรกรในจังหวัดอุบลราชธานีเข้าร่วมเซ็นสัญญาน้อยลงในปี มีเพียงเกษตรกรที่ประสบ
 ความสำเร็จในปีที่แล้วเท่านั้นที่กลับมาเซ็นสัญญาการผลิตในปี โดยทั่วไป แล้วพื้นที่ผลิตเมล็ดพันธุ์
 ในจังหวัดอุบลราชธานีเป็นที่ลุ่ม จึงไม่ค่อยเหมาะในการผลิตเมล็ดพันธุ์หญ้ามูลาโท II เหมือนพื้นที่ใน
 จังหวัดมุกดาหารและอำนาจเจริญ

ตารางที่ 3 การผลิตเมล็ดพันธุ์หมูล่าโท II โดยเกษตรกรในหมู่บ้าน ปี พ.ศ. 2550

จังหวัด	หมู่บ้าน	อำเภอ	จำนวนเกษตรกร	พื้นที่ปลูกตามแผน (ไร่)
อุบลราชธานี				
1	ปากกุดหวาย	วารินชำราบ	31	50
2	สร้างถ่อ	เหล่าเสือโก้ก	7	19
3	คูซาด	เขื่องใน	9	12
4	ยางซิ่นก	เขื่องใน	12	20
5	สว่าง	ดอนมดแดง	3	5
6	แก่งกลาง	บุณฑริก	11	44
7	หนองแสงใหญ่	โขงเจียม	7	7
อำนาจเจริญ				
1	นาแต่	เมือง	1	10
2	คำงูเหลื่อม	เมือง	16	58
3	นาเยี่ย	เมือง	45	192
4	แก่งกฐิน	เมือง	30	134
5	ปากอ	ขามเฒ่า	13	35
6	ห้วยหม	ขามเฒ่า	7	16
มุกดาหาร				
1	โพนทราย	เมือง	22	68
2	นาตะแบง	หนองสูง	108	467
ศรีสะเกษ				
1	นารังกา	กันทรลักษ์	1	4
	รวม		323	1,141

4.1.2 ญาพาสพาลัมอุบล

วัตถุประสงค์

วัตถุประสงค์หลักของงานวิจัยนี้เพื่อส่งเสริมให้ญาพาสพาลัมอุบลเป็นพืชเศรษฐกิจที่ทำรายได้ที่ดีสำหรับเกษตรกรในหมู่บ้าน

วิธีการ

เกษตรกรจำนวน 30 รายที่บ้านปากกุดหวาย อำเภอวารินชำราบ ได้เซ็นสัญญาเพื่อผลิตเมล็ดพันธุ์ญาพาสพาลัมอุบล รายละเอียด 220 กิโลกรัม (โคกตา) ที่ราคาซื้อขาย 80 บาท/กิโลกรัม เกษตรกรกลุ่มนี้มีประสบการณ์ร่วมสิบปีในการผลิตเมล็ดพันธุ์ญาพาสพาลัมอุบล เพื่อขายให้กับโครงการ

ปัญหาเริ่มแรกของเกษตรกรในการปลูกหญ้าเพื่อผลิตเมล็ดพันธุ์ก็คือ การปลูกหญ้าให้ทันในต้นฤดูฝน เพราะสาเหตุจากความแห้งแล้ง เป็นเหตุให้เกษตรกรบางรายต้องปลูกหญ้าถึงสองครั้ง การปลูกหญ้าพาสปาลัมอุบลเพื่อเก็บเมล็ดพันธุ์จำเป็นต้องปลูกหญ้าพาสปาลัมอุบลตั้งแต่ต้นฤดูฝน มิฉะนั้นหญ้าจะไม่ผลิตเมล็ดพันธุ์

ผลการวิจัย

ในเดือนตุลาคม พ.ศ. 2549 ทางโครงการได้รับซื้อเมล็ดพันธุ์ปริมาณ 6,600 กิโลกรัม จากเกษตรกรจำนวน 30 ราย และได้จ่ายเป็นเงินสดรวม 528,000 บาท โดยเกษตรกรผลิตเมล็ดพันธุ์ได้ตามโครงตาทุกรายๆละ 220 กิโลกรัม หลังจากนั้นนำเมล็ดพันธุ์ดังกล่าวมาทำความสะอาดอีกครั้งที่มหาวิทยาลัย ได้เมล็ดพันธุ์ดีที่เก็บรักษารวม 5,800 กิโลกรัม

บริษัท Grupo Papalotla ได้รับซื้อเมล็ดพันธุ์รวม 5,000 กิโลกรัม ในราคา 135 บาท/กิโลกรัม ส่วนเมล็ดพันธุ์ที่เหลืออีก 800 กิโลกรัม โครงการจะจำหน่ายเองในราคา 150 บาท/กิโลกรัม

เมล็ดพันธุ์ที่บริษัท Grupo Papalotla รับซื้อไป 5,000 กิโลกรัม ได้ส่งออกไปยังประเทศกัวเตมาลา 1,500 กิโลกรัม และประเทศคอสตาริกา 500 กิโลกรัม ส่วนเมล็ดพันธุ์ที่เหลืออีก 3,000 กิโลกรัม จะถูกส่งไปยังรัฐฟลอริดา ประเทศสหรัฐอเมริกาเพื่อเตรียมส่งไปจำหน่ายในอเมริกากลางและอเมริกาใต้ต่อไป

ในปีเก็บเกี่ยว พ.ศ. 2550 เกษตรกรจำนวน 30 รายที่บ้านปากกุดหวายได้เซ็นสัญญาเมื่อเดือนเมษายน เพื่อผลิตเมล็ดพันธุ์ 250 กิโลกรัม/ราย (โควตา) ที่ราคารับซื้อ 80 บาท/กิโลกรัม

สรุป

การผลิตเมล็ดพันธุ์หญ้าพาสปาลัมอุบลไม่ใช่เรื่องยากสำหรับเกษตรกร ปัญหาหลักที่พบในปีที่แล้วก็คือ ความแห้งแล้งในช่วงต้นฤดูฝนที่ทำให้มีความยากลำบากในการปลูกหญ้า และฝนที่ตกในช่วงระยะเวลาเก็บเกี่ยวเมล็ดทำให้เกิดเมล็ดพันธุ์ขนาดเล็กจำนวนมาก ซึ่งได้ถูกคัดทิ้งไปในระหว่างการทำความสะอาดที่มหาวิทยาลัย ซึ่งมีปริมาณสูงถึง 800 กิโลกรัมทำให้โครงการสูญเสียรายได้ไปบางส่วน

สิ่งที่ท้าทายในอนาคตสำหรับโครงการก็คือ การแสวงหาและเพิ่มจำนวนตลาดสำหรับส่งออกเมล็ดพันธุ์ต่างประเทศ ทั้งนี้เพื่อที่จะได้ขยายและเพิ่มเกษตรกรจำนวนมากขึ้นในการผลิตเมล็ดพันธุ์ในประเทศไทย แทนที่จะมีเพียงเกษตรกรเพียงจำนวน 30 รายในหมู่บ้านเดียวที่ผลิต

4.1.3 ถั่วสโตโลอุบล

วัตถุประสงค์

วัตถุประสงค์หลักของงานวิจัยนี้เพื่อชี้ให้เห็นว่า เกษตรกรสามารถผลิตเมล็ดพันธุ์ถั่วอาหารสัตว์ให้ได้ผลผลิตสูงในฤดูแล้ง ซึ่งมีผลทำให้เกษตรกรปลูกพืชในฤดูแล้งที่ทำรายได้ดีได้

วิธีการ

เกษตรกรจำนวน 30 รายที่บ้านปากกุดหวาย อำเภอวารินชำราบ จังหวัดอุบลราชธานี ได้เซ็นสัญญาเพื่อผลิตเมล็ดพันธุ์ถั่วสโตโล 250 กิโลกรัม/ราย (โควตา) ที่ราคา 100 บาท/กิโลกรัม ซึ่ง

เกษตรกรทุกรายในกลุ่มนี้ต่างมีประสบการณ์ ในการผลิตเมล็ดพันธุ์ถั่วสโตโลฮามาตาให้กับ กรมปศุสัตว์มาก่อนร่วมห้าปี และผลิตเมล็ดพันธุ์ถั่วสโตโลฮอบลให้กับโครงการสามปี ซึ่งวิธีการผลิตเมล็ดพันธุ์ถั่วสโตโลฮามาตาและฮอบลมีลักษณะเหมือนกัน

ผลการวิจัย

ในเดือนกุมภาพันธ์ พ.ศ. 2550 โครงการได้รับซื้อเมล็ดพันธุ์ถั่วสโตโลฮอบลปริมาณ 7,138 กิโลกรัม จากเกษตรกรจำนวน 30 ราย โดยได้จ่ายเป็นเงินสดรวม 713,800 บาท หลังจากการใช้เครื่องจักรขุดผิวเมล็ดและทำความสะอาดอีกครั้งที่มหาวิทยาลัย มีเมล็ดพันธุ์เหลือเข้าโรงเก็บรวม 5,838 กิโลกรัม

บริษัท Grupo Papalotla ได้ซื้อเมล็ดพันธุ์ไปปริมาณ 4,000 กิโลกรัม ที่ราคา 135 บาท/กิโลกรัม ส่วนที่เหลืออีก 1,838 กิโลกรัม นั้น โครงการจะจำหน่ายเองในราคา 150 บาท/กิโลกรัม

บริษัท Grupo Papalotla ได้จำหน่ายเมล็ดพันธุ์นี้แล้วไปยังประเทศคอสตาริกาในปริมาณ 300 กิโลกรัม และไปยังประเทศวานูอาตูปริมาณ 2,300 กิโลกรัม ส่วนเมล็ดพันธุ์ที่เหลือ 3,400 กิโลกรัม จะถูกส่งไปยังรัฐฟลอริดาเพื่อจำหน่ายต่อไปยังอเมริกากลางและอเมริกาใต้

สำหรับการเก็บเกี่ยวเมล็ดพันธุ์ครั้งต่อไป (เดือนกุมภาพันธ์ พ.ศ. 2551) เกษตรกรจำนวน 30 รายที่บ้านปากกุดหวาย ได้เซ็นสัญญากับโครงการแล้วในเดือนเมษายน พ.ศ. 2550 เพื่อผลิตเมล็ดพันธุ์จำนวน 150 กิโลกรัม/ราย (โคตา) ที่ราคารับซื้อ 100 บาท/กิโลกรัม

สรุป

การผลิตเมล็ดพันธุ์ถั่วสโตโลฮอบลไม่ใช่เรื่องง่าย เกษตรกรต้องยกเครื่องเพื่อความสะดวกในการกวาดเมล็ดพันธุ์ที่ตกอยู่บนพื้นดิน และจำเป็นต้องกำจัดวัชพืชทั้งแปลงด้วยมืออย่างปราณีต เนื่องจากเมล็ดพันธุ์ถั่วสโตโลฮอบลออกหามไม่หมีเมล็ดวัชพืชปนอยู่ วิธีการกวาดเพื่อรวบรวมเมล็ดพันธุ์จากพื้นดินนั้นเป็นงานที่สกปรกและน่าเหนื่อยหน่าย

อย่างไรก็ตาม เนื่องจากการเก็บเกี่ยวเมล็ดพันธุ์ทำในช่วงในฤดูแล้ง (เดือนกุมภาพันธ์) ซึ่งเป็นช่วงที่เกษตรกรไม่มีการเก็บเกี่ยวพืชผลอื่นในเวลานี้ ทำให้เกษตรกรสามารถมีรายได้ที่ดีในฤดูแล้ง

สรุปได้ว่าการผลิตเมล็ดพันธุ์ถั่วสโตโลฮอบลทำให้เกษตรกรได้รับรายได้ที่ดี ในช่วงเวลาที่พวกเขาไม่มีพืชผลอื่นจะจำหน่าย

4.1.4 สภาพเศรษฐกิจของเกษตรกรในหมู่บ้านที่ผลิตเมล็ดพันธุ์พืชอาหารสัตว์

การปลูกพืชอาหารสัตว์สำหรับผลิตเมล็ดพันธุ์ในที่ดอนซึ่งเคยปลูกมันสำปะหลัง อ้อย หรือข้าวโพดมาก่อนหรือในนาดอนให้ผลผลิตข้าวต่ำเนื่องจากไม่มีน้ำขังทุกปี เช่น หญ้าพาสพาลฮอบล ถั่วสโตโลฮอบล และหญ้ามูลาโท II พบว่าสามารถสร้างรายได้ให้กับเกษตรกรสูงกว่าการปลูกพืชผลทั่วไป (ตารางที่ 4 และ 5)

การผลิตเมล็ดพันธุ์พืชอาหารสัตว์จะมีผลกระทบที่เห็นได้รวดเร็วและชัดเจนต่อรายได้ของเกษตรกร โดยเกษตรกรจะมีรายได้ขึ้นหลายเท่าตัว หญ้ามูลาโท II ที่เกษตรกรปลูกสามารถสร้างรายได้

ได้เพิ่มจากการจำหน่ายหญ้าสด หน่อพันธุ์ และต้นกล้า จึงทำให้หญ้าชนิดนี้เป็นพืชผลที่สร้างผลกำไรมากที่สุดในการปลูก อย่างไรก็ตาม ตลาดหญ้าสดและหน่อพันธุ์คงจะอยู่ได้อีกไม่กี่ปี เนื่องจากในปัจจุบันปริมาณของหญ้าสดที่ผลิตในประเทศมีมากเกินไป อันเป็นผลจากมีการปลูกหญ้านี้สีม่วงมากเกินไปนั่นเอง

เกษตรกรที่ปลูกพืชอาหารสัตว์โดยมีวัตถุประสงค์เพื่อผลิตเมล็ดพันธุ์นั้น หญ้าพาสพาลัมอุบล และหญ้ามูลาโท II สามารถปล่อยสัตว์ลงแทะเล็มหรือตัดไปให้สัตว์กินก็ได้ในช่วงก่อน หรือหลังการเก็บเกี่ยวเมล็ดพันธุ์(ตามคำแนะนำ) แต่ในกรณีของถั่วสโตโลอุบล จะไม่มีการปล่อยสัตว์หรือตัดให้สัตว์กินทั้งก่อนหรือหลังการเก็บเกี่ยวเมล็ดพันธุ์

ตารางที่ 4 ผลผลิตเฉลี่ย ราคาต่อกิโลกรัม และรายได้ จากข้าว มันสำปะหลัง อ้อย ข้าวโพด และเมล็ดพันธุ์พืชอาหารสัตว์ ในจังหวัดอุบลราชธานี

พืชผล	ผลผลิตเฉลี่ย (กก./ไร่)	ราคา (บาท/กก.)	รายได้ทั้งหมด/ไร่ (บาท)	รายได้สุทธิ/ไร่ (บาท)
ข้าวหอมมะลิ	500	9	4,500	1,960
มันสำปะหลัง	2,000	3	6,000	2,800
อ้อย	9,000	0.70	6,300	2,500
ข้าวโพด	1,000	5	5,000	1,850
หญ้าพาสพาลัมอุบล	150	80	12,000	9,770
หญ้ามูลาโท II*	40	200	8,000	5,390*
ถั่วสโตโลอุบล	120	100	12,000	9,030

* เกษตรกรมีรายได้พิเศษจากการจำหน่ายหญ้าสดและต้นกล้า (8,000 บาท/ไร่)

การผลิตเมล็ดพันธุ์หญ้ามูลาโท II น่าที่จะสร้างผลกำไรเพิ่มขึ้นได้อีก หากผลผลิตเมล็ดพันธุ์สามารถเพิ่มขึ้นถึงระดับ 150 กิโลกรัม/ไร่ เช่นเดียวกับหญ้าพาสพาลัมอุบล โครงการได้ทำงานทดลองในแปลงเพื่อเพิ่มผลผลิตเมล็ดพันธุ์โดยวิธีการจัดการต่างๆ อย่างไรก็ตาม วิธีที่ดีที่สุดอาจเป็นการใช้หญ้าพันธุ์ลูกผสมที่ให้ผลผลิตเมล็ดสูงกว่า ในปัจจุบัน โครงการกำลังประเมินหญ้าบราเคียเรียลูกผสมที่ได้มาจาก CIAT จำนวน 15 สายพันธุ์ จากงานทดลองในแปลงสองงานทดลองที่ดำเนินการในปี พ.ศ. 2549 พบว่าหญ้าลูกผสมพันธุ์ใหม่จำนวน 3 สายพันธุ์ให้ผลผลิตเมล็ดพันธุ์เป็นสองเท่าของหญ้ามูลาโท II โดยที่ยังให้ผลผลิตวัตถุดิบและคุณภาพของหญ้า(ต้นและใบ)ใกล้เคียงกัน โครงการจึงคาดหวังว่า ในอนาคตอันใกล้ จะมีการแนะนำหญ้าลูกผสมพันธุ์ใหม่ที่ให้ผลผลิตเมล็ดพันธุ์ดี ที่จะสร้างผลกำไรให้กับเกษตรกรผู้ผลิตเมล็ดพันธุ์ และมีเมล็ดพันธุ์ราคาต่ำให้เกษตรกรผู้เลี้ยงสัตว์ได้ใช้

ตารางที่ 5 ประมาณการค่าใช้จ่ายการผลิต และรายได้ทั้งหมดและรายได้สุทธิ (บาท/ไร่) จากข้าว มันสำปะหลัง อ้อย ข้าวโพด และเมล็ดพันธุ์อาหารสัตว์ ในจังหวัดอุบลราชธานี

	ข้าว	มัน สำปะหลัง	อ้อย	ข้าวโพด	หญ้าพาส พาลัมบอล	หญ้า มูลาโท II	ถั่วอบล สไตโล
ค่าใช้จ่าย							
ตรง							
ไถ	400	400	400	400	400	400	400
ยกร่อง	-	200	200	200	-	-	200
ปุ๋ย	1,500	1,500	2,000	1,500	1,000	1,000	1,000
ตายหญ้า		160	400	160	160	160	320
เก็บเกี่ยว	480	380	400	380	380	760	760
ทำความ	-	-	-	-	290	290	290
สะสม							
ขนส่ง	160	160	400	190	-	-	-
ตัด หรือ	-	400	-	320	-	-	-
แกะเปลือก							
รวมค่าใช้จ่าย	2,540	3,200	3,800	3,150	2,230	2,610	2,970
จ่ายตรง							
ราคาขาย	9	3	0.70	5	80	200	100
บาท/กก.							
กก./ไร่	500	2,000	9,000	1,000	150	40	120
รายได้ทั้ง	4,500	6,000	6,300	5,000	12,000	8,000	12,000
หมด							
รายได้สุทธิ	1,960	2,800	2,500	1,850	9,770	5,390	9,030
รายได้สุทธิ	-	-	-	-	-	8,000	-
พิเศษ							
รวมรายได้	1,960	2,800	2,500	1,850	9,770	13,390	9,030
สุทธิ							

4.2 งานวิจัยการผลิตเมล็ดพันธุ์

4.2.1 หญ้ามูลาโท II และพอลิเมออร์จากแป้ง

วัตถุประสงค์

วัตถุประสงค์หลักของงานวิจัยนี้ เพื่อเพิ่มผลผลิตเมล็ดพันธุ์ของหญ้ามูลาโท II โดยการลดเปอร์เซ็นต์เมล็ดเบาและเมล็ดลีบ และเพิ่มปริมาณเมล็ดพันธุ์ดี ซึ่งแนวทางที่จะเป็นไปได้ก็คือ การลดความเครียดของหญ้าจากปัญหาเรื่องน้ำในช่วงออกดอกและช่วงติดเมล็ด โดยการใส่สารพอลิเมออร์

จากแบ่งบริเวณรอบเขตรากของหญ้ามูลาโท II ซึ่งพอลิเมอร์จากแป้งนี้จะทำหน้าที่ดูดซับน้ำและ ช่วยเก็บกักไว้เป็นเวลานาน แล้วจึงค่อยๆปลดปล่อยน้ำออกมาในเขตรากของหญ้าเพื่อให้หญ้านำไปใช้

วิธีการ

ดำเนินงานทดลองในแปลง 2 งานทดลองที่มหาวิทยาลัยในปี พ.ศ. 2548 และเก็บเกี่ยวเมล็ดพันธุ์ในเดือนพฤศจิกายน พ.ศ. 2548 โดยงานทดลองที่ 1 ปลูกหญ้ามูลาโท II ในวันที่ 25 พฤษภาคม ส่วนงานทดลองที่ 2 ในวันที่ 31 พฤษภาคม งานทดลองทั้งสองนี้ใช้แผนการทดลอง RCBD จำนวนห้าซ้ำ และหาวิธีทดลอง คือ วิธีทดลองที่ เป็นแปลงควบคุม ส่วนวิธีที่ 2,3,4 และ 5 ใส่สารพอลิเมอร์ Zeba อัตรา 5,10,15 และ 20 กิโลกรัม/เฮกตาร์ ตามลำดับ

ปลูกหญ้ามูลาโท II โดยใช้หน่อพันธุ์ และใช้ระยะห่างระหว่างแถว 1 เมตร และระยะห่างระหว่างต้นในแถว 50 เซนติเมตร ผสมพอลิเมอร์ Zeba ลงในดินรอบเขตรากของหน่อพันธุ์ในช่วงปลูก ตัดหญ้าในแปลงทั้งสองสูง 5 เซนติเมตร เหนือระดับดินในวันที่ 5 สิงหาคม คายหญ้าระหว่างแถว และใส่ปุ๋ย (สูตร 15:15:15 อัตรา 200 กก./เฮกตาร์) และใส่ปุ๋ยนี้อีกครั้งหนึ่งในอัตราเดียวกันในวันที่ 7 ตุลาคม 2548

ในเดือนพฤศจิกายน พ.ศ. 2548 ซึ่งเป็นระยะที่หญ้าออกดอกสูงสุด นับจำนวนช่อดอกทั้งหมดภายในกรอบสี่เหลี่ยมขนาด 1 เมตร x 2 เมตร เก็บตัวอย่างช่อดอกจากหญ้าที่อยู่นอก แต่ติดกับกรอบสี่เหลี่ยมจำนวน 20 ช่อ เพื่อวิเคราะห์การสืบพันธุ์ของหญ้า นับจำนวนช่อกระจะทั้งหมดในช่อดอกแต่ละช่อ และนับจำนวนช่อดอกย่อยต่อช่อกระจะ โดยนับจากช่อกระจะจำนวนสามช่อต่อช่อดอก ที่เก็บจากส่วนยอด กลาง และล่าง ของช่อดอกแต่ละช่อ ส่วนภายในกรอบสี่เหลี่ยมซึ่งเป็นที่กำหนดไว้สำหรับเก็บเกี่ยวเมล็ดพันธุ์ ทำการผูกช่อดอกเข้าด้วยกัน และในแต่ละวัน เคาะช่อดอกเบาๆ เพื่อให้เมล็ดร่วงลงสู่ถุง นำเมล็ดพันธุ์ไปลดความชื้นอย่างช้าๆ ในถาดในห้องปฏิบัติการ หลังจากนั้นนำเมล็ดไปทำความสะอาดโดยผ่านตะแกรงและเครื่องเป่าเมล็ดแบบ South Dakota หลังจากทำความสะอาด ปรับผลผลิตเมล็ดพันธุ์ และน้ำหนัก 1,000 เมล็ด ให้เมล็ดพันธุ์อยู่ที่ระดับความชื้น 10%

ผลการวิจัย

ผลการทดลองพบว่าพอลิเมอร์ Zeba ไม่มีผลต่อผลผลิตเมล็ดพันธุ์หญ้ามูลาโท II (ตารางที่ 6) จุดมุ่งหมายของการใช้พอลิเมอร์ Zeba ก็เพื่ออุ้มน้ำหรือความชื้นในดินรอบบริเวณเขตรากของพืช เพื่อที่พืชจะไม่ถูกผลกระทบจากความแห้งแล้ง โดยส่วนใหญ่แล้วนิยม Zeba กับเมล็ดพันธุ์พืชสวนและพืชไร่ที่เพาะอยู่ในเรือนเพาะชำก่อนย้ายปลูกต้นกล้าในเวลาต่อมา การใช้ Zeba จะช่วยลดปริมาณน้ำที่ต้องให้ในช่วงที่เมล็ดพันธุ์งอก โผล่ขึ้นเหนือดิน และเติบโต ในงานทดลองในแปลงของโครงการนี้ โดยเหตุที่ความชื้นรอบเขตรากหญ้ามูลาโท II มีเพียงพอตลอดเวลา ดังนั้น การใช้ Zeba จึงไม่มีประโยชน์ เนื่องจากมีฝนตกมากเพียงพอในปี พ.ศ. 2548 คือที่ปริมาณถึง 1,500 มิลลิเมตร นอกจากนี้แปลงที่ใช้ในงานทดลองที่ 2 ยังมีน้ำท่วมขังเล็กน้อยในเดือนกันยายน ทำให้ผลผลิตเมล็ดพันธุ์ในงานที่ 2 นี้ได้เพียงครึ่งหนึ่งของงานทดลองที่ 1 (ตารางที่ 6)

ตารางที่ 6 ผลของสารพอลิเมอร์ Zeba ที่มีต่อองค์ประกอบของผลผลิตและผลผลิตเมล็ดพันธุ์ของ
หนุ่ยมูลาโท II

วิธีทดลอง	จำนวน ช่อดอก /ตารางเมตร	จำนวน ช่อกระจะ /ช่อดอก	จำนวน ช่อดอกย่อย /ช่อกระจะ	ผลผลิต เมล็ดพันธุ์ (กก./ไร่)*
งานทดลองที่ 1				
ควบคุม	175	5.4	36.4	35.2
Zeba 5 กก./เฮกแตร์	184	5.2	36.4	34.1
Zeba 10 กก./เฮกแตร์	175	5.1	36.4	37.8
Zeba 15 กก./เฮกแตร์	194	5.2	35.9	35.0
Zeba 20 กก./เฮกแตร์	170	5.4	36.6	35.8
LSD P<0.05	Ns	ns	ns	ns
งานทดลองที่ 2				
ควบคุม	112	5.5	35.7	18.1
Zeba 5 กก./เฮกแตร์	118	5.5	34.3	17.3
Zeba 10 กก./เฮกแตร์	146	5.4	35.6	20.8
Zeba 15 กก./เฮกแตร์	114	5.5	35.2	17.6
Zeba 20 กก./เฮกแตร์	166	5.3	35.7	21.8
LSD P<0.05	Ns	ns	ns	ns

* ปรับให้ความชื้นของเมล็ดพันธุ์อยู่ที่ระดับ 10%

สรุป

Zeba ไม่มีประโยชน์ในการลดความเครียดจากปัญหาการน้ำในระยะยาว สำหรับพืชอาหาร
สัตว์อายุหลายปีปลูกเพื่อผลิตเมล็ดพันธุ์ สารนี้จะมีประโยชน์ก็คือ ใช้เพื่อช่วยในการงอกของเมล็ด
พันธุ์ และในระยะตั้งตัวของต้นกล้า ในกรณีที่เกิดผลกระทบจากช่วงแล้งหรือช่วงที่มีฝนน้อย

4.2.2 วิธีเก็บเกี่ยวหนุ่ยมูลาโท II

วัตถุประสงค์

สมมติฐานของงานวิจัยนี้ก็คือ วิธีเก็บเกี่ยวเมล็ดพันธุ์ในถุงไนลอนที่สวมผูกกับช่อดอก จะทำให้
ได้ผลผลิตเมล็ดพันธุ์สูงกว่า และเมล็ดพันธุ์มีคุณภาพดีกว่า วิธีเก็บเกี่ยวด้วยมือวิธีอื่นๆ

วัตถุประสงค์ก็เพื่อเปรียบเทียบการผลิเมล็ดพันธุ์จากการเก็บด้วยถุงไนลอนกับวิธีธรรมดาที่
เกษตรกรในประเทศไทยใช้กัน คือ การเคาะช่อดอก และวิธีที่ใช้ในประเทศบราซิล คือ การกวาดเมล็ด
จากพื้นดิน

วิธีการ

ปลูกหน่อมูลาโท II โดยใช้หน่อพันธุ์(แยกจากต้นที่มีอายุหนึ่งปี) ระยะห่าง 1 เมตร x 50 เซนติเมตร ในวันที่ 31 พฤษภาคม 2548 ที่มหาวิทยาลัย ในวันที่ 2 สิงหาคม ตัดหน่อในแปลงให้อยู่เหนือระดับดิน 5 เซนติเมตร ใส่ปุ๋ยในวันที่ 2 สิงหาคม (NPK 15-15-15 อัตรา 200 กก./เฮกตาร์) และ 6 ตุลาคม (ยูเรีย อัตรา 20 กก./เฮกตาร์)

ใช้แผนการทดลอง RCBD จำนวนสี่ซ้ำ และห้าวิธีทดลอง โดยแต่ละแปลงย่อยมีขนาด 4 เมตร x 5 เมตร วิธีทดลองมีดังนี้

- T1 ผูกช่อดอกเข้าด้วยกัน และเคาะทุกวัน วันละครั้ง
- T2 ผูกช่อดอกเข้าด้วยกัน และเคาะทุกวัน วันละสองครั้ง
- T3 ผูกช่อดอกเข้าด้วยกัน และเคาะทุกสองวัน
- T4 สวมถุงไนลอนเข้ากับช่อดอก และรวบรวมเมล็ดพันธุ์ที่ร่วงหล่นอยู่ในถุงทุกเจ็ดวัน
- T5 ปลดปล่อยเมล็ดพันธุ์ร่วงหล่นบนพื้นดิน แล้วจึงกวาดรวบรวม

เก็บเกี่ยวเมล็ดพันธุ์จากแปลงย่อยทั้งแปลง แล้วนำเมล็ดไปลดความชื้นอย่างช้าๆในภาชนะในห้องปฏิบัติการ หลังจากนั้นนำไปทำความสะอาดด้วยตะแกรงมือและเครื่องเป่าเมล็ดแบบ South Dakota หลังจากทำความสะอาด ปรับผลผลิตเมล็ดพันธุ์ให้อยู่ที่ระดับความชื้นเมล็ด 10% ข้อมูลที่เก็บประกอบด้วย ผลผลิตเมล็ดพันธุ์ น้ำหนักหนึ่งพันเมล็ด และความมีชีวิตของเมล็ดพันธุ์ (ทดสอบด้วยเตตระโซเลียม)

ผลการวิจัย

จากผลการวิจัย พบว่าวิธีที่ใช้ถุงไนลอนสวมไว้กับช่อดอกเพื่อรวบรวมเมล็ดพันธุ์เป็นวิธีที่ให้ผลผลิตเมล็ดพันธุ์สูงสุด (ตารางที่ 7) ผลผลิตเมล็ดพันธุ์โดยวิธีใช้ถุงไนลอนพบว่าสูงกว่าวิธีเคาะทุกวัน วันละสองครั้ง ซึ่งเป็นวิธีที่ให้ผลผลิตเมล็ดพันธุ์สูงเป็นลำดับที่สอง อย่างมีนัยสำคัญ (สูงกว่า 88%) สำหรับผลผลิตเมล็ดพันธุ์ที่เก็บเกี่ยวได้จากวิธีเคาะสามวิธีพบว่าไม่มีความแตกต่างอย่างมีนัยสำคัญ ส่วนวิธีกวาดเมล็ดพันธุ์จากพื้นดินให้ผลผลิตเมล็ดพันธุ์ต่ำสุด เมล็ดพันธุ์มีน้ำหนักเบาที่สุด และมีชีวิตต่ำสุด (ตารางที่ 7)

สรุป

วิธีใช้ถุงไนลอนในการเก็บเกี่ยวเมล็ดเป็นวิธีที่ได้ผลผลิตเมล็ดพันธุ์สูงสุด อย่างไรก็ตามเกษตรกรมีความรู้สึกว่าถุงซึ่งมีราคา 8-10 บาท/ใบ ค่อนข้างแพง โดยเหตุที่ก้านช่อดอกของหน่อมูลาโท II ค่อนข้างเปราะ ดังนั้นจึงตาข่ายที่นำมาทำถุงไนลอนจำเป็นจะต้องมีน้ำหนักเบา ทั้งนี้เพื่อลดปัญหาการหักของก้านช่อดอกเนื่องจากน้ำหนักของถุง ถุงตาข่ายไนลอนควรมีรูโปร่ง เพื่อให้อากาศไหลผ่านได้ การทำถุงเก็บเกี่ยวนี้ทำโดยนำตาข่ายมาตัดและเย็บเป็นถุง โดยทำให้มีช่องเปิดขนาดเล็กที่ปลายด้านหนึ่ง และสามารถแก้ออกได้ง่ายเพราะจะต้องแก้ออกทุกสี่ถึงเจ็ดวันเพื่อเก็บรวบรวมเมล็ดพันธุ์

โดยที่ถูงมีราคา 8-10 บาท/ใบ และต้องใช้ประมาณ 3,000 ถูง/ไร่ ดังนั้นเมื่อคิดเป็นเงินจะเป็นเงินรวมทั้งสิ้น 24,000-30,000 บาท/ไร่ ปัจจุบันที่เกษตรกรได้รับเงินที่โครงการรับซื้อเมล็ดพันธุ์หมูลาโท II คืนในราคา 200 บาท/กิโลกรัม ดังนั้นแม้ว่าเกษตรกรจะสามารถผลิตเมล็ดพันธุ์ได้สูงสุด 80 กิโลกรัม/ไร่ ค่าใช้จ่ายจากการใช้ถูงในลอนยังคงสูงเกินรายได้ทั้งหมด โดยความจริงแล้วถูงในลอนสามารถใช้ได้นานหลายปี ซึ่งในระยะยาวจะช่วยลดค่าใช้จ่ายลงได้มาก แต่ถึงกระนั้นก็ยังไม่ชัดเจนพอที่จะจูงใจเกษตรกรให้ทำ

ดังนั้น วิธีเคาะช่อดอก วันละครั้งหรือสองครั้ง จึงเป็นวิธีที่เหมาะสมที่สุดสำหรับเกษตรกร และเกษตรกรรายที่ได้ผลิตเมล็ดพันธุ์สูงสุด คือรายที่เก็บเกี่ยวเมล็ดโดยใช้วิธีเคาะช่อดอกวันละสองครั้ง

วิธีการเก็บเกี่ยวเมล็ดพันธุ์หมูลาโท II ของอเมริกาได้โดยการกวาดเมล็ดพันธุ์ที่ร่วงหล่นอยู่บนดิน ดูจะไม่เหมาะสมสำหรับในสภาพของประเทศไทย คือสังเกตเห็นได้ว่า เมล็ดพันธุ์จำนวนมากถูกมดคาบไปกิน และในบางครั้งมีเมล็ดพันธุ์จำนวนหนึ่งเน่าเสียหายอยู่บนดิน เนื่องจากเมล็ดพันธุ์หมูลาโท II มีลักษณะค่อนข้างนิ่มเมื่อร่วงหล่นลงมา มดจึงสามารถกินได้ง่าย และจากสภาพเปียกชื้นในช่วงเก็บเกี่ยว เนื่องมาจากฝนและน้ำค้างที่ตกหนัก มีส่วนทำให้เมล็ดพันธุ์หมูลาโท II เน่าอยู่บนพื้นดิน

ตารางที่ 7 ผลของวิธีเก็บเกี่ยวที่มีต่อผลผลิตและความมีชีวิตของเมล็ดพันธุ์หมูลาโท II

วิธีเก็บเกี่ยว	ผลผลิตเมล็ดพันธุ์* (กก./ไร่)	น้ำหนัก 1,000 เมล็ด* (ก.)	ความมีชีวิตของ เมล็ดพันธุ์ (%)
T1 เคาะทุกวัน วันละครั้ง	36.8	8.79	92.0
T2 เคาะทุกวัน วันสองครั้ง	43.4	8.68	92.0
T3 เคาะทุกสองวัน	40.7	8.94	89.3
T4 ถูงในลอน	81.5	9.03	90.5
T5 กวาดจากพื้นดิน	14.0	8.20	84.0
LSD P<0.05	11.7	0.38	5.8

* ปรับให้ความชื้นของเมล็ดพันธุ์อยู่ที่ระดับ 10%

4.2.3 หญ้ามูลาโท II และสารควบคุมการเจริญเติบโต Primo Maxx

วัตถุประสงค์

วัตถุประสงค์หลักของงานวิจัยนี้ เพื่อลดอัตราส่วนของเมล็ดที่ไม่เต็มหรือเมล็ดลีบและมีน้ำหนักเบา และเพิ่มผลผลิตเมล็ดพันธุ์

อาจจะกล่าวได้ว่ายังไม่เคยมีการศึกษาการใช้สาร Primo Maxx ในหญ้าเซตรอนสำหรับผลิตเมล็ดพันธุ์มาก่อน เนื่องจากเกษตรกรและนักวิจัยยังไม่ตระหนักถึงประโยชน์จากการใช้สารนี้ ได้เคยมีการใช้สารควบคุมการเติบโตของพืชโดยบริษัทผู้ผลิตเมล็ดพันธุ์ชั้นนำ ที่ผลิตเมล็ดพันธุ์หญ้าไรย์ (rye) และทอลล์เฟสคิว (tall fescue) ในประเทศเซตอปูน สารควบคุมการเติบโตของพืชจะทำหน้าที่ในการช่วยยับยั้งการสังเคราะห์จิบเบอเรลลิน และช่วยลดการหักล้มและความยาวของลำต้นหญ้าสำหรับผลิตเมล็ดพันธุ์ที่มีลักษณะลำต้นเตี้ยสามารถส่งคาร์โบไฮเดรตไปยังเมล็ดพันธุ์ได้ดีกว่า และเพิ่มการติดเมล็ดพันธุ์โดยการลดสัดส่วนของเมล็ดที่ไม่เต็มและมีน้ำหนักเบา ผลงานวิจัยก่อนหน้านี้ในช่วงทศวรรษ 1980 และ 1990 รายงานว่าผลผลิตเมล็ดพันธุ์เพิ่มขึ้นได้ตั้งแต่ 8-136% อย่างไรก็ตาม เนื่องจากมีผลิตภัณฑ์ที่ให้ผลตอบแทนที่ยอมรับได้จากบริษัท Syngenta ซึ่งมีชื่อเรียกว่า Primo Maxx (สารออกฤทธิ์คือ *Trinexapac-ethyl* 12%) ทำให้เกษตรกรผู้ผลิตเมล็ดพันธุ์หญ้าไรย์และทอลล์เฟสคิวในประเทศนิวซีแลนด์และสหรัฐอเมริกาในปัจจุบันสามารถได้ผลผลิตเมล็ดพันธุ์เพิ่มขึ้น 30-50%

วิธีการ

ทางโครงการได้ทำงานทดลองในแปลงสองงานทดลอง โดยมีวัตถุประสงค์เพื่อศึกษาผลของสารควบคุมการเติบโตพืช Primo Maxx ที่มีต่อผลผลิตเมล็ดพันธุ์หญ้ามูลาโท II ที่มหาวิทยาลัย ในแปลงหญ้ามูลาโท II อายุหนึ่งปี ในเดือนพฤษภาคม 2548 โดยใช้ระยะปลูก 1 เมตร x 50 เซนติเมตร

งานทดลองที่ 1 อัตรา Primo Maxx ที่ใช้งานทดลองนี้ใช้แผนการทดลอง RCBD มีห้าวิธีทดลอง (ควบคุม และ Primo Maxx อัตรา 1 2 3 และ 4 ลิตร/เฮกตาร์) รวมสี่ซ้ำ ใส่ Primo Maxx ในวันที่ 7 กันยายน 2549 เมื่อหญ้ามูลาโท II อยู่ในระยะการเติบโต 1-2 ข้อ

งานทดลองที่ 2 ระยะ เวลาใส่ Primo Maxx งานทดลองนี้ใช้แผนการทดลอง RCBD มีห้าวิธีทดลอง (ควบคุม และ Primo Maxx อัตรา 2 ลิตร/เฮกตาร์) โดยใส่ในวันที่ 7 กรกฎาคม 7 สิงหาคม 7 กันยายน และ 7 ตุลาคม 2549] และมีสี่ซ้ำ

ตัดหญ้าในแปลงของงานทดลองทั้งสองให้สูง 5 เซนติเมตรเหนือระดับดินในวันที่ 4 สิงหาคม 2549 และใส่ปุ๋ยในวันที่ 4 สิงหาคม (NPK 200 กก./เฮกตาร์ 15:15:15) 7 กันยายน (ยูเรีย อัตรา 100 กก./เฮกตาร์) และ 7 ตุลาคม (ยูเรีย อัตรา 100 กก./เฮกตาร์)

ที่ระยะออกดอกสูงสุดคือในวันที่ 13 พฤศจิกายน (งานทดลองที่ 1) และ 14 พฤศจิกายน (งานทดลองที่ 2) นับจำนวนดอกทั้งหมดในพื้นที่ 3 แถว x ยาว 2 เมตร (พื้นที่รวม 6 ตารางเมตร) และสวมถุงถุงในลอนเข้ากับช่อดอกเพื่อเก็บรวบรวมเมล็ดพันธุ์ เก็บช่อดอกจำนวนสามสิบช่อจากภายนอกแต่

ติดกับแปลงย่อยนี้ เพื่อวิเคราะห์การสืบพันธุ์และวัดความสูงของลำต้น นับจำนวนช่อกระจะทั้งหมดในช่อดอกแต่ละช่อ และนับจำนวนช่อดอกย่อยต่อช่อกระจะ โดยนับจากช่อกระจะจำนวนสามช่อต่อช่อดอก ที่มาจากส่วนยอด กลาง และล่าง ของช่อดอกแต่ละช่อ วัดความยาวของช่อดอกแต่ละช่อจากระดับดินถึงยอดของช่อกระจะที่อยู่สูงสุด และจากใบที่โผล่ออกมาล่าสุดถึงยอดของช่อกระจะที่อยู่สูงสุด

เก็บรวบรวมเมล็ดจากถุงในลอนเมื่อสิ้นสุดการเก็บเกี่ยวคือในวันที่ 4 ธันวาคม นำเมล็ดไปลดความชื้นอย่างช้าๆ ในถุงในลอนขนาดเล็กที่แขวนบนราวอยู่ในโรงเรือน ทำความสะอาดเมล็ดพันธุ์ในวันที่ 20 ธันวาคม ด้วยเครื่องเป่าเมล็ดแบบ South Dakota หลังจากทำความสะอาด ปรับผลผลิตเมล็ดพันธุ์และน้ำหนัก 1,000 เมล็ด โดยให้ความชื้นของเมล็ดพันธุ์อยู่ที่ระดับ 10%

ผลการวิจัย

งานทดลองที่ 1 อัตรา *Primo Maxx* ที่ใช้ จากผลการทดลองพบว่าการใช้ *Primo Maxx* ในอัตราต่างๆ ไม่ได้เพิ่มผลผลิตเมล็ดพันธุ์หรือองค์ประกอบผลผลิตเมล็ดพันธุ์ของหญ้ามูลาโท II (ตารางที่ 8) ส่วนความยาวของลำต้นลดลงเล็กน้อยคือเพียง 3-6 เซนติเมตร เท่านั้น

ตารางที่ 8 ผลของอัตราของ *Primo Maxx* (ลิตร/เฮกตาร์) ที่มีต่อองค์ประกอบผลผลิตและผลผลิตเมล็ดพันธุ์ของหญ้ามูลาโท II

อัตรา	ความยาว	จำนวน	จำนวน	จำนวนช่อ	ผลผลิต	น้ำหนัก	
Primo	ลำต้น (ซม.)	ช่อดอก	ช่อกระจะ	ดอกย่อย	เมล็ดพันธุ์	1,000	
Maxx		/ตร.ม.	/ช่อดอก	/ช่อกระจะ	(กก./ไร่)*	เมล็ด (ก.)*	
(ลิตร/ เฮกตาร์)							
	ฐาน ถึงยอด	ใบสุด ท้ายถึง ยอด					
ควบคุม	104	37	82	4.0	33.1	15.8	9.81
2	100	36	98	3.9	33.1	16.7	10.43
3	99	37	68	4.0	33.1	12.5	7.77
4	101	37	78	4.0	33.5	16.6	10.34
5	98	37	78	4.0	32.6	13.2	8.26
LSD	3.8	ns	ns	Ns	ns	Ns	ns
P<0.05							

* ปรับให้ความชื้นของเมล็ดพันธุ์อยู่ที่ระดับ 10%

งานทดลองที่ 2 ระยะเวลาใส่ Primo Maxx จากผลการทดลองพบว่าการใส่ Primo Maxx ในเวลาต่างๆ ไม่มีผลต่อผลผลิตเมล็ดพันธุ์และองค์ประกอบผลผลิตของหญ้ามูลาโท II (ตารางที่ 9) และการใส่ Primo Maxx ในเดือนกันยายนทำให้ความยาวลำต้นลดลงเกือบ 10 เซนติเมตร (ตารางที่ 9)

สรุป

การควบคุมการเติบโต Primo Maxx ไม่มีประสิทธิภาพในการเพิ่มผลผลิตเมล็ดพันธุ์ของหญ้ามูลาโท II แม้จะพบว่าผลทำให้ลำต้นหญ้าสั้นลง และมีกิ่งก้านที่เพิ่มขึ้นแต่ไม่ได้ทำให้หญ้าสร้างข้อกระจะและช่อดอกย้อยมากขึ้น และการติดเมล็ดก็ไม่ดีขึ้น

แม้จะมีการใช้ Primo Maxx กันอย่างกว้างขวางในสนามกอล์ฟในประเทศไทยเพื่อเพิ่มความหนาแน่นของหญ้าในสนาม ลดขนาดลำต้น และลดความถี่ในการตัดหญ้าลง อย่างไรก็ตาม สารนี้ไม่มีประโยชน์ในการเพิ่มผลผลิตหญ้ามูลาโท II ในประเทศไทย

ตารางที่ 9 ผลของระยะเวลาใส่ Primo Maxx ที่มีต่อองค์ประกอบผลผลิตและผลผลิตเมล็ดพันธุ์หญ้ามูลาโท II

ระยะเวลา ใส่ Primo Maxx	ความยาวลำต้น (ซม.)	จำนวน ช่อดอก /ตร.ม.	จำนวน ช่อกะจะ /ช่อดอก	จำนวนช่อ ดอกย้อย /ช่อกะจะ	ผลผลิต เมล็ดพันธุ์ (กก./ไร่)*	น้ำหนัก เมล็ด (ก.)*	
	ฐาน ถึงยอด	ใบสุด ท้ายถึง ยอด					
ควบคุม	114	38	124	3.9	33.5	20.9	7.95
มิถุนายน	115	37	121	3.9	33.5	20.4	7.96
กรกฎาคม	112	37	79	4.1	33.1	12.5	8.05
สิงหาคม	108	37	94	4.1	33.1	10.8	7.87
กันยายน	103	34	126	4.1	33.3	19.3	7.95
LSD	6.4	2.0	ns	ns	ns	ns	ns
P<0.05							

* ปรับให้ความชื้นของเมล็ดพันธุ์อยู่ที่ระดับ 10%

4.2.4 หญ้าพาสพาลัมอุบล และสารควบคุมการเติบโตของพืช Primo Maxx

วัตถุประสงค์

วัตถุประสงค์หลักของงานวิจัยนี้ เพื่อเพิ่มผลผลิตเมล็ดพันธุ์ของหญ้าพาสพาลัมอุบล โดยการลดความสูงของลำต้นและลดการหักล้ม

วิธีการ

โครงการได้ทำงานทดลองในแปลงสองงานทดลอง โดยมีวัตถุประสงค์เพื่อศึกษาผลของสารควบคุมการเติบโตของพืช Primo Maxx ที่มีต่อการผลิตเมล็ดพันธุ์หญ้าพาสพาลัมอูบล ที่มหาวิทยาลัย ในแปลงหญ้าพาสพาลัมอูบลที่ปลูกในเดือนพฤษภาคม 2549 โดยใช้ระยะปลูก 1 เมตร x 50 เซนติเมตร

งานทดลองที่ 1 อัตรา Primo Maxx ที่ใช้ งานทดลองนี้ใช้แผนการทดลอง RCBD มีห้าวิธีทดลอง (ควบคุม และ Primo Maxx ในอัตรา 1 2 3 และ 4 ลิตร/เฮกตาร์) รวมสี่ซ้ำ ใส่ Primo Maxx ในวันที่ 7 สิงหาคม 2549 เมื่อหญ้าพาสพาลัมอูบลอยู่ที่ระยะเติบโตสองข้อ และสูง 50 เซนติเมตร

งานทดลองที่ 2 ระยะ เวลาใส่ Primo Maxx งานทดลองนี้ใช้แผนการทดลอง RCBD มีห้าวิธีทดลอง (ควบคุม และ Primo Maxx (อัตรา 2 ลิตร/เฮกตาร์) ใส่ในวันที่ 7 มิถุนายน 7 กรกฎาคม 7 สิงหาคม และ 7 กันยายน) รวมสี่ซ้ำ

ตัดหญ้าในแปลงทดลองทั้งสองงานทดลองลงเหลือ 10 เซนติเมตร เหนือพื้นดินในวันที่ 7 กรกฎาคม 2549 และใส่ปุ๋ยในวันที่ 7 กรกฎาคม (NPK 200 กก./เฮกตาร์ 15:15:15) 7 สิงหาคม (ยูเรีย 100 กก./เฮกตาร์) และ 7 กันยายน (ยูเรีย 100 กก./เฮกตาร์)

เมื่อถึงระยะออกดอกสูงสุดคือในวันที่ 25 กันยายน ในงานทดลองทั้งสอง นับจำนวนช่อดอกทั้งหมดในพื้นที่ 3 แถว x ความยาว 2 เมตร (พื้นที่รวม 6 ตารางเมตร) แล้วสวมถุงลงในลอนเข้ากับช่อดอกเพื่อเก็บรวบรวมเมล็ดพันธุ์ เก็บช่อดอกจำนวนสามสิบช่อจากภายนอกแต่ติดกับแปลงย่อยนี้ เพื่อวิเคราะห์การสืบพันธุ์และวัดความยาวของลำต้น นับจำนวนช่อกระจะทั้งหมดในช่อดอกแต่ละช่อ และนับจำนวนช่อดอกย่อยต่อช่อกระจะ โดยนับจากช่อกระจะจำนวนสามช่อต่อช่อดอก ในส่วนยอดกลาง และล่าง ของช่อดอกแต่ละช่อ วัดความยาวของช่อดอกแต่ละช่อโดยวัดจากระดับพื้นดินถึงยอดของช่อกระจะที่อยู่บนสุด และจากใบที่โผล่ล่าสุดถึงยอดของช่อกระจะบนสุด

เก็บรวบรวมเมล็ดพันธุ์จากถุงในลอนเมื่อสิ้นสุดการเก็บเกี่ยวในวันที่ 13 ตุลาคม นำเมล็ดไปลดความชื้นอย่างช้าๆ ในถุงในลอนขนาดเล็กที่แขวนบนราวภายในโรงเรือน ทำความสะอาดเมล็ดพันธุ์ในวันที่ 6 พฤศจิกายน ด้วยเครื่องเป่าเมล็ดแบบ South Dakota หลังจากทำความสะอาด ปรับผลผลิตเมล็ดพันธุ์และน้ำหนัก 1,000 เมล็ดให้ความชื้นของเมล็ดพันธุ์ อยู่ที่ระดับ 10%

ผลการวิจัย

งานทดลองที่ 1 อัตรา Primo Maxx ที่ใช้ จากผลการทดลองพบว่าการใช้ Primo Maxx ในอัตราต่างๆ นอกจากไม่ได้เพิ่มผลผลิตเมล็ดพันธุ์ของหญ้าพาสพาลัมอูบล (ตารางที่ 10) การใช้ Primo Maxx ในอัตรา 3 ลิตร/เฮกตาร์ ยังทำให้ผลผลิตเมล็ดพันธุ์ลดลงเกือบ 40% เมื่อเทียบกับการไม่ใส่สารนี้ (ควบคุม) และพบว่า Primo Maxx ทำให้ความสูงของลดลง และเพิ่มจำนวนช่อกระจะและช่อดอกย่อย

งานทดลองที่ 2 ระยะ เวลาใส่ Primo Maxx จากผลการทดลองพบว่าการใช้ Primo Maxx ตั้งแต่เดือนกรกฎาคมเป็นต้นไปทำให้ผลผลิตเมล็ดพันธุ์หญ้าพาสพาลัมบอลลดลงอย่างมีนัยสำคัญ เมื่อเทียบกับการใส่ Primo Maxx ในเดือนมิถุนายน หรือไม่ใส่เลย (ควบคุม) (ตารางที่ 11) และการใส่ Primo Maxx ในเดือนกันยายนลดความยาวลำต้น จำนวนช่อดอก ผลผลิตเมล็ดพันธุ์ และน้ำหนัก 1,000 เมล็ด แต่เพิ่มจำนวนช่อดอกย่อยเมื่อเทียบกับการใส่ Primo Maxx ก่อนหน้านี้

สรุป

การใช้ Primo Maxx ในอัตราและเวลาต่างๆไม่มีประโยชน์ในการเพิ่มผลผลิตเมล็ดพันธุ์หญ้าพาสพาลัมบอล แม้จะพบว่าจำนวนช่อกะจะและช่อดอกย่อยได้เพิ่มขึ้น แต่จำนวนช่อดอกก็ลดลงเป็นสัดส่วนกัน จึงทำให้ผลผลิตเมล็ดพันธุ์โดยรวมไม่เพิ่มขึ้น นอกจากนี้ ยังมีแนวโน้มที่ค่อนข้างชัดเจนว่าผลผลิตเมล็ดพันธุ์จะลดลงจากการใช้ Primo Maxx เมื่อเทียบกับการไม่ใส่สารนี้

ความสูงของลำต้นที่ลดลงซึ่งเป็นผลมาจากสาร Primo Maxx อาจเป็นประโยชน์ในกรณีที่มีการหักล้มของต้นหญ้า แต่เนื่องจากเกษตรกรสามารถตัดหญ้าที่เติบโตมากเกินไปในเดือนกรกฎาคมเพื่อป้องกันการหักล้มได้ จึงอาจไม่มีประโยชน์ในทางเศรษฐกิจจากการใช้ Primo Maxx

สรุปได้ว่าในประเทศไทย สาร Primo Maxx จะไม่ช่วยในการเพิ่มผลผลิตเมล็ดพันธุ์ของหญ้าพาสพาลัมบอล

ตารางที่ 10 ผลของอัตรา Primo Maxx (ลิตร/เฮกตาร์) ที่มีต่อองค์ประกอบผลผลิตและผลผลิตเมล็ดพันธุ์หญ้าพาสพาลัมบอล

อัตรา Primo Maxx (ลิตร /เฮกตาร์)	ความสูงลำต้น (ซม.)		จำนวน ช่อดอก /ตร.ม.	จำนวน ช่อกะจะ /ช่อดอก	จำนวนช่อดอกย่อย /ช่อกะจะ	ผลผลิต เมล็ดพันธุ์ (กก./ไร่)*	น้ำหนัก 1,000 เมล็ด (ก.)*
	ฐาน ถึงยอด	ใบสุด ท้ายถึง ยอด					
ควบคุม	190	71	49.7	9.9	133.6	122	3.51
2	170	65	54.2	10.5	141.1	113	3.36
3	170	64	44.5	10.8	144.4	75	3.39
4	172	63	50.9	10.8	139.3	110	3.35
5	162	59	48.4	11.4	142.6	118	3.32
LSD P<0.05	10.2	5.3	ns	0.9	6.7	26	ns

* ปรับให้ความชื้นของเมล็ดพันธุ์อยู่ที่ระดับ 10%

ตารางที่ 11 ผลของเวลาใส่ Primo Maxx ที่มีต่อองค์ประกอบผลผลิตและผลผลิตเมล็ดพันธุ์หญ้าพาลพัลลุม

เวลาใส่ Primo Maxx	ความสูงลำต้น (ซม.)		จำนวน ช่อดอก /ตร.ม.	จำนวน ช่อกระจะ /ช่อดอก	จำนวนช่อ ดอกย่อย /ช่อกระจะ	ผลผลิต เมล็ดพันธุ์ (กก./ไร่)*	น้ำหนัก 1,000 เมล็ด (ก.)*
	ฐาน ถึงยอด	ในสุด ทำยถึง ยอด					
ควบคุม	180	65	60.4	10.0	122.1	158	3.47
มิถุนายน	183	68	54.1	10.0	128.3	140	3.40
กรกฎาคม	179	65	50.8	10.8	124.0	121	3.55
สิงหาคม	173	63	56.7	10.5	129.0	112	3.43
กันยายน	161.7	60	47.7	10.1	133.2	71	3.36
LSD P<0.05	11.2	4.6	7.4	ns	6.3	32	0.84

* ปรับให้ความชื้นของเมล็ดพันธุ์อยู่ที่ระดับ 10%

5 สรุปงานวิจัยและพัฒนาที่สำคัญของโครงการในช่วง 18 เดือน

5.1 ผลงานวิชาการ

โครงการได้ตีพิมพ์บทความวิชาการจำนวน 9 เรื่องในช่วงระยะเวลา 18 เดือน โดยที่ผลงานเหล่านั้นยังคงเป็นผลงานทางวิชาการในระดับนานาชาติ

- 1 Hare M.D. 2006 Applied research leads to successful export seed production of South American forages in Ubon Ratchathani province, Thailand. *International Herbage Seed Group Newsletter*, 40: 6-9. (Appendix 1).
- 2 Hare, M.D. and Wongpichet, K. 2007 (eds) Forages: A Pathway to Prosperity for Smallholder Farmers. *Proceedings of an International Forage Symposium, Faculty of Agriculture, Ubon Ratchathani University, Thailand*. (Title page Appendix 2).
- 3 Hare, M.D. 2007 Successful seed production of South American forages in Ubon Ratchathani province, Thailand: Research, development and export. In: Hare, M.D. and Wongpichet, K. (eds) *Forages: A Pathway to Prosperity for Smallholder Farmers. Proceedings of an International Forage Symposium, Faculty of Agriculture, Ubon Ratchathani University, Thailand*. pp. 35-60. (Faculty of Agriculture, Ubon Ratchathani University, Thailand). (Appendix 3).

- 4 Hare, M.D., Tatsapong P. and Saiprasert, K. 2007 Seed production of two brachiaria hybrid cultivars in north-east Thailand. 1. Method and time of planting. *Tropical Grasslands*, 41, 26-34. (Appendix 4).
- 5 Hare, M.D., Tatsapong, P. and Saiprasert, K. 2007 Seed production of two brachiaria hybrid cultivars in north-east Thailand. 2. Closing date. *Tropical Grasslands*, 41, 35-42. (Appendix 5).
- 6 Hare, M.D., Tatsapong, P. and Saiprasert, K. 2007 Seed production of two brachiaria hybrid cultivars in north-east Thailand. 3. Harvesting method. *Tropical Grasslands*, 41, 43-49. (Appendix 6).
- 7 Hare, M.D., Tatsapong P., Phengphet, S. and Lunpha, S. 2007 *Stylosanthes* species in north-east Thailand: dry matter yields and seed production *Tropical Grasslands*, 41, (in press). (Appendix 7).
- 8 Miles, J.W. and Hare, M.D. 2007 Plant breeding and seed production of apomictic tropical forage grasses. *Proceedings of International Herbage Seed Group Conference* (in press). (Appendix 8).
- 9 Hare, M.D., Lunpha, A. and Phengphet, S 2007 Effect of foliar applications of trinexapac-ethyl plant growth regulator on seed yield in brachiaria hybrid cv. Mulato II and *Paspalum atratum*. *Tropical Grasslands* (submitted). (Appendix 9).

5.2 การผลิตเมล็ดพันธุ์โดยเกษตรกรในหมู่บ้าน

ทางโครงการได้พิสูจน์หญ้ามูลาโท II หญ้าพาสพาลัมอุบล และถั่วสไตโลอุบล สามารถเป็นพืชเศรษฐกิจที่ทำรายได้ที่ดีให้กับเกษตรกรในภาคนี้ โดยทำให้เกษตรกรมีรายได้ 2-3 เท่าของรายได้จากการปลูกพืชไร่เศรษฐกิจทั่วไป เช่น ข้าวโพด มันสำปะหลัง และอ้อย ตลอดจนยังได้รับรายได้เป็นเงินสดมากกว่าจากการปลูกข้าว

หญ้าพาสพาลัมอุบลและถั่วสไตโลอุบลเป็นพืชที่สร้างรายได้สูงสุดให้กับเกษตรกร อย่างไรก็ตาม ตลาดสำหรับเมล็ดพันธุ์เหล่านี้มีจำกัด ทางโครงการสามารถจำหน่ายเมล็ดพันธุ์ได้เพียง 4,000-7,000 กิโลกรัม/ปี เท่านั้น ในแต่ละปีมีเกษตรกรเพียง 30 รายที่ทำสัญญาเพื่อผลิตเมล็ดพันธุ์หญ้าสองชนิดนี้ และเกษตรกรเหล่านี้ก็อยู่ในหมู่บ้านเดียวกันเท่านั้น คือ บ้านปากกุดหวาย อำเภอวารินชำราบ จังหวัดอุบลราชธานี โครงการไม่สามารถที่จะขยายการผลิตเมล็ดพันธุ์หญ้าพาสพาลัมอุบลและถั่วสไตโลอุบล เพราะตลาดไม่ใหญ่พอ แม้บริษัท Grupo Papalotla กำลังพยายามเปิดตลาดเมล็ดพันธุ์ของพืชทั้งสองชนิดนี้ในอเมริกากลางและอเมริกาใต้ และหวังว่าตลาดจะขยายออกได้ในอนาคต แต่คาดว่าจะยังคงเป็นตลาดขนาดเล็ก คือประมาณน้อยกว่า 10,000 กิโลกรัม/ปี

ในทางตรงกันข้าม ตลาดเมล็ดพันธุ์ของหญ้ามูลาโท II มีขนาดใหญ่มาก โดยอาจจำหน่ายได้มากถึง 500,000 กิโลกรัม/ปี อย่างง่ายดายในต่างประเทศ แต่โครงการประสบกับปัญหาใหญ่ในการผลิตเมล็ดพันธุ์หญ้านี้ เกษตรกรทั่วไปที่เห็นสัญญาเพื่อผลิตเมล็ดพันธุ์มักล้มเหลว เหตุผลหลักสำหรับความล้มเหลวก็คือ เกษตรกรเหล่านี้ไม่มีความชำนาญในการผลิตเมล็ดพันธุ์พืชอาหารสัตว์ และปลูกข้าวเป็นพืชหลักและเกษตรกรมักให้ความสำคัญกับ การปลูกข้าวมากกว่า

นอกจากนี้ พื้นที่โดยทั่วไปในจังหวัดอุบลราชธานี เป็นพื้นที่ลุ่ม ในขณะที่หญ้ามูลาโท II เติบโตได้ดีที่สุดในพื้นที่ดอน พื้นที่ในจังหวัดอำนาจเจริญและมุกดาหารมีความเหมาะสมมากกว่าสำหรับการผลิตเมล็ดพันธุ์หญ้ามูลาโท II เกษตรกรในสองจังหวัดดังกล่าวประสบความสำเร็จในการผลิตเมล็ดพันธุ์หญ้านี้สีม่วงมาแล้วเป็นเวลานานหลายปี และเมื่อถั่วหญ้านี้สีม่วงเติบโตได้ดี หญ้ามูลาโท II ก็จะเป็นที่เติบโตได้ดีเช่นกัน ในขณะนี้ ตลาดสำหรับหญ้านี้สีม่วงได้หยุดชะงักลง ทำให้เกษตรกรผู้ผลิตเมล็ดพันธุ์หญ้านี้สีม่วงต้องการที่จะปลูกหญ้ามูลาโท II แทน

โครงการมีความคาดหวังในแง่ดีว่า ในปี พ.ศ.2550 จะมีการผลิตเมล็ดพันธุ์หญ้ามูลาโท II ประมาณ 30,000-40,000 กิโลกรัม เพราะว่าเกษตรกรในจังหวัดอำนาจเจริญและมุกดาหารได้เข้าร่วมโครงการนี้ และคาดหวังว่าเกษตรกรเหล่านี้จะสามารถเพิ่มการผลิตให้สูงกว่า 200,000 กิโลกรัม ในปี พ.ศ. 2551 ได้อย่างง่ายดาย

5.3 งานวิจัยการผลิตเมล็ดพันธุ์

จากผลการวิจัยพบว่า วิธีผสมถุงไนลอนเข้ากับช่อดอกเป็นวิธีที่ให้ผลผลิตเมล็ดพันธุ์หญ้ามูลาโท II สูงสุด (81 กิโลกรัม/ไร่) คือ ประมาณสองเท่าของผลผลิตเมล็ดพันธุ์ที่ได้จากการเคาะช่อดอก อย่างไรก็ตาม เนื่องจากถุงไนลอนมีราคาสูง (8-10 บาท/ถุง) เกษตรกรจึงนิยมที่จะใช้วิธีเคาะช่อดอกวันละครั้งหรือสองครั้งมากกว่า ส่วนการกวาดเมล็ดพันธุ์จากพื้นดินซึ่งเป็นวิธีการผลิตเมล็ดพันธุ์หญ้าที่แพร่หลายในอเมริการกลางและอเมริกาใต้ และเป็นวิธีที่ใช้สำหรับการผลิตเมล็ดพันธุ์ถั่วลิสงในประเทศไทย พบว่าไม่เหมาะสมสำหรับการเก็บเกี่ยวหญ้ามูลาโท II จากผลการทดลองพบว่าวิธีกวาดเมล็ดพันธุ์จากพื้นดินนี้ได้ผลผลิตต่ำมากคือ เพียง 14 กิโลกรัม/ไร่

การใช้สารควบคุมการเติบโต Primo Maxx และการใช้พอลิเมอร์จากแป้ง Zeba พบว่าไม่มีประโยชน์สำหรับการเพิ่มผลผลิตเมล็ดพันธุ์หญ้ามูลาโท II

6 วัตถุประสงค์ของโครงการนี้บรรลุผลหรือไม่?

ในข้อเสนอของโครงการที่ได้เสนอต่อสำนักงานกองทุนสนับสนุนการวิจัยเพื่ออนุมัติในปี พ.ศ. 2548 โครงการนี้มีวัตถุประสงค์หลักสี่ข้อ ดังนี้

6.1 เพื่อช่วยบรรเทาปัญหาขาดแคลนเมล็ดพันธุ์พืชอาหารสัตว์ในประเทศไทย

วัตถุประสงค์นี้ไม่ประสบความสำเร็จ เพราะไม่มีการขาดแคลนเมล็ดพันธุ์พืชอาหารสัตว์ในประเทศไทยอีกแล้ว ในปัจจุบัน มีอุปทานหรือปริมาณการผลิตของเมล็ดพันธุ์พืชอาหารสัตว์ในปริมาณมหาศาล โดยเฉพาะเมล็ดพันธุ์หญ้ากินนีสีม่วง โดยในปี พ.ศ. 2549 มีการผลิตเมล็ดพันธุ์หญ้ากินนีสีม่วงเกือบสองล้านกิโลกรัม แต่มีการจำหน่ายเมล็ดพันธุ์นี้ออกไปได้เพียง 30% เท่านั้น

6.2 เพื่อสนับสนุนเมล็ดพันธุ์พืชอาหารสัตว์คุณภาพสูงให้โครงการ “โคล้านตัว” ของรัฐบาล ซึ่งจะต้องการพืชอาหารสัตว์คุณภาพดีปริมาณมหาศาล

วัตถุประสงค์นี้บรรลุผลในปี พ.ศ. 2549 เพราะโครงการได้ผลิตเมล็ดพันธุ์คุณภาพสูงของหญ้าพาสกาลัมบูบลและถั่วสโตโลบล ซึ่งได้ออกจำหน่ายในประเทศไทย แม้ว่าจะมีเมล็ดพันธุ์หญ้ามูลาโท II ปริมาณเพียงเล็กน้อยจำหน่ายในประเทศไทย แต่ก็มีการผลิตหญ้ามูลาโท II ในสภาพของหญ้าสดปริมาณมากมายโดยเกษตรกรผู้ผลิตเมล็ดพันธุ์ไม่ว่าจะใช้สำหรับสัตว์เลี้ยงของเกษตรกรเหล่านั้นเอง หรือขายเป็นหญ้าสด

ปัจจุบัน โครงการ “โคล้านตัว” ของรัฐบาลได้สิ้นสุดลงแล้ว ดังนั้น วัตถุประสงค์นี้จึงไม่ตรงกับข้อเท็จจริงอีกต่อไป

6.3 เพื่อส่งเสริมการผลิตเมล็ดพันธุ์คุณภาพสูงของหญ้าและถั่วบางชนิดในหมู่บ้าน

ในจังหวัดอุบลราชธานี ยโสธร ศรีสะเกษ และอำนาจเจริญ

วัตถุประสงค์นี้บรรลุผลในจังหวัดอุบลราชธานีและอำนาจเจริญ ทางโครงการจะทำสัญญาต่อกับเกษตรกรผู้ผลิตเมล็ดพันธุ์ในปี พ.ศ. 2550 และหลังจากนั้น จังหวัดมุกดาหารจะกลายเป็นศูนย์กลางการผลิตเมล็ดพันธุ์พืชอาหารสัตว์ด้วยกัน อย่างไรก็ตาม โครงการไม่ประสบความสำเร็จในการส่งเสริมการผลิตเมล็ดพันธุ์พืชอาหารสัตว์ในจังหวัดศรีสะเกษและยโสธร เนื่องจากเกษตรกรในสองจังหวัดนี้สนใจการผลิตข้าว (ยโสธรและศรีสะเกษ) และพืชสวน (ศรีสะเกษ) มากกว่า

6.4 เพื่อถ่ายทอดเทคโนโลยีการผลิตเมล็ดพันธุ์พืชอาหารสัตว์ของเกษตรกร หมู่บ้านหนึ่งของจังหวัดอุบลราชธานี ให้กับหมู่บ้านอีกมากกว่า 50 แห่งในสี่ จังหวัดข้างต้น

วัตถุประสงค์นี้บรรลุผลในหมู่บ้าน 17 แห่งในปี พ.ศ. 2549 แม้ว่าโครงการจะมีโปรแกรมการผลิตเมล็ดพันธุ์ในหมู่บ้าน 45 แห่ง แต่มีเกษตรกรเพียง 17 หมู่บ้านที่ประสบความสำเร็จในการผลิตเมล็ดพันธุ์ ในปี พ.ศ. 2550 โครงการได้ลดจำนวนหมู่บ้านลงเหลือเพียง 16 หมู่บ้าน และลดจำนวนเกษตรกรลง เหลือเพียง 323 ราย แต่ทว่าในพื้นที่ที่มากกว่า เกษตรกรเหล่านี้มีประสิทธิภาพมากในการผลิตเมล็ดพันธุ์พืชอาหารสัตว์ ดังนั้น โครงการคาดหวังว่าน่าที่จะได้ผลผลิตเมล็ดพันธุ์เพิ่มมากขึ้นหลายเท่าในปี พ.ศ. 2550 เมื่อเทียบกับในปี พ.ศ. 2549

6.5 เพื่อแสดงว่า การผลิตเมล็ดพันธุ์พืชอาหารสัตว์สามารถสร้างรายได้ให้กับเกษตรกรใน หมู่บ้านมากกว่าพืชไร่เศรษฐกิจอื่น ๆ

วัตถุประสงค์นี้บรรลุผล ดังที่ผลจากการวิเคราะห์ผลตอบแทนทางเศรษฐกิจของโครงการได้แสดงให้เห็นว่า ฝารผลิตเมล็ดพันธุ์พืชอาหารสัตว์ให้รายได้สองถึงสามเท่าของการผลิตพืชเศรษฐกิจอื่นในพื้นที่เดียวกัน

6.6 เพื่อพัฒนาการจัดการการผลิตเมล็ดพันธุ์พืชอาหารสัตว์แบบใหม่ ซึ่งจะทำให้ได้ผลผลิตเมล็ดพันธุ์สูงขึ้น

วัตถุประสงค์นี้บรรลุผลบางส่วนด้วยเทคนิคเก็บเกี่ยวที่ช่วยเพิ่มผลผลิตเมล็ดพันธุ์ แต่เทคนิคการจัดการอื่นๆ (การควบคุมการเติบโต และพอลิเมอร์จากแป้ง) ไม่ได้ช่วยเพิ่มผลผลิตเมล็ดพันธุ์ การเพิ่มผลผลิตเมล็ดพันธุ์พืชอาหารสัตว์ในอนาคตน่าจะมาจากการปรับปรุงพันธุ์ มากกว่าที่จะมาจากการปรับปรุงการจัดการ

6.7 เพื่อพัฒนาตลาดสำหรับเมล็ดพันธุ์พืชอาหารสัตว์ในระยะยาว ทั้งภายในและต่างประเทศ

วัตถุประสงค์นี้บรรลุผลด้วยการจำหน่ายเมล็ดพันธุ์หญ้าพาสพาลัมอุบล ถั่วสโตโลอุบล และหญ้ามูลาโท II ไปยังต่างประเทศ โครงการกำลังอยู่ระหว่างที่เริ่มจำหน่ายเมล็ดพันธุ์ภายในประเทศให้มากขึ้น แต่เป็นเรื่องที่ค่อนข้างยากลำบาก เพราะเมล็ดพันธุ์ของโครงการมีราคาแพงกว่าเมล็ดพันธุ์หญ้ากินนีสีม่วง ซึ่งผลิตมากเกินไปจึงทำให้ราคาเมล็ดพันธุ์หญ้ากินนีสีม่วงต่ำลง

6.8 เพื่อส่งเสริมจังหวัดอุบลราชธานี ยโสธร ศรีสะเกษ และอำนาจเจริญ เป็นศูนย์กลางหลักของการผลิตเมล็ดพันธุ์พืชอาหารสัตว์คุณภาพสูงในทวีปเอเชีย

วัตถุประสงค์นี้บรรลุผลบางส่วน เพราะโครงการจะยังคงดำเนินการผลิตเมล็ดพันธุ์ในจังหวัดอุบลราชธานีและอำนาจเจริญต่อไป แต่ไม่ใช่ในจังหวัดยโสธร และในเพียงหมู่บ้านเดียวในจังหวัดศรีสะเกษ

6.9 เพื่อส่งเสริมและสนับสนุนให้เมล็ดพันธุ์พืชอาหารสัตว์เป็นผลิตภัณฑ์ของประเทศไทยที่มี คุณภาพสูง (ความบริสุทธิ์สูง และความงอกสูง)

วัตถุประสงค์นี้บรรลุผลอย่างชัดเจน เพราะในขณะนี้ ต่างประเทศทราบว่าเมล็ดพันธุ์พืชอาหารสัตว์ที่เก็บเกี่ยวด้วยมือจากประเทศไทยมีคุณภาพสูงมาก แม้ว่าเมล็ดพันธุ์ของบริษัท Grupo Papalotla รับซื้อจากประเทศไทยมีราคาแพงกว่าเมล็ดพันธุ์ของประเทศบราซิล แต่เกษตรกรในอเมริกากลางและอเมริกาใต้เริ่มจะต้องการเมล็ดพันธุ์ที่ผลิตจากประเทศไทย เมล็ดพันธุ์ที่ผลิตจากประเทศบราซิลมักจะมีควมบริสุทธิ์ต่ำคือ เพียง 50% และมีความงอกต่ำกว่า 40% เพียงแต่ว่ามีราคาถูก ในขณะที่เมล็ดพันธุ์ของโครงการ โดยทั่วไป มีความบริสุทธิ์มากกว่า 98% และมีความงอกสูงกว่า 80%

6.10 เพื่อส่งเสริมและสนับสนุนให้มหาวิทยาลัยอุบลราชธานีเป็นศูนย์กลางการวิจัยด้านการผลิตเมล็ดพันธุ์พืชอาหารสัตว์คุณภาพสูงของประเทศ โดยผ่านการตีพิมพ์บทความวิจัยระดับนานาชาติ การจัดการประชุม ฝึกอบรม งานวันเกษตรกร และสื่อสารมวลชน

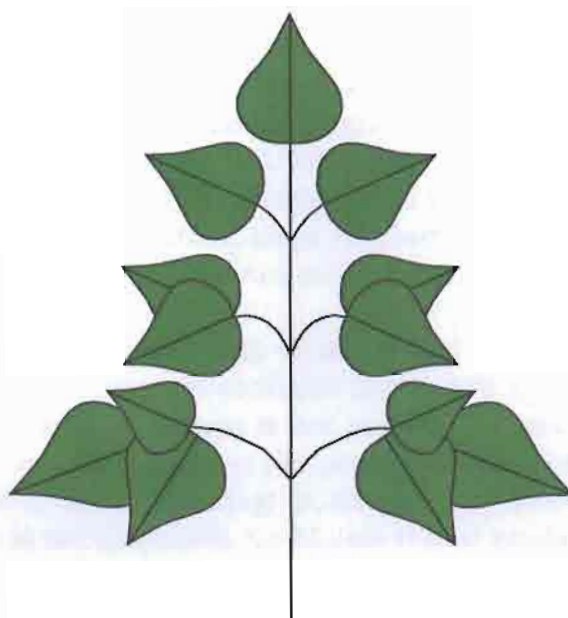
วัตถุประสงค์นี้บรรลุผลอย่างชัดเจน โดยมีการจัดการประชุมพืชอาหารสัตว์ระดับนานาชาติที่ประสบความสำเร็จ ในหัวข้อเรื่อง *"Forages: A Pathway to Prosperity for Smallholder Farmers"* เมื่อเดือนมีนาคม 2550 ที่มหาวิทยาลัยอุบลราชธานี โดยมีผู้เข้าร่วมประชุมจาก 25 ประเทศซึ่งมีความประทับใจมากเกี่ยวกับปริมาณงานวิจัยด้านเมล็ดพันธุ์ที่ทำที่มหาวิทยาลัย รวมทั้งโปรแกรมการผลิตเมล็ดพันธุ์ของโครงการโดยเกษตรกรในหมู่บ้าน

โครงการได้รับการร้องขอให้เจ้าภาพจัดการประชุมวิชาการกลุ่มเมล็ดพันธุ์พืชอาหารสัตว์นานาชาติ ครั้งที่ 7 (7th International Herbage Seed Group) ในปี พ.ศ. 2554 เนื่องมาจากชื่อเสียงของโครงการที่เป็นศูนย์กลางความเป็นเลิศในการผลิตเมล็ดพันธุ์ การประชุมวิชาการนี้คาดว่าจะดึงดูดตัวแทนอย่างน้อย 150 คน จากมากกว่า 50 ประเทศ

7 สรุปโดยรวม

โครงการไม่ประสบความสำเร็จในเป้าหมายทั้งหมดเกี่ยวกับการผลิตเมล็ดพันธุ์ในหมู่บ้าน (หมู่บ้านลาโท II) แต่โครงการได้สร้างความสนใจให้กับเกษตรกรในจังหวัดอำนาจเจริญและมุกดาหารเป็นอย่างมาก เนื่องจากโครงการมีแผนที่จะขยายการผลิตเมล็ดพันธุ์ในหมู่บ้านให้เป็นไปอย่างรวดเร็วในอนาคตอันใกล้นี้ จึงกล่าวได้ว่า โครงการประสบความสำเร็จบางส่วน

โครงการนี้จะดำเนินการต่อไปอย่างต่อเนื่องต่อไปด้วยเงินจากกองทุนหมุนเวียนของโครงการ และเงินสนับสนุนจากบริษัทเมล็ดพันธุ์เม็กซิกัน คือ Grupo Papalotla



**Forage Seed Production
for increasing
Village Farmer's Income**

Final Report

November 1 2005 to April 30 2007

**Faculty of Agriculture
Ubon Ratchathani University**

Executive summary

The Thailand Research Fund project, '**Forage seed production for increasing village farmer's income**', was conducted at the Faculty of Agriculture, Ubon Ratchathani University from November 2005 to April 2007.

The project's village seed production programme was partially successful with high quality seed produced of Mulato II, Ubon paspalum and Ubon stylo. Production of Ubon paspalum (6,600 kgs) and Ubon stylo (7,138 kgs) was done by 30 farmers in one village in Warin Chamrab district, Ubon Ratchathani province. The 30 farmers received 1,241,800 baht in cash for the two seed crops and this was paid on the same day as the seed was purchased.

The project was less successful with Mulato II seed production because only 9% of the farmers who signed contracts produced seed (2598 kgs) for sale. The major reason for this low return by the farmers is that generally, farmers in many villages in Ubon Ratchathani are more interested in rice production and rice harvesting is at the same time as Mulato II seed harvesting. In addition, the low-lying land in Ubon Ratchathani province is not so suitable for Mulato II seed production which requires well-drained upland soils. Only a few areas in Buntharik, Warin Chamrab and Khung Nai districts have suitable land and interested farmers.

In 2007, 323 farmers have signed contracts to produce Mulato II seed and of these farmers, 112 are in Amnart Charern and 130 in Mukdahan. Farmers in these two provinces have a long experience in growing forage seeds and it is these farmers who will produce most of the Mulato II seed in 2007. The project will continue with private funding indefinitely and continue to promote this region as a centre of excellence in forage seed production.

An economic analysis of forage seed production showed that producing forage seeds will return farmers 2-3 times the income from growing alternative upland crops of maize, cassava and sugarcane.

The method of placing nylon bags over the seed heads to collect seed produced the highest seed yields of Mulato II. Studies on growth regulators and a starch-based polymer did not increase seed yields of Ubon paspalum and Mulato II.

Abstract

The Thailand Research Fund project, '**Forage seed production for increasing village farmer's income**', was conducted at the Faculty of Agriculture, Ubon Ratchathani University from November 2005 to April 2007.

The project's village seed production programme was partially successful with high quality seed produced of Mulato II, Ubon paspalum and Ubon stylo. Production of Ubon paspalum (6,600 kgs) and Ubon stylo (7,138 kgs) was done by 30 farmers in one village in Warin Chamrab district, Ubon Ratchathani province. The 30 farmers received 1,241,800 baht in cash for the two seed crops and this was paid out on the same day as the seed was purchased.

The project was less successful with Mulato II seed production because only 9% of the farmers who signed contracts (128 from 1438) produced seed (2598 kgs) for sale. The major reason for this low return by the farmers is that generally, farmers in many villages in Ubon Ratchathani are more interested in rice production and rice harvesting is at the same time as Mulato II seed harvesting. In addition, the low-lying land in Ubon Ratchathani province is not so suitable for Mulato II seed production which requires well-drained upland soils. Only a few areas in Buntharik, Warin Chamrab and Khung Nai districts have suitable land and interested farmers.

The project has developed a small export market for Ubon paspalum (5,000 kgs) and Ubon stylo (4,000 kgs). Mulato II seed was exported to Vanuatu, Costa Rica, and Laos and a small local market has started to develop within Thailand, with some farmers willing to pay 500 baht/kg for acid-scarified Mulato II seed.

In 2007, 323 farmers have signed contracts to produce Mulato II seed and of these farmers, 112 are in Amnart Charern and 130 in Mukdahan. Farmers in Amnart Charern and Mukdahan provinces have a long experience in growing forage seeds and it is these farmers who will produce most of the Mulato II seed in 2007. The project will continue with private funding indefinitely from Grupo Papalotla and from our own revolving seed fund and continue to promote this region as a centre of excellence in forage seed production.

An economic analysis of forage seed production showed that producing forage seeds will return farmers 2-3 times the income from growing alternative upland crops of maize, cassava and sugarcane. Forage seed crops return a nett income of between 5,000-9,800 baht per rai, while other upland crops return between 1,200-3,000 baht/rai.

The method of placing nylon bags over the seed heads to collect seed produced the highest seed yields of Mulato II. Studies on growth regulators and a starch-based polymer did not increase seed yields of Ubon paspalum and Mulato II.

Eight papers were written and published during the 18 month phase of the project. The project maintained a high international scientific output.

Final Report to the Thailand Research Fund

1. Project

Forage seed production for increasing village farmer's income

2. Project Leader Professor Dr. Michael Hare

Research Associates

Dr. Kungwan Thummasaeng

Associate Professor Dr. Worapong Suriyapat

Associate Professor Dr. Kitti Wongpichet

Research Officers

Mr. Kittipat Saiprasert

Miss Areerat Lunpha

3. Period of report

November 1, 2005 to April 30, 2007

4. Project research results

4.1 Seed production by village farmers

4.1.1 Mulato II seed production

Objective

The main objective of this research was to show that seed production of Mulato II can be successfully done by smallholder farmers.

Methods

In 2006, 1,438 farmers signed contracts to produce Mulato II seed (Table 1). From November 2005 to April 2006, villages were visited that were interested in producing forage seeds and meetings held in these villages. This project was greatly assisted through the cooperation of district councilors (Sor Jor) in Ubon Ratchathani province and the Bank of Agricultural and Cooperatives in Amnart Charern province. The Ubon Ratchathani district councilors were outstanding in contacting farmers, arranging meeting venues and assisting with contract signing. Without their assistance it would not have been possible to have 1,438 farmers sign contracts.

Farmers received in-village training on forage seed production. Video and power point presentations of village farmer seed production were presented in villages and technical brochures were distributed on how to grow, manage and produce forage seeds. At the time of contract signing, each farmer received 100 grams (1-2 rai) or 200 grams (more than 2 rai) of free seed to plant seed nurseries.

The Mulato II seed given to the farmers was scarified for 20 minutes in sulphuric acid in March 2006 to increase germination from 24% to 89%. 70 kgs of seed at a time were poured into a concrete mixer and mixed with sulphuric acid for 20 minutes. The seed was then put into water and lime to neutralize the acid, washed in running water and dried. Each packet of 100 grams contained approximately 13,000 seeds.

From May to October 2006, villages were regularly visited (about every 3-4 weeks) and seed crops inspected. The growing season was very difficult. In the first 3 months, May-July, rainfall was below average and many seed crops were sown late. Some early sown crops died in June from drought and had to be replanted. Heavy rain in August and September waterlogged many fields and in some places flooding occurred, causing plant death.

Project field officers did an excellent job in advising the good farmers on how to prepare the seed crops for harvest. CDs of pre-harvest management were distributed to

all seed groups. Farmers tied plants into upright bunches during seedhead emergence and at flowering tied the seed heads into bunches (Plates 1 & 2). The plants were tied twice.

The farmers knocked the ripe Mulato II seed out into seed trays every day during harvest (Plate 3). The harvested seed was dried slowly in the shade for 3 days and on the fourth day dried in the sun.

The seed was purchased at two prices. Farmers that harvested more than 100 kgs received 200 baht/kg and for amounts less than 100 kgs/farmers they received 180 baht/kg.



Plate 1 Mulato II seed crop in Amnart Charern province



Plate 2 Mulato II seed crop in Amnart Charern province



Plate 3 Mulato II seed harvesting in Amnat Charern province

Table 1 Mulato II village farmer seed production in 2006

Province	Village	District	No. of farmers signing contracts	No. of farmers that harvested seed	Seed produced (kgs)
Ubon					
1	Bark Kud Waay	Warin Chamrab	30	30	462
2	Tang Saay	Warin Chamrab	13	-	-
3	Kham Yai	Muang	131	4	30
4	Kii Lek	Muang	93	-	-
5	Hua Rua	Muang	108	-	-
6	Pa Aow	Muang	138	-	-
7	Sawang	Somrong	7	1	11
8	Pa Kha	Sawang Wirawong	2	1	16
9	Kud Pra Taay	Det Udom	8	1	10
10	Na Yia	Na Yia	27	-	-
11	Nong Buk	Lao Sua Kok	9	5	-
12	Jik	Lao Sua Kok	4	-	-
13	Sang Tor	Lao Sua Kok	11	3	39
14	Hart Yai	Lao Sua Kok	16	2	20
15	Hart Noi	Lao Sua Kok	18	2	10
16	Sawang	Don Mut Daeng	41	2	19
17	Kham Hai Yai	Don Mut Daeng	16	-	-
18	Sawang Ming	Muang Saam Sip	3	-	-
19	Nong Lak & Lao Buk	Muang Saam Sip	156	-	-
20	Dum Yai	Muang Saam Sip	21	-	-
21	Thung Ma Nii	Muang Saam Sip	61	3	40
22	Wang Mon	Muang Saam Sip	13	1	14

23	Kham Waa	Tarn Sum	29	-	-
24	Tha Khor	Khuang Nai	15	-	-
25	Yang Kii Nok	Khuang Nai	77	11	120
26	Non Kha	Phibun	17	-	-
27	Ang Sii La	Phibun	19	-	-
28	RiangTaewDai	Sirinthon	31	-	-
29	Khaw Ptun	Kud Khaw Ptun	8	-	-
30	Non Yai	Po Sai	63	-	-
31	Kaw Klang	Buntharik	25	14	105
32	Jukan	Sri Muang Mai	9	-	-
33	Kum Tory	Sri Muang Mai	33	-	-
34	Nong Saeng Yai	Khong Chiam	21	6	20
35	Nong Pua Noi	Khong Chiam	9	-	-
36	Bark Saeng	Naa Taan	8	-	-
Amnart					
37	Na Tair	Muang	30	2	421
38	Kum Ngu Luam	Muang	39	10	232
39	Kaeng Katin	Muang	22	15	507
40	Pa Kor	Chanuman	36	19	498
41	Rai Kii	Lu Amnart	19	-	-
Yasothon					
42	ChiangPaeng	PaTuew	1	-	-
Sisaket					
43	NaaRangKa	Kantharalak	1	1	24
Total			1438	128	2598

Results

In December 2006, **2598 kgs** of good quality Mulato II were purchased from **128** farmers and **484,760 baht** paid out in cash to them on the day of purchase. The seed was treated with sulphuric acid at the university and re-cleaned to produce a final total of **2,000 kgs** of seed.

1,900 kgs has been exported (Table 2) and 100 kgs kept for sale in Thailand.

Table 2 Mulato II seed export 2007

Country	Amount (kgs)
Vanuatu	1800
Laos	100

1,438 farmers signed contracts to produce seed but only 128 farmers (9%) successfully produced seed because of the following reasons:

1 Many new farmers came to the meetings but they only signed contracts because the local district councilor (Sor Jor) told them to sign. They received per diem for coming to the meeting and they never had any intention to grow a seed crop. In other words, signing the contract was just a joke and the meetings were arranged for political purposes. The seed in many cases just stayed in their house. Some farmers returned the seed.

2 Many new farmers planted seed nurseries but did not transplant to fields because they did not have sufficient arable upland. But they never told us this at the meetings. They still signed contracts even though their land was unsuitable. They signed just to please the district councilor.

3 Some farmers transplanted into very low land which became waterlogged in August-September causing the Mulato II plants to die. They thought that land would not become waterlogged.

4 Some farmers planted seed crops on very light sandy soil and these crops produced a very low number of seedheads.

5 Some farmers grew Mulato II for forage. They never had any intention to produce seed. Some farmers sold fresh grass or cut the grass to feed to their own cattle.

For 2007, 323 farmers have signed contracts to produce Mulato II seed (Table 3). They are planning to plant 1141 rai and if they average 30 kg/rai they should produce 34,000 kgs. The contract prices are; less than 50 kg/farmer, 150 baht/kg; 50-100 kg/farmer, 175 baht/kg; more than 100 kg/farmer, 200 baht/kg.

This year has seen an influx of new farmers from Mukdahan who previously grew Purple guinea for seed but with the collapse of the Purple guinea seed market they have contacted the project to produce Mulato II. We are very pleased to have these farmers because they are experienced forage seed producers. More experienced forage seed growers from Na Yia in Amnart have also joined the project.

Mukdahan and Amnart will be the main centres of Mulato II seed production. The seed production areas there are very suitable because they are on well-drained upland soils that previously grew Purple guinea for seed, sugarcane or cassava.

Fewer farmers in Ubon Ratchathani signed contracts this year. Only farmers who had success last year came back to sign contracts this year. Generally, the seed sites in Ubon Ratchathani are low lying and are less suitable for Mulato II seed production than in Mukdahan and Amnart.

Table 3 Mulato II village farmer seed production in 2007

Province	Village	District	No. of farmers	Planned planting area (rai)
Ubon				
1	Bark Kud Waay	Warin Chamrab	31	50
2	Sang Tor	Lao Sua Kok	7	19
3	Kukhaat	Khuang Nai	9	12
4	Yang Kii Nok	Khuang Nai	12	20
5	Sawang	Don Mut Daeng	3	5
6	Kaw Klang	Buntharik	11	44
7	Nong Saeng Yai	Khong Chiam	7	7
Amnart				
1	Na Tair	Muang	1	10
2	Kum Ngu Luam	Muang	16	58
3	Na Yia	Muang	45	192
4	Kaeng Katin	Muang	30	134
5	Pa Kor	Chanuman	13	35
6	Huay Thum	Chanuman	7	16
Mukdahan				
1	Phonsaay	Muang	22	68
2	Natabaeng	Nongsung	108	467
Sisaket				
1	Naa Rang Ka	Kantharalak	1	4
Total			323	1141

4.1.2 Ubon paspalum

Objective

The main objective of this research was to consolidate Ubon paspalum as a lucrative cash crop for village farmers.

Methods

30 farmers in Bark Kud Waay village, Warin Chamrab, signed contracts to produce 220 kgs each (quota) of Ubon paspalum seed at a price of 80 baht/kg. These farmers all had nearly 10 years experience in growing Ubon paspalum seed for our project. The farmers initially had difficulty planting the seed crops in the early wet season because of drought. Some farmers had to replant 2 times. Ubon paspalum must be planted very early in the wet season, otherwise it will not produce seed.

Results

In October 2006, **6,600 kgs** of seed were purchased from **30** farmers with **528,000 baht** paid out in cash. They all produced their quota of 220 kgs each. Following recleaning at the university 5,800 kgs of good seed was stored.

Grupo Papalotla purchased 5,000 kgs at 135 baht/kg and the remaining 800 kgs will be sold by the project for 150 baht/kg.

From the 5,000 kgs, Grupo Papalotla has exported 1,500 kgs to Guatemala and 500 kgs to Costa Rica. The remaining 3,000 kgs will be sent to Florida for selling in Central and South America.

For the 2007 harvest, 30 farmers in Bark Kud Waay signed contracts in April to produce 250 kgs/farmer (quota) at a purchase price of 80 baht/kg.

Conclusion

Production of Ubon paspalum seed by village farmers is not difficult. The main problems last year were the drought at the beginning of the wet season which made planting very difficult and the rain during seed harvesting which caused a lot of small seed to form. This seed was removed during seed cleaning at the university and it was a financial loss for us because 800 kgs were removed.

The challenge for us in the future is to try and increase the overseas export market so that more farmers can produce seed in Thailand instead of just 30 farmers in one village.

4.1.3 Ubon stylo

Objective

The main objective of this research was to show that farmers could harvest high seed yields of a forage legume in the dry season and earn a good income from a dry season cash crop.

Methods

30 farmers in Bark Kud Waay village, Warin Chamrab, signed contracts to produce 250 kgs each (quota) of Ubon stylo seed at a price of 100 baht/kg. All of these farmers had nearly 5 years experience in growing hamata stylo for the Department of Livestock Development and 3 years growing Ubon stylo for our project. Seed production of hamata and Ubon stylo are the same.

Results

In February 2007, **7,138 kgs** of Ubon stylo seed were purchased from **30** farmers with **713,800 baht** paid out in cash. Following machine scarification and recleaning at the university, 5,838 kgs of seed were stored.

Grupo Papalotla purchased 4,000 kgs at 135 baht/kg and the remaining 1,838 kgs will be sold by the project for 150 baht/kg.

Grupo Papalotla have already sold 300 kgs to Costa Rica and 2300 kgs to Vanuatu and the remaining 3,400 kgs will be shipped to Florida for sale in Central and South America.

For the next harvest (February 2008), 30 farmers in Bark Kud Waay signed contracts in April to produce 150 kgs/farmer (quota) at a purchase price of 100 baht/kg.

Conclusion

Production of Ubon stylo seed is not easy. The farmers have to raise seedbeds in furrows which facilitates ground sweeping the seed; they have to thoroughly hand-weed the fields because no weed seeds can be in the stylo seeds for export; hand-sweeping seed from the ground is a dirty and tiring job.

However, because seed is harvested in the dry season (February) when farmers have no other crop at that time, the farmers are able to earn a very good dry season income.

Ubon stylo seed production provides the farmers with good money at a time when they have no other crops to sell.

4.1.4 Economics of village farmer forage seed production

Forage seeds are grown on upland that previously was planted in cassava, sugarcane or maize, or on the upland rice paddies which are marginally productive for rice because they are not inundated with water every year. Ubon paspalum, Ubon stylo and Mulato II grown for seed produce far higher incomes than alternate crops (Tables 4 & 5).

Forage seed production will impact immediately on farmer's income by substantially increasing their income many fold. Mulato II can generate additional income from the sale of fresh forage, rootstock and seedlings which makes it the most profitable crop to grow. However, this market for fresh forage and rootstock may not last for many years as there is now an over-supply of fresh forage in Thailand from over-production of Purple guinea grass.

Ubon paspalum and Mulato II forage can also be grazed or cut from the fields for the farmers' own animals, before closing for seed production (June-July) and after seed harvest. There is no forage production before or after seed harvest from Ubon stylo seed, crops because the plants do not grow fast enough for a closing cut and after harvest, the harvest straw has no leaf and is very unpalatable.

Table 4 Average yields, price per kg and income from rice, cassava, sugarcane, maize and forage seeds in Ubon Ratchathani province

Crop	Average yield (kg/rai)	Price (baht/kg)	Gross income/rai (baht)	Nett income/rai (baht)
Rice HomMali	500	9	4,500	1,960
Cassava	2,000	3	6,000	2,800
Sugarcane	9,000	0.70	6,300	2,500
Maize	1,000	5	5,000	1,850
Ubon paspalum	150	80	12,000	9,770
Mulato II*	40	200	8,000	5,390*
Ubon stylo	120	100	12,000	9,030

* Mulato II extra income from sale of fresh forage and seedlings (8,000 baht/rai)

Table 5 Estimated costs and gross and nett income (baht/rai) from rice, cassava, sugarcane, maize and forage seeds in Ubon Ratchathani province

	Rice	Cassava	Sugarcane	Maize	Ubon paspalum	Mulato II	Ubon stylo
Direct Costs							
Ploughing	400	400	400	400	400	400	400
Raising furrows	-	200	200	200	-	-	200
Fertiliser	1,500	1,500	2,000	1,500	1,000	1,000	1,000
Labour for weeding	-	160	400	160	160	160	320
Labour for harvesting	480	380	400	380	380	760	760
Labour for cleaning	-	-	-	-	290	290	290
Transport	160	160	400	190	-	-	-
Chopping or Husking	-	400	-	320	-	-	-
Total direct costs	2,540	3,200	3,800	3,150	2,230	2,610	2,970
Sale price baht/kg	9	3	0.70	5	80	200	100
kg/rai	500	2,000	9,000	1,000	150	40	120
Gross Income	4,500	6,000	6,300	5,000	12,000	8,000	12,000
Nett Income	1,960	2,800	2,500	1,850	9,770	5,390	9,030
Extra Nett Income						8,000	
Total Nett Income	1,960	2,800	2,500	1,850	9,770	13,390	9,030

Profitability of Mulato II seed production would be further increased if seed yields increased to levels produced by Ubon paspalum, 150 kg/rai. We have been conducting field trials to increase seed yields by agronomic management. However, the best way may be the release of higher seed producing brachiaria hybrids. Currently, we are evaluating 15 brachiaria hybrids lines from CIAT. In two field trials in 2006, 3 new hybrids produced twice the seed yields of Mulato II with similar dry matter production and quality. We are optimistic that in the near future, good seed producing brachiaria hybrids will be released that will be profitable for seed growers and provide seed at lower retail prices to livestock farmers.

4.2 Seed production research

4.2.1 Mulato II and starch-based polymer

Objective

The main objective of this research was to increase seed yields of Mulato II by lowering the percentage of light and empty seed and increasing the amounts of good seed. This was to be achieved by reducing water-stress during anthesis and seed-set by placing the starch-based polymer around the Mulato II plant root zone. The polymer takes up water which it holds for long periods and releases it slowly into the root zone.

Methods

Two field trials were planted at the university in 2005 and harvested for seed in November 2005. Trial 1 was planted on May 25 and Trial 2 on May 31. Both trials were a RCBD with 5 replications and 5 treatments (control, Zeba polymer at 5 kg/ha, Zeba at 10 kg/ha, Zeba at 15 kg/ha, Zeba at 20 kg/ha).

Mulato II tillers were planted in rows 1 m apart and 50 cm apart within rows. Zeba polymer was mixed into the soil around the root zone of the tillers as they were planted. Both fields were cut to 5 cm above ground level on August 5, inter-rows were hoed and fertiliser (200 kg/ha NPK 15:15:15) applied. The same fertiliser rate was applied again on October 7, 2005.

At peak anthesis in November 2005, all inflorescences in a fixed quadrat of 1 m x 2 m were counted and 20 inflorescences were taken from just outside this area for reproductive analysis. All racemes were counted on each inflorescence and spikelets per raceme were counted from 3 racemes per inflorescence, taken from the top, middle and bottom of each inflorescence. Seeds were harvested from within the fixed quadrat by tying the inflorescences into living sheaves and gently knocking the seed into bags each day. Seed was dried slowly on top of trays inside a laboratory and then cleaned through hand screens and a South Dakota seed blower. Following cleaning, seed yields and thousand seed weight (TSW) were corrected to 10% seed moisture content.

Results

Zeba polymer had no effect on Mulato II seed yields (Table 6). The purpose of using Zeba polymer is to retain soil moisture around the root zone of the plants so that the plants are not affected by drought. Zeba is mainly used with seeds of horticulture and field crops that are sown in seed nurseries for transplanting at a later date. Using Zeba reduces the amount of irrigation water that has to be applied as the seeds germinate, emerge and grow. In our field trials there was always sufficient soil moisture around the root zones of the Mulato II plants so Zeba was of no use. Rainfall during the 2005 was very good with 1500 mm falling. In addition, the field in Trial 2 was slightly waterlogged in September which caused seed yields in Trial 2 to be half the yields of Trial 1 (Table 6).

Table 6 Effect of Zebra on seed yield components and seed yields of Mulato II

Treatments	Inflorescences/m ²	Racemes/ inflorescence	Spikelets/ raceme	Seed yield (kg/rai)*
Trial 1				
control	175	5.4	36.4	35.2
Zeba 5 kg/ha	184	5.2	36.4	34.1
Zeba 10 kg/ha	175	5.1	36.4	37.8
Zeba 15 kg/ha	194	5.2	35.9	35.0
Zeba 20 kg/ha	170	5.4	36.6	35.8
LSD P<0.05	ns	ns	ns	ns
Trial 2				
control	112	5.5	35.7	18.1
Zeba 5 kg/ha	118	5.5	34.3	17.3
Zeba 10 kg/ha	146	5.4	35.6	20.8
Zeba 15 kg/ha	114	5.5	35.2	17.6
Zeba 20 kg/ha	166	5.3	35.7	21.8
LSD P<0.05	ns	ns	ns	ns

* corrected to 10% seed moisture content

Conclusion

Zebra is of no benefit in reducing water-stress long-term in perennial forage seed crops. Its use is in assisting seed germination and establishment during periods of drought or low rainfall.

4.2.2 Mulato II harvesting methods

Objective

The hypothesis of this research is that the method of collecting seed in nylon bags tied over seed heads will produce higher seed yields and better seed quality than other hand-harvesting methods.

The objective was to compare seed production from nylon bag collection with the common method used by farmers in Thailand of knocking seed heads and the method used in Brazil of sweeping seed from the ground.

Methods

Mulato II tillers (divided from one-year old plants) were planted at a spacing of 1 m x 50 cm on May 31, 2005 at the university. On August 2, the field was cut to 5 cm above ground level. Fertiliser was applied on August 2 (NPK 15-15-15 200 kg/ha) and on October 6 (Urea 20kg/ha).

The trial was a RCBD with 4 replications and 5 treatments and each plot measured 4 x 5 m. Treatments were

- T1) flower heads tied up and knocked once every day,
- T2) flower heads tied up and knocked twice daily,
- T3) flower heads tied up and knocked every two days,
- T4) flower heads covered up with a nylon bag and fallen seed collected every seven days from the bag.
- T5) Seed allowed to fall on to the ground and then swept up.

Seeds were harvested from the whole plots and then dried slowly on top of trays inside a laboratory before cleaning through hand screens and a South Dakota seed blower. Following cleaning, seed yields were corrected to 10% seed moisture content. Data collection included seed yield, seed weight and seed viability (tetrazolium tests TZ).

Results

The method of placing nylon bags over the seed heads to collect seed produced the highest seed yield (Table 7). The nylon bag yield was significantly higher than the second best method of twice daily knocking (88% more). There were no significant differences among seed yields of the three methods of knocking. Sweeping seed from the ground produced the lowest seed yields, the lightest seed and the seed with the lowest viability (Table 7).

Conclusion

The nylon bag method produced the most seed. However, farmers think that the costs of the bags are expensive at 8-10 baht/bag. Because Mulato II seed head stems are fairly fragile, very light-weight nylon net material must be used to avoid breaking the stems with their weight. The nylon netting must be porous to allow air-flow through the bags. The netting is cut and sown into bags that have a small aperture at one end that can be untied every 4-7 days to collect seed.

The bags cost 8-10 baht each and approximately 3,000 bags/rai are used, for a cost of 24,000-30,000 baht/rai. Farmers are currently being paid 200 baht/kg for Mulato II seed and, even if they produce 80 kg/rai, the cost of the nylon bags exceeds

their gross returns. The bags can be used for several years, which does reduce their cost over time, but apparently not sufficiently to be attractive to farmers.

Therefore knocking the seedheads once or twice a day is the most appropriate method for farmers. The village farmers who get the highest seed yields knock seedheads twice a day.

The South American method of ground sweeping fallen seed appears not suitable for harvesting Mulato II seed in Thailand. We consider that a lot of the seed is eaten by ants and perhaps a smaller amount rots on the ground. Mulato II seeds are relatively soft when they shed and can be easily eaten by ants. Moist conditions during harvest, from either rain or heavy dews, could contribute to Mulato II seed rotting on the ground.

Table 7 Effect of harvesting method on Mulato II seed yields and seed viability

Harvest method	Seed yield* (kg/rai)	TSW* (g)	Seed viability (%)
T1 Knocking once daily	36.8	8.79	92.0
T2 Knocking twice daily	43.4	8.68	92.0
T3 Knocking every 2 days	40.7	8.94	89.3
T4 Nylon bag	81.5	9.03	90.5
T5 Swept from ground	14.0	8.20	84.0
LSD P<0.05	11.7	0.38	5.8

* corrected to 10% seed moisture content

4.2.3 Mulato II and growth regulator Primo Maxx

Objective

The main objective of this research was to reduce the proportion of empty and light seeds and increase seed yields.

The use of Primo Maxx has not been studied on tropical grass seed crops because farmers and researchers have not been aware of its effective use. Plant growth regulators (PGR) are used by the majority of top seed producers of ryegrass and tall fescue in temperate countries. PGRs inhibit gibberellin biosynthesis and reduce lodging and stem length. The short stem seed crops are able to provide a better carbohydrate supply to the seeds and increase seed set by reducing the proportion of empty and light seeds. In early work in the 1980s and 1990s, seed yield increases varied from 8-136%. However, with an acceptable, cost-effective product from Syngenta called Primo Maxx (Active ingredient *Trinexapac-ethyl* 12%), ryegrass and tall fescue seed growers now achieve 30-50% increases in seed yields in New Zealand and the USA.

Methods

Two field trials studied the effects of Primo Maxx plant growth regulator on Mulato II seed production. Both trials were conducted at the university in a one-year old Mulato II field planted in May 2005 in spacings of 1 m x 50 cm.

Trial 1 Rates of Primo Maxx This trial was a RCBD with 5 treatments (control and Primo Maxx at 2, 3, 4, 5 litres/ha) and 4 replications. Primo Maxx was applied on September 7, 2006 when Mulato II plants were at the 1-2 node growth stage.

Trial 2 Timing of applying Primo Maxx This trial was a RCBD with 5 treatments [control and Primo Maxx (2 litres/ha) applied on July 7, August 7, September 7, October 7, 2006] and 4 replications.

Both trials were cut 5 cm above ground level on August 4, 2006 and fertiliser was applied on August 4 (NPK 200 kg/ha 15:15:15), September 7 (Urea 100 kg/ha) and October 7 (Urea 100 kg/ha).

At peak anthesis on November 13 (Trial 1) and November 14 (Trial 2), all inflorescences in 3 rows x 2 m in length (6 m²) were counted and nylon bags tied over the seed heads to collect the seed. Thirty inflorescences were taken from just outside this area for reproductive analysis and stem length. All racemes were counted on each inflorescence and spikelets per raceme were counted from 3 racemes per inflorescence, taken from the top, middle and bottom of each inflorescence. The length of each inflorescence was measured from ground level to top of highest raceme and from the last emerged leaf to the top of the highest raceme.

Seed was collected from the nylon bags at the end of harvest on December, 4. The seed was slowly dried in small nylon bags hung from a rail inside a shed until seed cleaning commenced on December, 20. The seed was cleaned through a South Dakota seed blower. Following cleaning, seed yields and thousand seed weight (TSW) were corrected to 10% seed moisture content.

Results

Trial 1 Rates of Primo Maxx Applying varying rates of Primo Maxx did not increase seed yields or seed yield components of Mulato II (Table 8). Stem lengths were slightly reduced by 3-6 cm only.

Table 8 Effect of rates of Primo Maxx (l/ha) on seed yield components and seed yield of Mulato II

Treatment	Stem length (cm)		Inflorescences /m ²	Racemes/ inflorescence	Spikelets /raceme	Seed yield (kg/rai)*	TSW (g)*
Primo Maxx	Base to top	Last leaf to top					
control	104	37	82	4.0	33.1	15.8	9.81
2 l/ha	100	36	98	3.9	33.1	16.7	10.43
3 l/ha	99	37	68	4.0	33.1	12.5	7.77
4 l/ha	101	37	78	4.0	33.5	16.6	10.34
5 l/ha	98	37	78	4.0	32.6	13.2	8.26
LSD	3.8	ns	ns	ns	ns	ns	ns
P<0.05							

* corrected to 10% seed moisture content

Trial 2 Timing of applying Primo Maxx Applying Primo Maxx at different times had no effect on seed yield and seed yield components of Mulato II (Table 9). Applying Primo Maxx in September shorten stem lengths by nearly 10 cm (Table 9).

Conclusion

Growth regulator Primo Maxx was not effective in increasing seed yields of Mulato II. Even though stems were shorten, increased branching leading to more racemes and spikelets did not occur and seed-set was not improved.

Primo Maxx is widely used in Thailand on golf courses to increase turf density, reduce stems appearing and reduce mowing frequency. However, it is of no use in increasing seed yields of Mulato II in Thailand.

Table 9 Effect of timing of Primo Maxx on seed yield components and seed yield of Mulato II

Treatment	Stem length (cm)		Inflorescences /m ²	Racemes/ inflorescence	Spikelets /raceme	Seed yield (kg/rai)*	TSW (g)*
Primo Maxx	Base to top	Last leaf to top					
Control	114	38	124	3.9	33.5	20.9	7.95
July	115	37	121	3.9	33.5	20.4	7.96
August	112	37	79	4.1	33.1	12.5	8.05
September	108	37	94	4.1	33.1	10.8	7.87
October	103	34	126	4.1	33.3	19.3	7.95
LSD	6.4	2.0	ns	ns	ns	ns	ns
P<0.05							

* corrected to 10% seed moisture content

4.2.4 Ubon paspalum and plant growth regulator Primo Maxx

Objective

The main objective of this research was to increase seed yields of Ubon paspalum by shortening stem lengths and reducing lodging.

Methods

Two field trials studied the effects of Primo Maxx plant growth regulator on Ubon paspalum seed production. Both trials were conducted at the university in plots of Ubon paspalum planted in May 2006 in spacings of 1 m x 50 cm.

Trial 1 Rates of Primo Maxx This trial was a RCBD with 5 treatments (control and Primo Maxx at 2, 3, 4, 5 litres/ha) and 4 replications. Primo Maxx applied on August 7, 2006 when Ubon paspalum plants were at the 2 node stage and 50 cm in height.

Trial 2 Timing of applying Primo Maxx This trial was a RCBD with 5 treatments [control and Primo Maxx (2 litres/ha) applied on June 7, July 7, August 7, September 7] and 4 replications.

Both trials were cut 10 cm above ground level on July 7, 2006 and fertiliser was applied on July 7 (NPK 200 kg/ha 15:15:15), August 7 (Urea 100 kg/ha) and September 7 (Urea 100 kg/ha).

For both trials at peak anthesis on September 25, all inflorescences in 3 rows x 2 m in length (6 m²) were counted and nylon bags tied over the seed heads to collect the seed. Thirty inflorescences were taken from just outside this area for reproductive analysis and stem length. All racemes were counted on each inflorescence and spikelets per raceme were counted from 3 racemes per inflorescence, taken from the top, middle and bottom of each inflorescence. The length of each inflorescence was measured from ground level to top of highest raceme and from the last emerged leaf to the top of the highest raceme.

Seed was collected from the nylon bags at the end of harvest on October 13. The seed was slowly dried in small nylon bags hung from a rail inside a shed until seed cleaning commenced on November 6. The seed was cleaned through a South Dakota seed blower. Following cleaning, seed yields and thousand seed weight (TSW) were corrected to 10% seed moisture content.

Results

Trial 1 Rates of Primo Maxx Applying varying rates of Primo Maxx did not increase seed yields of Ubon paspalum (Table 10). A rate of 3l/ha reduced seed yields by nearly 40% compared to not applying Primo Maxx (control). Primo Maxx reduced stem lengths and increased the number of racemes and spikelets.

Trial 2 Timing of applying Primo Maxx Applying Primo Maxx from July onwards significantly reduced seed yields of Ubon paspalum compared to applying Primo Maxx in June or not applying at all (control) (Table 11). Applying Primo Maxx in September reduced stem length, number of inflorescences, seed yield and TSW, and increased spikelet numbers compared to earlier applications of Primo Maxx.

Table 10 Effect of rates of Primo Maxx (l/ha) on seed yield components and seed yield of Ubon paspalum

Treatment Primo Maxx	Stem length (cm)		Inflorescences /m ²	Racemes/ inflorescence	Spikelets /raceme	Seed yield (kg/rai)*	TSW (g)*
	Base to top	Last leaf to top					
control	190	71	49.7	9.9	133.6	122	3.51
2 l/ha	170	65	54.2	10.5	141.1	113	3.36
3 l/ha	170	64	44.5	10.8	144.4	75	3.39
4 l/ha	172	63	50.9	10.8	139.3	110	3.35
5 l/ha	162	59	48.4	11.4	142.6	118	3.32
LSD	10.2	5.3	ns	0.9	6.7	26	ns
P<0.05							

* corrected to 10% seed moisture content

Table 11 Effect of timing of Primo Maxx on seed yield components and seed yield of Ubon paspalum.

Treatment Primo Maxx	Stem length (cm)		Inflorescences /m ²	Racemes/ inflorescence	Spikelets /raceme	Seed yield (kg/rai)*	TSW (g)*
	Base to top	Last leaf to top					
Control	180	65	60.4	10.0	122.1	158	3.47
June	183	68	54.1	10.0	128.3	140	3.40
July	179	65	50.8	10.8	124.0	121	3.55
August	173	63	56.7	10.5	129.0	112	3.43
September	161.7	60	47.7	10.1	133.2	71	3.36
LSD	11.2	4.6	7.4	ns	6.3	32	0.84
P<0.05							

* corrected to 10% seed moisture content

Conclusion

Applying Primo Maxx at different rates and at different times was of no benefit in increasing Ubon paspalum seed yields. Even though raceme and spikelet numbers did increase, there was a corresponding decrease in inflorescence numbers which prevented seed yield increasing. Instead, there was a strong trend towards reduced seed yields from using Primo Maxx compared to control.

Plant stem lengths were shortened which may be of benefit if lodging occurs, but given that farmers can cut back excessive forage growth in July to prevent lodging, there would be no economic benefit gained from applying Primo Maxx.

In Thailand, Primo Maxx will not increase seed yields of Ubon paspalum.

5 Important project research and development conclusions over the last 18 months

5.1 Papers

Nine papers were written during the 18 month phase of the project. The project maintained a high international scientific output.

- 1 Hare M.D. 2006 Applied research leads to successful export seed production of South American forages in Ubon Ratchathani province, Thailand. *International Herbage Seed Group Newsletter*, 40: 6-9. (Appendix 1).
- 2 Hare, M.D. and Wongpichet, K. 2007 (eds) Forages: A Pathway to Prosperity for Smallholder Farmers. *Proceedings of an International Forage Symposium, Faculty of Agriculture, Ubon Ratchathani University, Thailand*. (Title page Appendix 2).
- 3 Hare, M.D. 2007 Successful seed production of South American forages in Ubon Ratchathani province, Thailand: Research, development and export. In: Hare, M.D. and Wongpichet, K. (eds) *Forages: A Pathway to Prosperity for Smallholder Farmers. Proceedings of an International Forage Symposium, Faculty of Agriculture, Ubon Ratchathani University, Thailand*. pp. 35-60. (Faculty of Agriculture, Ubon Ratchathani University, Thailand). (Appendix 3).
- 4 Hare, M.D., Tatsapong P. and Saiprasert, K. 2007 Seed production of two brachiaria hybrid cultivars in north-east Thailand. 1. Method and time of planting. *Tropical Grasslands*, 41, 26-34. (Appendix 4).
- 5 Hare, M.D., Tatsapong, P. and Saiprasert, K. 2007 Seed production of two brachiaria hybrid cultivars in north-east Thailand. 2. Closing date. *Tropical Grasslands*, 41, 35-42. (Appendix 5).
- 6 Hare, M.D., Tatsapong, P. and Saiprasert, K. 2007 Seed production of two brachiaria hybrid cultivars in north-east Thailand. 3. Harvesting method. *Tropical Grasslands*, 41, 43-49. (Appendix 6).
- 7 Hare, M.D., Tatsapong P., Phengphet, S. and Lunpha, A. 2007 *Stylosanthes* species in north-east Thailand: dry matter yields and seed production *Tropical Grasslands*, 41, (in press). (Appendix 7).
- 8 Miles, J.W. and Hare, M.D. 2007 Plant breeding and seed production of apomictic tropical forage grasses. *Proceedings of International Herbage Seed Group Conference* (in press). (Appendix 8).
- 9 Hare, M.D., Lunpha, A. and Phengphet, S. 2007 Effect of foliar applications of trinexapac-ethyl plant growth regulator on seed yield in brachiaria hybrid cv. Mulato II and *Paspalum atratum*. *Tropical Grasslands* (submitted). (Appendix 9).

5.2 Seed production by village farmers

Mulato II, Ubon paspalum and Ubon stylo are lucrative cash crops for farmers in this region. They produce 2-3 times the income from traditional upland cash crops of maize, cassava and sugarcane. They produce more cash income than rice.

Ubon paspalum and Ubon stylo produce the highest income for farmers. However, the market for their seeds is limited. We can only sell between 4,000-7,000

kgs/year. Only 30 farmers are contracted each year to produce seed of these two species and these farmers are only in one village, Bark Kud Waay, Warin Chamrab district, Ubon Ratchathani province. We can not expand seed production of Ubon paspalum and Ubon stylo because the market is not big enough. Grupo Papalotla is trying to market seed of these two species in Central and South America and hopefully the market will expand in future years. But the market will always be small and probably less than 10,000 kgs/year.

In contrast, the market for Mulato II is huge; with up to 500,000 kgs/year that could easily be sold overseas. But we have had major problems in producing seed. The farmers we have contracted to produce seed have generally failed. The major reason for failure is that these farmers are not forage seed specialists and their major crop is rice which is more important for them.

In addition, the land in Ubon Ratchathani province is generally low-lying and Mulato II is best grown on upland areas. Areas in Amnart Charern and Mukdahan are more suitable for Mulato II seed production. Farmers there have successfully grown Purple guinea seed for many years and if Purple guinea grows well, Mulato II will also grow well. Now that the market for Purple guinea has collapsed, the seed farmers there want to grow Mulato II.

We are optimistic that approximately 30,000-40,000 kgs will be produced in 2007 because farmers in Amnart Charern and Mukdahan have joined our project. Production could easily increase to over 200,000 kgs in 2008.

5.3 Seed production research

The method of placing nylon bags over seedheads produced the highest seed yield of Mulato II (81 kg/rai) which was nearly 2 times the yield produced by knocking. However, because of the high cost of nylon bags (8-10 baht/bag), farmers prefer to knock seedheads once or twice a day. The method of ground sweeping seed, which is the common method of grass seed production in Central and South America and for stylo seed crops in Thailand, was not suitable at all for Mulato II. A very low seed yield of 14 kg/rai was produced by ground sweeping Mulato II seed.

Applying a growth regulator, Primo Maxx, and using a starch-based polymer, Zeba, were of no benefit at all in increasing seed yield of Mulato II.

6 Were the objectives of this project achieved?

In the project proposal submitted to the Thailand Research Fund for approval in 2005, there were 10 main project objectives.

6.1 To help alleviate the forage seed shortage problem in Thailand.

This objective was not achieved because there is no longer a forage seed shortage in Thailand. Instead, there is currently a huge oversupply of seed, particularly Purple guinea grass. Nearly 2 million kgs of Purple guinea seed were produced in Thailand in 2006 and only about 30% of this seed has been sold.

6.2 To support with high quality forage seeds the Thailand Government's Project "Cows for One Million Families" which will require a huge supply of good quality forage.

This objective was achieved in 2006 because the project produced high quality seed of Ubon paspalum and Ubon stylo which has been sold in Thailand. Even though only a small amount of Mulato II seed has been sold in Thailand, there has been a lot of Mulato II fresh forage produced from former seed crops, for either farmers' own cattle consumption or sold as fresh forage.

The Thailand Government's Project "Cows for One Million Families" has now stopped so this objective no longer is relevant.

6.3 To promote high quality seed production of selected grasses and legumes in villages in Ubon Ratchathani, Yasothon, Sisaket and Amnart Charern provinces.

This objective was achieved in Ubon Ratchathani and Amnart Charern provinces where the project will continue contracts with seed growers in 2007 and thereafter. Mukdahan province will also become a centre of forage seed production. However, the project was not successful in promoting forage seed production in Sisaket and Yasothon provinces. Farmers in these two provinces are more interested in rice production (Yasothon and Sisaket) and horticulture crops (Sisaket).

6.4 To transfer existing village forage seed production technology that is available in one village in Ubon Ratchathani province to more than 50 villages in the above four provinces.

This objective was achieved in 17 villages in 2006. Even though we had a seed production programme in 45 villages, only farmers in 17 villages successfully produced seed. In 2007, we have now reduced the number of villages to only 16 villages and a smaller number of farmers, 323, but with larger areas. These farmers are very efficient at forage seed production and so we should get many more times the amount of seed in 2007 than in 2006.

6.5 To demonstrate that forage seed production produces far more income for village farmers than other upland arable crops.

This objective was achieved as our economic analysis showed that forage seeds will produce 2-3 times the income of alternate crops grown on the same land.

6.6 To develop new forage seed production management that will improve forage seed yields.

This objective was partially achieved with harvesting techniques increasing seed yield but other management techniques (growth regulators and starch-based polymer) not increasing seed yield. Future increases in seed yield will come from plant breeding and not from improved management.

6.7 To develop long-term markets for these forage seeds within Thailand and overseas.

This objective was achieved with the sale of Ubon paspalum, Ubon stylo and Mulato II seed overseas. We are also starting to sell more seeds within Thailand but this has been difficult because our seed is far more expensive than Purple guinea, because over-production has lowered prices of Purple guinea seed.

6.8 To promote Ubon Ratchathani, Yasothon, Sisaket and Amnart Charern provinces as the main centre of high quality forage seeds in Asia.

This objective was only partially achieved because we will continue seed production in Ubon Ratchathani and Amnart provinces but not in Yasothon province and only in one village in Sisaket province.

6.9 To promote forage seeds as a Product of Thailand associated with High Quality (High Purity and High Germination).

This objective was definitely achieved because overseas countries now know that hand-harvested forage seeds from Thailand have high quality. Even though the seeds Grupo Papalotla buys in Thailand are more expensive than Brazilian seeds, farmers in Central and South America are starting to demand seeds from Thailand. Brazilian seeds usually only have a purity of 50% and a germination of less than 40%

but they are cheap. Our seed purities are generally over 98% and with germinations higher than 80%.

6.10 To promote Ubon Ratchathani University as a research centre of high quality forage seed production in Thailand through international publications, conferences, training, field days and the mass media.

This objective was definitely achieved with the running of the successful International Forage Conference '*Forages: A Pathway to Prosperity for Smallholder Farmers*' in March 2007 at the university. Delegates from 25 countries were very impressed with the amount of seed research conducted at the university and the village farmer seed production programme.

We have been asked to host the 7th International Herbage Seed Group conference in 2011 because of our reputation as a centre of seed production excellence. This conference will probably attract at least 150 delegates from over 50 countries.

7 Overall conclusion

The project was not totally successful in reaching all its goals with village seed production (Mulato II) but it has created enormous interest with farmers in Amnart Charern and Mukdahan provinces. Because we will rapidly expand village seed production in future years we can say that our project was partially successful.

The project will continue indefinitely with funding from our revolving seed fund and from the Mexican seed company, Grupo Papalotla.

Appendices

- 1 Hare M.D. 2006 Applied research leads to successful export seed production 53
of South American forages in Ubon Ratchathani province, Thailand.
International Herbage Seed Group Newsletter, 40: 6-9.
- 2 Hare, M.D. and Wongpichet, K. 2007 (eds) Forages: A Pathway to Prosperity 59
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brachiaria hybrid cultivars in north-east Thailand. 3. Harvesting method.
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- 7 Hare, M.D., Tatsapong P., Phengphet, S. and Lunpha, A. 2007 *Stylosanthes* 128
species in north-east Thailand: dry matter yields and seed production
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- 9 Hare, M.D., Lunpha, A. and Phengphet, S 2007 Effect of foliar applications 148
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hybrid cv. Mulato II and *Paspalum atratum*. *Tropical Grasslands*
(submitted).

Appendix 1

Applied Research leads to successful export seed production of South American forages in Ubon Ratchathani province, Thailand

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Introduction

In 1995, the Faculty of Agriculture, Ubon Ratchathani University, received research funding from the Thailand Research Fund (TRF) to study improved forages for dairy cows in Thailand. Following 10 years of continuous research, three forage species from South America, Ubon paspalum, Ubon stylo and Mulato II, have been found to be suitable to grow in Northeast Thailand. A village seed production programme was initiated to produce seed for farmers in Thailand and recently a seed export market has developed with seed being sold back to Central and South America, the place of origin of these new forages.

Research and development of the forages to reach commercial export seed production followed a clear long-term plan set out by the research project team in the Faculty of Agriculture.

- Field research on applied agronomic management and seed technology.
- Pilot project feasibility studies.
- Selection and training of farmers in seed crop management, harvesting and cleaning.
- Providing technical support to seed growers.
- Contracting farmers to buy the seed at a guaranteed price and being the main buyer of seed.
- Processing, storing and marketing the forage seeds.
- Creating markets for forage seeds.

Origin of the three forage species

Ubon paspalum (*Paspalum atratum*) is a wild species native to the states of Mato Grosso do Sul, Goiás and Minas Gerais in central-western Brazil (Quarin *et al.*, 1997). An accession of this wild species, BRA 009610, was originally collected near the village of Terenos, Mato Grosso do Sul State, Brazil, by Dr. J. Valls in April 1986 (J. Valls pers. com.). In November 1994, Ubon Ratchathani University received 100 grams of BRA 009610 from Dr. Werner Stur of the Forages for Smallholders Project based at IRRI, Philippines (a project funded by AustAid and managed by CSIRO (Australia) and CIAT (Colombia)). Fifty grams of this seed were used for the initial evaluation research (Hare *et al.*, 1999a) and the other 50 grams were used for seed multiplication (Hare *et al.*, 2001a).

Following 3 years of evaluation work in Northeast Thailand, *P. atratum* was consistently found to be the best grass on seasonally wet-seasonally dry soils and in 1997 it was released for forage use by Ubon Ratchathani University as cultivar Ubon (Hare *et al.*, 1999a).

Ubon stylo (*Stylosanthes guianensis* var. *vulgaris* x var. *pauciflora*) is a blend of four lines (GC 1463, GC 1480, GC 1517, and GC 1579) derived from *S. guianensis* var. *vulgaris* x var. *pauciflora* by selection for long-term resistance to anthracnose by Dr Bela

Grof at the Embrapa Beef Cattle Research Centre, Campo Grande, Brazil in the 1990s (Grof, *et al.* 2001). Seeds of these four lines were physically mixed in order to create greater genetic diversity for durable resistance to anthracnose. Three of the components (GC 1463, GC 1517 and GC 1579) are single-plant selections made in the Philippines by Dr Grof from the hybrid population CIAT 11833 which was selected in the Colombian Llanos by Dr John Miles at CIAT. The fourth component (GC 1480) is from accession CIAT 2340, which originates from the Casanare region of Colombia. Selection for anthracnose resistance was carried out in the Philippines and in regional trials conducted in Brazil.

In November 1999, we received from Dr Bela Grof 20 grams of seed. We grew 2622 seedlings which we planted into a 510 m² area on the university farm in May 2000. Twenty-six kgs of seed were harvested from this area in February 2001. We used this seed for dairy trials, where we found that dairy cows grazing Ubon stylo produced high milk yields without any extra feeding of concentrates (Thummasaeng *et al.* 2004).

The *S. guianensis* var. *vulgaris* x var. *pauciflora* blend has been registered in Australia as ATF 3308 and released as cultivar Nina in 2003 (Cook *et al.* 2005). However, in Thailand, farmers growing seed and forage call it "Ubon stylo" and so we have continued to use this name since releasing it in 2002.

We used this seed for dairy grazing trials, where we found that dairy cows grazing Ubon stylo produced high milk yields without any extra feeding of concentrates (Thummasaeng *et al.*, 2004). In small plot trials, Ubon stylo produced significantly more dry matter than hamata stylo, the commonly grown stylo in Thailand. Following 3 years research at the university we found Ubon stylo to be the best stylo legume on upland soils. It produced equal dry matter yields to Tha Phra stylo but because of its greater resistance to anthracnose, greater palatability, rapid seed germination and high seed yields (Table 1), we decided to produce more seed in our village farmer seed production programme.

Table 1. Effect of cultivar on seed yields and seed weight of stylo.

Cultivar	Seed yield (kg/ha) ¹	TSW (g) ¹
Ubon stylo	958.6	2.50
Tha Phra stylo	365.0	2.59
LSD (P<0.05)	425.0	0.06

¹ Corrected to 10% seed moisture content

Mulato II (*Brachiaria ruziziensis* x *B. decumbens* x *B. brizantha*) is a tetraploid, interspecific hybrid bred at CIAT, Colombia. The International Center for Tropical Agriculture [Centro Internacional de Agricultura Tropical (CIAT)] in Cali, Colombia, began its *Brachiaria* breeding programmes 18 years ago to attempt to increase resistance to spittlebugs (Hemiptera: Cercopidae) (Miles *et al.* 2006) and improve nutritive quality and dry matter production of *Brachiaria* spp. through interspecific hybridisation and selection. The major achievements of the programme have been stable tetraploid sexual germplasm (Miles *et al.* 2004) and the release of two *brachiaria* hybrid cultivars, Mulato and Mulato II. After extensive selection in field trials throughout the 1990s, cv. Mulato (*B. ruziziensis* x *B. brizantha*), the first interspecific *Brachiaria* hybrid was released in 2000 through Grupo Papalotla, a Mexican seed company.

A second hybrid cultivar, Mulato II (*B. ruziziensis* x *B. decumbens* x *B. brizantha*), was developed from an original *B. ruziziensis* x *B. decumbens* cross followed by 2

generations of hybridisation by exposure to *B. brizantha* pollen in the field and released by Grupo Papalotla in 2004. In trials in Central and South America, Mulato II produced more dry season forage and had better milk production over time than Mulato and other *Brachiaria* cultivars (CIAT 2004). It also produced more seed than Mulato.

Like conventional cultivars of *B. decumbens* and *B. brizantha*, both hybrids are apomicts (reproduce asexually by seed), and hence are true-breeding (Miles *et al.* 2004 and J.W. Miles, personal communication, 2006).

In 2003, Grupo Papalotla made the business decision to come to Thailand to produce brachiaria hybrid seed. The decision to produce seed in Thailand was because of forage seed quality, smallholder experience and professionalism and public sector involvement in forage seed production (Hare and Horne 2004). Grupo Papalotla also wanted to break into the Asian market for forage seed. In addition, there was an expectation that seed yields of brachiaria hybrids may be higher in Thailand, because of intensive agronomic management and hand harvesting of seed from small fields, than in Brazil and Mexico under extensive management and machine of sweeping seed from the ground from large fields. Low seed yields in Brazil and Mexico (less than 200 kg/ha) meant that the price of brachiaria hybrids seeds was 3-4 times higher than that of seeds of other commercial *Brachiaria* spp. in Latin America.

Forage seed research and development

Ubon paspalum

A series of problem solving research studies were undertaken on method of sowing, time of planting, closing date, methods of hand harvesting seed and juvenility and long-short day requirement for flowering (Hare *et al.* 1999b; 2001a; 2001b).

Ubon stylo

Studies on closing date from that cutting Ubon stylo seed crops in September produced significantly more seed than cutting in October and 50% more seed than the control plots. (Table 2).

Table 2. Effect of closing on Ubon stylo seed yields and seed weight

Time of closing	Seed yield (kg/ha) ¹	TSW (g) ¹
Control	844	2.52
September	1294	2.46
October	725	2.43
LSD (P<0.05)	513	0.078

¹ Corrected to 10% moisture content.

Mulato II

High seed yields of Mulato II are extremely difficult to achieve because all the new hybrid brachiarias appear to have very low seed set of between 2-10%. They produce a lot of seed but most of this seed is either light or empty. This apparently is a genetic factor and it is difficult to overcome by agronomic management techniques.

Field trials commenced at Ubon Ratchathani University, Thailand, in 2003 to investigate agronomic management of brachiaria hybrids in order to increase seed yields. A series of trials studied the effects of method and time of planting (Hare *et al.* 2007a), closing date defoliation (Hare *et al.* 2007b) and harvesting methods (Hare *et al.* 2007c) on seed production of cvv. Mulato and Mulato II.

The method of placing nylon bags over the seed heads to collect seed produced the highest seed yield (Table 3). The nylon bag yield was significantly higher than the second

best method of twice daily knocking (88% more). The South American method of ground sweeping fallen seed appears not suitable for Thailand.

Table 3 Effect of harvesting method on Mulato II seed yields and seed viability

Harvest method	Seed yield* (kg/ha)	TSW* (g)	Seed viability (%)
Knocking once daily	230.2	8.79	92.0
Knocking twice daily	271.2	8.68	92.0
Knocking every 2 days	254.6	8.94	89.3
Nylon bag	509.4	9.03	90.5
Swept from ground	87.3	8.20	84.0
LSD P<0.05	73.2	0.38	5.8

* corrected to 10% seed moisture content

Smallholder farmer seed production

Ubon paspalum

Since 2003, a total of 12,320 kgs of seed have been produced and 985,600 baht paid in cash to the farmers in Bark Kud Waay village (Table 4).

Seed is harvested by tying seed heads and knocking the seed out into bamboo trays

Table 4. Ubon paspalum village seed production.

Year	No of farmers	Quota per farmer (kgs)	Amount of seed (kgs)	Amount of money paid (baht)
2003	22	250	5,500	440,000
2004	22	100	2,200	176,000
2005	42	110	4,620	369,600
2006	30	220	6,600 ¹	528,000 ¹

¹ Estimated targets for 2006

Ubon stylo

At seed harvest, the farmers allow nearly all the seed to fall to the ground and then beat any remaining seed out of the seed heads with sticks. The vegetation is cut to ground level and removed. Seed is swept from the ground and cleaned by the farmers in the field.

In February each year, the project purchases the seed in the village and pays out cash the same day. The seed is then scarified through a rice thresher at the university to remove soil and seed coats to improve seed purity and seed germination.

Farmers produce more than 900 kg/ha of seed each year. Seed harvesting is a dirty and dusty job as the seed has to be swept from the ground and cleaned through screens in the field. However, with the high seed yields, the farmers find Ubon stylo seed production to be a lucrative cash crop (Table 5).

Table 5. Ubon stylo village seed production

Year	No of farmers	Amount of seed produced (kgs)	Amount of money paid (baht)	Amount of seed exported (kg)
2003	4	541	54,100	-
2004	2	651	65,100	-
2005	10	2,070	207,000	1,800
2006	15	5,590	559,000	4,000
2007 ¹	30 ¹	7,500 ¹	750,000 ¹	4,000 ¹

¹ Estimated targets for 2007

1,800 kgs and 4000 kgs of Ubon stylo seed were exported in 2005 and 2006, respectively to Grupo Papalotla, Miami, USA. Grupo Papalotla then sold this seed in 10 countries in Central and South America.

Mulato II

A Memorandum of Understanding was signed on April 27, 2004 between the Faculty of Agriculture, Ubon Ratchathani University and a Mexican seed company, Grupo Papalotla, to produce seed of Mulato II in villages in Northeast Thailand for export to Central and South America.

Smallholder village farmers sign contracts with the project at the beginning of each wet season to produce and sell all Mulato II seed harvested. Each farmer receives a seed production brochure and 0.5 kg of seed to plant a seed nursery. The farmers transplant seedlings into cultivated fields in May and June each wet season, in rows 1 m x 50 cm apart.

At seed harvest, the farmers tie the seed heads into living sheaves and knock the seed out in trays every day. Seed is dried slowly in the shade for 3 days and then sun-dried for 1-2 days before cleaning.

In 2004 and 2005, respectively, 2,070 kgs and 1292 kgs of high quality seed (7.3 % moisture, 99.9 % purity and 83 % viability TZ test) were produced by farmers in one village. 1,500 kgs and 1,000 kgs respectively, were exported in 2005 and 2006 to Grupo Papalotla, Miami, USA.

400 village farmers in Ubon Ratchathani and Amnart Charoen signed contracts to produce Mulato II seed this year. The project target is 15,000 kgs in 2006.

If this pilot project lives up to expectations, Grupo Papalotla expects to produce up to 1000 tones of Mulato II seed annually in Thailand. The major markets will initially be in Mexico and Brazil followed by other countries in Central and South America, but the company also intends to develop a seed market in Asia. A small market will develop in Thailand (perhaps 100 tones per year), with Mulato II replacing other species because of its superior dry matter production, particularly in the dry season.

Conclusion

Our focus at Ubon Ratchathani University is primarily research and so we have limited our seed production to what we believe we can sell annually. The forage research team is endeavouring to provide a real and sustainable market for the three forages, that does not depend on government funding. The joint venture with the Mexican seed company will further decrease our reliance on public sector funding. We have set up a revolving fund that pays the farmers promptly on the day of seed purchase and employs staff to carry out research and development work.

The development of Ubon paspalum from being a wild native plant in Brazil to a commercial forage in Thailand has been rapid. It only took a little over 10 years for this wild accession to become a proven forage crop in Thailand, which shows the potential impact forage germplasm collection can have on the future agriculture needs of mankind. Ubon stylo and Mulato II were developed through breeding programmes in South America and within 5 years of their release they have proven to be exciting new forages for Northeast Thailand. The applied research and subsequent development of the three South American forages at Ubon Ratchathani University was achieved initially through personal contacts between scientists and then the trust that a commercial overseas private

seed company placed in our research programme at Ubon Ratchathani University to deliver seed in large quantities for export.

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Appendix 2

**Forages:
A Pathway to Prosperity
for
Smallholder Farmers**

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Faculty of Agriculture, Ubon Ratchathani University,
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Appendix 3

Successful seed production of South American forages in Ubon Ratchathani province, Thailand: Research, development and export

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Abstract

In 1995, the Faculty of Agriculture, Ubon Ratchathani University, received research funding from the Thailand Research Fund (TRF) to study improved forages for dairy cows in Thailand. During 11 years of continuous research, three forage species from South America, Ubon paspalum, Ubon stylo and Mulato II, have been found to be suitable to grow in Northeast Thailand.

This paper details the applied research studies on seed production of the three species at Ubon Ratchathani University and the development of a village seed production programme to produce seed for farmers in Thailand and for export. A Memorandum of Understanding was signed in 2004 between the Faculty of Agriculture, Ubon Ratchathani University and a Mexican seed company, Grupo Papalotla, to produce seed of Mulato II in villages in Northeast Thailand for export. A seed export market for all three species has developed, with seed being sold back to Central and South America, the place of origin of these new forages.

Introduction

Thailand, for nearly 30 years, has had a government supported forage seed production programme producing a wide range of forage seeds on government stations and in villages (Hare 1993; Hare and Phaikaew 1999). Tropical forage seed

production has evolved through research, pilot projects and long-term government support. Forage seed production has been integrated into the village cropping systems in Northeast Thailand and become the main commercial crop for many smallholder farmers.

Forage seed production in Thailand is concentrated in the northeast region (14-18°N, 1200-1600 mm average annual rainfall, 100-300 m asl). The well-defined wet and dry seasons are conducive for flowering, harvesting and drying (Hare and Phaikaew 1999). The region is at sufficiently high latitude to enable a strong flowering response of tropical forage plants to short days and with some species to long days (Hare *et al.* 2001b). The reliable dry season contributes to successful ground harvesting legume seed of some species (Wickham *et al.* 1977; Hare and Phaikaew 1999).

Sandy soils on flat to gently rolling land in northeast Thailand are easily cultivated for seed-bed preparation. While the soils are acid and low in organic matter, nitrogen, phosphorus and sulphur, most tropical grasses and legumes grow satisfactorily with the addition of fertiliser. The soils are well-drained and while low in water-holding capacity, the sufficient amount of wet season rain (1200-1600 mm) prevents seed crops from suffering water stress. The soil texture of the sandy soils in Northeast Thailand is an important factor in facilitating ground sweeping of fallen legume seeds. Clay and laterite soils leave granules that make seed cleaning difficult.

In 1995, the Faculty of Agriculture, Ubon Ratchathani University, received research funding from the Thailand Research Fund (TRF) to study improved forages for dairy cows in Thailand. During 11 years of continuous research, three forage species from South America, Ubon paspalum, Ubon stylo and Mulato II, have been found to be suitable to grow in Northeast Thailand. A village seed production programme was initiated to produce seed for farmers in Thailand and recently a seed export market has developed with seed being sold back to Central and South America, the place of origin of these new forages.

Research and development of the forages to reach commercial export seed production followed a clear long-term plan set out by the research project team in the Faculty of Agriculture.

- Field research on applied agronomic management and seed technology.
- Pilot project feasibility studies.
- Selection and training of farmers in seed crop management, harvesting and cleaning.
- Providing technical support to seed growers.
- Contracting farmers to buy the seed at a guaranteed price and being the main buyer of seed.
- Processing, storing and marketing the forage seeds.
- Creating markets for forage seeds.

Origin of the three forage species

Ubon paspalum (*Paspalum atratum*) is a wild species native to the states of Mato Grosso do Sul, Goiás and Minas Gerais in central-western Brazil (Quarin *et al.* 1997). An accession of this wild species, BRA 009610, was originally collected near the village of Terenos, Mato Grosso do Sul State, Brazil, by Dr. J. Valls in April 1986 (J. Valls personal communication). Small amounts of seed were subsequently distributed to research institutions in Brazil, Argentina, Colombia, Florida and the Philippines.

In November 1994, Ubon Ratchathani University received 100 grams of BRA 009610 from Dr. Werner Stur of the Forages for Smallholders Project based at IRRI, Philippines (a project funded by AustAid and managed by CSIRO (Australia) and CIAT (Colombia)). Fifty grams of this seed were used for the initial evaluation research (Hare *et al.* 1999a) and the other 50 grams were used for seed multiplication (Hare *et al.* 2001a).

Following 3 years of evaluation work in Northeast Thailand, *P. atratum* was consistently found to be the best grass on seasonally wet-seasonally dry soils and

in 1997 it was released for forage use by Ubon Ratchathani University as cultivar Ubon (Hare *et al.* 1999a). It has also been released in Florida as cultivar Suerte atrapaspalum (Kalmbacher *et al.* 1997), in Australia as cultivar Hi-Gane (Loch and Ferguson 1999), in Argentina as cultivar Camba FCA (J. Valls personal communication) and in the Philippines as cultivar Terenos (Horne and Stur 1999).

Ubon stylo (*Stylosanthes guianensis* var. *vulgaris* x var. *pauciflora*) is a blend of four lines (GC 1463, GC 1480, GC 1517, and GC 1579) selected by Dr Bela Grof at the Embrapa Beef Cattle Research Centre, Campo Grande, Brazil in the 1990s (Grof *et al.* 2001). Seeds of these four lines were physically mixed in order to create greater genetic diversity for durable resistance to anthracnose. Three of the components (GC 1463, GC 1517 and GC 1579) are single-plant selections made in the Philippines by Dr Grof from the hybrid population CIAT 11833 which was selected in the Colombian Llanos by Dr John Miles at CIAT. The fourth component (GC 1480) is from accession CIAT 2340, which originates from the Casanare region of Colombia. Selection for anthracnose resistance was carried out in the Philippines and in regional trials conducted in Brazil.

In November 1999, we received from Dr Grof 20 grams of seed from which we grew 2622 seedlings and planted these into a 510 m² area on the university farm in May 2000. Twenty-six kgs of seed were harvested from this area in February 2001. We used this seed for dairy trials, where we found that dairy cows grazing Ubon stylo produced high milk yields without any extra feeding of concentrates (Thummasaeng *et al.* 2004).

The *S. guianensis* var. *vulgaris* x var. *pauciflora* blend has been registered in Australia as ATF 3308 and released as cultivar Nina in 2003 (Cook *et al.* 2005). However, in Thailand, farmers growing seed and forage call it "Ubon stylo" and so we have continued to use this name since releasing it in 2002.

Following 3 years research at the university we found Ubon stylo to be the best stylo legume on upland soils (Hare *et al.* 2007a). It produced equal dry matter yields to Tha Phra stylo (CIAT 184) (Table 1), but because of its greater resistance to anthracnose, greater palatability, rapid seed germination and high seed yields

(Table 2), we decided to produce seed in our village farmer seed production programme.

Table 1. Plant counts 6 weeks after sowing and dry matter yields of five stylo cultivars.

Cultivar	Plant counts (no/m ²)	Dry matter yield					
		Wet	Dry	Wet	Dry	Wet	Dry
		2003	2003-4	2004	2004-5	2005	2005-6
Verano	253	5580	2800	8336	536	4280	3669
Tha Phra	306	7746	5863	14423	3718	10638	6245
Ubon stylo	381	6993	5857	14899	3459	10673	6396
Temprano	264	5521	4363	12692	2724	8963	5383
Seca	46	1443	3293	9035	1562	4738	1925
LSD (P<0.05)	62	1816	1282	1380	556	1896	1381

Table 2. Effect of stylo cultivar on seed yields and seed weight.

Treatment	Seed yield*	TSW*
Cultivar	(kg/ha)	(g)
Ubon stylo	959	2.50
Tha Phra	365	2.59
LSD (P<0.05)	425	0.06

* corrected to 10% seed moisture content

Mulato II (*Brachiaria ruzizensis* x *B. decumbens* x *B. brizantha*) is a tetraploid, interspecific hybrid bred at the International Center for Tropical Agriculture [Centro Internacional de Agricultura Tropical (CIAT)] in Cali, Colombia. CIAT began its *Brachiaria* breeding programmes 18 years ago to attempt to increase resistance to spittlebugs (Hemiptera: Cercopidae) (Miles *et al.* 2006) and improve nutritive quality and dry matter production of *Brachiaria* spp. through interspecific hybridisation and selection. The major achievements of the programme have been stable tetraploid sexual germplasm (Miles *et al.* 2004) and the release of two *brachiaria* hybrid cultivars, Mulato and Mulato II. After extensive selection in field trials throughout the

1990s, cv. Mulato (*B. ruziziensis* x *B. brizantha*), the first interspecific *Brachiaria* hybrid was released in 2000 through Grupo Papalotla, a Mexican seed company.

A second hybrid cultivar, Mulato II (*B. ruziziensis* x *B. decumbens* x *B. brizantha*), was developed from an original *B. ruziziensis* x *B. decumbens* cross followed by 2 generations of hybridisation by exposure to *B. brizantha* pollen in the field and released by Grupo Papalotla in 2004. In trials in Central and South America, Mulato II produced more dry season forage and had better milk production over time than Mulato and other *Brachiaria* cultivars (CIAT 2004). It also produced more seed than Mulato.

Like conventional cultivars of *B. decumbens* and *B. brizantha*, both hybrids are apomicts (reproduce asexually by seed), and hence are true-breeding (Miles *et al.* 2004 and J.W. Miles personal communication 2006).

In 2003, Grupo Papalotla made the business decision to come to Thailand to produce brachiaria hybrid seed. The decision to produce seed in Thailand was because of forage seed quality, smallholder experience and professionalism and public sector involvement in forage seed production (Hare and Horne 2004). Grupo Papalotla also wanted to break into the Asian market for forage seed. In addition, there was an expectation that seed yields of brachiaria hybrids may be higher in Thailand, because of intensive agronomic management and hand harvesting of seed from small fields, than in Brazil and Mexico under extensive management and machine of sweeping seed from the ground from large fields. Low seed yields in Brazil and Mexico (less than 200 kg/ha) meant that the price of brachiaria hybrids seeds was 3-4 times higher than that of seeds of other commercial *Brachiaria* spp. in Latin America.

Forage seed research and development

Ubon paspalum

When we started our research in 1995 we found that Ubon paspalum established easily from seed but we knew very little about its seed production performance. In a preliminary observation, a small 1000 m² plot which had been hand planted with

seedlings in May 1995 from the original 50 grams of seed, was cut to ground level in early August 1995 when the plants were more than 2 m high and starting to lodge heavily, even though no inflorescences had emerged. Following defoliation, even though the plants grew very well over the next 3 months and received good rainfall and increasing exposure to short day lengths, none of the Ubon paspalum plants produced inflorescences.

In the following year, 1996, we did not defoliate these plots during the wet season and, at the time of inflorescence emergence in September, most plants were lodging heavily. We had to support the plants with wooden stakes and tie the inflorescences to the stakes with wire in order to hand harvest seed.

We also encountered further problems in 1997 when we contracted farmers to produce Ubon paspalum seed. Many farmers delayed planting their fields until later in the wet season, which has been the traditional time to plant *Brachiaria ruzizensis* (ruzi grass) and *Stylosanthes hamata* (Verano stylo) seed crops (Hare and Phaikaew 1999). Late-sown crops produced very little or no seed at all (Hare *et al.* 2001a).

A series of problem solving research studies were undertaken.

Methods of sowing Seed crops of Ubon paspalum established by sowing seed produced no seed at all in the first year of establishment (Table 3). Planting rooted tillers or transplanting 2 month old seedlings grown in plastic bags, into the field in May, produced the highest seed yields of first-year established plants (Hare *et al.* 2001a), though not as high as 2nd year plants.

Table 3. Effect of methods of sowing on Ubon paspalum seed yields.

Treatment	Seed yield (kg/ha) ¹
Seed sown 1 st year	0
Tillers planted 1 st year	132 a ²
Plastic bag seedlings 1 st year	91 a
2 nd year plants	171 a

¹ corrected to 10% seed moisture content.

² Within columns, means followed by different letters are significantly different ($P < 0.05$) by Duncan's Multiple Range Test.

Table 4. Effect of date of planting rooted tillers on Ubon paspalum seed yields in the first year of establishment.

Planting date	Seed yield (kg/ha) ¹
May 7	331 a ²
May 21	274 a
June 4	115 b
June 18	69 b
July 2	70 b
July 16	25 b

¹ corrected to 10% seed moisture content.

² Within columns, means followed by different letters are significantly different ($P < 0.05$) by Duncan's Multiple Range Test.

Time of planting Seed crops planted with rooted tillers at the beginning of May, produced 132 kg/ha seed 5 months after sowing in one trial (Table 3) and 331 kg/ha seed in a second trial (Table 4). Planting tillers in June and July severely reduced seed yields (Hare *et al.* 2001a).

Closing date Cutting seed crops of Ubon paspalum in August and September produced little or no seed at all (Table 5). Cutting and closing crops in June produced the best seed yields, as crops closed in May were more susceptible to lodging (Hare *et al.*, 1999c).

Table 5. Effect of time of final closing cut on seed yield (kg/ha)* of Ubon paspalum.

Month of final closing cut	Trial 1	Trial 2
May	65.6	-
June	88.8	127
July	43.4	127
August	13.8	43
September	0	-
LSD ($P < 0.05$)	48.0	59.6

* corrected to 10% seed moisture content.

Table 6. Effect of different seed harvesting methods on seed yields of Ubon paspalum.

Harvesting methods	Seed yield (kg/ha) ¹
Knocking	230 a ²
Cut and thresh	104 b
Cut, sweat 2 days, thresh	119 b
Cut, sweat 4 days, thresh	131 b

¹ corrected to 10% seed moisture content.

² Within columns, means followed by different letters are significantly different ($P < 0.05$) by Duncan's Multiple Range Test.

Methods of hand harvesting seed Hand knocking mature Ubon paspalum seed from seed heads into bags every day produced 230 kg/ha, more than twice the amount produced by threshing or sweating seed heads (Table 6) (Hare *et al.* 1999c). Farmers using the hand knocking method averaged 600 kg/ha (Hare *et al.* 2001a) and when seed heads were covered with nylon bags, 1108 kg/ha of seed were produced on a research station (Phaikaew *et al.* 2001).

Site appears to have a significant impact on Ubon paspalum seed production. The university site where Ubon paspalum has been successfully grown for forage (Hare *et al.*, 1999a; 1999b) has consistently produced lower seed yields in trials than yields produced by farmers and at other research stations. Drainage, trees and method of harvesting all appear to influence seed yields (Hare *et al.* 2001a).

Juvenility and long-short day requirement for flowering In a plant growth chamber study on flowering, Ubon paspalum was confirmed as a long-short day plant exhibiting a quantitative response to long days followed by a qualitative response to short days (Hare *et al.* 2001b). Plants must be at least 60 days of age before the summer solstice (June 22) in order to flower in September, explaining why crops sown with seed or planted late do not flower profusely in the year of establishment (Tables 3 & 4). Plants cut close to ground level after the summer solstice also do not receive enough long days to flower well and produce good seed yields in the same year (Table 5). The study also confirmed that no juvenile phase exists in Ubon paspalum (Hare *et al.* 2001b).

Ubon stylo

Seed production of stylo species has been studied for many years in Thailand (Wickham *et al.* 1977; Hare and Waranyuwat 1980; Hare 1993). However, seed research has been mainly on annual and biennial cultivars of Townsville stylo (*S. humilis*) and Verano stylo. These cultivars are low growing and do not have to be defoliated in the wet season for good seed production. We noticed that Ubon stylo growing throughout the wet season, without defoliation, became very tall and rank and seed yields did not seem to be reaching their potential.

Closing date Ubon stylo was planted in June and plots were either not cut (control), cut in September or cut in October. Cutting Ubon stylo seed crops in September produced significantly more seed than cutting in October and 50% more seed than the control plots (Hare *et al.* 2007a) (Table 7). We now recommend cutting tall dense seed crops in September but not crops which are sown late or are growing very slowly.

Table 7. Effect of closing on Ubon stylo seed yields and seed weight.

Time of closing	Seed yield (kg/ha) ¹	TSW (g) ¹
Control	844	2.52
September	1294	2.46
October	725	2.43
LSD (P<0.05)	513	0.078

¹ corrected to 10% seed moisture content.

Mulato II

Producing good seed yields of Mulato II have been very difficult to achieve. Mulato II produces sufficient inflorescences, racemes and spikelets to indicate a potential for useful seed yields. However, by seed harvest, there is usually a massive failure of seed set, caryopsis maturation or both, with the cleaned seed containing less than 9% of the spikelets formed by the crops. The weather conditions during seed maturation (October-November) in Northeast Thailand are suitable for seed set, with bright sunshine and no rain. The subsequent failure of seed-set is probably due to pollen sterility, if judged by a study on brachiaria hybrids showing that more than

65% of pollen grains were sterile (Risso-Pascotto *et al.* 2005) and that this sterility was genetic.

However, the demand for Mulato II seed is very high in Central and South America, because of the high quality forage produced. Grupo Papalotla expects the market for Mulato II seed to reach 1,000,000 kgs per year and they would like most this amount of seed to be produced in Thailand. The main thrust of our Mulato II seed research at Ubon Ratchathani has been to see if we can get higher seed yields by applying different strategic agronomic management techniques.

Method and time of planting The first trial was conducted with Mulato. Planting with tillers produced higher seed yields than seed sowing (Hare *et al.* 2007b) (Table 8). There were no significant differences in Mulato seed yields from seed crops planted at the beginning of May to the beginning of August (Table 8). The second trial was conducted with Mulato II and seed crops planted at the beginning of May and June produced more seed than crops planted in July and August (Table 9).

Table 8. Effect of method and time of planting Mulato on seed yields and seed yield components.

Method of planting	Inflorescences /m ²	Racemes /Inflorescence	Spikelets /raceme	Seeds /m ²	Seed yield* (kg/ha)	TSW [†] (g)
Seed	190	5.4	35.4	654	57	8.57
Tillers	220	5.4	34.8	1370	124	8.93
LSD (P<0.05)	ns	ns	ns	306	28	ns
Time of planting						
May	247	4.6	33.9	1084	96	8.84
June	224	5.0	33.6	990	88	8.73
July	217	5.9	35.1	1048	95	8.78
August	134	6.0	37.8	925	82	8.64
LSD (P<0.05)	57	0.49	1.91	ns	ns	ns

* corrected to 10% seed moisture content.

Table 9. Effect of time of planting Mulato II tillers on seed yields and seed yield components.

Time of planting	Inflorescences /m ²	Racemes /inflorescence	Spikelets /raceme	Seeds /m ²	Seed yield* (kg/ha)	TSW* (g)
May 16	163	4.7	35.0	1647	138	8.4
June 1	138	5.2	34.6	1304	109	8.4
June 16	122	5.3	34.0	937	80	8.5
July 1	104	5.0	32.7	643	54	8.6
July 15	59	2.8	25.5	298	20	8.2
August 1	23	2.7	21.9	77	6	6.3
August 16	-	-	-	-	-	-
LSD (P<0.05)	28	0.7	6.4	294	28	1.9

*corrected to 10% seed moisture content.

Table 10. Effect of timing date of closing defoliation on Mulato and Mulato II seed yields and seed yield components.

Closing defoliation	Inflorescences/m ²		Racemes/inflorescence		Spikelets/raceme	
	Mulato	Mulato II	Mulato	Mulato II	Mulato	Mulato II
May 6	299	299	6.3	6.0	42.8	35.8
July 6	330	330	6.0	5.5	37.3	33.5
August 6	278	278	5.8	5.0	35.0	28.0
September 6	152	152	4.8	-	35.0	-
LSD (P<0.05)	88.9		0.55		4.1	
	Seed yield (kg/ha)*		Seeds/m ²		TSW (g)*	
	Mulato	Mulato II	Mulato	Mulato II	Mulato	Mulato II
May 6	149	232	1608	3009	9.4	7.7
July 6	161	258	1746	3374	9.2	7.6
August 6	119	76	1392	924	8.6	6.8
September 6	65	-	783	-	8.3	-
LSD (P<0.05)	83.3		1078		1.5	

*corrected to 10% seed moisture content

In order for farmers to get both forage and seed in the same year, we would recommend Mulato II seed crops to be planted with tillers as early as possible in the wet season, in order to produce a strong rooting system, tiller out and produce forage for feeding livestock before closing. There is a very high demand for fresh Mulato II forage, both before and after seed harvest.

Closing date Mulato II and Mulato seed yields were significantly reduced by closing late in the wet season (Hare *et al.* 2007c). Closing Mulato II in early August significantly reduced seed yields compared to closing in May and July and no seed was produced from closing in September (Table 10). Mulato can be closed a month later than Mulato II.

Mulato produced significantly more inflorescences, racemes and spikelets than Mulato II and heavier seed (Table 10). But Mulato produced a larger portion of light-immature seeds which were removed at seed cleaning. As a result, the highest seed yield of Mulato II (258 kg/ha) was 60 % higher than the highest seed yield of Mulato (161 kg/ha) (Table 10).

Because of the light seed, Mulato had much lower economical spikelet site utilization % (SSU%) than Mulato II. SSU is best determined using the formula:

$$\text{SSU\%} = \frac{\text{seed yield/m}^2}{\text{Inflorescences/m}^2 \times \text{TSW/1000} \times \text{spikelets per inflorescence} \times 100}$$

Using this formula and data from the above study, we found that the best treatment for both cultivars (July closing) produced a SSU of 9.9 % for Mulato II and 2.34% for Mulato. Both figures are very low when compared to temperate grasses which are in the range of 20 to 30% and even up to 60% in some species.

Method of harvest Tying light-weight nylon net bags over seedheads at anthesis to collect seed, yielded 82% and 38% more Mulato seed in 2003 and 2004, respectively, than 3 methods of hand knocking seed from seedheads (Hare *et al.* 2007d) (Table 11). In 2005, the nylon net bag method produced twice as much seed of Mulato II (508 kg/ha) as 3 methods of knocking seed from seedheads (252 kg/ha) (Table 12). Seed yields from ground sweeping produced the lowest seed

yields in 2004 (Mulato) and 2005 (Mulato II). Seed viability was lower in ground-swept Mulato II seed than in seed from other harvesting methods.

The method of nylon bag collection produced the most seed in all trials. However, farmers think that the cost of bags are expensive and therefore knocking the seedheads once or twice a day is the most appropriate method for them. The South American method of ground sweeping fallen seed appears not suitable for Thailand.

Table 11. Effect of harvesting method on Mulato seed yields and seed viability.

Harvest method	Seed yield* (kg/ha)	TSW* (g)	Seed viability (%)
2003			
Knocking daily	49.4	8.50	68.6
Knocking 2 days	40.6	8.73	71.6
Knocking 3 days	47.5	8.78	72.4
Nylon net bag	83.8	8.55	74.5
Ground sweeping	42.5	7.99	70.3
LSD (P<0.05)	18.6	ns	ns
2004			
Knocking daily	168.6	8.43	79.8
Knocking 2 days	123.9	8.13	68.8
Knocking 3 days	146.3	8.75	75.8
Nylon net bag	202.5	8.40	77.0
Ground sweeping	75.7	8.89	76.0
LSD (P<0.05)	30.5	ns	6.64

*corrected to 10% seed moisture content

Table 12. Effect of harvesting method on Mulato II seed yields and seed viability.

Harvest method	Seed yield* (kg/ha)	TSW* (g)	Seed viability (%)
Knocking daily	230.2	8.79	92.0
Knocking twice daily	271.2	8.68	92.0
Knocking 2 days	254.6	8.94	89.3
Nylon net bag	509.4	9.03	90.5
Ground sweeping	87.3	8.20	84.0
LSD (P<0.05)	73.2	0.38	5.8

*corrected to 10% seed moisture content

Smallholder farmer seed production

Ubon paspalum

Successful forage seed production in Thailand has hinged on smallholder farmers hand-harvesting seed of ruzi grass and Verano stylo (Hare 1993; Hare and Phaikaew 1999). In 1996, after observing the outstanding growth of Ubon paspalum in initial forage evaluation trials (Hare *et al.* 1999a) we realised that there would be a future demand for seed. We contracted one experienced smallholder farmer in Bark Kud Waay village, Warin Chamrab district, Ubon Ratchathani province, who had previously grown forage seed crops for the Department of Livestock Development. In May 1996, we gave the farmer rooted tillers of Ubon paspalum dug from one year old plants at the university which she hand planted in a 50 x 50 cm pattern in a 1400 m² field. In September 1996 she harvested 47.5 kg of seed, equivalent to 340 kg/ha.

Neighbouring farmers in the same village saw her success and observed that seed production of Ubon paspalum appeared to be easier than seed production of ruzi grass and Verano stylo which they had grown for 3-4 years. In March 1997, we contracted 20 farmers, including the first farmer, to grow Ubon paspalum seed. The farmers each received 300 grams of seed in March 1997 and were instructed to plant the seed in nurseries and transplant strong plants to their fields in May-June. Each farmer was contracted to grow a field not exceeding 1600 m². Fields planted

in May and June averaged 315 kg/ha and 65 kg/ha, respectively, whereas fields planted in July produced no seed (Hare *et al.* 2001a). Harvesting from the same fields in 1998 and 1999 produced mean seed yields of 632 kg/ha and 651 kg/ha, respectively (Hare *et al.* 2001a). The method of hand knocking mature seed from tied seed heads into bags every day produces high seed yields and followed by slow drying in the shade and cleaning and winnowing on cane trays produces seed with a purity of 99% and an average germination of 80%.

Since 2003, a total of 12,320 kgs of seed have been produced and 985,600 baht paid in cash to the farmers in Bark Kud Waay village (Table 13).

Even though Ubon paspalum seed production is well synchronised, with flowering occurring predictably every year in September and hand harvesting taking place over 7-10 days in early October, seed production is not without its difficulties. Heavy thunderstorms frequently occur during the September-October flowering and harvesting period, causing seed to shed. Foraging birds may also dramatically reduce seed yields. Farmers have to set up nets to capture the birds for sale or install bird-scaring devices, such as scarecrows and tins filled with stones. Some farmers sleep in their fields in order to chase away birds which usually forage in the early morning.

Table 13. Smallholder farmer Ubon paspalum seed production.

Year	No of farmers	Quota per farmer (kgs)	Amount of seed (kgs)	Amount of money paid (baht)
2003	22	250	5,500	440,000
2004	22	100	2,200	176,000
2005	42	110	4,620	369,600
2006	30	220	6,600	528,000
Total			18,920	985,600

Ubon stylo

In 2003, we contacted 4 farmers in Bark Kud Waay village to see if they would be interested in producing Ubon stylo seed. The process of producing seed is identical to producing Verano stylo seed which they were familiar with. The seed is allowed

to fall to ground in the dry season and then is swept up and cleaned. The farmers sign contracts at the beginning of each wet season to produce and sell all Ubon stylo seed at 100 baht/kg. Farmers receive 0.5 kg of seed to plant a nursery and in June-July, seedlings are transplanted in 1 m x 50 cm rows on to raised beds.

At seed harvest in late January, the farmers beat any remaining seed that has not fallen, out of the seed heads with sticks and the vegetation is cut to ground level and removed. Seed is swept from the ground and cleaned by the farmers in the field.

In February the seed is purchased and scarified through a rice thresher at the university to remove soil and seed coats to improve seed purity and seed germination.

Farmers usually produce more than 900 kg/ha of seed each year. Seed harvesting is a dirty and dusty job as the seed has to be swept from the ground and cleaned through screens in the field. However, with the high seed yields, the farmers find Ubon stylo seed production to be a lucrative cash crop (Table 14).

Table 14. Smallholder farmer Ubon stylo seed production.

Year	No of farmers	Amount of seed produced (kgs)	Amount of money paid (baht)	Amount of seed exported (kg)
2003	4	541	54,100	-
2004	2	651	65,100	-
2005	10	2,070	207,000	1,800
2006	15	5,590	559,000	4,000
2007	30	7,500	750,000	4,000
Total		16,352	1,635,200	9,800

To date, 9,800 kgs of seed have been purchased by Grupo Papalotla and exported to Central and South America. Farmers have found Ubon stylo seed to be of a very high quality, with rapid germination. Our tests at Ubon Ratchathani University in 2006 showed Ubon stylo seed to have purity of 95.5% and 50.5% germination after 7 days, with 49.5% hard seed. Further tests at the Oregon State

University Seed Testing Laboratory showed that after 10 months storage the purity was 96% and seed viability (TZ test) was 98%.

Recent tests (January 2007) on 1-year old stored Ubon stylo seed, showed that hot water and machine scarification significantly increased germination and reduced hard and dead seed (Table 15). Without scarification seed germination was less than 10%. Scarifying the seed 4 times through a machine significantly increased speed of germination at 7 days compared to hot water. However, after 14 days there was no difference in total germination between hot water treatments and scarifying 4 times through a machine (Table 15).

Machine scarification is far easier than hot water treatment because no drying is needed after treatment and large quantities (several hundred kgs) can be scarified daily. All Ubon stylo seed sold from the university is machine scarified to ensure high germination.

Table 15. Effect of hot water and machine scarification on Ubon stylo seed germination.

Treatment	Germination (%)			
	7 day germination	14 germination	Hard	Dead
Control	7.4	9.9	58.4	31.7
Hot water 5 minutes	67.3	88.0	6.3	5.7
Hot water 10 minutes	60.3	84.0	11.1	4.9
Machine scarification 2 passes	72.4	75.3	21.5	3.2
Machine scarification 4 passes	81.9	89.9	8.5	1.6
LSD (P<0.05)	10.5	5.5	11.9	10.5

Mulato II

A Memorandum of Understanding was signed on April 27, 2004 between the Faculty of Agriculture, Ubon Ratchathani University and a Mexican seed company, Grupo Papalotla, to produce seed of Mulato II in villages in Northeast Thailand for export to Central and South America.

Smallholder village farmers sign contracts with the project at the beginning of each wet season to produce and sell to the project all Mulato II seed produced.

Each farmer receives a seed production brochure and 0.1 kg of seed to plant a seed nursery. The farmers transplant month-old seedlings into cultivated fields in May and June each wet season, in rows 1 m x 50 cm apart.

During seedhead emergence in early November, the farmers firstly, tie the stems together on each plant to make an upright bunch, and secondly, at anthesis tie the seed heads into living sheaves (Kowithayakorn and Phaikaew 1993). The seed is knocked out into trays every day, dried slowly in the shade for 3 days and then sun-dried for 1-2 days before cleaning.

In December, the project purchases the seed from the farmers in the village and pays out cash the same day. The project recleans the seed again at the university and packages the seed for export overseas.

In 2004, 2,070 kgs of high quality seed (7.3% moisture, 99.9% purity and 83% viability TZ test) were produced by 60 farmers in Bark Kud Waay village (Table 16). 1,500 kgs were exported in March 2005 to Grupo Papalotla, Miami, USA and was sold in over 10 countries in Central and South America. The remaining seed used by the project for seed production and pasture research in Thailand.

Table 16. Smallholder farmer Mulato II seed production.

Year	No of farmers	Amount of seed produced (kgs)	Amount of money paid	Amount of seed exported (kg)
2004	60	2,070	258,750 baht (7,188 US\$)*	1,500
2005	127	1,292	161,500 baht (4,486 US\$)	1,000
2006	128	2,597	484,760 baht (13,466 US\$)	2,000
Total		5,959	905,010 baht (25,139 US\$)	4,500

*US\$ 1 = 36 baht

In 2005, 1,292 kgs of high quality seed (10.0% moisture, 99.8% purity, 55.3% germination and 83.5% viability TZ test) were produced by 127 farmers in Ubon Ratchathani and Amnart Charoen provinces (Table 16). 1,000 kgs were exported and the remaining 292 kgs were scarified in sulphuric acid to improve germination for seed multiplication. Seed germination and seed viability increased from 55.3% and 83.5% to 89% and 94%, respectively.

If this pilot project lives up to expectations, Grupo Papalotla expects to produce up to 1000 tones of Mulato II seed annually in Thailand. The major markets will initially be in Central and South America, but the company also intends to develop a seed market in Asia. A small market will develop in Thailand (perhaps 100 tones per year), with Mulato II replacing ruzi because of its superior dry matter production, particularly in the dry season.

Profitability of forage seed production for smallholder farmers

Forage seeds are grown on upland that previously was planted in cassava, sugarcane or maize, or on the upland rice paddies which are marginally productive for rice because they are not inundated with water every year. Ubon paspalum, Ubon stylo and Mulato II grown for seed produce far higher incomes than alternate crops (Tables 17 & 18).

Forage seed production will impact immediately on farmer's income by substantially increasing their income many fold. Mulato II can generate additional income from the sale of fresh forage, rootstock and seedlings which makes it the most profitable crop to grow. Ubon paspalum and Mulato II forage can also be grazed or cut from the fields for the farmers' own animals when not in use for seed production. There is no forage production before or after harvest from Ubon stylo seed crops.

Table 17. Average yields, price per kg and gross income from rice, cassava, sugarcane, maize and forage seeds in Ubon Ratchathani province.

Crop	Average yield (kg/ha)	Price per kg	Gross Income/ha	Nett Income/ha
Rice Hom Mali	3,125 kg	9 baht/kg (0.25 US\$/kg)	28,125 baht (881 US\$)	15,325 baht (426 US\$)
Cassava	12,500 kg	3 baht/kg (0.08 US\$/kg)	37,500 baht (1,042 US\$)	21,200 baht (589 US\$)
Sugarcane	12,500 kg	2 baht/kg (0.06 US\$/kg)	25,000 baht (694 US\$)	11,200 baht (311 US\$)
Maize	6,250 kg	5 baht/kg (0.14 US\$/kg)	31,250 baht (868 US\$)	15,450 baht (9429 US\$)
Ubon paspalum	940 kg	80 baht/kg (2.22 US\$/kg)	75,200 baht (2,089 US\$)	63,200 baht (1,756 US\$)
Mulato II*	250 kg	200 baht/kg (5.56 US\$/kg)	50,000 baht (1,389 US\$)	35,600 baht* (989 US\$)
Ubon stylo	750 kg	100 baht/kg (2.78 US\$/kg)	75,000 baht (2,083 US\$)	58,200 baht (1617 US\$)

* Extra income from sale of fresh forage and seedlings (50,000 baht/ha) ((1,389 US\$/ha).

**US\$ 1 = 36 baht

Profitability of Mulato II would be further increased if seed yields increased to levels produced by Ubon paspalum. We are conducting field trials to increase seed yields by agronomic management. However, the best way may be the release of higher seed producing brachiaria hybrids. Currently we are evaluating 15 brachiaria hybrids lines. In two field trials in 2006, 2 new hybrids produced twice the seed yields of Mulato II with similar dry matter production and quality. We are optimistic that in the near future, good seed producing brachiaria hybrids will be available that will be profitable for seed growers and provide seed at lower retail prices to livestock farmers.

Table 18. Estimated costs and gross and net income (baht/ha) from rice, cassava, sugarcane, maize and forage seeds in Ubon Ratchathani province.

	Rice	Cassava	Sugarcane	Maize	Ubon paspalum	Mulato II	Ubon stylo
Direct Costs							
Ploughing	800	800	800	800	800	800	800
Raising furrows		400	400	400			400
Fertiliser	8000	8000	8000	8000	6000	6000	6000
Labour for weeding		1000	1000	1000	1000	1000	2000
Labour for harvesting	3000	2400	2400	2400	2400	4800	4800
Labour for cleaning					1800	1800	2800
Transport	1000	1200	1200	1200			
Chopping or Husking		2500		2000			
Total direct costs	12800 (356)*	16300 (453)	13800 (383)	15800 (439)	12000 (333)	14400 (400)	16800 (467)
Sale price /kg	9 (0.25)	3 (0.08)	2 (0.06)	5 (0.14)	80 (2.22)	200 (5.55)	100 (2.78)
kg/ha	3125	12500	12500	6250	940	250	750
Gross Income	28125 (781)	37500 (1042)	25000 (694)	31250 (868)	75200 (2089)	50000 (1389)	75000 (2083)
Nett Income	15325 (426)	21200 (589)	11200 (311)	15450 (429)	63200 (1756)	35600 (989)	58200 (1617)
Extra Nett Income						50000 (1389)	
Total Net Income	15325 (426)	21200 (589)	11200 (311)	15450 (429)	63200 (1756)	85600 (2378)	58200 (1617)

*US\$ 1 = 36 baht

Conclusion

Our focus at Ubon Ratchathani University is primarily research and so we have limited our seed production to what we believe we can sell annually. The forage research team is endeavouring to provide a real and sustainable market for the three forages, that does not depend on government funding. The joint venture with Grupo Papalotla seed company will further decrease our reliance on public sector funding. We have set up a revolving fund that pays the farmers promptly on the day of seed purchase and employs staff to carry out research and development work.

The development of Ubon paspalum from being a wild native plant in Brazil to a commercial forage in Thailand has been rapid. It only took a little over 10 years for this wild accession to become a proven forage crop in Thailand, which shows the potential impact forage germplasm collection can have on the future agriculture needs of mankind. Ubon stylo and Mulato II were developed through breeding programmes in South America and within 5 years of their release they have proven to be exciting new forages for Northeast Thailand. The applied research and subsequent development of the three South American forages at Ubon Ratchathani University was achieved initially through personal contacts between scientists and then the trust that a commercial overseas private seed company placed in our research programme at Ubon Ratchathani University to deliver seed in larger quantities for export.

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Appendix 4**Seed production of two brachiaria hybrid cultivars in north-east Thailand. 1. Method and time of planting**

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Abstract

Four field experiments were conducted during 2003-2005 in north-east Thailand to compare method and time of planting on seed production, forage production before closing to seed and forage as harvest stubble of two apomictic brachiaria hybrid cultivars, Mulato (*Brachiaria ruziziensis* x *B. brizantha*) and Mulato II (*B. ruziziensis* x *B. decumbens* x *B. brizantha*).

Seed crops established from planting tillers produced 60% (Trial 2 vs Trial 1) and 117% (Trial 3) more seed than seed crops established from sowing seed. Crops planted with tillers produced approximately 20% more inflorescences and 90% more seeds/m² than crops planted with seed. Planting early in the wet season (May-June) produced the most brachiaria hybrid seed in 3 out of 4 trials in the current study, with inflorescence numbers and seeds/m² being the determining seed yield components.

Forage production before closing to seed was significantly higher in early planted seed crops than those planted late and in crops planted with tiller than in those sown from seed.

Seed yields of both hybrid cultivars were extremely low (≤ 150 kg/ha). The failure of cv. Mulato, in particular, to produce adequate quantities of good seed, was attributed to a failure of seed set, caryopsis maturation or a combination. (most likely caused by pollen sterility). The low seed production of cv. Mulato II was caused by waterlogging, because, in an adjacent trial with no waterlogging, seed yields were over 500 kg/ha.

Introduction

The International Center for Tropical Agriculture [Centro Internacional de Agricultura Tropical (CIAT)] in Cali, Colombia, began its *Brachiaria* breeding programmes 18 years ago to attempt to increase resistance to spittlebugs (Hemiptera: Cercopidae) (Miles *et al.* 2006) and improve nutritive quality and dry matter production of *Brachiaria* spp. through interspecific hybridisation and selection. The major achievements of the programme have been stable tetraploid sexual germplasm (Miles *et al.* 2004) and the release of two brachiaria hybrid cultivars, Mulato and Mulato II. After extensive selection in field trials throughout the 1990s, cv. Mulato (*B. ruziziensis* x *B. brizantha*), the first interspecific *Brachiaria* hybrid was released in 2000 through Grupo Papalotla, a Mexican seed company.

A second hybrid cultivar, Mulato II (*B. ruziziensis* x *B. decumbens* x *B. brizantha*), was developed from an original *B. ruziziensis* x *B. decumbens* cross followed by 2 generations of hybridisation by exposure to *B. brizantha* pollen in the field and released by Grupo Papalotla in 2004. In trials in Central and South America, Mulato II produced more dry season forage and had better milk production over time than Mulato and other *Brachiaria* cultivars (CIAT 2004). It also produced more seed than Mulato.

Like conventional cultivars of *B. decumbens* and *B. brizantha*, both hybrids are apomicts (reproduce asexually by seed), and hence are true-breeding (Miles *et al.* 2004 and J.W. Miles, personal communication, 2006).

In 2003, Grupo Papalotla made the business decision to come to Thailand to produce brachiaria hybrid seed. The decision to produce seed in Thailand was because of forage seed quality, smallholder experience and professionalism and public sector involvement in forage seed production (Hare and Horne 2004). Grupo Papalotla also wanted to break into the Asian market for forage seed. In addition, there was an expectation that seed yields of brachiaria hybrids may be higher in Thailand, because of intensive agronomic management and hand harvesting of seed from small fields, than in Brazil and Mexico under extensive management and machine of sweeping seed from the ground from large fields. Low seed yields in Brazil and Mexico (less than 200 kg/ha) meant that the price of brachiaria hybrids seeds was 3-4 times higher than that of seeds of other commercial *Brachiaria* spp. in Latin America.

Field trials commenced at Ubon Ratchathani University, Thailand, in 2003 to investigate agronomic management of brachiaria hybrids in order to increase seed yields. A series of trials investigated the effects of method and time of planting, closing date defoliation and harvesting methods on seed production of cvv. Mulato and Mulato II. This paper reports the results of method and time of planting.

Establishing grass seed crops with seed in rows is the preferred method of establishment in Brazil, but in Australia, broadcasting seed through the fertiliser spreader is the common practice. Time of sowing for seed crops depends primarily on the reliability of rainfall, increasing temperatures and potential evapotranspiration during the growing season (Loch *et al.* 1999). Early sowings generally produce the most seed and have the added advantage of forage production from a closing cut. All *Brachiaria* spp. seed crops in Brazil (Souza 1999) and brachiaria hybrid seed crops in Mexico and Brazil (E. Stern, personal communication) are established by sowing seed.

However, method and time of seed crop establishment can significantly affect grass seed yields in Thailand. Seed crops of *Paspalum atratum* cv. Ubon failed to produce seed in the first year when established by sowing seed (Hare *et al.* 2001). *P. atratum* seed crops planted with tillers in May and early June produced 2-3 times more seed than crops planted from mid-June to mid-July. Farmers plant commercial seed crops of *B. ruziziensis* using seed from late May to late June (Hare and Phaikaew 1999), whereas all commercial seed crops of *Panicum maximum* cv. Purple are planted with tillers in July (M.D. Hare, unpublished observations).

The hypotheses tested in this research are that: brachiaria hybrid seed crops established by planting tillers produce more seed than crops established by seed; and early established crops produce more seed than later established crops. The main objective was to measure the seed production of brachiaria hybrids planted with seed or with tillers.

Materials and methods

Four field experiments were conducted in Ubon Ratchathani province, north-east Thailand (15°N, 104°E; 130 m asl; AAR 1538 mm) on the Ubon Ratchathani University farm in a 0.15 ha field from 2003 to 2005. Annual rainfall was recorded at the trial site (Figure 1). The site was on an upland sandy low humic gley soil (Roi-et soil series) (Mitsuchi *et al.* 1986). Soil samples to 10 cm, taken in May 2003, showed that the soil was acid (pH 4.8; water method), and low in organic matter (0.9%), N (0.03%), P (4.9 ppm; Bray II extraction method) and K (53.6 ppm). Prior to cultivation, the site had been planted to *Stylosanthes guianensis* var. *vulgaris* x *pauciflora* (ATF 3308) for 2 years.

Trial 1 – Effect of time of seed sowing on seed production of Mulato

Four sowing dates (May 6, June 6, July 6 and August 6, 2003) were compared in a 5-replicate, randomised complete block field experiment. Seeds (5 kg/ha) were sown at a spacing of 50 cm x 50 cm into well cultivated plots of 4 m x 5 m. To increase seed germination to 70 %, seeds were scarified in sulphuric acid for 10 minutes, washed in running cold water and dried before sowing. Fertiliser (NPK 15:15:15) was applied at the rate of 160 kg/ha to each new plot at sowing and again to all plots on September 20, 2003. Only the May-planting treatments were cut to 10 cm above ground level on August 1. Dry matter yield was measured from 2 m of 3 rows in each plot and crude protein concentrations were determined.

At peak anthesis, all inflorescences in a fixed 1 m x 2 m quadrat were counted and 20 inflorescences harvested from just outside this quadrat for reproductive assessment. All racemes were counted on each inflorescence and spikelets per raceme were counted on 3 racemes per inflorescence, taken from the top, middle and base of each inflorescence. Seeds were harvested from within the fixed quadrat by tying the inflorescences in living sheaves and gently knocking the seed into bags each day. After harvest, dry matter yield was measured by collecting the harvest stubble from 2 m of 3 rows in each plot and crude protein concentrations were determined.

Seed was dried slowly on trays inside a laboratory and then cleaned through hand screens and a South Dakota seed blower to 99.0% seed purity. Following cleaning, pure seed yield and thousand-seed weight (TSW) were corrected to 10% seed moisture content.

Trial 2 – Effect of time of tiller planting on seed production of Mulato

Four tiller planting dates (May 16, June 16, July 16 and August 16, 2003) were compared in a 5-replicate, randomised complete block field experiment. Tillers with roots were divided from 1-yr-old Mulato plants dug from an adjacent field and planted at a spacing of 50 cm x 50 cm into well cultivated plots of 4 m x 5 m. Fertiliser (NPK 15:15:15) at the rate of 160 kg/ha was applied to each new plot at sowing and again to all plots on September 20, 2003. May- and June-planted

plots were cut to 10 cm above ground level on August 1 and dry matter yields measured from 2 m of 3 rows in each plot and crude protein concentrations determined as in Trial 1.

Reproductive data, seed yield, seed weight, harvest stubble dry matter and crude protein concentrations were measured as in Trial 1.

Trial 3 – Effect of method and time of planting on seed production of Mulato

Four planting dates (May 4, June 4, July 2 and August 4, 2004) and two methods of planting (with seed or with rooted tillers) were compared in a 4-replicate, randomised complete block field experiment. Tillers or seeds (5 kg/ha) were planted into well cultivated soil in rows 1 m apart (50 cm apart within rows) in 4 m x 4 m plots. Seeds were acid-scarified as in Trial 1. Rooted tillers were divided from 1-yr-old Mulato plants dug from an adjacent field. Fertiliser (NPK 15:15:15) at the rate of 200 kg/ha was applied to each new plot at planting and subsequently at the beginning of each month until September.

Closing dry matter cuts (2 m of 3 rows) were taken 10 cm above ground level from May plots, planted with tillers, on July 2 and from May and June plots, planted with tillers and seed, on August 4, 2004. Dry matter yields were measured and crude protein concentrations determined as in Trial 1.

Reproductive data, seed yield, seed weight and harvest stubble dry matter were measured as in Trial 1.

Trial 4 – Effect of time of planting tillers on seed production of Mulato II

Seven tiller planting dates (May 16, June 1, June 16, July 1, July 15, August 1 and August 16, 2005) were compared in a 5-replicate, randomised complete block field trial. Tillers with roots were divided from 1-yr-old Mulato II plants dug from an adjacent field and planted at a spacing of 1 m x 50 cm into well cultivated plots of 6 m x 5 m.

Fertiliser (NPK 15:15:15) at the rate of 200 kg/ha was applied on August 2, 2005 to plots planted in May, June and July and on September 1, 2005 to August-planted plots. All plots received urea (20 kg/ha) on October 6, 2005.

On August 1, 2005, closing date cuts (2 m of 3 rows) were taken 10 cm above ground level from all plots by July 1, dry matter yields measured and crude protein concentrations determined. No samples were taken from July 15-plots because of limited growth, but the plots were trimmed to 5 cm above ground level on August 1. Plots planted on August 1 and August 16 were not cut before seed harvest.

Reproductive data, seed yield, seed weight and harvest stubble dry matter were measured as in Trial 1.

Data from each trial were analysed by conventional analysis of variance, using the IRRISTAT program from The International Rice Research Institute (IRRI). Treatment means were compared by LSD at the $P = 0.05$ probability level.

Results

Rainfall

Rainfall at the trial site was below the 13-yr (1992-2004) mean of 1538 mm/annum in the first 2 years of the study (1430 mm and 1045 mm) and was average (1545 mm) in the third year of the study (Figure 1). The second year, 2004, was particularly dry, with rainfall 30% below the mean. Wet season rain finished early, in mid-September 2004, and most seed crops were severely moisture-stressed during seed-set in October and November. In contrast, very heavy rainfall (433 mm) in September 2005 caused waterlogging in Trial 4.

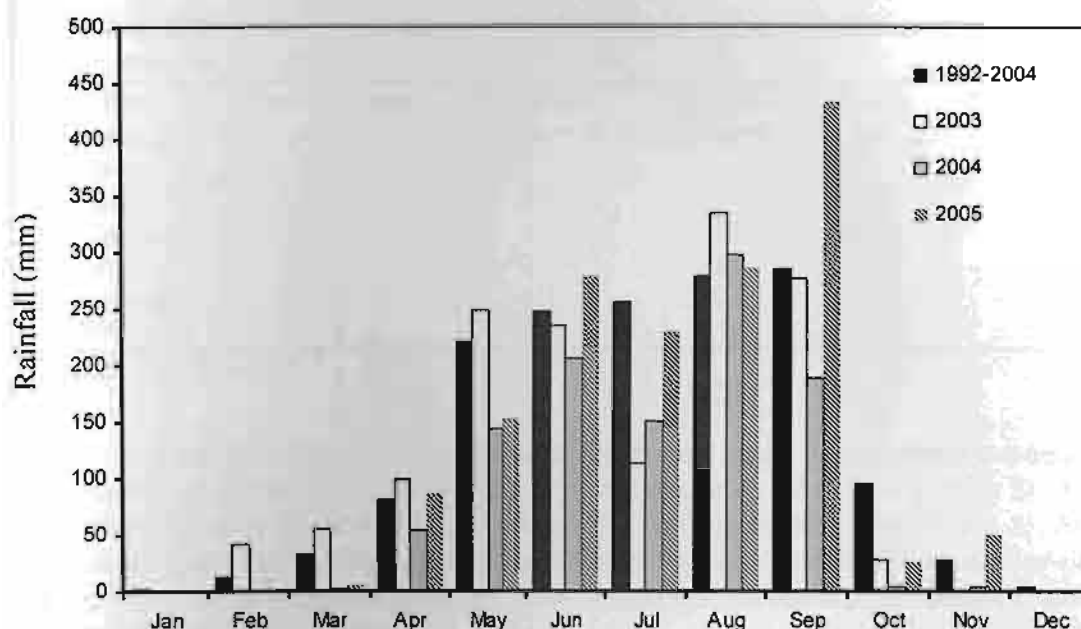


Figure 1. Rainfall at Ubon Ratchathani University during the study and the 13-yr mean (1992-2004).

Seed yields

In Trial 1, sowing seeds in May or June produced higher ($P < 0.05$) Mulato seed yields than sowing in July (Table 1). Mulato sown in August did not germinate. Early sowing in May, increased the numbers of inflorescences and seeds per unit area but reduced the numbers of racemes per inflorescence and spikelets per raceme. weight

In Trial 2, there was no difference in seed yield or seed number for tillers planted in May, June or July, which all produced higher ($P < 0.05$) seed yields and seed numbers than the August-planted plots (Table 2). May- and June-planted plots produced ($P < 0.05$) more inflorescences than later-planted plots. However, plots planted later in the wet season, July and August, produced more racemes/inflorescence and spikelets/raceme than May-planted plots.

Table 1. Effect of time of planting Mulato seed on seed yields and seed yield components (Trial 1).

Seed planting time	Inflorescences /m ²	Racemes /inflorescence	Spikelets /raceme	Seeds /m ²	Seed yield (kg/ha)	TSW ¹ (g)
May	360	3.7	31.7	1043	91	8.64
June	315	4.6	36.5	959	82	8.44
July	258	5.2	36.2	708	59	8.30
LSD(P<0.05)	47	0.7	3.33	229	22	ns

¹ 1000-seed weight**Table 2.** Effect of time of planting Mulato tillers on seed yields and seed yield components (Trial 2).

Tiller planting time	Inflorescences /m ²	Racemes /inflorescence	Spikelets /raceme	Seeds /m ²	Seed yield (kg/ha)	TSW ¹ (g)
May	407	4.0	32.4	1772	148	8.66
June	443	4.5	35.1	1606	144	8.92
July	256	5.1	36.0	1459	129	8.78
August	219	4.9	36.6	875	76	8.72
LSD(P<0.05)	15	0.35	2.78	367	34	ns

¹ 1000-seed weight

In Trial 3, plots planted with tillers produced more than twice the seed yields ($P<0.05$) of those sown seed and a greater number of seeds (Table 3). Time of planting (May to August) had no effect ($P>0.05$) on seed yields (Table 3). August-planted seed crops produced fewer inflorescences ($P<0.05$) than earlier-planted crops but more racemes/inflorescence and spikelets/raceme ($P<0.05$) than crops planted in May and June.

Table 3. Effect of method and time of planting Mulato on seed yields and seed yield components (Trial 3).

Method of planting	Inflorescences /m ²	Racemes /inflorescence	Spikelets /raceme	Seeds /m ²	Seed yield (kg/ha)	TSW ¹ (g)
Seed	190	5.4	35.4	654	57	8.57
Tillers	220	5.4	34.8	1370	124	8.93
LSD(P<0.05)	ns	ns	ns	306	28	ns
Time of planting						
May	247	4.6	33.9	1084	96	8.84
June	224	5.0	33.6	990	88	8.73
July	217	5.9	35.1	1048	95	8.78
August	134	6.0	37.8	925	82	8.64
LSD(P<0.05)	57	0.49	1.91	ns	ns	ns

¹ 1000-seed weight

In Trial 4, seed yield declined progressively as time of planting was delayed, with highest ($P<0.05$) yields from plantings in mid-May (Table 4). Planting in August produced either very low seed yield (6 kg/ha) with low thousand-seed weight, or no seed at all. Raceme and spikelet numbers were reduced when tillers were planted later than early July.

Table 4. Effect of time of planting Mulato II on seed yields and seed yield components (Trial 4).

Time of planting	Inflorescences /m ²	Racemes /inflorescence	Spikelets /raceme	Seeds /m ²	Seed yield* (kg/ha)	TSW* (g)
May 16	163	4.7	35.0	1647	138	8.4
June 1	138	5.2	34.6	1304	109	8.4
June 16	122	5.3	34.0	937	80	8.5
July 1	104	5.0	32.7	643	54	8.6
July 15	59	2.8	25.5	298	20	8.2
August 1	23	2.7	21.9	77	6	6.3
August 16	-	-	-	-	-	-
LSD($P<0.05$)	28	0.7	6.4	294	28	1.9

*1000-seed weight

Dry matter production from seed crops

In Trial 1, only the May-planted crops were cut in August (the other plots were too short for cutting), producing 9263 kg/ha DM (51% stem; 49% leaf) with crude protein concentrations of 6% for stems and 11.8% for leaves. May-planted crops had less total and stem stubble DM at seed harvest than June- and July-planted crops and less leaf stubble DM than June-planted crops (Table 5). June-planted plots produced more total and leaf stubble DM than July-planted plots. Time of planting seed had no effect on crude protein concentrations in the harvest stubble (Table 5).

Table 5. Effect of time of seed planting of Mulato on dry matter yields and crude protein (CP) concentrations in stubble at seed harvest (Trial 1).

Seed planting time	Stem DM (kg/ha)	Stem CP (%)	Leaf DM (kg/ha)	Leaf CP (%)	Total DM (kg/ha)
May	12084	2.4	5460	4.8	17544
June	18236	2.8	6581	5.7	24817
July	16157	2.8	4879	5.6	21036
LSD($P<0.05$)	2374	ns	1116	ns	2778

In Trial 2, Mulato seed crops planted in May produced nearly 4 times the quantity of forage (3 times as much leaf) at the closing cut in early August, of crops planted in June (Table 6). However, stem crude protein concentrations in the June-planted forage were higher than in May-planted forage. Crops planted in May, June or July produced more total and stem stubble DM at seed harvest

than crops planted in August (Table 7). Crude protein concentrations in stubbles were similar for all crops.

Table 6. Effect of time of tiller planting of Mulato on dry matter yields and crude protein (CP) concentrations in forage cut at closing for seed production in August (Trial 2).

Tiller planting time	Stem DM (kg/ha)	Stem CP (%)	Leaf DM (kg/ha)	Leaf CP (%)	Total DM (kg/ha)
May	3288	8.2	3263	13.0	6551
June	713	12.0	1081	15.9	1794
LSD(P<0.05)	1569	3.2	1313	ns	2887

Table 7. Effect of time of planting tillers of Mulato on dry matter yields and crude protein (CP) concentrations in stubble at seed harvest (Trial 2).

Tiller planting time	Stem DM (kg/ha)	Stem CP (%)	Leaf DM (kg/ha)	Leaf CP (%)	Total DM (kg/ha)
May	14817	3.2	4591	5.3	19428
June	15875	2.6	4811	4.8	20686
July	15712	2.7	4180	4.9	19892
August	11643	2.2	4617	4.7	16260
LSD(P<0.05)	1072	ns	ns	ns	2789

In Trial 3, crops planted with tillers produced more than 4 times the amount of forage at closing in August of crops planted with seeds (Table 8). However, crude protein concentrations in leaves of crops planted with seeds were higher than those in crops planted with tillers. May-planted crops produced twice the amount of forage at closing of June-planted crops but with lower leaf crude protein concentrations (Table 8). Harvest stubble stem DM and total DM were higher in crops planted with tillers than in crops planted with seeds (Table 9). August-planted crops had less stubble DM than crops planted earlier.

Table 8. Effect of method and time of planting of Mulato on dry matter yields and crude protein (CP) concentrations in forage cut at closing for seed production in August (Trial 3).

Method of planting	Stem DM (kg/ha)	Stem CP (%)	Leaf DM (kg/ha)	Leaf CP (%)	Total DM (kg/ha)
Seed	495	15.9	702	20.7	1196
Tillers	2211	14.0	2802	18.3	5013
LSD(P<0.05)	613	ns	622	1.5	1184
Time of planting					
May	1812	14.1	2342	18.5	4154
June	895	15.8	1162	20.5	2057
LSD(P<0.05)	613	ns	622	1.5	1184

Table 9. Effect of method and time of planting of Mulato on dry matter yields in harvest stubble (Trial 3).

Method of planting	Stem DM (kg/ha)	Leaf DM (kg/ha)	Total DM (kg/ha)
Seed	5220	3381	8601
Tillers	6212	3693	9905
LSD(P<0.05)	940	ns	1238
Time of planting			
May	5991	3793	9784
June	6031	3563	9594
July	6420	3787	10207
August	4423	3005	7428
LSD(P<0.05)	1329	587	1752

In Trial 4, forage yields at closing in August were directly related to the time since planting ($P<0.05$) (Table 10). However, the crude protein levels were higher in the later planted crops than the May-planted crop. Stubble yields at harvest declined progressively as time of planting was delayed ($P<0.05$) (Table 11).

Table 10. Effect of time of planting of Mulato II on dry matter yields and crude protein (CP) concentrations in forage cut at closing for seed production in August (Trial 4).

Tiller planting time	Stem DM (kg/ha)	Stem CP (%)	Leaf DM (kg/ha)	Leaf CP (%)	Total DM (kg/ha)
May 16	1433	10.2	1725	13.4	3158
June 1	440	12.0	653	17.6	1093
June 16	123	13.4	312	17.8	434
July 1	46	15.5	165	17.2	211
LSD(P<0.05)	325	2.0	335	1.8	647

Table 11. Effect of time of planting of Mulato II on dry matter yields in stubble at seed harvest (Trial 4).

Tiller planting time	Stem DM (kg/ha)	Leaf DM (kg/ha)	Total DM (kg/ha)
May 16	5085	4524	9609
June 1	4073	3549	7622
June 16	3568	3681	7249
July 1	2824	3172	5996
July 15	2197	2666	4863
August 1	1475	2152	3627
August 16	595	1357	1952
LSD(P<0.05)	1402	750	1919

Discussion

The main outcome of brachiaria hybrid seed production from this study is that the seed yields were extremely low and not commercially viable. Seed yields were

less than 150 kg/ha and were far below average yields of 200-300 kg/ha regularly harvested in Mexico (E. Stern personal communication). However, seed yields of Mulato II were far better than those of ruzi grass (30-80 kg/ha seed) or other *Brachiaria* spp. (negligible seed yields) in earlier trials on the same site (Hare *et al.* 2005), but below seed yields of ruzi grass (313-350 kg/ha) elsewhere in Thailand (Phaikaew and Pholsen 1993; Kowithayakorn and Phaikaew 1993).

Both Mulato and Mulato II produced sufficient inflorescences, racemes and spikelets to indicate a potential for useful seed yields. However, by seed harvest, there was massive failure of seed set, caryopsis maturation or both, with the cleaned seed containing less than 2% of the spikelets formed by the crops. The weather conditions during seed maturation were suitable for seed set, with bright sunshine and no rain. The subsequent failure of seed-set most probably was due to pollen sterility, if judged by a study on brachiaria hybrids showing that more than 65% of pollen grains were sterile (Risso-Pascotto *et al.* 2005) and that this sterility was genetic.

However, in further trials on closing date (Hare *et al.* 2007a) and harvesting methods (Hare *et al.* 2007b), the highest seed yields of Mulato II reached 258 and 580 kg/ha, respectively, while those of Mulato remained low, indicating that not all brachiaria hybrids have genetically low seed yields. The low seed yields of Mulato II in this study (Trial 4) were due to the trial site becoming severely waterlogged in September, causing tiller death and a very low emergence of inflorescences. In contrast, the harvesting method trial 50 m away in the same paddock was not waterlogged and the best treatment produced seed yields of 580 kg/ha (Hare *et al.* 2007b). Smallholder farmers have also produced Mulato II seed yields of over 500 kg/ha.

The results emphasise the importance of method of establishment for seed production in these brachiaria hybrids. In our studies, seed crops established from tillers produced 60% (Trial 2 vs Trial 1) and 117% (Trial 3) more seed than seed crops established from seed. When the components of seed yield were examined, it appeared that the number of inflorescences and seeds/m² were the most critical components of yield. Crops planted with tillers produced approximately 20% more inflorescences and 90% more seeds/m² than crops planted with seed.

Currently, 2 of the 3 most important grass seed crops in Thailand, Ubon paspalum and Purple guinea, are established by planting tillers. While the third crop, ruzi grass, has usually been established with seed, there has been a shift recently towards planting tillers, because vegetative plantings usually produce quick establishment. Farmers also prefer tiller planting because it is similar to their traditional method of establishing rice, in which rice is first sown into nurseries and 4- to 6-wk-old seedlings are then transplanted into paddies. Identical practices are followed with first-year grass seed crops. For second-year and subsequent grass seed crops, plants in existing fields can be dug up and rooted tillers divided and transplanted into new seed fields. By planting grass seed crops with tillers, farmers can plant in wide rows, which facilitates weeding and harvesting and leads to increased seed yields (Loch *et al.* 1999; Souza 1999).

Planting early in the wet season (May or June) produced the most brachiaria hybrid seed in 3 out of 4 trials in the current study. Trial 3 was severely affected by drought, with the wet season rains finishing 6 weeks early, in mid-September, 2004. May- and June-planted crops in Trial 3 were defoliated in early August and, because of the drought, regrowth was very slow, resulting in seed yields similar to July- and August-planted seed crops.

Inflorescence numbers and seeds/m² were again the most critical seed yield components determining higher seed yields from early establishment. As planting date progressed through the wet season, inflorescence numbers declined, but raceme and spikelet numbers increased. However, increased raceme and spikelet numbers did not compensate for the lower inflorescence numbers and lead to increased seed yields. Hare *et al.* (2001) also found that inflorescence and seed numbers were the most important seed yield components influencing seed yields of Ubon paspalum. When both components declined with later planting, seed yields also declined.

Forage production from grass seed crops is extremely important for smallholder farmers in Thailand. Farmers either feed the forage to their own livestock or sell it as fresh grass to other farmers (Khemsawat and Phonbumrung 2002) for current prices of US\$0.05-0.07/kg fresh weight.

Planting early enables farmers to cut forage from their seed crops before closing in late July - early August (Hare *et al.* 2007a). The forage of the brachiaria hybrids cut before closing was of a very high quality in all trials, with a high proportion of leaf (55-60%) and a high leaf crude protein concentration that averaged over 15%. In addition, the harvest stubble of brachiaria hybrids in the trials remained green, the stems were not hard and woody and the overall stubble was of a good quality. Farmers have commented on how the harvest stubble of brachiaria hybrids is far more readily eaten by livestock than that of Ubon paspalum, Purple guinea or rice, which are generally very stemmy and fibrous. The stubble yields of up to 25 t/ha DM will provide a valuable feed resource for farmers in the dry season, when feed supplies are limited.

While the low seed yields of Mulato have proved to be not commercially viable, the better seed yields of Mulato II in villages and in other trials (Hare *et al.* 2007a; 2007b) are commercially viable. To produce acceptable seed yields, brachiaria hybrid seed crops should be hand-planted with tillers early in the wet season. Early sowing also enables high quality forage to be produced before closing to seed.

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Appendix 5

Seed production of two brachiaria hybrid cultivars in north-east Thailand. 2. Closing date defoliation

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Abstract

Two field trials were conducted during 2003-2004 in north-east Thailand to examine the effects of timing of closing defoliation on seed production, forage production before closing to seed and harvest stubble yield and quality of two brachiaria hybrid cultivars, Mulato (*Brachiaria ruziziensis* x *B. brizantha*) and Mulato II (*B. ruziziensis* x *B. decumbens* x *B. brizantha*).

In Trial 1, second- and third-year Mulato seed crops closed in early July and early August produced more seed than crops closed in May and September.

In Trial 2, seed yields of first-year Mulato seed crops closed in September were reduced by over 50% relative to crops closed May – August. Seed yields of first-year Mulato II seed crops were reduced by 70% when closed in August rather than May or July, and September closing produced no seed at all. The highest seed yield of Mulato II (258 kg/ha) was 60% higher than the highest seed yield of Mulato (161 kg/ha), mainly because it nearly twice the number of pure seeds/m².

From the results of our research we would recommend a final closing defoliation for brachiaria hybrid cultivars in Thailand any time in July.

Forage production before closing to seed was significantly higher in late-closed seed crops than in early-closed seed crops. In contrast, harvest stubble DM yields increased progressively as the date of closing was advanced earlier into the wet season.

The difficulties of implementing closing defoliations by smallholder seed producers and the methods of harvesting are discussed.

Introduction

Two brachiaria hybrid forage grasses, *Brachiaria ruziziensis* x *B. brizantha* cv. Mulato and *B. ruziziensis* x *B. decumbens* x *B. brizantha* cv. Mulato II, have been recently bred at The International Center for Tropical Agriculture [Centro Internacional de Agricultura Tropical (CIAT)] in Cali, Colombia and released by a Mexican seed company, Grupo Papalotla. Since the release, in 2000, of cv. Mulato, with low seed yields (less than 200 kg/ha) the price of Mulato seed has been 3-4 times that of seeds of other commercial brachiaria cultivars in Latin America. The high seed price and limited availability of commercial seed have been obstacles to the widespread uptake of Mulato by farmers. The release in 2004 of cv. Mulato II was partly in the expectation that its supposedly higher seed yields would lead to lower seed prices and higher volumes of seed traded.

In 2003, Grupo Papalotla made the business decision to produce seed of Mulato and later Mulato II in Thailand. This decision was based on the high forage seed quality, smallholder experience and professionalism, and public sector involvement in forage seed production in that country (Hare and Horne 2004). In 2003, field trials commenced at Ubon Ratchathani University, Thailand, to investigate agronomic management of brachiaria hybrids in order to increase seed yields. A series of trials studied the effects of method and time of planting (Hare *et al.* 2007a), date of closing defoliation and harvesting methods (Hare *et*

al. 2007b) on seed production of Mulato and Mulato II. This paper reports the results of closing date defoliation.

With tropical grass seed production, it is an important aim of agronomic management to produce a synchronised high-yielding seed crop by promoting inflorescence development and restricting this to a short period of emergence (Loch *et al.* 1999). Closing date defoliation is a part of agronomic management which aims to prevent tall vegetative material lodging the seed crop and to encourage a strong synchronised flush of inflorescences leading to higher harvest presentation and higher seed yields.

The timing of defoliation is critical to the success of closing date defoliation management. Early defoliation will produce excessive bulk at harvest, which can either lodge the crop or interfere with inflorescence emergence and harvesting. Late defoliation can remove many of the developing reproductive apices leading to low inflorescence numbers and low seed yields.

Optimum dates of closing have been determined for *Paspalum atratum* cv. Ubon in Thailand (Hare *et al.* 1999), *Brachiaria ruziziensis* (common Thailand type) in Thailand (Phaikaew and Pholsen 1993) and *Chloris gayana* cv. Callide in Australia (Loch 1983). These dates are approximately 90-100 days before harvest and vary according to time of inflorescence emergence and harvest.

Forage production from grass seed crops is important for smallholder seed producers in Thailand, who are predominantly mixed livestock and cropping farmers. Species that can produce moderate quantities of forage in the wet season before closing are accepted more because they fit in with smallholder farm management.

The hypothesis tested in this research is that strategic date of closing defoliation in the wet season will increase seed yields of Mulato and Mulato II by decreasing lodging and increasing flowering and seed-set. The objective of the research was to cut seed crops at monthly intervals during the wet season to determine the optimal date of last closing defoliation for seed production. We also sought to determine the effect of closing date on forage yield and quality (CP content) at closing and following seed harvest.

Materials and methods

Two field trials were conducted in Ubon Ratchathani province, north-east Thailand (15°N, 104°E; 130 m asl; AAR 1593 mm) on the Ubon Ratchathani University farm in a 0.15 ha field from 2003 to 2004. Annual rainfall was recorded at the trial site (Figure 1). The field trial site was on an upland sandy low humic gley soil (Roi-et soil series) (Mitsuchi *et al.* 1986). Soil samples to 10 cm, taken in May 2003, showed that the soil was acid (pH 4.8; water method), and low in organic matter (0.9%), N (0.03%), P (4.9 ppm; Bray II extraction method) and K (53.6 ppm). Prior to cultivation, the site had been planted to *Stylosanthes guianensis* var. *vulgaris* x *pauciflora* (ATF 3308) for 2 years.

Trial 1 – Effect of closing date defoliation on seed production of Mulato

In both 2003 and 2004, 5 closing date defoliations (May 3, June 3, July 3, August 3 and September 3) were compared in a 5-replicate, randomised complete block field experiment. The trial was conducted on a Mulato field planted in May 2002 with plants spaced at 50 cm x 50 cm. At each closing date, all plots that were not already closed, were cut 5 cm from ground level as follows:

Treatment 1: May closing defoliation. One cut only.

Treatment 2: June closing defoliation. Two cuts in May and June.

Treatment 3: July closing defoliation. Three cuts in May, June and July.

Treatment 4: August closing defoliation. Four cuts in May, June, July and August.

Treatment 5: September closing defoliation. Five cuts in May, June, July, August and September.

Each plot measured 4 m x 5 m. At each sampling cut, material from 2 m of 3 rows was cut, weighed fresh and a 300 g subsample sorted into leaves and stems and dried at 70°C for 48 h to determine dry weight and crude protein. Fertiliser was applied to all plots every 60 days in 2003 (160 kg/ha NPK 15:15:15) and every 30 days in 2004 (200 kg/ha NPK 15:15:15).

At peak anthesis, all inflorescences in a fixed quadrat of 3 rows x 2 m in length were counted and 20 inflorescences taken from just outside this area for reproductive assessment. All racemes were counted on each inflorescence and spikelets were counted from 3 racemes per inflorescence, taken from the top, middle and base of each inflorescence. Seed was harvested in 2003 from the fixed quadrat by tying the inflorescences in living sheaves and gently knocking the seed into bags each day. In 2004, nylon bags were tied over the living sheaves and the seed allowed to fall naturally into the bags. Seed was collected from the bags once a week.

Seed was dried slowly on trays inside a laboratory and then cleaned through hand screens and a South Dakota seed blower to 99.0% seed purity. Following cleaning, seed yields and thousand-seed weights were corrected to 10% seed moisture content.

Dry matter was measured in the stubble left after harvest from 2 m of 3 rows in each plot and crude protein concentrations determined in 2003 only. The field was cut to ground level in December 2003 and allowed to grow until second-year defoliation treatments commenced on May 3, 2004.

Trial 2 – Effect of closing date defoliation on seed production of Mulato and Mulato II

Two cultivars (Mulato and Mulato II) and 4 closing date defoliations (May 6, July 6, August 6 and September 6, 2004) were compared in a 4-replicate, randomised complete block field experiment. The trial was sown on May 6, 2004. The field was ploughed and disced into a fine seed-bed in April 2004. The 2 cultivars were tested for germination (Mulato 34% and Mulato II 26%) and sown at a rate of 3.1 kg/ha. The seeds were sown in shallow holes (2 cm depth) in rows 1 m apart, and 50 cm apart in the row. Fertiliser (200 kg/ha NPK 15:15:15) was applied at

sowing and at monthly intervals thereafter until September. Plots measured 4 x 5 m.

Plots were only cut once, on the day of closing date defoliation, except for May 6 closing date, which was the day of sowing. On each subsequent closing date, sampling cuts were taken from 2 m of 3 rows, 5 cm above ground level, weighed fresh and a 300 g subsample sorted into leaves and stems and dried at 70°C for 48 h to determine dry weight and crude protein. The remaining herbage in the plots was cut (5 cm above ground level) and removed on the same day as sampling cuts.

At peak anthesis, all inflorescences in a fixed quadrat of 3 rows x 2 m in length were counted and 20 inflorescences taken from just outside this area for reproductive assessment. All racemes were counted on each inflorescence and spikelets were counted from 3 racemes per inflorescence, taken from the top, middle and base of each inflorescence. Nylon bags were tied over the inflorescences and the seed allowed to fall naturally into the bags. Seed was collected from the bags once a week.

Seed harvesting, seed cleaning and data collection were the same as in Trial 1.

Data from each trial were analysed by conventional analysis of variance, using the IRRISTAT program from The International Rice Research Institute (IRRI). Treatment means were compared by LSD at the $P = 0.05$ probability level.

Results

Rainfall

Rainfall at the trial site (Figure 1) was below the 13-yr (1992-2004) mean of 1538 mm/annum in the 2 years of the study (1430 mm and 1045 mm). The second year, 2004, was particularly dry, with rainfall 30% below the 13-yr mean. Wet season rain finished early, in mid-September 2004, and most seed crops were severely moisture-stressed during seed-set in October and November.

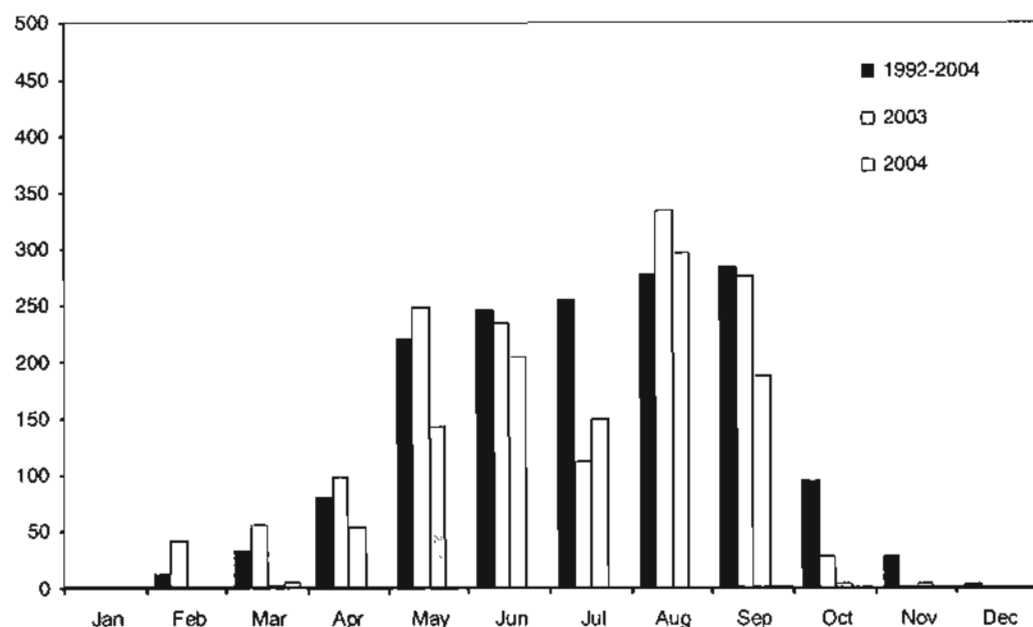


Figure 1. Rainfall at Ubon Ratchathani University during the study and the 13-yr mean (1992-2004)

Seed yields

In Trial 1 in 2003, closing defoliation at the beginning of August produced a higher seed yield than other closing date defoliations (Table 1). In 2004, the highest seed yields were from July and August closing defoliations but yields from August closing defoliation were similar to those produced by June closing defoliation. Closing defoliation in May and September in both years reduced Mulato seed yield to 10 - 36% of those from July and August closing defoliation.

Mulato inflorescence and seed numbers were increased by August closing defoliation compared with other closing date defoliations in 2003 (Table 1). September defoliation reduced inflorescence numbers, seed numbers and seed weights compared with earlier defoliations in both years. Closing in May and June significantly increased spikelets/raceme compared with closing in August and September 2003 and July - September 2004.

In Trial 2, the highest seed yield of Mulato II was 60% higher than the highest seed yield of Mulato (258 vs 161 kg/ha; Table 2). Seed yields of Mulato II were similar when closed in May and July but were reduced as closing defoliation was delayed with September-defoliated plots producing no seed. Mulato plots defoliated in September produced less seed than plots defoliated earlier. Mulato produced more inflorescences and spikelets and heavier seed than Mulato II from all closing date defoliations (Table 2). However, Mulato II produced higher seed yields than Mulato from May and July closing date defoliations by producing nearly twice the number of pure seeds/m².

Table 1. Effect of timing date of closing defoliation on Mulato seed yield components and seed yield (Trial 1).

Final closing defoliation	Inflorescences /m ²	Racemes /inflorescence	Spikelets /raceme	Seeds/m ²	Seed yield (kg/ha)	TSW ¹ (g)
2003						
May	220	4.1	28.6	189	6.9	8.50
June	223	4.0	28.3	253	22.5	8.84
July	233	3.9	29.4	312	28.1	8.48
August	302	3.0	25.3	441	39.4	8.68
September	31	2.9	23.9	56	5.0	7.90
LSD(P<0.05)	45	0.25	2.37	94	8.4	0.44
2004						
May	284	3.0	38.6	583	51.6	8.77
June	389	4.6	34.6	1000	91.0	9.01
July	411	4.8	29.4	1516	140.5	9.32
August	445	4.8	28.4	1360	122.0	8.87
September	120	4.2	28.6	169	14.2	8.45
LSD(P<0.05)	111	0.72	0.97	427	40.5	0.56

¹ 1000-seed weight**Table 2.** Effect of timing date of closing defoliation on Mulato and Mulato II seed yields and seed yield components (Trial 2).

Closing defoliation	Inflorescences/m ²		Racemes/inflorescence		Spikelets/raceme	
	Mulato	Mulato	Mulato	Mulato II	Mulato	Mulato II
May	299	299	6.3	6.0	42.8	35.8
July	330	330	6.0	5.5	37.3	33.5
August	278	278	5.8	5.0	35.0	28.0
September	152	152	4.8	-	35.0	-
LSD (P<0.05)	88.9		0.55		4.1	
	Seed yield (kg/ha)		Seeds/m ²		TSW ¹ (g)	
	Mulato	Mulato II	Mulato	Mulato II	Mulato	Mulato II
May	149	232	1608	3009	9.4	7.7
July	161	258	1746	3374	9.2	7.6
August	119	76	1392	924	8.6	6.8
September	65	-	783	-	8.3	-
LSD (P<0.05)	83.3		1078		1.5	

¹ 1000-seed weight*Dry matter production*

In Trial 1, closing plots in September in both years produced more dry matter (stem, leaf and total DM) than plots closed in June and July (Table 3). Crude protein (CP) concentrations were higher in plots cut in June 2003 than in later-cut plots, but in 2004 closing date had no significant effect on crude protein concentration.

In Trial 2, DM production at closing was similar for Mulato and Mulato II but CP in Mulato was 3 percentage points higher than in Mulato II (Table 4). Plots closed in September produced more than 3 times the amount of DM at closing than plots closed earlier but with significantly lower crude protein concentration.

Table 3. Effect of timing date of closing defoliation for seed production on Mulato dry matter yields and crude protein concentrations (Trial 1).

Closing date defoliation	Stem DM (kg/ha)	Stem CP (%)	Leaf DM (kg/ha)	Leaf CP (%)	Total DM (kg/ha)
2003					
June	262	12.0	918	15.3	1180
July	547	8.2	1738	12.7	2285
August	1054	9.1	2952	12.4	4006
September	1344	8.2	3599	11.8	4943
LSD (P<0.05)	168	1.5	423	1.7	564
2004					
June	442	10.3	1123	12.6	1565
July	504	10.0	1424	13.4	1928
August	933	10.1	2439	13.2	3372
September	1224	12.2	3151	15.3	4375
LSD (P<0.05)	553	ns	1040	ns	1584

Table 4. Effect of timing date of closing defoliation for seed production on dry matter yields and crude protein concentrations of two brachiaria hybrid cultivars at closing for seed production (Trial 2).

Treatment	Stem DM (kg/ha)	Stem CP (%)	Leaf DM (kg/ha)	Leaf CP (%)	Total DM (kg/ha)
Cultivar					
Mulato	1822	13.3	1971	17.5	3793
Mulato II	2337	9.9	2239	14.6	4576
LSD (P<0.05)	ns	1.7	ns	1.5	ns
Closing defoliation					
July	36	16.0	188	17.7	224
August	1254	10.6	1603	16.5	2857
September	4949	8.2	4522	14.0	9471
LSD (P<0.05)	1305	2.1	779	1.8	2032

Harvest stubble DM in Trial 1 was less in plots closed in August and September 2003 and in September 2004 than in plots closed earlier, which produced, on average, 17.7 tonnes and 12.2 tonnes, respectively, in 2003 and 2004 (Table 5). CP concentration in the stubble, measured only in 2003, was not affected by closing date defoliations, with means of 1.7% in stem CP and 4.5% in leaf.

There was no difference in harvest stubble DM between Mulato and Mulato II in Trial 2, but defoliating at closing in August and September reduced harvest stubble DM compared with closing in May and July (Table 6).

Table 5. Effect of timing date of closing defoliation on Mulato stubble dry matter yields at seed harvest (Trial 1).

Closing date defoliation	Stem DM (kg/ha)	Leaf DM (kg/ha)	Total DM (kg/ha)
2003			
May	11995	7979	19974
June	10973	5889	16862
July	11234	4991	16225
August	8058	3426	11484
September	2749	2842	5591
LSD(P<0.05)	2689	1367	3835
2004			
May	8453	6151	14604
June	6507	5485	11992
July	6351	4894	11245
August	6584	4531	11115
September	1689	1868	3557
LSD(P<0.05)	2082	1535	3465

Table 6. Effect of timing date of closing defoliation on stubble dry matter yields in two brachiaria hybrid cultivars at seed harvest (Trial 2).

Treatment	Stem DM (kg/ha)	Leaf DM (kg/ha)	Total DM (kg/ha)
Cultivar			
Mulato	7219	3859	11078
Mulato II	6148	4469	10617
LSD(P<0.05)	ns	ns	ns
Closing defoliation			
May	8728	5069	13797
July	9414	4819	14233
August	6454	4029	10483
September	2138	2740	4878
LSD(P<0.05)	2074	1105	3087

Discussion

The time of final closing date defoliation was found to be extremely important for seed production of brachiaria hybrids in Thailand. The ideal time to implement a final closing defoliation on seed crops of Mulato and Mulato II was 90-120 days (early July-early August) before seed harvest, which was similar to times found for Ubon paspalum (Hare *et al.* 1999; Phaikaew *et al.* 2002) and ruzi grass (Phaikaew and Pholsen 1993) seed crops in Thailand. Early defoliation (May-June) and late defoliation (September) reduced seed yield quite dramatically.

However, seed yields of first-year Mulato and Mulato II seed crops planted in early May and not defoliated in the growing season, were no different from those of July-defoliated crops (Trial 2). This contrasted with our previous experience where in average rainfall years, brachiaria hybrid seed crops planted

at the University and in villages in early May and not defoliated, produced considerably lower seed yields than crops that were defoliated in July. The undefoliated crops grow excessive herbage bulk that reduces/suppresses inflorescence emergence resulting in low seed yields. The explanation probably lies in the low wet season rainfall (305 below the 13-yr mean). The dry end to the wet season in 2004 resulted in considerably less herbage bulk than normal at harvest (13 vs 19 t/ha DM), which did not interfere with inflorescence emergence.

With second- and third-year seed crops (Trial 1), mid-wet season defoliation was found to be critical for successful seed production. Crops defoliated in May and June produced 18-65% of seed yields of crops defoliated in early August (average rainfall year 2003) and in July (below average rainfall year 2004). The early defoliated seed crops did not lodge, but they produced bulky herbage (14-19 t/ha DM), which inhibited the emergence of a sufficient number of inflorescences to produce acceptable seed yields.

Late defoliation (September) in all seed crops, regardless of age, removed many of the developing reproductive apices, leading to either low inflorescence number and low seed yields (Mulato) or no inflorescences and no seed at all (Mulato II).

From the results of our research, we would recommend a final closing defoliation in July. Recommending an early August defoliation has proved confusing for farmers who, in many cases, have defoliated crops from mid- to late-August. This practice has produced either very low seed yields or no seed at all. Therefore, we avoid referring to August defoliation and recommend July defoliation, when advising farmers on management of seed crops.

In recommending brachiaria hybrid seed production to smallholder farmers in order to attract a large number of seed producers in north-east Thailand, we emphasise the amount and quality of forage produced before closing and after harvest. Farmers have been very impressed with the forage produced. In particular, the quality before closing, which reached over 15% crude protein in first-year crops in our trials. Farmers state that their cattle readily eat all stems and leaves, unlike some other forage grass species that have unpalatable stems.

However, a problem has arisen in that farmers cut only a section of their field each day, harvesting enough forage with hand sickles to feed their own 3-4 head of cattle. A 0.5 ha field may take 1 month to cut, resulting in a 30-day spread of closing date defoliations. Consequently, seed yields across a field can vary considerably, particularly if the last cuts take place in late August. When we explain that seed crops must be cut on the same day or at least within 2-3 days, they reply that either they can not cut all their fields by hand in such a short time frame or their cattle can not eat such a large amount of freshly cut forage before it deteriorates.

We are examining ways to enable farmers to cut their whole field in as short a time frame as possible. Selling surplus fresh grass cut over 2-3 days is the most viable option, as there is a strong market in north-east Thailand for fresh forage (Khemsawat and Phonbumrung 2002). Farmers lack the equipment and expertise to make hay or silage. While grazing seed crops to remove excess herbage in winter and early spring is widely practised in many temperate

countries (Rolston *et al.* 1997; Simon *et al.* 1997), farmers in Thailand refuse to graze seed crops, as they fear grazing cattle will cause trampling damage to plants leading to low seed yields.

In many tropical grasses, seed yields do not decline with age of stand provided adequate levels of soil N are maintained, but, in some other cases, productivity of older stands are greatly reduced (Loch *et al.* 1999). This has been the experience with brachiaria hybrids in Thailand and in central and south America (E. Stern personal communication). The seed yield decline is believed to be caused by larger tillers in older stands apparently providing greater and/or more prolonged nutritional support for weaker tillers (low-yielding or sterile) to the detriment of their own development and the long-term productivity of the stand (Loch *et al.* 1999). Applying N increases inflorescence density and tiller fertility. In Trial 1, Mulato seed yields in the third harvest year (2004) were more than 4 times those in the second harvest year (2003), due primarily to a 60% increase in inflorescence numbers. Inflorescence number was boosted by increasing fertiliser (NPK) from 160 kg/ha every 60 days (2003), to 200 kg/ha every 30 days (2004) from May to September.

Seed yield in the third-year stand was also increased by harvesting technique. In the second-year stand (2003), seed was harvested by daily knocking of seedheads, but in the third-year stand, nylon bags tied over the seedheads collected the seed. The nylon bag technique of harvesting tropical grass seed in Thailand has doubled seed yield of Mulato and Mulato II (Hare *et al.* 2007b) and Ubon paspalum (Phaikaew *et al.* 2001).

Farmers in north-east Thailand replant grass seed crops every year using tillers divided from rootstock from stands planted the previous year. They maintain that older stands are less productive than first-year stands. The decline in productivity, however, may be due to applying insufficient N, as most farmers apply less than 40 kg/ha N. In our Mulato II village farmer seed program, we distribute to each farmer 100-200 g of seed in the first year to start a nursery, from which seedlings are transplanted into the seed production field. In second and subsequent years, these farmers divide tillers for transplanting from the previous year stand. However, the best farmers in our Mulato II village seed production program state that stands planted with new seedlings from seed nurseries are more productive than stands planted with rootstock tillers divided from plants in older stands. They therefore request new seed each year to establish seed nurseries to replant their seed crops. We have no research evidence to support their belief that seed production plots established from transplanted seedlings are more productive than plots established with tillers divided from 1-yr-old plants.

The release in 2004 of Mulato II was in the expectation that it would produce higher seed yields than Mulato. This was proved correct in our trial with the highest seed yield of Mulato II 60% higher than the highest seed yield of Mulato. Consequently, Grupo Papalotla is now producing only Mulato II seed in Thailand and production of Mulato has stopped. Seed yields of Mulato II (232-258 kg/ha) were also far better than seed yields of ruzi grass (30-80 kg/ha) or other brachiaria spp. (negligible seed yields) in earlier trials on the same site

(Hare *et al.* 2005), but below experimental seed yields of ruzi grass (313-350 kg/ha) elsewhere in Thailand (Phaikaew and Pholsen 1993; Kowithayakorn and Phaikaew 1993).

Seed production of brachiaria hybrid seed crops in Thailand are is by mid-wet season (July) defoliation with the high quality forage obtained an added bonus for sale or feeding to stock.

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Appendix 6**Seed production of two brachiaria hybrid cultivars in north-east Thailand. 3. Harvesting method**

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Abstract

Two field trials were conducted during 2003-2005 in north-east Thailand to investigate the seed yield and seed viability of 2 hybrid brachiariagrass cultivars, Mulato (*Brachiaria ruziziensis* x *B. brizantha*) and Mulato II (*B. ruziziensis* x *B. decumbens* x *B. brizantha*) from a range of non-destructive manual harvesting methods and the method of manual ground recovery of fallen seed.

Tying light-weight nylon net bags over seedheads at anthesis to collect seed, yielded 82% and 38% more Mulato seed in 2003 and 2004, respectively, than 3 methods of hand knocking seed from seedheads. In 2005, the nylon net bag method produced twice as much seed of Mulato II (508 kg/ha) as 3 methods of knocking seed from seedheads (252 kg/ha). Seed yields from ground sweeping produced the lowest seed yields in 2004 (Mulato) and 2005 (Mulato II). Seed viability was lower in ground-swept Mulato II seed than in seed from other harvesting methods.

The difficulties of manually harvesting brachiaria hybrids by farmers in Thailand and prospects for improving seed yields are discussed.

Introduction

Low seed yields, less than 200 kg/ha, of two brachiaria hybrid cultivars, Mulato (*Brachiaria ruziziensis* x *B. brizantha*) and Mulato II (*B. ruziziensis* x *B. decumbens* x *B. brizantha*), have resulted in commercial seed prices being 3-4 times higher than those of seeds of other commercial brachiaria cultivars. The high price and limited availability of commercial seed have been obstacles to the widespread uptake of brachiaria hybrids by farmers.

Field trials commenced at Ubon Ratchathani University, Thailand, in 2003, to investigate agronomic management of brachiaria hybrids in order to increase seed yields. Two previous papers reported the effects of method and time of planting (Hare *et al.* 2007a) and closing date defoliation (Hare *et al.* 2007b) on seed production of Mulato and Mulato II. This paper reports the effects of harvesting method.

Harvesting of tropical grass seeds is done by either a single destructive harvest of the standing crop, multiple non-destructive harvests from the standing crop, or, ground recovery of seeds shed from the standing crop (Loch and Souza 1999). In Australia, harvesting is mechanized, and in Brazil, harvesting, which was generally manual a decade ago, has become predominantly mechanized. In Thailand, as in other tropical developing countries, harvesting is predominantly manual, because of low costs and the ready availability of hand labour.

A single destructive harvest removes all the moist seedheads in one cut, either with a combine harvester or manually by sickles. Seedheads cut manually can immediately be threshed to remove seed or threshed after drying in a stook or sweating in a piled stack for a few days before threshing (Loch and Souza 1999). However, seeds from a single destructive harvest usually contain a very high proportion of immature seeds, which can be up to 70% in a seedlot (Hopkinson and English 1985). Improvements in management and direct heading

of *B. decumbens* seed crops in Australia has improved seed yields (Hopkinson and Clifford 1993). Seed crops are heavily fertilized to cause lodging and the seed allowed fall and accumulate on the leaf mat before being harvested in one destructive harvest by powerful axial-flow combine harvesters.

The aim of multiple, non-destructive harvests is to avoid harvesting immature seeds and to leave these seeds intact after harvest to allow them to continue ripening on the plant. Multiple non-destructive harvesting is best done by hand (Kowithayakorn and Phaikaew 1993; Phaikaew *et al.* 1993). Generally, higher seed yields and better quality seed are produced by manual harvesting than from machine harvesting (Humphreys and Riveros 1986). In countries that have a high wage structure, beater harvesters, brush harvesters and stripper harvesters successfully multiple harvest non-destructively a range of grass species (Loch and Souza 1999), but these species do not include brachiaria.

Ground recovery of fallen grass seed is the common harvesting practice in Brazil, either by manual sweeping, with tractor-mounted sweeping brooms or with specially designed self-propelled brachiaria seed harvesters (Loch and Souza 1999; Souza 1999). Ground-swept seed is favoured in the South American market because of its high germination, high vigour and low dormancy (Souza 1999). However, purity levels are low, ranging from 25-40% PGS in the formal seed trade market.

In Thailand, grass seed harvesting has always been carried out manually, progressing over the past 3 decades from single destructive harvests to multiple non-destructive harvests. Ground recovery of fallen seed is used to harvest only *Stylosanthes* species (Hare and Phaikaew 1999) and has never been practised with grass seed crops, because of the likelihood of wet conditions at harvest time. With single destructive harvests, crops are either hand cut with sickles and immediately threshed (*B. ruziziensis* and *Paspalum plicatulum*), or cut and then sweated before threshing (*Panicum maximum*).

Research studies, however, have found that higher seed yields in Thailand are obtained from multiple non-destructive manual harvests, with seedheads tied into living sheaves and the seed knocked daily into seed-net receptacles (Kowithayakorn and Phaikaew 1993; Phaikaew *et al.* 1993). Daily knocking of *B. ruziziensis* (ruzi grass) yielded 50% more seed than cutting and sweating (233 kg/ha vs 155 kg/ha) (Phaikaew and Pholsen 1993), and 95% more seed of *P. atratum* (Ubon paspalum) was harvested by daily knocking (230 kg/ha) than by cutting and sweating (118 kg/ha) (Hare *et al.* 1999). This method of daily knocking seedheads is now used by the majority of smallholder seed growers in Thailand to harvest ruzi grass, guinea grass (*P. maximum* cv. Purple) and Ubon paspalum.

Seed yields can be substantially increased by tying light-weight nylon net bags over the seedheads and allowing mature seed to fall into these bags. The seed is collected every 4-7 days from the bags. Guinea grass yielded 39% more seed by the nylon net bag method (793 kg/ha), than from knocking seedheads every 3-5 days (572 kg/ha) (Phaikaew *et al.* 1996). Ubon paspalum yielded 76% more seed from nylon net bags (636 kg/ha) than by knocking seedheads every 3

days (362 kg/ha) (Phaikaew *et al.* 2001). Neither of these studies compared daily knocking of seedheads with seed collected in nylon net bags.

In order to increase seed yields of brachiaria hybrids we investigated several multiple non-destructive manual harvesting methods that are used to harvest other grass species in Thailand and the method of manual ground recovery of fallen seed as is used in Brazil.

The hypothesis tested in this research was that the method of collecting seed from nylon net bags tied over seedheads of brachiaria hybrids would produce higher seed yield and better seed quality than other manual harvesting methods. The objective was to compare seed yield and seed quality from nylon net bag collection with the common method used by farmers in Thailand of knocking tied seedheads and the method used in Brazil of sweeping seed from the ground.

Materials and methods

Two field trials were conducted in Ubon Ratchathani province, north-east Thailand (15°N, 104°E; 130 m asl; AAR 1593 mm) on the Ubon Ratchathani University farm in a 0.15 ha field from 2003 to 2005. Annual rainfall was recorded at the trial site (Figure 1). The field trial site was on an upland sandy low humic gley soil (Roi-et soil series) (Mitsuchi *et al.* 1986). Soil samples to 10 cm, taken in May 2003, showed that the soil was acid (pH 4.8; water method), and low in organic matter (0.9%), N (0.03%), P (4.9 ppm; Bray II extraction method) and K (53.6 ppm). Prior to cultivation, the site had been planted to *Digitaria milanjiana* cv. Jarra for 3 years.

Trial 1 – Effect of harvesting method on seed yield and seed quality of Mulato

In both 2003 and 2004, five harvesting methods were compared in a 4-replicate, randomised complete block field experiment, on second-year Mulato fields, planted in May 2002 and May 2003, respectively, with plants spaced at 50 cm x 50 cm. Each plot measured 4 m x 5 m.

The treatments were

- 1) Knocking daily. Seedheads tied up and knocked once every day.
- 2) Knocking every 2 days. Seedheads tied up and knocked once every 2 days.
- 3) Knocking every 3 days. Seedheads tied up and knocked once every 3 days.
- 4) Nylon net bag. Nylon net bag tied over seedheads and seed collected every 7 days from the bag.
- 5) Ground sweeping. Seed swept from the ground after all seed had fallen.

Pre-trial preparation included cutting the fields (5cm above ground level) to remove all the forage at the beginning of June and August in both years. Fertiliser was applied to all plots on June 3, August 4 and September 20 in 2003 (160 kg/ha NPK 15:15:15 on each occasion) and on June 3, July 3, August 3 and September 3 in 2004 (200 kg/ha NPK 15:15:15 on each occasion).

At anthesis in mid-October of each year, all seedheads in the knocking and nylon bag treatment plots were tied and nylon net bags tied over seedheads in Treatment 4. In the knocking treatments (Treatments 1-3), seedheads were knocked in large cloth bags in the morning or the appropriate days to remove mature seed. In Treatment 5 plots, in the first week of December of each year, all plants were cut to ground level and removed, and the fallen seed hand-swept from the ground.

Harvested seed from Treatments 1-4 was dried slowly on trays inside a laboratory. Seed from Treatment 5 was already dry at harvest. Seeds were cleaned through hand screens and a South Dakota seed blower to 99.0% seed purity.

Data collection included seed yield and seed weight corrected to 10% seed moisture content and seed viability (tetrazolium tests TZ).

Trial 2 – Effect of harvesting method on seed yield and seed quality of Mulato II

In 2005, on a first-year-planted Mulato II field, five harvesting method treatments were compared in a 4-replicate, randomised complete block experiment. Mulato II tillers were planted at spacings of 1 m x 50 cm on May 31. Each plot measured 4 m x 5 m.

The treatments were

- 1) Knocking daily. Seedheads tied up and knocked once every day.
- 2) Knocking twice daily. Seedheads tied up and knocked twice (morning and late afternoon), every day.
- 3) Knocking every 2 days. Seedheads tied up and knocked once every 2 days.
- 4) Nylon net bag. Nylon net bag tied over seedheads and seed collected every 7 days from the bag.
- 5) Ground sweeping. Seed swept from the ground after all seed had fallen

Pre-trial management included cutting the field on August 2, 2005 to 5 cm above ground level and removing all the forage. Fertiliser was applied on August 2 (200 kg/ha NPK 15-15-15) and October 6 (200 kg/ha urea).

At anthesis in late October, all seedheads in the plots were tied in Treatments 1-4 and nylon bags placed over seedheads in Treatment 4. Ground swept seed in Treatment 5 was collected in the first week of December. Seed harvesting, seed cleaning and data collection were the same as in Trial 1.

Data from each trial were analysed by conventional analysis of variance, using the IRRISTAT program from The International Rice Research Institute (IRRI). Treatment means were compared by LSD at $P = 0.05$ probability level.

Results

Rainfall

Rainfall at the trial site was below the 13-yr (1992-2004) mean of 1538 mm/annum in the first two years of the study (1430 mm and 1045 mm) and

similar to the mean in the third year (1545 mm) (Figure 1). The second year, 2004, was particularly dry, with rainfall 30% below the mean. Wet season rain finished early in mid-September, 2004, and most seed crops in Trial 1 were severely moisture-stressed during seed-set in October and November. In contrast, in 2005, 433 mm in September and 50 mm in November resulted in soil moisture levels remaining high during seed-set and seed-maturation in Trial 2.

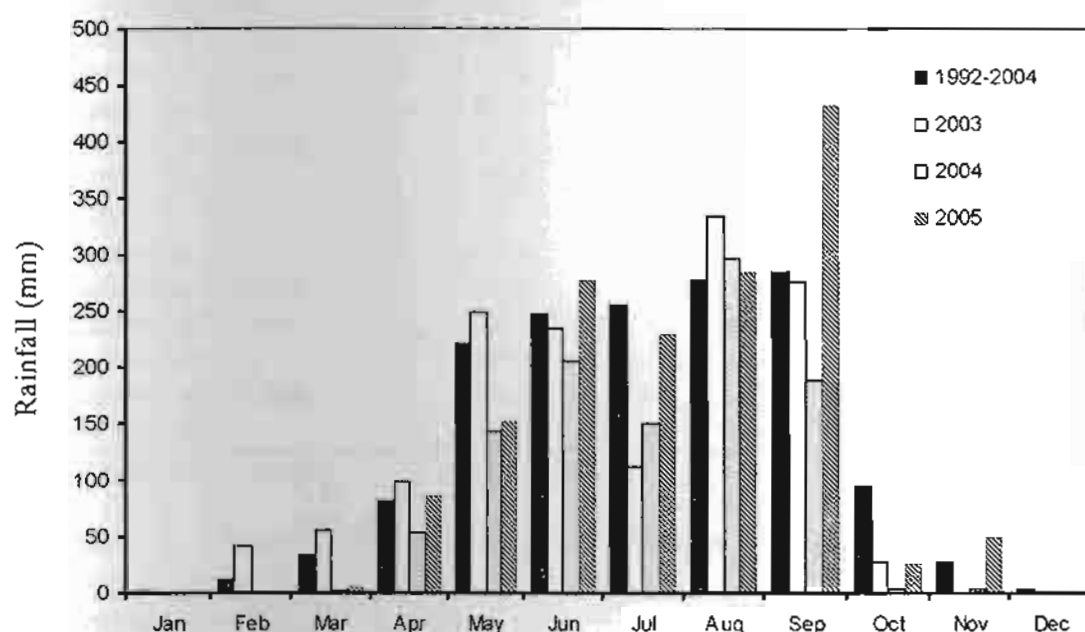


Figure 1. Rainfall at Ubon Ratchathani University during the study and the 13-yr mean (1992-2004)

Trial 1 – Effect of harvesting method on seed yield and seed quality of Mulato

Nylon net bags tied over the seedheads to collect seed produced the highest Mulato seed yields in both years (Table 1). The seed yield from nylon net bags was 82% (2003) and 38% (2004) more than the yield from the 3 methods of knocking seedheads. Knocking produced 90% more seed than ground sweeping in 2004 but similar yields in 2003.

Seed viability of Mulato was not affected by harvesting method in 2003, but in 2004, seed knocked every 2 days had lower viability than seed harvested by other methods (Table 1).

Trial 2 – Effect of harvesting method on seed yield and seed quality of Mulato II

The nylon net bag method produced the highest Mulato II seed yield, twice that from the 3 methods of knocking seedheads (Table 2). Sweeping Mulato II seed from the ground produced a much lower seed yield, lighter seed and seed with lower viability than other harvesting methods.

Table 1. Effect of harvesting method on Mulato seed yields and seed viability (Trial 1).

Harvest method	Seed yield (kg/ha)	TSW ¹ (g)	Seed viability (%)
2003			
Knocking daily	49.4	8.50	68.6
Knocking 2 days	40.6	8.73	71.6
Knocking 3 days	47.5	8.78	72.4
Nylon net bag	83.8	8.55	74.5
Ground sweeping	42.5	7.99	70.3
LSD P<0.05	18.6	ns	ns
2004			
Knocking daily	168.6	8.43	79.8
Knocking 2 days	123.9	8.13	68.8
Knocking 3 days	146.3	8.75	75.8
Nylon net bag	202.5	8.40	77.0
Ground sweeping	75.7	8.89	76.0
LSD P<0.05	30.5	ns	6.64

¹ 1000-seed weight**Table 2.** Effect of harvesting method on Mulato II seed yields and seed viability (Trial 2).

Harvest method	Seed yield (kg/ha)	TSW ¹ (g)	Seed viability (%)
Knocking daily	230.2	8.79	92.0
Knocking twice daily	271.2	8.68	92.0
Knocking 2 days	254.6	8.94	89.3
Nylon net bag	509.4	9.03	90.5
Ground sweeping	87.3	8.20	84.0
LSD P<0.05	73.2	0.38	5.8

¹ 1000-seed weight

Discussion

Choosing an appropriate method to harvest brachiaria hybrids is extremely important for producing good seed yields, to enable high quality seed to be commercially available to farmers at a reasonable price. In South America, seed yields must reach at least 500 kg/ha in order to compete in price with other commercial brachiaria cultivars, which average 600-700 kg/ha from mechanised ground sweeping (Souza 1999). In our trials, only Mulato II produced more than 500 kg/ha by using the nylon net bag method to harvest seed.

The nylon net bag method produced substantially higher seed yields than knocking seedheads and ground sweeping for both Mulato and Mulato II. However, the highest seed yield of Mulato was just over 200 kg/ha, less than half that produced by Mulato II. After 3 years research, this was the highest seed

yield we could achieve with Mulato in Thailand. Farmers in Thailand harvesting Mulato seed by daily knocking have also experienced very disappointing seed yields up to 100 kg/ha. With the persistently low seed yields, the Mexican seed company that released these two brachiaria hybrids, Grupo Papalotla, has discontinued Mulato seed production in Thailand and instead will concentrate on Mulato II seed production.

In research trials, the nylon net bag method has consistently produced higher seed yields than knocking seedheads of guinea grass (Phaikaew *et al.* 1996), Ubon paspalum (Phaikaew *et al.* 2001) and now brachiaria hybrids in these trials. However, farmers have not adopted this harvest method for two reasons.

Firstly, experienced farmers who give grass seed production their top priority, can achieve high seed yields, over 800 kg/ha for guinea grass and Ubon paspalum and over 600 kg/ha for Mulato II, by knocking seedheads 2-3 times per day (dawn, midday and in the evening). This attention to harvesting minimises losses from seed shedding. In our trials, harvesting is constrained by government working hours, with the first knocking between 08:00 and 10:00 h, and the second knocking between 15:00 and 17:00 h. Despite knocking twice daily, seed-shedding losses still occur.

Secondly, the nylon net bags are too expensive for the farmers. Since Mulato II seedhead stems are fairly fragile, very light-weight nylon net material must be used to avoid breaking the stems with their weight. The nylon netting must be porous to allow air-flow through the bags. The netting is cut and sown into bags that have a small aperture at one end that can be untied every 4-7 days to collect seed. Each bag costs approximately US\$0.25 and approximately 18000 bags/ha are used for a cost of US\$4500/ha. Farmers are currently being paid US\$5/kg for Mulato II seed and, even if they produce 500 kg/ha, the cost of the nylon bags exceeds their gross returns. The bags can be used for several years, which reduces their cost over time, but apparently not sufficiently to be attractive to producers.

Some farmers who are unable to give their full attention to daily grass seed harvesting are examining using cheaper netting fabric and double row planting, so that more seedheads can be covered with one bag to reduce the number of bags. We are also studying the placing of cheap cloth mats down the rows to collect fallen seed.

Ground sweeping in our studies was unsuccessful. Yet in Brazil, this method has been the predominant seed-harvesting method of *Brachiaria* spp. for the past 2 – 3 decades, producing up to 700 kg/ha from either manual or machine sweeping (Souza 1999). In Thailand, we have no problem sweeping over 900 kg/ha of stylo seed from the ground (Hare *et al.* 2007c). Hence, the fate of the fallen seed must be resolved. In Trial 2, ground sweeping Mulato II seed yielded 422 kg/ha less seed than from nylon net bags. Yet this amount of seed was not on the ground. The vegetative material was beaten to allow any seed in the foliage to fall to the ground before cutting and removing to clear the plots for sweeping.

We consider that a lot of the seed is eaten by ants and perhaps a smaller amount rots on the ground. *Brachiaria* hybrid seeds are relatively soft when they shed and can be easily eaten by ants. Seed-harvesting ants are also active in stylo seed crops, but as stylo seeds are very hard, the ants eat only the seed testa and leave the hard seeds intact. Moist conditions during harvest, from either rain or heavy dews, could contribute to *brachiaria* hybrid seed rotting on the ground.

Despite very dry conditions in 2004, causing moisture stress during reproductive development until seed harvest, Mulato seed yields in Trial 1 in 2004 were nearly 3 times the yields produced in 2003, when crops suffered no moisture stress. The increase in seed yield was probably due to the increase in fertiliser (NPK), which increased from 160 kg/ha applied 3 times (2003), to 200 kg/ha applied 4 times (2004). Similar seed yield increases occurred in the adjacent closing date defoliation trials, with increases in fertiliser increasing inflorescence numbers (Hare *et al.* 2007b).

A feature of the studies was the very high levels of pure viable seed, especially with Mulato II in Trial 2. We cleaned the seed to 99.0% purity and, with 90.5% seed viability, produced 89.5% pure live seed with nylon net bags (454 kg/ha pure live seed). These levels are many times greater than the Brazilian legal minimum seed quality standards of 10-24% pure live seed, although seed traded internally in Brazil is mostly 25-40% pure live seed with of high levels of soil (Souza 1999). The highest quality Mulato II seed is produced in the first week of harvesting, when seed is green and hard at harvest and constitutes about 9% of the total seed harvest. Seed harvested after the first week is brown, light, soft and usually empty, but makes up nearly 90% of the seed lot. This light seed is of low viability (0-5%) and is removed during cleaning and winnowing. Experienced Mulato II seed producers in Thailand stop harvesting seed once this light brown seed starts to appear during harvesting, as they know that all this seed will be blown off during seed cleaning. Less experienced farmers continue to harvest all seed, but end up with a large pile of light, empty seed outside their cleaning stations.

Achieving good seed yields of the current *brachiaria* hybrids has been a difficult process. After 3 years research, we have been unable to produce satisfactory seed yields of Mulato. To achieve over 500 kg/ha from Mulato II has been very encouraging. Several farmers are producing Mulato II seed yields of over 600 kg/ha. These yields are far better than experimental seed yields of ruzi grass (30-80 kg/ha) or other *Brachiaria* spp. (negligible seed yields) in earlier trials on the same site (Hare *et al.* 2005) and above experimental seed yields of ruzi grass (233-350 kg/ha) reported elsewhere in Thailand (Kowithayakorn and Phaikaew 1993; Phaikaew and Pholsen 1993). However, the seed yields achieved to date for Mulato II are lower than commercial seed yields of 650 kg/ha for Marandu (*B. brizantha*) and Basilisk signal grass in Brazil (Souza 1999) and of up to 1000 kg/ha for Basilisk signal grass in Australia (Hopkinson and Clifford 1993). The high signal grass seed yields in Australia were achieved only following nearly 20 years research and development in harvesting technology, which increased seed yields 10-fold.

We have conducted only 2-years research on seed production of Mulato II and consider that, with more agronomic management and improvements in harvesting methods, further increases in Mulato II seed yields in Thailand are possible.

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Appendix 7

***Stylosanthes* species in north-east Thailand: dry matter yields and seed production**

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Abstract

A field experiment was conducted in north-east Thailand between 2003 and 2006 to compare dry matter yields of *Stylosanthes hamata* cv. Verano, *S. guianensis* cvv. Tha Phra, Ubon stylo and Temprano, and *S. scabra* cv. Seca. A second field experiment in 2004 compared the effect of closing date defoliation on subsequent seed yields of Tha Phra and Ubon stylo.

Ubon stylo and Tha Phra produced at least 90% more dry matter than Verano over 3 years, with advantages particularly obvious in the dry season, when they produced 2-6 times the yield of Verano. Ubon stylo and Tha Phra produced 13, 18 and 17 t/ha/yr DM, in the first, second and third years of production respectively. Temprano produced intermediate dry matter yields, being generally inferior to Ubon stylo and Tha Phra, but superior to Verano and Seca. Both Ubon stylo and Tha Phra would be suitable replacements for Verano.

Ubon stylo produced 2.6 times the seed yield of Tha Phra (959 vs 365 kg/ha). Closing in September doubled seed yield over closing in October.

Management of perennial stylo pastures to increase the commercial use of stylo pastures is discussed. Ubon stylo's stronger resistance to anthracnose, better grazing persistence and higher seed yields than Tha Phra, suggest it would be a better replacement for Verano.

Introduction

The first commercial use of *Stylosanthes* spp. in Thailand, in the mid 1960s, was based upon the importation of seed of Australian cultivars, chiefly Townsville stylo (*Stylosanthes humilis*). Following the devastating outbreak of the fungal disease anthracnose (*Colletotrichum gloeosporioides*) in 1976, Verano (*S. hamata*), which was more resistant than Townsville stylo, replaced it and large-scale pasture development ensued.

Verano has been the backbone of pasture legume development for animal production in north-east Thailand for 30 years. Between 1976 and up to the present, the Department of Livestock Development (DLD) has improved nearly 320000 ha of communal grazing land by oversowing Verano (Phaikaew and Hare 2005). Over 4000 t of Verano seed has been harvested in north-east Thailand since 1976 and annual production has stabilised at about 50-100 t/y.

Perennial stylo (*S. guianensis* var. *guianensis*) has been used to a lesser extent than Verano in Thailand for cut-and-carry forage systems. Cultivars Cook, Schofield and Endeavour were evaluated by the DLD in the 1970s, but were replaced by the better performing cv. Graham in the 1980s and 1990s. Anthracnose destroyed Graham in 1996, and the more resistant and higher-producing CIAT 184 (Tha Phra stylo) was substituted (Phaikaew and Hare 2005). It performs very well in the humid tropics (Miles and Lascano 1997).

With the future possibility of both Verano and Tha Phra stylos succumbing to anthracnose, there was a need to evaluate anthracnose-resistant species. In November 1999, we received seed of a blend of lines derived from *S. guianensis* var. *vulgaris* x var. *pauciflora* (ATF 3308) selected for long-term resistance to anthracnose (Grof *et al.* 2001). This blend has been released in Australia as

cultivar Nina (Cook *et al.* 2005). However, in Thailand, farmers growing seed and forage call it "Ubon stylo" and we have continued to use this name since its release in 2002.

In 2001, we received seed of another anthracnose-resistant blend (GC 1576 plus GC 1524), deriving from *S. guianensis* var. *vulgaris* x var. *pauciflora* hybrid material (ATF 3309 cv. Temprano). This selection is less erect than Ubon stylo, similar to Graham, and more suited to dry environments (B. Grof, personal communication).

The hypothesis of this research was that stylos could be identified, which were more productive in Thailand than cv. Verano. The objective was to compare wet and dry season forage production of the new stylos with that of Verano.

Since stylo adoption in Thailand has been a result of successful seed production (Hare and Phaikaew 1999), any new stylo species would need good seed production characteristics. Hence, an additional objective was to compare seed yields of Ubon stylo and Tha Phra.

Materials and methods

Two field experiments were conducted from 2003 to 2006 in Ubon Ratchathani province, north-east Thailand (15°N, 104°E; 130 m asl; AAR 1593 mm) on the Ubon Ratchathani University farm in a 0.15 ha field. The sites were on an upland sandy low humic gley soil (Roi-et soil series) (Mitsuchi *et al.* 1986). Soil samples to 10 cm, taken at sowing in May 2003, showed that the soil was acid (pH 4.3; water method), and low in organic matter (1.5%), N (0.03%), P (3.0 ppm; Bray II extraction method), S (9 ppm) and K (54.5 ppm). Prior to cultivation, the site had been planted to *Digitaria milanjiana* cv. Jarra for 3 years and ruzi grass, mixed with Verano stylo, for 6 years (Hare *et al.* 2004b).

Trial 1 – Dry matter yields

Five *Stylosanthes* cultivars (*S. hamata* cv. Verano, *S. guianensis* var. *guianensis* cv. Tha Phra, *S. guianensis* var. *vulgaris* x var. *pauciflora* cv. Ubon stylo, *S. guianensis* var. *vulgaris* x var. *pauciflora* cv. Temprano and *S. scabra* cv. Seca) were compared in a 6-replicate, randomised complete block, field experiment. The site was ploughed in March and April 2003 and then rotary hoed to produce a fine seed bed the day before planting in May 2003. Details of field management are summarised in Table 1.

Seed was tested for germination immediately before sowing and all accessions were sown at a rate of 10 kg/ha germinable seed. The exception was Seca, which because of limited seed supply, was sown at 5 kg/ha.

At each sampling date, herbage was cut to 10 cm from ground level, weighed fresh and sorted into stylo and weeds. A 300 g stylo subsample was taken and dried at 70°C for 48 hours to determine moisture content. Dried samples were stored for crude protein, acid detergent fibre (ADF) and neutral detergent fibre (NDF) concentration analysis. After each sampling cut, the remaining herbage was cut to 10 cm and removed.

Table 1. Field crop management of stylo evaluation trial (Trial 1).

Field cultivation	Ploughing x 2, discing x 1, harrowing x 1
Plot size	8 m x 5 m
Sowing date	May 16, 2003
Sowing method	Broadcast
Establishment plant counts	6 weeks after sowing; four x 0.25 m ² quadrats/ plot
Sampling cuts	Eight x 0.25 m ² quadrats/plot
First wet season	Aug 20 & Oct 29, 2003
First dry season	Feb 20 & Apr 28, 2004
Second wet season	Jun 28, Aug 30 & Oct 29, 2004
Second dry season	Mar 4 & Apr 25, 2005
Third wet season	Jun 29, Aug 29, & Oct 28, 2005
Third dry season	Jan 24 & Apr 25, 2006
Fertiliser	
At sowing	20 kg/ha P, 50 kg/ha K, 20 kg/ha S
After cutting	20 kg/ha P, 50 kg/ha K, 20 kg/ha S
	2003 Aug 20 & Oct 30
	2004 Apr 28, Aug, 30 & Oct 29
	2005 Apr 25, Aug 29 & Oct 28

Trial 2 – Seed production

Seed production from *S. guianensis* cultivars (cvv. Tha Phra and Ubon stylo) was compared using 3 closing date defoliation treatments (no cutting from sowing, September 1 and October 1, 2004) in a 5-replicate, randomised complete block field experiment. The field was ploughed and disced into a fine seed bed in April and May, 2004 and the trial was planted on June 11, 2004. Seed was tested for germination (Ubon stylo 67% and Tha Phra 47%), and was broadcast at a rate of 5 kg/ha germinable seed on to plots measuring 3 m x 3 m (1 m walkways between plots) and raked into the soil. Fertiliser (P 20 kg/ha, K 50 kg/ha, S 20 kg/ha) was applied at sowing and again in October.

At each closing date (September 1 and October 1), four 0.25 m² quadrats were cut at 10 cm above the ground and weighed fresh. A 300 g subsample was taken to determine moisture content and crude protein. The remaining herbage on the plots was cut to 10 cm and removed.

Plots were harvested for seed from February 21 - 23, 2005. At harvest, the herbage was beaten with sticks to make all remaining seed fall to the ground before all herbage on each plot was cut and removed. Each plot was swept with brooms and the collected material sieved and winnowed to collect the stylo seed. The seed was further cleaned in the laboratory and a purity test performed on each seed lot. Seed yields were corrected to 10% seed moisture and 100% pure seed.

Data from each trial were analysed by conventional analysis of variance and treatment means compared by LSD at the P = 0.05 probability level.

Results

Rainfall

Rainfall at the trial site was below the 14-yr mean of 1538 mm/annum in the first two years of the study but similar to the mean in the third year (Table 2). The second year, 2004, was particularly dry, with rainfall 30% below the mean and wet season rain finishing early, in mid-September. In contrast, very heavy rainfall (433 mm) fell in September 2005 and 144 mm of rain fell from January to April 2006.

Table 2. Rainfall at Ubon Ratchathani University during the study and the 14-yr mean (1992-2005).

Month	Rainfall				
	Mean	2003	2004 (mm)	2005	2006
Jan	1	0	0	0	0
Feb	12	42	0	0	7
Mar	30	55	1	5	29
Apr	81	99	53	87	108
May	216	249	143	152	
Jun	249	234	206	278	
Jul	254	112	150	229	
Aug	278	335	297	285	
Sep	295	276	188	433	
Oct	90	28	4	26	
Nov	29	0	3	50	
Dec	4	0	0	0	
Total	1539	1430	1045	1545	

Trial 1 – Dry matter yields

All stylo cultivars, except Seca, established well, with seedling counts $>250/\text{m}^2$ (Table 3). Seca plant numbers were much lower at $46/\text{m}^2$.

In the first wet season, Tha Phra produced more dry matter ($P<0.05$) than Verano, Temprano and Seca (Table 3). Weeds, mainly *Zornia* spp. constituted 80% of the herbage in the Seca plots. In the following seasons, volunteer seedlings of Verano replaced the weeds and by the third year, Verano constituted nearly 90% of the herbage in the Seca plots.

Dry matter yields of Tha Phra and Ubon stylo were higher ($P<0.05$) than those of other cultivars in the following seasons, except for Temprano in the third year (Table 3). Temprano outyielded Verano and Seca in most seasons.

Crude protein concentrations of Verano were higher than those of Ubon stylo, Temprano and Seca in the first and third wet seasons and higher than those of all cultivars in the second wet season (Table 4). In the dry season, CP concentrations in Verano tended to be lower than those of other cultivars but differences were not always significant. Crude protein concentrations of all cultivars were, on average, 4.4 (Seca) to 8.0 (Verano) percentage points higher in the wet season than in the dry season.

In the second and third wet seasons, ADF (30.8 & 31.7%) and NDF (40.9 & 32.5%) concentrations in Verano were lower than other cultivars. In the dry season, ADF concentrations in Verano (39.3 - 45.0%) tended to be higher than

those of other cultivars but NDF concentrations in Verano (49.6 - 53.8%) were similar to those of other cultivars.

Table 3. Plant counts 6 weeks after sowing and dry matter yields of 5 stylo cultivars.

Cultivar	Plant counts	Dry matter yield							
		Wet 2003	Dry 2003-04	Wet 2004	Dry 2004-05	Wet 2005	Dry 2005-06	3 year means	
	(no/m ²)							Wet	Dry
		(kg/ha)							
Verano	253	5580	2800	8336	536	4280	3669	6065	2335
Tha Phra	306	7746	5863	14423	3718	10638	6245	10936	5275
Ubon stylo	381	6993	5857	14899	3459	10673	6396	10855	5236
Temprano	264	5521	4363	12692	2724	8963	5383	9059	4157
Seca	46	1443	3293	9035	1562	4738	1925	5072	2260
LSD(P<0.05)	62	1816	1282	1380	556	1896	1381	1690	1084

Table 4. Crude protein concentrations of 5 stylo cultivars.

Cultivar	Crude protein					
	Wet 2003	Dry 2003-04	Wet 2004	Dry 2004-05	Wet 2005	Dry 2005-06
	(%)					
Verano	20.0	12.4	20.9	12.6	22.1	13.9
Tha Phra	19.2	14.3	19.6	15.5	22.0	15.6
Ubon stylo	18.4	14.5	19.7	16.4	20.9	14.6
Temprano	18.2	13.9	19.4	14.9	20.8	14.5
Seca	17.1	13.2	16.9	14.1	19.6	13.1
LSD P<0.05)	1.2	ns	1.1	1.2	1.0	0.9

Trial 2 – Seed yields

Seed yields of Ubon stylo were 2.6 times those of Tha Phra, but with slightly lower 1000-seed weight (Table 5). Seed crops cut in September had twice the seed yield of crops cut in October.

Ubon stylo produced more dry matter than Tha Phra at closing for seed production, but this forage was 1 percentage point lower in crude protein concentration than Tha Phra (Table 6). Closing in October produced 3 times as much forage, but with lower crude protein concentrations, as closing in September.

Table 5. Effect of cultivar and time of closing on seed yields and seed weights of 2 stylo cultivars.

Treatment	Seed yield	TSW
Cultivar	(kg/ha)	(g)
Ubon stylo	959	2.50
Tha Phra	365	2.59
LSD (P<0.05)	425	0.06
Time of final closing cut		
Control (not cut)	618	2.60
September	921	2.53
October	453	2.50
LSD (P<0.05)	449	0.08

Table 6. Dry matter yield and crude protein concentration in stylo forage at time of closing seed crops.

Treatment	Dry matter	Crude protein
Cultivar	(kg/ha)	(%)
Ubon stylo	2562	21.3
Tha Phra	2114	22.4
LSD (P<0.05)	353	0.8
Time of final closing cut		
September	1054	22.4
October	3622	21.3
LSD (P<0.05)	353	0.8

Discussion

This research has shown that 2 perennial stylo cultivars (Ubon stylo and Tha Phra) produced higher dry matter yields than Verano in both wet and dry seasons, 90% more over 3 years. These advantages were especially pronounced in the dry season, when Ubon stylo and Tha Phra produced 2 – 6 times the yield of Verano. These large differences in dry matter yields were because the perennials stayed green and productive throughout the year, whereas Verano, a biennial, dried off or died in the dry season. This is particularly important as stylo cultivars that have superior dry season production and broad adaptability and are more suitable for cut-and-carry forage than Verano, are of special interest to farmers in Thailand.

Dry matter production from Ubon stylo and Tha Phra in this trial was excellent. Ubon stylo and Tha Phra produced 13, 18 and 17 t/ha/yr DM in the first, second and third years of production, respectively. These yields are far greater than those of Tha Phra in other trials in Thailand (Phaikaew *et al.* 2004). Of special interest was that the dry matter yields of Ubon stylo and Tha Phra were equal to yields produced by the grasses *Brachiaria* spp. (Hare *et al.* 2005) and *Digitaria milaniana* cv. Jarra (Hare *et al.* 2004b) in earlier trials on the same site. Moreover, the stylos produced twice the amount of crude protein as the grasses and with no applied fertiliser nitrogen.

Dry matter yields of Temprano, which is also a perennial, were generally lower than those of Ubon stylo and Tha Phra but higher than Verano and Seca. Temprano was selected as a more prostrate perennial stylo, suitable for grazing in low rainfall areas (AAR 700-1000 mm) (B. Grof, personal communication). It has multi-gene resistance to anthracnose and could be a good replacement for Verano in drier environments, should the single-line resistance of Verano (Iamsupasit *et al.* 1995) succumb.

While production from Seca was lower than that of the other 3 perennial stylos, it did produce 4.7, 10.6 and 6.7 t/ha/yr DM, in the first, second and third year of production, respectively. These yields are above those normally produced by Seca on dry, infertile soils and equal to yields obtained on more fertile soils under lenient cutting (Cook *et al.* 2005). Because of limited seed supply, Seca was sown at a low sowing rate of 1.15 kg/ha germinable seed, compared to the other stylo cultivars which were sown at 10 kg/ha germinable seed. If Seca had

been sown at the higher sowing rate, it may have been more productive. Seca is normally in association with perennial sown and native grasses which are grazed. It is not well adapted to cut-and-carry management due to slow establishment, low palatability and poor persistence in cut-and-carry systems.

The forage quality of Verano was generally better than that of Ubon stylo and Tha Phra (higher CP) in the wet season because of fresh new forage produced by young plants which grew from fallen seed. However, in the dry season, the crude protein concentration of Verano decreased rapidly as it senesced and died. In contrast, the crude protein concentrations in Ubon stylo and Tha Phra, remained good throughout the dry season. Both Ubon stylo and Tha Phra seem to be superior to Verano for use by smallholder farmers, with the higher yields of better quality fodder in the dry season being a critical advantage.

However, a major limitation of perennial stylos in Thailand has been their lack of persistence and decline in productivity beyond 2 years (Hare *et al.* 2003; 2004a), because of continual hard grazing or close to ground level, persistent cutting. By cutting to 10 cm and providing a good recovery period, in our trial all stylo species were still growing very well at the end of the third year and, except for Seca, maintaining a very strong plant density in the plots.

Farmers in Thailand use sown pastures for cut-and-carry forage rather than for grazing. They prefer to plant grasses rather than legumes, because of higher forage yields (Phaikaew and Hare 2005). However, if Ubon stylo and Tha Phra produce the yields in villages that we achieved in our research plots, there may be more farmer interest in sowing stylos, especially given the higher forage quality of the legumes and the savings in applied nitrogen fertiliser.

In order to increase stylo adoption by farmers, particular attention must be given to promoting correct cutting management to maintain stylo stand density and persistence. Cutting after plants have become tall and woody can kill the plants, since there are few growing points close to the ground on mature plants (Cook *et al.* 2005). We stimulated lower branching early, by cutting to 10 cm 3 months after sowing and then cutting at the same height at 2-month intervals in the wet season and at longer periods in the dry season. After 3 years, the Ubon stylo, Tha Phra and Temprano plots were still dense and almost weed-free.

While Ubon stylo and Tha Phra produced similar dry matter yields in this trial, the single line resistance of Tha Phra to anthracnose may cause it to succumb to anthracnose in the future. The multi-line resistance to anthracnose of Ubon stylo may make it persist better than Tha Phra. Tha Phra also has the tendency to become more woody with age than Ubon stylo, which makes it more vulnerable to dying out. Ubon stylo stems are a lot finer than Tha Phra stems and may be part of the reason for its persistence in grazed pastures. Cattle graze both leaves and stems of Ubon stylo, but with Tha Phra they prefer leaves, leaving the stems to become large and woody (Hare, unpublished data).

To be adopted by farmers, new stylo species need to be good seed producers. Ubon stylo is a prolific seeder, producing over 950 kg/ha, nearly 3 times the seed yield of Tha Phra. Phaikaew *et al.* (2004) also reported that Ubon stylo produced more seed than Tha Phra.

This study has reinforced earlier findings on the importance of closing strategy on both seed and forage production of perennial stylos. Excessive vegetative growth in perennial stylo seed crops can produce moisture stress during flowering, resulting in lower seed yields (Hare 1985). Cutting to 40 cm in August produces shorter plants at flowering and reduces moisture stress allowing a heavier seed set (Hare 1985). Loch *et al.* (1976) showed that the timing of perennial stylo defoliation was critical and was best carried out about 4 weeks before first-flower initiation, although timing differ by cultivar. In South America, cutting too low or too late in the wet season has been a frequent cause of failure of perennial stylo seed crops (Ferguson *et al.* 1999).

The major advantage of defoliation compared with not defoliating for smallholder farmers is that forage can be fed to livestock. In the current study, cutting Ubon stylo and Tha Phra in October, after the first flowers appeared, decreased seed yields to half produced by defoliating in September. The undefoliated plots did not suffer from moisture stress, even though they produced a considerable bulk between flowering and harvest.

If farmers can develop the skills to manage perennial stylos as a sown pasture and a legume protein bank for dry season forage, there will be more widespread use of perennial stylo. With proper cutting management, Ubon and Tha Phra perennial stylos can produce excellent regrowth and can persist strongly for at least 3 years and could be ideal replacements for Verano. Ubon stylo's stronger resistance to anthracnose, better grazing persistence and higher seed yields than Tha Phra, make it the better choice.

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Appendix 8

Plant breeding and seed production of apomictic tropical forage grasses

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ABSTRACT

Since apomictic reproduction (asexual reproduction by seed) avoids meiosis it ought to ensure good seed set even in meiotically unstable hybrids. However, this seems not generally to be the case. Improvement of apomictic brachiariagrasses in Colombia began with hybridization using a tetraploidized, sexual ruzigrass biotype developed in Belgium. Commercial seed production of the first two hybrid-derived apomictic cultivars from the CIAT breeding program are described. The first release, cv. Mulato, yields only about one-tenth as much seed as conventional brachiariagrass cultivars, which are derived directly from apomictic germplasm accessions collected in Africa. Low seed yield in Mulato is owing to poor seed set, rather than poor flowering. A second released cultivar, Mulato II, has better seed yield than Mulato although it has lower inflorescence density. It is still much lower yielding than conventional cultivars. The brachiariagrass breeding scheme currently employed at CIAT is briefly described and the issues involved in applying effective selection pressure to achieve cumulative genetic gains in the seed yield of apomictic hybrids are discussed.

Key words: apomixis, brachiariagrasses, cultivar, seed set, seed yield.

INTRODUCTION

Ruminant livestock production in the tropics and subtropics relies to a large extent on grazing of C₄ grasses. While the main C₄ crop species (e.g., maize [*Zea mays* L.], sorghum [*Sorghum bicolor* (L.) Moench], pearl millet [*Pennisetum glaucum* (L.) R. Br.], and sugarcane [*Saccharum officinarum* L.]) reproduce sexually, many of the economically important C₄ forage grasses reproduce by apomixis – asexual reproduction by seeds (Asker & Jerling 1992). Apomicts are among the most economically important warm-season forage grass species, and include buffelgrass [*Pennisetum ciliare* (L.) Link (syn *Cenchrus ciliaris* L.)], guineagrass (*Panicum maximum* Jacq.), bahiagrass (*Paspalum notatum* Flüggé), and three of the four commercial species of brachiariagrasses [*Brachiaria brizantha* (A. Rich.) Stapf (palisadegrass); *B. decumbens* Stapf (signalgrass); and *B. humidicola* (Rendle) Schweick. (koroniviagrass)].

Apomixis offers a unique means directly and faithfully to propagate even highly heterozygous genotypes through the convenient vehicle of seed. In fact, among the known apomictic crop plants, the only group where commercial multiplication combines asexual reproduction with seed propagation are the tropical forage grasses. Other domesticates where apomictic reproduction is known are fruit species where commercial propagation is by vegetative means (cuttings or grafting).

Two types of apomixis are found in the warm-season grasses: diplospory and apospory. These differ by the origin of the unreduced cell that gives rise to the female gametophyte: the diplosporous gametophyte originates by mitosis from an unreduced megaspore mother cell following a failure of meiosis; the aposporous gametophyte originates directly from a somatic, nucellar cell. Apospory is the type of apomixis found in the most important of the commercial warm-season forage grasses (e.g., the brachiariagrasses, guineagrass, buffelgrass, and bahiagrass).

To date, the vast majority of commercial warm-season forage grass cultivars are direct selections from collections of natural germplasm, commonly known as "ecotype selections" (Vogel & Burson 2004). Breeding programs based on deliberate hybridization and selection exist (buffel-, guinea-, brachiaria-, and bahiagrass), but their practical success to date has been very limited. One of the constraints on plant breeding of apomicts is the need to modify and adapt breeding techniques to take into account the peculiarities of apomictic reproduction and effectively and efficiently harness the advantages of asexual reproduction to exploit heterosis. Where cross compatible sexual germplasm exists, as it generally does, to allow genetic recombination in an apomictic species, then apomixis offers many distinct advantages in a plant breeding program (Vogel & Burson 2004).

It is commonly supposed that apomictic reproduction, in and of itself and owing to the fact that it bypasses female meiosis, should lead to improved reproductive fertility, and by extension, higher seed yields, particularly in apomicts of hybrid origin (e.g., Vogel & Burson 2004). An often repeated statement by Darlington (1939) asserts that "apomixis is an escape from sterility..." However, greater seed fertility for apomicts is not inevitable, particularly in pseudogamous apomicts where fertile pollen is required for the development of endosperm. A recent report from Brazil (Risso-Pascotto *et al.* 2005) suggests that genetic incompatibilities in an aposporous interspecific hybrid (*Brachiaria ruziziensis* x *B. brizantha*) resulted in up to 65% sterile pollen grains. Since apomictic brachiariagrasses are pseudogamous, the authors suggest that pollen sterility may be an important cause of poor seed fill in interspecific hybrids. And Asker and Jerling (1992) observe that "In *Poa pratensis*, sexual aberrants may have better seed-setting than original, facultatively apomictic types."

The present paper aims to:

1. Describe breeding procedures currently employed in CIAT's brachiariagrass breeding program and how these have evolved since the first experimental hybrids were made in 1988.

2. Outline the difficulties that have been encountered in commercial seed production of the first hybrid brachiariagrass cultivar (cv. Mulato) and their probable causes.
3. Describe seed production of a second brachiaria hybrid cultivar release (Mulato II).
4. Describe possible plant breeding approaches aimed at improving seed production characteristics of future brachiariagrass hybrid cultivars.

Brachiariagrass breeding program at CIAT

All four commercial *Brachiaria* species are of African origin. These commercial species (with the exception of ruzigrass) are polyploid, aposporous apomicts, i.e., they reproduce asexually by seed. Ruzigrass is a diploid, allogamous sexual species (Ferguson & Crowder 1974). Taken together, the apomictic polyploid species (signalgrass, palisadegrass, and koroniviagrass) are by far the most important sown forage grasses in the neo-Tropics (Santos Filho 1996). Ruzigrass is commercialized only to a limited extent in tropical America owing to its extreme susceptibility to spittlebugs and poor edaphic adaptation. It is much more important commercially where spittlebugs are not a production limitation, e.g., in Thailand (Hare & Phaikew 1999).

The early brachiariagrass cultivars (Basilisk signalgrass; Marandu, La Libertad, and Toledo palisadegrass; and Tully and Llanero koroniviagrass) are "ecotype selections", apomictically reproducing clones selected from ex situ germplasm collections, either in northern Australia (Basilisk, Tully) or in tropical America (Marandu, in Brazil; La Libertad, Toledo, and Llanero, in Colombia). Kennedy ruzigrass is a sexual population released in Australia.

Interest in brachiariagrass breeding was motivated by the perceived deficiencies of existing cultivars: spittlebug susceptibility in Basilisk and Kennedy; lack of adaptation to the very acid, infertile soils common in the American savannas in Marandu, La Libertad, and Toledo; poor feed quality and excessive seed dormancy in Tully and Llanero.

Signalgrass, palisadegrass, and ruzigrass are closely related, while koroniviagrass is phylogenetically more distant (Renvoize *et al.* 1996). Genetic recombination even within groups was, until the mid-1980s, restricted by intra- and interspecific ploidy differences, and especially by apomictic reproduction, which precludes direct hybridization between apomictic genotypes even at the same ploidy level.

An important breakthrough came with the development, in Belgium, of a tetraploidized, sexual ruzigrass (Svenne *et al.* 1981). Preliminary results of crossing studies (Ndikuniana 1985) suggested that apomixis was simply inherited as a monogenic dominant, with sexual genotypes being homozygous recessive at the apomixis locus, as had previously been reported for guineagrass (Savidan 1975; 1983). These preliminary results, which were subsequently fully confirmed by C.B. do Valle and collaborators (Valle *et al.* 1994; Valle & Savidan 1996), suggested that the reproductive mode might readily be manipulated in a plant breeding program (Miles & Valle 1996).

Experimental hybridization at CIAT in the signal-/ palisade-/ ruzigrass group began with the acquisition, in 1988, from Dr. Cacilda B. do Valle of Embrapa's Beef Cattle Center, of tetraploid, sexual ruzigrass germplasm derived directly from the Belgian material. The basic procedure for achieving genetic recombination was to use the cross-compatible tetraploid, sexual germplasm as female, and pollinate with the normal pollen produced by tetraploid apomicts. Such crosses were expected to "release" abundant genetic variation (Vogel & Burson 2004), given presumed genetic heterozygosity in both parents, but particularly in the natural tetraploid apomicts.

Most of the early proposals of breeding schemes for apomicts (summarized in Savidan 2000; Vogel & Burson 2004) were based either on incomplete or erroneous information on inheritance of the reproductive mode (e.g., Taliaferro & Bashaw 1966, for buffelgrass; Burton 1992, for bahiagrass), or had a very short-term perspective (e.g., Taliaferro & Bashaw 1966; Bashaw 1980b; Bashaw & Funk 1987). Only the breeding scheme proposed for guineagrass by Pernès *et al.* (1975), explicitly contemplated the accumulation of genetic gain over recurrent cycles of selection and recombination. Although many authors note the advantages of apomictic (asexual) reproduction to faithfully reproduce heterozygous genotypes, and hence to exploit heterosis (e.g., Vogel & Burson 2004), almost none of the proposed breeding schemes describes a mechanism that would accumulate the non-additive, heterotic effects contributing to heterosis (However, see Miles 1995).

The brachiariagrass breeding program at CIAT began with the assumption that repeated cycles of hybridization and selection would be needed to achieve the combination of characters and levels of character expression needed in improved cultivars (Miles & Valle 1996). The available sexual germplasm, derived from the Belgian tetraploidized sexual ruzigrass, has a very narrow genetic base [as evidenced by low polymorphism of molecular genetic markers (J. Tohme unpublished)]. Further, this germplasm is highly susceptible to spittlebugs (Cardona *et al.* 1999), and has poor edaphic adaptation (Rao *et al.* 1998). The characters to be combined (spittlebug resistance and edaphic adaptation) were available in separate apomictic accessions. Hence, the initial plan was:

1. Cross different apomicts, each having one or another of the desired characters, to the sexual tetraploid ruzigrass.
2. Identify superior first cycle sexual hybrids (homozygous recessive at the apomixis locus) with expression of the desired characters.
3. Recombine selected hybrid sexual clones by open pollination in an isolated crossing block to synthesize a sexually reproducing, tetraploid breeding population with a broad genetic base, i.e., including genes from accessions of signalgrass and palisadegrass as well as ruzigrass.

Since sexuality in brachiariagrass is conditioned by the homozygous recessive genotype (aaaa) at a single "apomixis locus" (Valle & Savidan 1996), the synthetic sexual

population will remain fully sexual as long as it is isolated from contamination by pollen from cross-compatible apomicts (genotype Aaaa). Hence, the synthetic brachiariagrass breeding population, like any allogamous sexual crop species (e.g., maize), can be subjected to recurrent cycles of selection and hybridization to improve the levels of expression of desired characters.

Given the obvious advantages of apomictic reproduction in maintaining cultivar purity (no cross-pollination) and faithfully and easily propagating heterozygous (and heterotic) genotypes, the intention was always to release only apomictic genotypes as commercial cultivars. Thus, in order to capture genetic gain in the synthetic sexual breeding population, elite sexual clones derived from the population are crossed (as females) with selected apomicts (as pollen parents) to produce hybrid populations segregating for reproductive mode (Miles *et al.* 2004). Following the identification of apomictic segregants in such hybrid populations, either by cytological examination of embryo sacs, by progeny test, or by molecular markers, the best apomictic hybrids can be multiplied directly and evaluated for eventual commercial release.

Six 2-yr selection cycles have been conducted in the tetraploid sexual breeding population since it was synthesized, with heavy selection pressure on spittlebug resistance. Resistance has responded steadily to selection, so that we now routinely isolate sexual clones that are more resistant to spittlebugs than any accession in the brachiariagrass germplasm collection (Miles *et al.* 2006). Recent results show that this resistance is inherited by a significant proportion of sexual-by-apomictic hybrids, even if the apomictic parent is highly susceptible (e.g., Basilisk signalgrass) (C. Cardona unpublished data).

Recently, a cyclic breeding scheme -- recurrent selection on specific combining ability (Hull 1945; Miles 1997) -- designed to accumulate non-additive genetic effects contributing to heterosis has been implemented (Miles in press). In this scheme, selection in the synthetic sexual breeding population is based not on performance of sexual clones *per se*, but on the performance of their hybrid progeny. Briefly, a series of sexual clones are crossed (as females) with a single (male) "tester" genotype to produce a series of hybrid, testcross families. These testcross progenies, rather than the sexual clones *per se*, are evaluated to determine which of the sexual clones will be recombined to reconstitute the sexual population. The breeding scheme automatically generates a cohort of apomictic hybrid clones each breeding cycle. The best apomictic individuals in the best testcross progenies are potential cultivars.

Seed production and seed set

In spite of expectations that apomictic reproduction will circumvent potential sterility problems, empirical results to date suggest that other factors are operating. The first hybrid brachiariagrass cultivar released, cv. Mulato, has disappointingly low seed yields, in spite of prolific, well-synchronized flowering induced by short daylength. Low seed yields are associated with poor seed set (Hare, 2007a), rather than low spikelet density. While conventional cultivars (e.g., Basilisk signalgrass, Marandu and Toledo palisadegrass) routinely produce commercial pure seed yields in the range of 500 to 1,000

kg ha⁻¹ (Hopkinson et al. 1996; Souza 1999), average commercial yields of Mulato do not exceed 100 kg ha⁻¹, with maximum yields rarely passing 200 kg ha⁻¹.

Seed yields of Mulato II, under both experimental and commercial conditions, have consistently exceeded those of its predecessor, cv. Mulato. In one trial, the highest seed yield of Mulato II (258 kg ha⁻¹) was 60% higher than the highest seed yield of Mulato (161 kg ha⁻¹) (Hare *et al.* 2007b). In another trial, seed yield of Mulato II reached 500 kg ha⁻¹ (Hare *et al.* 2007c) and several smallholder farmers in Thailand regularly hand harvest over 600 kg ha⁻¹.

While the published literature is scanty, poor seed yields, whether owing to poor seed set or shy flowering, seem to be a common defect of newly formed apomictic hybrids. The first buffelgrass hybrids released from the Texas A&M breeding program (Bashaw 1968; 1980a) were never widely adopted in spite of their improved forage characteristics, and this failure was apparently associated with erratic and often poor seed yields (M.A. Hussey, personal communication) and consequently scarce supplies of commercial seed and high seed prices. Likewise, a promising, hybrid-derived apomictic bahiagrass clone, Tifton 7 was never released owing to concerns about low seed yields (W.W. Hanna, personal communication). Published data on commercial seed yields of guineagrass cultivars (Souza 1999) likewise suggests lower yield for newly synthesized hybrid cultivars (e.g., 130-145 kg ha⁻¹ for ground swept seed of cvs. Centenário and Vencedor) than for cultivars selected from collections of natural apomictic germplasm (e.g., 180-200 kg ha⁻¹ for cvs. Tanzânia-1 and Mombaça).

We hypothesize that the low seed yield of new hybrids is owing to insufficiently rigorous selection being applied on seed production characteristics, combined possibly with a negative association between seed yield and vegetative vigor or forage yield. The relatively high seed yields of conventional cultivars selected from natural germplasm is probably attributable mainly to the effect of natural selection of genotypes with prolific seed set from populations of natural hybrids.

In order to achieve progress in the genetic improvement of seed yields, we will need a scheme to select cyclically on this trait. However, there is an important unknown in this regard. We know, for instance, that selection directly on phenotype in our synthetic sexual tetraploid population for spittlebug resistance gives good genetic gain in the population (Miles *et al.* 2006). Further, this gain in resistance is recovered in apomictic hybrids that are candidates for commercial release (CIAT 2007). For seed yield, the feasibility of capturing genetic gains achieved in the sexual population has yet to be demonstrated and is not so obvious. It is possible that the genes that contribute importantly to seed yield – particularly genes contributing to high seed set – in sexually reproducing plants are not the same as the genes contributing to seed set in apomicts, owing to the differences in gametophyte, fertilization, and early embryo and endosperm development between the two reproductive types. If this is true, then genetic gain for seed set in the synthetic sexual population may not be fully recovered in apomictic hybrids formed with sexual clones improved for seed set. This question could be answered experimentally, but this would be a fairly major project.

In any case, and until quantitative data are available, it is probably safe to assume that any difference in magnitude of correlations of seed set between relatives of different reproductive modes is unlikely to be so great as to change the sign of the correlation, i.e., that selection on seed set of sexuals will produce a negative correlated response in the resulting apomictic hybrids. Hence, it should be possible to capture at least a portion of the genetic response to selection on seed set in the synthetic sexual population in apomictic hybrids.

It should be even more effective to select on seed set in testcross progenies, and perhaps better yet to select on seed set of only the apomictic individuals in testcross progenies. However, this would require phenotyping large numbers of individual testcross hybrids for reproductive mode at an early stage of testing to identify the apomictic testcross individuals, compromising efficiency unless there is a very large discrepancy in the genes controlling seed set as between sexual or apomictic genotypes. At CIAT we do not have this capacity, and will not any time soon, unless a reliable molecular genetic marker of apomixis can be developed.

Hence, the strategy at present is simply to cull on poor seed set at two stages in the recurrent selection cycle: firstly, on differences among sexual clones per se in seed set when exposed to pollination by the apomictic tester, and secondly, among sexual clones based on mean seed set of their testcross progenies. The first cycle of selection on testcross performance has not been completed. Hence, the viability of our strategy is as yet untested.

In the meantime, new sexual-by-apomictic hybrids that are candidates for eventual commercialization are now being culled rigorously on seed set at several points in their development, beginning at an early stage. We use the criterion of seed set, rather than seed yield, owing to the fact that flowering response at our very low-latitude testing sites in Colombia (3° to 4° N) does not necessarily reflect flowering at latitudes more typical of commercial seed production areas (15° to 20° N or S). We assume that caryopsis formation, or seed set, is largely or entirely independent of latitude.

In a first stage, seed resulting from open-pollination of promising individual plants in unreplicated, space-planted field nurseries of new hybrids is recovered by enclosing mature inflorescences in mesh bags. Crude seed weighed and "full" seeds (with caryopsis) are separated with a laboratory seed blower. "Percent seed set" is expressed as weight of full seeds divided by total seed weight of the harvested sample. In the most recent data set, these percent seed set values ranged between 0 and 57% for a set of 353 hybrids of unknown reproductive mode (cf. 49% for Basilisk or 41% for Marandu). Fully reliable data on seed yield will require proper confirmation in replicated trials conducted in relevant seed production environments. The preliminary data were used to cull 54% of the pre-selected new hybrids.

The open pollinated seed harvested from space planted hybrids in field nurseries is used to establish progeny trials to assess reproductive mode. Uniform progenies indicate an apomictic hybrid, segregation within the progeny indicates a sexual hybrid, or a highly

sexual facultative apomictic. When the apomictic hybrids have been identified, their seed is harvested by bagging inflorescences. Percent seed set, by weight, is determined for each apomictic progeny. Hybrids with low seed set are again culled at this stage before promising apomictic hybrids are distributed for further agronomic testing.

Ample variation among our brachiariagrass hybrids has been demonstrated. During 2006, 28 promising new hybrids were identified as apomicts in a progeny test conducted at the main CIAT experiment station. Progenies were replicated from one to four times in 5-plant plots, in a completely randomized design. Open-pollinated seed was harvested by enclosing inflorescences in mesh bags. "Percent seed set", estimated by dividing the weight of full seed by the total weight of harvested seed, ranged from zero to 41% (cf. cv. Marandu: 16%) ($P < 0.01$).

Culling on seed set in sexual-by-apomictic hybrid populations will help ensure elimination of hybrids with potentially poor seed set. However, any gain in seed set in a particular hybrid population will not be cumulative over breeding cycles.

Seed yield in apomictic forage grasses should be at least as responsive to selection as grain yield in annual crops, and perhaps even more so given the almost complete absence of prior artificial selection on seed yield. Hence, we remain optimistic that, with time, it will be possible to breed high yielding cultivars of apomictic tropical forage grasses with good forage quality combined with high commercial seed yields.

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Appendix 9**Effect of foliar applications of trinexapac-ethyl plant growth regulator on seed yield in brachiaria hybrid cv. Mulato II and *Paspalum atratum*.**

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Abstract

Field experiments were conducted in north-east Thailand in 2006 to study the effects of trinexapac-ethyl plant growth regulator on seed yield in brachiaria hybrid cv. Mulato II (*Brachiaria ruziziensis* x *B. decumbens* x *B. brizantha*) and Ubon paspalum (*Paspalum atratum* cv. Ubon). The treatments, in separate trials, consisted of different rates of trinexapac-ethyl (0, 240, 360, 480, 560 g active ingredient/ha) applied in early August (Ubon paspalum) or early September (Mulato II) and monthly application times from June to September (Ubon paspalum) and July to October (Mulato II).

Applying different rates of trinexapac-ethyl and at different times to Mulato II did not increase seed yield or any component of seed yield. Applying different rates of trinexapac-ethyl to Ubon paspalum also did not increase seed yields and 360 g ai/ha reduced seed yields by nearly 40% compared to not applying trinexapac-ethyl. Applying trinexapac-ethyl to Ubon paspalum from July to September significantly reduced seed yields compared to the untreated control.

The differential effect of trinexapac-ethyl on these tropical grasses vs. temperate species (i.e., no positive effect vs. significant positive effect, respectively) is discussed.

Introduction

Plant growth regulators (PGRs) have been widely evaluated in temperate grass seed crops, with their application resulting in seed yield increases that are often large (50-136%) (Rolston *et al.* 1997). Research developed during the 1980s and 1990s was mainly based on the use of soil applied triazole PGRs, particularly paclobutrazol, that reduced lodging and stem length and improved seed yields in a range of temperate grass species (Rolston *et al.* 1997). Very little work has been done on the use of PGR on tropical grasses, though paclobutrazol increase seed yields of *Digitaria eriantha* by 51% by decreasing lodging, reducing tiller height and increasing seed set, seed weight and seeds per panicle (Ramírez and Hacker 1993). However, due to the longevity of the triazole PGRs in the soil, residual carry-over effects to subsequent crops and inconsistent results, none of these chemicals was released for commercial use in grass seed crops.

The development and research of foliar applied PGR chemicals in the past 10 years has lead to these new PGRs being released for commercial use in temperate grass seed crops. These foliar applied PGRs readily breakdown in the environment, have no carry-over effect and are effective in controlling stem elongation. The most effective foliar applied PGR found has been trinexapac-ethyl (sold as Palisade®, Moddus® or Primo Maxx®).

In ten years' research at Oregon State University the application of trinexapac-ethyl on grass seed crops produced significant and consistent seed yield increases of between 25-60% in *Lolium perenne* (Silberstein *et al.* 2000; 2001; 2002), *Festuca arundinacea* (Silberstein *et al.* 2001) and *F. rubra* (Silberstein *et al.* 2001). Applying trinexapac-ethyl increased seed yields of *F. arundinacea* in New Zealand by 60% over 4 years (Rolston *et al.* 2003) and

Phleum pratense in Norway by 52% (Aamlid 2003). Trinexapac-ethyl has been registered to use in grass seed crops in all the major temperate grass seed producing countries.

Trinexapac-ethyl retards plant growth by inhibiting the 3 β hydroxylation of the growth inactive form of gibberellic acid to the active form, and thereby thereby reduces or delays lodging in grass seed crops. The seed yield increases are mainly caused by the increase in florets/spikelet and the conversion of florets to seed (% seed set) (Chastain *et al.* 2000), resulting in more seeds per seed head (Rolston *et al.* 2003).

Brachiaria hybrid cv. Mulato II (*Brachiaria ruziziensis* x *B. decumbens* x *B. brizantha*) produces sufficient inflorescences, racemes and spikelets to indicate a potential for useful seed yields. But by seed harvest, there is always a massive failure of seed set, caryopsis maturation or both, with the cleaned seed containing less than 2% of the spikelets formed by the crops resulting in seed yields, on average, of less than 200 kg/ha (Hare *et al.* 2007; Hare 2007). The low seed-set could be due to pollen sterility, if judged by a study showing that more than 65% of pollen grains on brachiaria interspecific hybrids were sterile (Risso-Pascotto *et al.* 2005) and that this sterility was genetic. Given the success of trinexapac-ethyl in improving seed set in other species, we were interested to see whether this PGR would be effective in improving Mulato II seed set and subsequent seed yields.

Ubon paspalum (*Paspalum atratum* cv. Ubon) seed yields in Thailand are generally good, with farmers producing average yields of 940 kg/ha (Hare 2007). However, lodging is a major problem in some crops that are not cut at closing in July (Hare *et al.* 1999) and heavily lodged crops produce lower seed yields. We were interested to test the effectiveness of trinexapac-ethyl in Ubon paspalum seed crops by reducing stem length and decreasing lodging.

The hypothesis tested in this research is that application of trinexapac-ethyl to two tropical forage grasses will improve seed set and subsequent seed yields. The main objectives were: to reduce the proportion of empty and light seeds and improve seed set and seed yields in Mulato II and shorten stem lengths, reduce lodging and produce consistent high seed yields in Ubon paspalum.

Materials and methods

Trials were conducted in 2006 in Ubon Ratchathani province, north-east Thailand (15°N, 104°E; 130 m asl; AAR 1593 mm) on the Ubon Ratchathani University farm in a 0.30 ha field. The sites were on an upland sandy low humic gley soil (Roi-et soil series) (Mitsuchi *et al.* 1986). Soil samples to 10 cm, taken in May 2005, showed that the soil was acid (pH 4.3; water method), and low in organic matter (1.5%), N (0.03%), P (3.0 ppm; Bray II extraction method), S (9 ppm) and K (54.5 ppm). Prior to cultivation, the sites had been planted to *S. guianensis* var. *vulgaris* x var. *pauciflora* cv. Ubon stylo for 3 years.

Trial 1 – Effect of trinexapac-ethyl on Mulato II seed production

Two field studies examined the effects of trinexapac-ethyl plant growth regulator on Mulato II seed production. Both studies were conducted at the university in a one-year old Mulato II field planted in May 2005 in spacings of 1 m x 50 cm. Experimental plots in both studies were 5 m x 4 m.

Study 1 compared five rates of trinexapac-ethyl (control and trinexapac-ethyl at 240, 360, 480, 560 g active ingredient/ha) in a randomized complete blocks experiment with four replications. Trinexapac-ethyl was applied in water at 10 l/100m² on September 7, 2006 when Mulato II plants were at a Zadoks growth stage 31 or 32 (1-2 nodes detectable) (Zadoks *et al.* 1974).

Study 2 examined date of application of trinexapac-ethyl in a four-replicate RCBD with five treatments [control and trinexapac-ethyl (240 g ai/ha) applied on July 7, August 7, September 7, October 7, 2006].

Both fields were cut 5 cm above ground level on July 4 and August 4, 2006 and fertiliser was applied on August 4 (NPK 200 kg/ha 15:15:15), September 7 (Urea 100 kg/ha) and October 7 (Urea 100 kg/ha).

At peak anthesis (November 13-14), all inflorescences in 3 rows x 2 m in length were counted and nylon bags tied over the seed heads to collect the seed. Thirty inflorescences were taken from just outside this area for reproductive analysis and stem length. For reproductive analysis, all racemes were counted on each inflorescence and spikelets per raceme were counted from 3 racemes per inflorescence, taken from the top, middle and bottom of each inflorescence. The length of each inflorescence was measured from ground level to top of the highest raceme.

Seed was collected from the nylon bags at the end of harvest on December 4. The seed was slowly dried in small nylon bags hung from a rail inside a shed until seed cleaning commenced on December 20. The seed was cleaned through a South Dakota seed blower. Following cleaning, seed yields and thousand seed weight (TSW) were corrected to 10% seed moisture content.

Trial 2 – Effect of trinexapac-ethyl on Ubon paspalum seed production

Two field studies examined the effects of trinexapac-ethyl plant growth regulator on Ubon paspalum seed production. Both studies were conducted at the university in a Ubon paspalum field planted with rooted tillers divided from older plants in May 2006 in spacings of 1 m x 50 cm. Experimental plots in both studies were 5 m x 4 m.

Study 1 examined rates of trinexapac-ethyl in a four-replicate RCBD with five treatments (control and trinexapac-ethyl at 240, 360, 480, 560 g active ingredient/ha). Trinexapac-ethyl was applied in water at 10 l/100m² on August 7, 2006 when Mulato II plants were at a Zadoks growth stage 31 or 32 (1-2 nodes detectable) (Zadoks *et al.* 1974) and 50 cm in height.

Study 2 examined date of application of trinexapac-ethyl in a four-replicate RCBD with five treatments [control and trinexapac-ethyl (240 g ai/ha) applied on June 7, July 7, August 7, September 7, 2006].

Both fields were cut 5 cm above ground level on July 7 and fertiliser was applied on July 7 (NPK 200 kg/ha 15:15:15), August 7 (Urea 100 kg/ha) and September 7 (Urea 100 kg/ha).

At peak anthesis on September 25, all inflorescences in 3 rows x 2 m in length were counted and nylon bags tied over the seed heads to collect the seed. Thirty inflorescences were taken from just outside this area for reproductive analysis and stem length and measured as in Trial 1. Seed was collected from the nylon bags at the end of harvest on October 13. The seed was slowly dried in small nylon bags hung from a rail inside a shed until seed cleaning commenced on November 6. The seed was cleaned through a South Dakota seed blower. Following cleaning, seed yields and thousand seed weight (TSW) were corrected to 10% seed moisture content.

Data from each trial were submitted to analysis of variance and treatment means compared by LSD at the $\alpha = 0.05$ probability level.

Results

Trial 1 – Effect of trinexapac-ethyl on Mulato II seed production

Applying different rates of trinexapac-ethyl reduced stem lengths by 3 to 6 cm but did not increase seed yields or any component of seed yield of Mulato II (Table 1). Applying trinexapac-ethyl at different times had no effect on seed yield or on seed yield components of Mulato II, but applications in October shortened stem length by 11 cm relative to the untreated control (Table 2).

Table 1. Effect of rates of trinexapac-ethyl (g ai/ha) on seed yield components and seed yield of Mulato II.

Rate	Stem length (cm)	Inflorescences /m ²	Racemes/ inflorescence	Spikelets /raceme	Seed yield (kg/ha) ¹	TSW (g) ¹
control	104	82	4.0	33.1	99	9.81
240	100	98	3.9	33.1	104	10.43
360	99	68	4.0	33.1	78	7.77
480	101	78	4.0	33.5	104	10.34
600	98	78	4.0	32.6	83	8.26
LSD	3.8	ns	ns	ns	ns	ns
P<0.05						

¹ corrected to 10% seed moisture content

Table 2. Effect of application date of trinexapac-ethyl on seed yield components and seed yield of Mulato II.

Date of application	Stem length (cm)	Inflorescences /m ²	Racemes/ inflorescence	Spikelets /raceme	Seed yield (kg/ha) ¹	TSW (g) ¹
Control	114	124	3.9	33.5	131	7.95
July	115	121	3.9	33.5	128	7.96
August	112	79	4.1	33.1	78	8.05
September	108	94	4.1	33.1	68	7.87
October	103	126	4.1	33.3	120	7.95
LSD	6.4	ns	ns	ns	ns	ns
P<0.05						

¹ corrected to 10% seed moisture content

Trial 2 – Effect of trinexapac-ethyl on Ubon paspalum seed production

Applying different rates of trinexapac-ethyl did not increase seed yield of Ubon paspalum and a rate of 360 g ai/ha reduced seed yields by nearly 40% compared to the untreated control (Table 3). Trinexapac-ethyl reduced Ubon paspalum stem length and increased the number of racemes and spikelets (Table 3).

Applying trinexapac-ethyl from July to September significantly reduced seed yields of Ubon paspalum compared to the untreated control (Table 4). Applying trinexapac-ethyl in September also reduced stem length and number of inflorescences but increased spikelet number per raceme compared to the untreated control (Table 4).

Table 3. Effect of rates of trinexapac-ethyl (g ai/ha) on seed yield components and seed yield of Ubon paspalum.

Rate	Stem length (cm)	Inflorescences /m ²	Racemes/ inflorescence	Spikelets /raceme	Seed yield (kg/ha) ¹	TSW (g) ¹
control	190	49.7	9.9	133.6	763	3.51
240	170	54.2	10.5	141.1	706	3.36
360	170	44.5	10.8	144.4	469	3.39
480	172	50.9	10.8	139.3	668	3.35
600	162	48.4	11.4	142.6	738	3.32
LSD	10.2	ns	0.9	6.7	163	ns
P<0.05						

¹ corrected to 10% seed moisture content

Table 4. Effect of application date of trinexapac-ethyl on seed yield components and seed yield of Ubon paspalum.

Date of application	Stem length (cm)	Inflorescences /m ²	Racemes/ inflorescence	Spikelets /raceme	Seed yield (kg/ha) ¹	TSW (g) ¹
Control	180	60.4	10.0	122.1	988	3.47
June	183	54.1	10.0	128.3	875	3.40
July	179	50.8	10.8	124.0	756	3.50
August	173	56.7	10.5	129.0	700	3.43
September	162	47.7	10.1	133.2	444	3.36
LSD	11.2	7.4	ns	6.3	200	ns
P<0.05						

¹ corrected to 10% seed moisture content

Discussion

The negative responses in seed yield of Mulato II and Ubon paspalum using foliar applications of trinexapac-ethyl are similar to results obtained by applying other PGRs to tropical grasses. *P. plicatulum* seed yields did not increase when chlormequat was applied shortly after floral initiation (Cameron and Humphreys 1976). *Panicum maximum* seed yields did not increase when ethephon was

applied at the beginning of anthesis and when it was applied before seed head emergence, seed yield decreased by nearly 90% (Joaquín *et al.* 2007).

Only two studies have reported seed yield increases in tropical grasses from using PGRs. In the first study, *D. eriantha* seed yield increased from 305 kg/ha (control) to 462 kg/ha when 0.75 kg ai/ha of paclobutrazol was applied at early seed head emergence (Ramírez and Hacker 1993). However, applying paclobutrazol before seed head emergence decreased *D. eriantha* seed yields by nearly 30%. In the second study, a commercial steroidal phyto-hormone, cidef-4, significantly increased seed yield of *P. maximum*, irrespective of stage of application (Joaquín *et al.* 2007).

The positive seed yield responses of two tropical grasses to PGRs (Ramírez and Hacker 1993; Joaquín *et al.* 2007) were optimized when PGRs were applied at seed head emergence or early anthesis, which was far later than in our studies. We followed the recommendations from research on temperate species which have consistently found that the 2 node stage [Zadoks growth stage 31 or 32 (Zadoks *et al.* 1974)] to be the most appropriate time to apply PGRs. The more rapid growth, different plant anatomy and photosynthesis of tropical C_4 grasses compared to temperate C_3 grasses (Humphreys 1981) may suggest, given the good results obtained with *D. eriantha* (Ramírez and Hacker 1993) and *P. maximum* (Joaquín *et al.* 2007), that a later application of PGRs at early seed head emergence [Zadoks growth stages 50-55 (Zadoks *et al.* 1974)] may be more appropriate. However, in a preliminary study in 2005, trinexapac-ethyl was applied to brachiaria hybrid cv. Mulato (*Brachiaria ruziziensis* x *B. brizantha*) at early seed head emergence (Zadoks growth stage 54) in late September (Hare unpublished data). Trinexapac-ethyl significantly reduced seed yield by over 80% compared to the control, by stunting the seed heads so severely that at harvest many seed heads, even though ripe, could not fully emerge from the flag leaf sheaths and allow seed to fall into the nylon bags. This time of application was therefore considered inappropriate for when we started our full studies in 2006 and earlier application times were therefore chosen.

Seed yields of Mulato II still remain very low with the cleaned seed containing less than 2% of the spikelets formed by the crops (Hare *et al.* 2007). PGRs may have a role in improving seed set in Mulato II and more studies should be conducted on timing of application of trinexapac-ethyl given that Ramírez and Hacker (1993) found that only one rate and one time of application of paclobutrazol increased seed yield of *D. eriantha*.

Seed yields of Ubon paspalum in the control plots were the highest we have ever harvested at the university in ten years research and equal to yields achieved on better soils by farmers (Hare 2007). A closing cut at the appropriate time (Hare *et al.* 1999) to prevent lodging will lead to higher Ubon paspalum seed yields and therefore is a more appropriate and cheaper management than using more expensive PGRs which do shorten Ubon paspalum seed head stems and prevent lodging but do not increase seed yield.

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