03-31-426

ภาษาอังกฤษเทคนิคด้านพืชศาสตร์
TECHNICAL ENGLISH FOR PLANT SCIENCE

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คณะเทคโนโลยีอุตสาหกรรมเกษตร
มหาวิทยาลัยเทคโนโลยีราชมงคลตะวันออก

คำนำ

เอกสารประกอบการสอนรายวิชา 03-31-426 ภาษาอังกฤษเทคนิคด้านพืชศาสตร์ (Technical English for Plant Science) ฉบับนี้ เป็นเอกสารที่จัดทำขึ้นตามหลักสูตรวิทยาศาสตร-บัณฑิต สาขาวิชาพืชศาสตร์ คณะเทคโนโลยีอุตสาหกรรมการเกษตร มหาวิทยาลัยเทคโนโลยีราชมงคลตะวันออก ผู้เขียนได้รวบรวมเนื้อหาของรายวิชาจาก หนังสือ บทความทางวิชาการ และเอกสารทางวิชาการ ซึ่งเป็นแหล่งเรียนรู้ที่ได้มาจากห้องสมุดมหาวิทยาลัยและจากทางเว็บไซต์อินเทอร์เน็ต ที่เป็นแหล่งเรียนรู้ซึ่งเชื่อถือได้ เพื่อใช้เป็นแนวทางในการจัดการเรียนการสอน ให้มีประสิทธิภาพตามจุดมุ่งหมายรายวิชา เอกสารฉบับนี้มีลักษณะเป็นแผนการสอนตลอดทั้งภาคการศึกษา โดยจัดแบ่งออกเป็น 7 หน่วยเรียน โดยได้อธิบายเนื้อหาการสอนในแต่ละหัวข้อไว้ ทำให้สะดวกต่อการจัดการเรียนการสอนของอาจารย์ผู้สอน และนักศึกษาสามารถใช้ในการศึกษาค้นคว้าล่วงหน้าก่อนเข้าชั้นเรียน โดยมุ่งหวังคุณภาพในการจัดการเรียนการสอน เพื่อให้สะดวกแก่นักศึกษาสำหรับใช้เป็นคู่มือในการเรียนภาคทฤษฎี

ผู้เรียบเรียงหวังเป็นอย่างยิ่งว่า เอกสารประกอบการสอนฉบับนี้ จะเป็นประโยชน์ต่อนักศึกษาที่เรียนวิชาอังกฤษเทคนิคด้านพืชสาสตร์ได้เป็นอย่างดี

บัญชา เวียงสมุทร
คณะเทคโนโลยีอุตสาหกรรมการเกษตร
มหาวิทยาลัยเทคโนโลยีราชมงคลตะวันออก วิทยาเขตจันทบุรี
พ.ศ. 2561

สารบัญเนื้อเรื่อง

สารบัญเนื้อเรื่อง (ต่อ)

สารบัญตาราง

สารบัญภาพ

สารบัญภาพ (ต่อ)

สารบัญภาพ (ต่อ)

วัตถุประสงค์

มหาวิทยาลัยเทคโนโลยีราชมงคลตะวันออก

มหาวิทยาลัยเทคโนโลยีราชมงคลตะวันออก เป็นสถาบันการศึกษาและวิจัย ส่งเสริมการศึกษาสายอาชีพ ระดับปริญญาโท ปริญญาตรี และประกาศนียบัตรวิชาชีพชั้นสูง เน้นการพัฒนาทุกหลักสูตรให้เหมาะสมกับความต้องการทางเทคโนโลยี มีความสอดคล้องกับการเปลี่ยนแปลงทางสังคม เศรษฐกิจ และความต้องการกำลังคนของประเทศ

ปรัชญาการจัดการศึกษา
มหาวิทยาลัยเทคโนโลยีราชมงคลตะวันออก

มหาวิทยาลัยเทคโนโลยีราชมงคลตะวันออก มีความเชื่อมั่นว่าเทคโนโลยีต่างๆ เป็นองค์ประกอบสำคัญ ในกระบวนการศึกษาที่ช่วยเสริมสร้างมาตรฐาน และคุณภาพชีวิต เพื่อเป็นกำลังสำคัญสำหรับการพัฒนาเศรษฐกิจและสังคมไทย

มหาวิทยาลัยเทคโนโลยีราชมงคลตะวันออก จัดการศึกษา โดยมุ่งพัฒนาบุคคลให้มีความเจนจัดทางวิชาการ มีความเชี่ยวชาญเชิงปฏิบัติ และมีคุณสมบัติที่จำเป็นตามลักษณะของงานอาชีพ รวมทั้งปลูกฝังความเป็นระเบียบวินัย และความสำนึกในจรรยาอาชีพ คุณธรรม ความรับผิดชอบต่อหน้าที่ และสังคม

ความมุ่งหมายของหลักสูตร
หลักสูตรระดับปริญญาตรี สาขาวิชาพืชศาสตร์

หลักสูตรวิทยาศาสตรบัณฑิต สาขาวิชาพืชศาสตร์ หลักสูตรปรับปรุง พ.ศ. 2559 เป็นหลักสูตรที่มุ่งจัดการเรียนการสอนให้ผู้เรียนมีความรู้ความเชี่ยวชาญในทักษะวิชาชีพเฉพาะด้านเพื่อให้ได้บัณฑิตนักปฏิบัติที่มีคุณภาพ ซึ่งมีความรู้ความสามารถทั้งภาคทฤษฎีและปฏิบัติตลอดจนมีความสอดคล้องกับเศรษฐกิจของท้องถิ่น ภูมิภาค และประเทศที่จะนำไปสู่การพัฒนาเพื่อประโยชน์ที่ยั่งยืนของสังคมไทย ตามหลักปรัชญาเศรษฐกิจพอเพียงได้อย่างยั่งยืน โดยมีวัตถุประสงค์ของหลักสูตรดังนี้

1. เพื่อผลิตบัณฑิตให้มีคุณธรรม จริยธรรม ซื่อสัตย์ มีวินัย รับผิดชอบต่อตนเองและสังคม
2. เพื่อผลิตบัณฑิตให้มีความรู้ความสามารถในด้านพืชศาสตร์ที่มีคุณภาพ
3. เพื่อผลิตบัณฑิตให้มีความรู้มีศักยภาพในการแข่งขันทางวิชาการและประกอบอาชีพได้
4. เพื่อผลิตบัณฑิตให้เข้าใจการทำงานเป็นทีม และปรับตัวเข้ากับวัฒนธรรมองค์กรได้
5. เพื่อผลิตบัณฑิตให้มีทักษะทางด้านการสื่อสารและประยุกต์ใช้เทคโนโลยีสารสนเทศได้อย่างเหมาะสม

ลักษณะรายวิชา

1. รหัสและชื่อวิชา	03-31-426 ภาษาอังกฤษเทคนิคด้านพืชศาสตร์ English Technique for Plant Science
2. สภาพรายวิชา	วิชาชีพบังคับ ในหลักสูตรวิทยาศาสตรบัณฑิต สาขาวิชาพืชศาสตร์
3. ระดับรายวิชา	ภาคการศึกษาที่ 1 ชั้นปีที่ 4 (ปริญญาตรี 4 ปี)
4. ผู้สอน	อาจารย์ ดร.บัญชา เวียงสมุทร
4. พื้นฐาน	-
5. เวลาศึกษา	54 คาบเรียนตลอด 18 สัปดาห์ แยกเป็นทฤษฎี 3 คาบต่อสัปดาห์ สอบและทวนสอบ 2 สัปดาห์ๆ ละ 3 คาบ และนักศึกษาต้องใช้เวลาศึกษาค้นคว้านอกเวลา 6 ชั่วโมงต่อสัปดาห์
6. จำนวนหน่วยกิต	3 หน่วยกิต
7. จุดมุ่งหมายรายวิชา	1. รู้ความหมายและความสำคัญของภาษาอังกฤษด้านพืชศาสตร์ 2. รู้และเข้าใจความหมายของคำศัพท์ภาษาอังกฤษเกี่ยวกับพืช 3. รู้และเข้าใจความหมายของคำศัพท์ภาษาอังกฤษเกี่ยวกับการขยายพันธุ์พืช 4. รู้และเข้าใจความหมายของคำศัพท์ภาษาอังกฤษเกี่ยวกับสรีรวิทยาของพืช 5. รู้และเข้าใจความหมายของคำศัพท์ภาษาอังกฤษเกี่ยวกับปฐพีวิทยา 6. เข้าใจบทความวิชาการภาษาอังกฤษ และสามารถจับใจความสำคัญ
8. คำอธิบายรายวิชา	ความหมาย และความสำคัญของภาษาอังกฤษเทคนิคด้านพืชศาสตร์ เข้าใจความหมายของคำศัพท์เทคนิคเกี่ยวกับพืชด้านต่างๆ ได้แก่ ด้านการขยายพันธุ์พืช สรีรวิทยาของพืช พืชสวน ผัก ไม้ผล ปฐพีวิทยา การอ่านบทความ เอกสารทางวิชาการเพื่อจับใจความ

การแบ่งหน่วย/บทเรียน

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จุดประสงค์การสอน

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1.1.3 บอกประวัติของพืชศาสตร์ยุคปัจจุบันของไทย

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1.2.1 บอกความหมายของพืชศาสตร์

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1.4.1 บอกความหมายของคำศัพท์ด้านพืชศาสตร์

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2.1.1 บอกความหมายของคำศัพท์ด้านการขยายพันธุ์พืช

2.2 รู้และเข้าใจความหมายและความสำคัญของการขยายพันธุ์พืช

2.2.1 บอกความหมายของการขยายพันธุ์พืช

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2.2.4 อธิบายความสำคัญของการขยายพันธุ์พืช

2.3 รู้ประเภทของการขยายพันธุ์พืช

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2.4 เข้าใจวิธีการขยายพันธุ์พืชโดยการตอนกิ่ง

2.4.1 อธิบายวิธีการขยายพันธุ์พืชโดยการตอนกิ่ง

2.5 เข้าใจวิธีการขยายพันธุ์พืชแบบต่อกิ่ง

2.5.1 อธิบายวิธีการขยายพันธุ์พืชแบบต่อกิ่ง

2.6 เข้าใจวิธีการขยายพันธุ์พืชโดยการทาบกิ่ง

2.6.1 อธิบายวิธีการขยายพันธุ์พืชโดยการทาบกิ่ง

2.7 เข้าใจวิธีการขยายพันธุ์พืชโดยการติดตา

2.7.1 อธิบายวิธีการขยายพันธุ์พืชโดยการติดตา

2.8 เข้าใจวิธีการขยายพันธุ์พืชโดยการตัดชำ

2.8.1 อธิบายวิธีการขยายพันธุ์พืชโดยการตัดชำ

หน่วยเรียนที่ 3 Plant Physiology

3.1 รู้ความหมายและความสำคัญของสรีรวิทยาของพืช

3.1.1 บอกความหมายของสรีรวิทยาของพืช

3.1.2 บอกความสำคัญของสรีรวิทยาของพืช

3.2 เข้าใจบทบาทของสรีรวิทยาของพืช

3.2.1 อธิบายบทบาทของสรีรวิทยาของพืช

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3.3.1 บอกปัญหาที่ส่งผลกระทบต่อกระบวนการทางสรีรวิทยาของพืช

3.4 รู้กายวิภาคของพืช

3.4.1 บอกกายวิภาคของพืช

3.5 เข้าใจกระบวนการสังเคราะห์ด้วยแสงของพืช

3.5.1 อธิบายกระบวนการสังเคราะห์ด้วยแสงของพืช

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3.7 เข้าใจกระบวนการคายน้ำของพืช

3.7.1 อธิบายกระบวนการคายน้ำของพืช

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3.9 รู้และเข้าใจบทบาทของฮอร์โมนพืชในการเจริญเติบโตของพืช

3.9.1 บอกชนิดของฮอร์โมนพืชที่มีผลต่อการเจริญเติบโตของพืช

3.9.2 อธิบายบทบาทของฮอร์โมนพืชในการเจริญเติบโตของพืช

หน่วยเรียนที่ 4 Horticulture

4.1 รู้ความหมายของพืชสวน

4.1.1 บอกความหมายของพืชสวน

4.2 รู้และเข้าใจความสำคัญของพืชสวน

4.2.1 บอกความสำคัญของพืชสวน

4.2.2 อธิบายความสำคัญของพืชสวน

4.3 เข้าใจบทสนทนาภาษาอังกฤษทั่วไปเกี่ยวกับฟาร์มขนาดใหญ่

4.3.1 อธิบายบทสนทนาภาษาอังกฤษทั่วไปเกี่ยวกับฟาร์มขนาดใหญ่

4.4 รู้ผัก

4.4.1 บอกชื่อผักบางชนิดที่คนไทยส่วนใหญ่นิยมรับประทาน

4.5 รู้ผลไม้

4.5.1 บอกชื่อผลไม้บางชนิดที่คนไทยส่วนใหญ่นิยมรับประทาน

4.6 รู้คุณค่าทางโภชนาการอาหารของผลไม้และผักบางชนิด

4.6.1 บอกคุณค่าทางโภชนาการอาหารของผลไม้และผักบางชนิด

4.7 รู้และเข้าใจวิธีการปลูกทุเรียน

4.7.1 บอกสภาพภูมิประเทศที่เหมาะสมต่อการปลูกทุเรียน

4.7.2 บอกวิธีการใส่ปุ๋ยทุเรียน และดินที่เหมาะสมต่อการปลูกทุเรียน

4.7.3 อธิบายวิธีการปลูกทุเรียน

4.7.4 บอกวิธีการขยายพันธุ์ทุเรียน

4.7.5 บอกวิธีการจัดการดูแลรักษาต้นทุเรียน

4.7.6 บอกวิธีการให้น้ำทุเรียน

4.7.7 บอกวิธีการควบคุมโรคและศัตรูของทุเรียน

4.7.8 อธิบายวิธีการเก็บเกี่ยวทุเรียน

หน่วยเรียนที่ 5 Basic Knowledge of Soil Science

5.1 รู้ความหมายของดิน

5.1.1 บอกความหมายของดิน

5.2 รู้และเข้าใจความสำคัญของดิน

5.2.1 บอกความสำคัญของดิน

5.2.2 อธิบายความสำคัญของดิน

5.3 รู้ส่วนประกอบของดิน

5.3.1 บอกส่วนประกอบของดิน

5.4 รู้ชนิดของดิน

5.4.1 บอกชนิดของดิน

5.5 รู้หน้าตัดของดิน (soil profile) และช่วงชั้นดิน (soil horizons)

5.5.1 บอกความหมายของหน้าตัดของดิน

5.5.2 บอกช่วงชั้นดิน

5.6 เข้าใจความสัมพันธ์ระหว่างดิน น้ำ และพืช

5.6.1 อธิบายความสัมพันธ์ระหว่างดิน น้ำ และพืช

หน่วยเรียนที่ 6 Reading Academic Sources

6.1 รู้ความหมายของแหล่งข้อมูลทางวิชาการ

6.1.1 บอกความหมายของแหล่งข้อมูลทางวิชาการ

6.2 รู้ประเภทของแหล่งข้อมูลทางวิชาการ

6.2.1 บอกประเภทของแหล่งข้อมูลทางวิชาการ

6.3 รู้เคล็ดลับและคำแนะนำในการอ่าน

6.3.1 บอกเคล็ดลับและคำแนะนำในการอ่าน

6.4 รู้และเข้าใจประเภทของทักษะการอ่าน

6.4.1 บอกประเภทของทักษะการอ่าน

6.4.2 อธิบายประเภทของทักษะการอ่าน

หน่วยเรียนที่ 7 Reading Academic Articles

7.1 รู้ความหมายของบทความทางวิชาการ

7.1.1 บอกความหมายของบทความทางวิชาการ

7.2 รู้ความสำคัญของบทความทางวิชาการ

7.2.1 บอกความสำคัญของบทความทางวิชาการ

7.3 รู้และเข้าใจหลักเกณฑ์ในการอ่านบทความทางวิชาการ

7.3.1 บอกหลักเกณฑ์ในการอ่านบทความทางวิชาการ

7.3.2 อธิบายหลักเกณฑ์ในการอ่านบทความทางวิชาการ

7.4 รู้และเข้าใจคำแนะนำแต่ละขั้นตอนในการอ่านบทความทางวิชาการ

7.4.1 บอกคำแนะนำแต่ละขั้นตอนในการอ่านบทความทางวิชาการ

7.4.2 อธิบายคำแนะนำแต่ละขั้นตอนในการอ่านบทความทางวิชาการ

7.5 รู้วิธีการเขียนประวัติย่อสำหรับการสมัครงาน

7.5.1 บอกวิธีการเขียนประวัติย่อสำหรับการสมัครงาน

7.6 รู้และเข้าใจกิจกรรม

7.6.1 บอกชื่อกิจกรรมประจำทุกปีของมหาวิทยาลัยเทคโนโลยีราชมงคลตะวันออก วิทยาเขตจันทบุรี

7.6.2 อธิบายลักษณะกิจกรรมประจำปีของมหาวิทยาลัยเทคโนโลยีราชมงคลตะวันออก วิทยาเขตจันทบุรี

7.6.3 บอกประวัติย่อของตนเองโดยจัดทำรายงานเป็นภาษาอังกฤษและนำเสนอหน้าชั้นเรียน

การประเมินผลรายวิชา

วิชานี้แบ่งออกเป็น 7 หน่วยการเรียนการวัดและประเมินผลดำเนินการดังนี้

1. วิธีการ รวบรวมข้อมูลเพื่อการประเมินผลแยกเป็น 4 ส่วนโดยแยกคะแนนแต่ละส่วนจากคะแนนเต็ม 100 คะแนน

1.1 พิจารณาจากงานที่มอบหมาย	20	คะแนน
1.2 พิจารณาจากจิตพิสัยความสนใจความรับผิดชอบ	10	คะแนน
1.3 การทดสอบกลางภาค	35	คะแนน
1.4 การทดสอบปลายภาค	35	คะแนน
รวม	100	คะแนน

2. เกณฑ์ผ่าน นักศึกษาที่จะผ่านเกณฑ์การวัดผลจะต้อง

2.1 มีคะแนนงานที่รับมอบหมายต้องไม่ต่ำกว่า 80%

2.2 มีเวลาเรียนไม่ต่ำกว่า 80%

2.3 มีคะแนนจิตพิสัยต้องไม่ต่ำกว่า 80%

2.4 มีผลรวมของคะแนนที่ได้ทั้งหมดต้องไม่ต่ำกว่า 50 คะแนนหรือ 50%

3. เกณฑ์ค่าระดับคะแนน

3.1 การประเมินผลแบ่งเป็น 2 ขั้นตอนคือการประเมินผลในครั้งที่ 1 โดยพิจารณาว่าผ่านหรือไม่ผ่านในข้อที่ 2 โดยที่ผู้ไม่ผ่านจะได้คะแนน F หรือ 0

3.2 ผู้ที่ผ่านจะนำคะแนนมากำหนดระดับคะแนนตามเกณฑ์ดังนี้

คะแนนร้อยละ	80 - 100	ได้ระดับคะแนน	A	หรือ	4
คะแนนร้อยละ	75–79	ได้ระดับคะแนน	B^+	หรือ	3.5
คะแนนร้อยละ	70– 74	ได้ระดับคะแนน	B	หรือ	3
คะแนนร้อยละ	65–69	ได้ระดับคะแนน	C^+	หรือ	2.5
คะแนนร้อยละ	60- 64	ได้ระดับคะแนน	C	หรือ	2
คะแนนร้อยละ	55 - 59	ได้ระดับคะแนน	D^+	หรือ	1.5
คะแนนร้อยละ	50 - 54	ได้ระดับคะแนน	D	หรือ	1
คะแนนร้อยละ	0 - 49	ได้ระดับคะแนน	F	หรือ	0

4. ข้อทดสอบแบ่งน้ำหนักของแต่ละจุดประสงค์ในระดับพฤติกรรมต่างๆ ตลอดจนคะแนนแต่ละหน่วยและเกณฑ์ผ่านดังตารางต่อไปนี้

ตารางกำหนดน้ำหนักคะแนนของหน่วยเรียนตามมาตรฐานผลการเรียนรู้

เลขที่หน่วย	คะแนนรายหน่วย และน้ำหนักคะแนนข้อสอบ / ชื่อหน่วย	คะแนนรายหน่วย	เกณฑ์ผ่านรายหน่วย (%)	น้ำหนักคะแนน					
				พุทธิพิสัย				ทักษะพิสัย	จิตพิสัย
				ความรู้ความจำ	ความเข้าใจ	การนำไปใช้	สูงกว่าการนำไปใช้		
1	History, Meaning and Importance of Plant Science	4	50	1	3	-	-	-	
2	Vocabularies, Definition and Importance of Plant Propagation	13	50	4	6	3	-	-	
3	Plant Physiology	18	50	6	10	2	-	-	
4	Horticulture	18	50	8	8	2	-	-	
5	Basic Knowledge of Soil Science	4	50	1	2	1	-	-	
6	Reading Academic Sources	4	50	1	2	1	-	-	
7	Reading Academic Articles	9	50	2	5	2	-	-	
รวม		70	50	23	36	11			10
ก	คะแนนพุทธิพิสัย	70	50	**หมายเหตุ**					
ข	คะแนนจิตพิสัย	10	80						
ค	คะแนนจากรายงานและการค้นคว้าเพิ่มเติม	20	80						
รวมทั้งสิ้น		100							

กำหนดการสอน (ภาคทฤษฎี)

สัปดาห์ที่	วัน/เดือน	ชั่วโมงที่	รายการ	หมายเหตุ
1		1-3	**แนะนำรายวิชา หน่วยเรียน เงื่อนไขการเรียน** **หน่วยเรียนที่ 1** History, Meaning and Importance of Plant Science 1.1 History of Plant Science 1.2 Meaning of Plant Science 1.3 Importance of Plant Science 1.4 Useful Vocabulary/ Technical Terms	3
2		1-3	**หน่วยเรียนที่ 2** Vocabularies/Technical Terms, Definition and Importance of Plant Propagation 2.1 Vocabularies/Technical Terms of Plant Propagation 2.2 Definition and Importance of Plant Propagation 2.3 Types of Plant Propagation 2.4 Marcotting Methods 2.5 Grafting Methods	9
3		4-6	2.6 Inarching Methods 2.7 Budding Methods	
4		7-9	2.8 Cutting Methods	
5		1-3	**หน่วยเรียนที่ 3** Plant Physiology 3.1 Definition and Importance of Plant	12

สัปดาห์ที่	วัน/เดือน	ชั่วโมงที่	รายการ	หมายเหตุ
			Physiology 3.2 Other Definition and Its Role to the Plants 3.3 Concerning Issue of Physiology 3.4 Plant Anatomy or Phytotomy	
6		4-6	3.5 Photosynthesis 3.6 Respiration 3.7 Transpiration	
7		7-9	3.8 Mechanism driving water and mineral movement in plants	
8		10-12	3.9 Plant Hormones	
9		1-3	**สอบกลางภาค**	
10		1-3	**หน่วยเรียนที่ 4** Horticulture 4.1 Definition of Horticulture 4.2 Importance of Horticulture	12
11		4-6	4.3 Conversation Regarding a Very Big Farm 4.4 Vegetables 4.5 Fruits 4.6 Nutritional Values of Some Fruits and Vegetables	
12		7-9	4.7 Durian Cultivation	
13		10-12	4.7 Durian Cultivation (continued)	
14		1-3	**หน่วยเรียนที่ 5** Basic Knowledge of Soil	3

สัปดาห์ที่	วัน/เดือน	ชั่วโมงที่	รายการ	หมายเหตุ
			Science 5.1 Definition of Soil 5.2 Importance of Soils 5.3 Components of Soil 5.4 Types of Soil 5.5 Soil Profile and Soil Horizons 5.6 Relationships of Soils, Water and Plants	
15		1-3	**หน่วยเรียนที่ 6** Reading Academic Sources 6.1 Definition of Academic Sources 6.2 Types of Academic Sources 6.3 Tips and Instructions for Reading 6.4 Types of Reading Skills	3
16		1-3	**หน่วยเรียนที่ 7** Reading Academic Articles 7.1 Definition of Academic Articles 7.2 Importance of Academic Articles 7.3 Guideline in Reading Academic Articles	6
17		4-6	7.3 Guideline in Reading Academic Articles (continued) 7.4 Step-By-Step Instruction in Reading Academic Articles 7.5 How to Write a Curriculum Vitae (CV) for a Job 7.6 Activity	
18		1-3	**สอบปลายภาค**	

สัปดาห์ที่ 1	แผนการสอน	รหัสวิชา 03-31-426
History, Meaning and Importance of Plant Science		หน่วยเรียนที่ 1
		เวลา 180 นาที

ชื่อบทเรียน 1.1 History of Plant Science
1.2 Meaning of Plant Science
1.3 Importance of Plant Science
1.4 Useful Vocabulary/Technical Terms

จุดประสงค์การสอน

1.1 รู้ประวัติของพืชศาสตร์
1.1.1 บอกประวัติของพืชศาสตร์ยุคแรก
1.1.2 บอกประวัติของพืชศาสตร์ยุคกลาง
1.1.3 บอกประวัติของพืชศาสตร์ยุคปัจจุบันของไทย
1.2 รู้ความหมายของพืชศาสตร์
1.2.1 บอกความหมายของพืชศาสตร์
1.3 รู้และเข้าใจความสำคัญของพืชศาสตร์
1.3.1 บอกความสำคัญของพืชศาสตร์
1.3.2 อธิบายความสำคัญของพืชศาสตร์
1.4 รู้ความหมายของคำศัพท์ด้านพืชศาสตร์
1.4.1 บอกความหมายของคำศัพท์ด้านพืชศาสตร์

ใบเตรียมการสอน	หน่วยเรียนที่ 1
	คาบที่ 1

เนื้อหา

1.1 History of Plant Science

The history of plant science is as follows:

1.1.1 First era of plant science

Three groups were found in the first era of plant science and are as follows:

1.1.1.1 Ancient India

An early example of ancient Indian plant classification is found in the Rigveda, a collection of Vedic Sanskrit hymns from about 3700–3100 BP (Before present years). Plants are divided into trees, herbs useful to humans, and creepers, with further subdivisions. The sacred Hindu text Atharvaveda divides plants into eight classes: spreading branches, leaves with long clusters, bushy plants, which expands, monocotyledons , creeping plants, with many stalks, and plants with knotty joints. The Taittiriya Samhita (one of the four scriptures in Hinduism) classifies the plant kingdom into trees, shrubs with spreading branches, herbs, spreading plant, climber, bushy plant, creeper, and spreading on the ground. Other examples of early Indian taxonomy include Manusmriti, the Law book of Hindus, which classifies plants into eight major categories. Important medieval works of plant physiology in India include the Prthviniraparyam of Udayana, Nyayavindutika of Dharmottara, Saddarsana-samuccaya of Gunaratna, and Upaskara of Sankaramisra (Morton, 1981).

1.1.1.2 Ancient China

In ancient China lists of different plants and herb concoctions for pharmaceutical purposes date back to at least the time of the Warring States (481-221 BC; an era in ancient Chinese history of intensive warfare all around China with the goal of creating one Chinese Empire). Many Chinese writers over the centuries contributed to the written knowledge

of herbal pharmaceutics. The Han Dynasty (202 BC-220 AD) includes the notable work of the Huangdi Neijing and the famous pharmacologist Zhang Zhongjing. There were also the 11th century scientists and statesmen Su Song and Shen Kuo who compiled learned treatises on natural history, emphasizing herbal medicine (Needham et al., 1986; Reed, 1942).

1.1.1.3 Greco-Roman

Among the earliest of botanical works in Europe, written around 300 B.C., are two large treatises by Theophrastus: On the History of Plants (Historia Plantarum) and On the Causes of Plants. Together these books constitute the most important contribution to botanical science during antiquity and on into the Middle Ages (Morton, 1981). The Roman medical writer Pedanius Dioscorides (ca.40-90) provides important evidence on Greek and Roman knowledge of medicinal plants. Dioscorides is famous for writing a five volume book in his native Greek Περίύλης ιατρικής (De Materia Medica - in the Latin translation) that is one of the most influential herbal books in history. In fact it remained in use until about CE 1600 (Common Era, also known as AD). Approximately 1300-1400 different plant species were known under Roman reign (Sengbusch, 2004).

1.1.2 Medieval plant science

The Kurdish biologist Al-Dinawari (828-896) is considered the founder of Arabic botany for his Book of Plants, in which he described at least 637 plants and discussed plant evolution from its birth to its death, describing the phases of plant growth and the production of flowers and fruit (Fahd, 1996). Theophrastus's Historia Plantarum served as a reference point in botany for many centuries, and was further developed around 1200 by Giovanni Bodeo da Stapelio, who added a comment and drawings (Thanos, 2005).

1.1.3 Plant science at present time

Started at the year of 2010, there were three universities in Thailand offering the curricula in Plant Science or Botany course from undergraduate to doctoral degree:

1. Chulalongkorn University under the Department of Botany, Faculty of Science offers the following curricula: Bachelor of Science (B.Sc) in Botany, Master of Science (M.Sc) in Botany, and Doctor of Science (D.Sc) in Botany.

2. Kasetsart University under the Department of Botany, Faculty of Science offers the following curricula: Bachelor of Science (B.Sc) in Botany, Master of Science (M.Sc) in Botany, and Doctor of Philosophy (Ph.D) in Botany.

3. Mahidol University under the Department of Plant Science, Faculty of Science offers the following curricula: Bachelor of Science (B.Sc) in Plant Science and Master of Science (M.Sc) in Plant Science, international program.

1.2 Meaning of Plant Science

Plant science, also known as botany or plant biology, is a branch of biology that involves the scientific study of plant life. A botanist, plant scientist, or phytologist is a scientist who specialises in this field. Botany covers a wide range of scientific disciplines including structure, growth, reproduction, metabolism, development, diseases, chemical properties, and evolutionary relationships among taxonomic groups. Botany began with early human efforts to identify edible, medicinal and poisonous plants, making it one of the oldest sciences. Today botanists study over 550,000 species of living organisms. The term "botany" comes from Greek βοτάνη, meaning "pasture, grass, fodder", perhaps via the idea of a livestock keeper needing to know which plants are safe for livestock to eat (Liddell and Scott, 1940).

1.3 Importance of Plant Science

Plant science (or Botany) is important primarily because it is the scientific study of plants, which are in turn used in many aspects of human life. Botanists study plants of all kinds and apply their knowledge of characteristics and traits of crops, plants and flowers to influence the fields of medicine, science and cosmetics among others. Plants support basic daily functions of human life by providing food and nutrition, supplementing medicines and cosmetic products and serving as important ingredients in a variety of medicines (Sengbusch, 2004). Plants are photoautotrophic and non-motile organisms. Compared to animals, they are less diverse in form and structure. They are, however, as highly organized. The availability of the basic requirements for photoautotrophic life (light, water, minerals, and carbon dioxide) largely determines the growth of plants. The basic functional structure of plants is the cell which, unlike animal cell, has cell wall, large central vacuole and chloroplast. The chloroplast is capable of utilizing sunlight for the synthesis of organic molecules. Plant bioenergetics is governed by the physical laws of energy flow. Endergonic or exergonic energy exchange occurs as organic molecules are synthesized or broken down in enzyme-catalyzed chemical processes (Alfonso-Alejar and Dionisio-Sense, 1999).

Botany affects most aspects of life in many different ways. Products such as food, medicine, wood, fabrics, alcohol and rubber are all derived from plants; botany has enabled these technologies and many more. Botany is key to the development of biofuels, such as biomass and methane gas, which are alternatives to fossil fuels. This science is also essential to economic productivity because it includes a study of crops and ideal growing techniques to help farmers increase production and make their practices more efficient. Botany is also important in the area of environmental protection. Botanists document the various types of plants existing on Earth and can sound warnings when populations begin to decline. Botanists may influence the studies of other academic disciplines, such as life science, science communication, ecology, and evolutionary biology (Morton, 1981).

1.4 Useful Vocabulary/Technical Terms

Vocabulary/Technical Terms	Translation
era	ยุค สมัย
plant physiology	สรีรวิทยาของพืช
concoctions	การปรุง
pharmaceutical purposes	วัตถุประสงค์ทางเภสัชกรรม
written knowledge	ความรู้ที่เขียนไว้เป็นลายลักษณ์อักษร
pharmacologist	เภสัชกร
century	ศตวรรษ
treatises	ตำรา
herbal medicine	ยาสมุนไพร
a reference point	จุดอ้างอิง
developed	พัฒนา
a branch	สาขาหนึ่ง
spreading branches (plants)	ไม้ที่กิ่งแผ่กว้าง
leaves with long clusters (plants)	ไม้ที่ใบเป็นกระจุกและยาว
bushy plants	ไม้พุ่ม
which expands (plants)	ไม้ที่แผ่ราบ
monocotyledons (plants)	ไม้ใบเลี้ยงเดี่ยว
creeping plants	ไม้เลื้อย
plants with many stalks	ไม้ที่มีกิ่งก้านมาก
plants with knotty joints	ไม้ที่มีปุ่มปมซับซ้อน
organisms	สิ่งมีชีวิต
specialises	ความเชี่ยวชาญ
scientific disciplines	สาขาวิชาวิทยาศาสตร์
edible	กินได้/ทานได้
medicinal	เป็นยา

ใบเตรียมการสอน	หน่วยเรียนที่ 1
	คาบที่ 3

Vocabulary/Technical Terms	**Translation**
poisonous plants	พืชที่เป็นพิษ
species	สายพันธุ์
scientific study	การศึกษาทางวิทยาศาสตร์
used in many aspects of human life	ใช้ในหลายๆ ด้านของชีวิตมนุษย์
all kinds	ทุกชนิด
daily functions of human life	ชีวิตประจำวันของมนุษย์
providing	การให้
supplementing	โภชนาการเสริม
serving	ทำหน้าที่เป็น
derived from	ที่ได้มาจาก
key to	กุญแจสำคัญในการ
alternatives	ทางเลือก
economic productivity	ผลผลิตทางเศรษฐกิจ
production	การผลิต
environmental protection	การคุ้มครองสิ่งแวดล้อม
sound warnings	เสียงแจ้งเตือน
existing	ที่มีอยู่
influence	มีอิทธิพลต่อ

ใบเตรียมการสอน	แบบฝึกหัดท้ายหน่วยเรียนที่ 1
	หลังจบหน่วยเรียน

Exercise 1: Based on the lectures, describe briefly the each era of plant science:

1) First era of plant science in ancient India

_____

2) Medieval plant science

_____

3) Plant science at present time in Thailand.

_____

Exercise 2: Answer the following questions.

1) What does "plant science" mean?

_____

2) What is the importance of plant science?

_____

3) Give one (1) example of curriculum program the universities offer for Plant Science program.

_____

4) Where are the food, medicine, wood, fabrics, alcohol and rubber all derived from in the history of plant science?

_____

5) Does botany cover a wide range of scientific disciplines including structure, growth, reproduction and chemical properties of the plants?

_____

6) Why is the plant science essential to economic productivity?

_____

7) What do the plants support basic daily functions of human life?

_____

8) Who is the founder of Arabic botany?

_____

9) What are the two large botanical treatises written by Theophrastus?

_____

10) What are the classes of plants in the sacred Hindu text Atharvaveda?

_____

Exercise 3: Match the words in Column A with their translations in Column B.

Column A	**Column B**
1. tree	a. การเจริญเติบโตประเภทไม่แตกกอ
2.herb	b. ไม้ที่แผ่ราบ
3.creeper	c. กิ่งแผ่กว้าง
4. plants with knotty joints	d. ไม้ต้น
5. plant kingdom	e. ไม้พุ่ม
6. shrubs	f. อาณาจักรพืช
7. monopodial growth	g. สมุนไพร
8. creeping plants	h. ใบเป็นกระจุกและยาว
9. spreading branches	i. ไม้ที่มีปุ่มปมซับซ้อน
10. leaves with long clusters	j. ไม้เลื้อย

Exercise 4: Fill in the blanks the correct word or phrase for each sentence.

1) A _____ is a scientist who specialises in plants.
2) Botany is _____ mainly because it is the scientific study of plants.
3) _____ support basic daily functions of human life by providing _____, supplementing medicines and cosmetic products and serving as important ingredients in a variety of medicines.
4) Biomass and methane gas are _____ to fossil fuels.

5) At present, there are 550, 000 _____ of living organisms being studied by plant scientists.
6) Over the centuries, Chinese writers have big contribution to the _____ knowledge of herbal medicines in the history of plant science.
7) Historically, _____ plants have been used since ancient times.
8) Botanists study all_____plants and apply their knowledge of characteristics and traits of crops, plants and flowers.
   The work of Theophrastus, Historia Plantarum, became a _____in botany for many centuries.

เอกสารอ้างอิงท้ายหน่วยเรียนที่ 1

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ใบเตรียมการสอน	สรุปกิจกรรมการสอน หลังจบหน่วยเรียน

วิธีสอนและกิจกรรม	1. สอนแบบบรรยายและถามตอบ 2. ให้นักศึกษามีส่วนร่วมในการเรียน การสอน 3. สรุปเนื้อหา	
สื่อการสอน	**เอกสารอ้างอิง**	เอกสารอ้างอิงหมายเลข 2,30,124,137,138,147,151 และ 161
	เอกสารประกอบ	-
	วัสดุโสตทัศน์	สไลด์หน่วยเรียนที่ 1 ทำด้วยโปรแกรม MS PowerPoint
งานที่มอบหมาย	1. Exercises 1, 2, 3 and 4 2. ให้นักศึกษาค้นคว้าเพิ่มเติม	
การวัดผล	1. สังเกตความสนใจ ซักถามรายบุคคล 2. พิจารณางานที่มอบหมาย	

หมายเหตุ

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สัปดาห์ที่ 2	แผนการสอน	รหัสวิชา 03-31-426
Vocabularies/Technical Terms, Definition and Importance of Plant Propagation		หน่วยเรียนที่ 2
		เวลา 180 นาที

ชื่อบทเรียน 2.1 Vocabularies/Technical Terms of Plant Propagation
2.2 Definition and Importance of Plant Propagation
2.3 Types of Plant Propagation
2.4 Marcotting Methods
2.5 Grafting Methods

จุดประสงค์การสอน

2.1 รู้คำศัพท์ด้านการขยายพันธุ์พืช
2.1.1 บอกความหมายของคำศัพท์ด้านการขยายพันธุ์พืช
2.2 รู้และเข้าใจความหมายและความสำคัญของการขยายพันธุ์พืช
2.2.1 บอกความหมายของการขยายพันธุ์พืช
2.2.2 อธิบายความหมายของการขยายพันธุ์พืช
2.2.3 บอกความสำคัญของการขยายพันธุ์พืช
2.2.4 อธิบายความสำคัญของการขยายพันธุ์พืช
2.3 รู้ประเภทของการขยายพันธุ์พืช
2.3.1 บอกประเภทของการขยายพันธุ์พืช
2.4 เข้าใจวิธีการขยายพันธุ์พืชโดยการตอนกิ่ง
2.4.1 อธิบายวิธีการขยายพันธุ์พืชโดยการตอนกิ่ง
2.5 เข้าใจวิธีการขยายพันธุ์พืชแบบต่อกิ่ง
2.5.1 อธิบายวิธีการขยายพันธุ์พืชแบบต่อกิ่ง

ใบเตรียมการสอน	หน่วยเรียนที่ 2
	คาบที่ 1

เนื้อหา

2.1 Vocabularies/Technical Terms of Plant Propagation

The useful vocabularies/technical terms in plant propagation are as follows:

Vocabulary/Technical Terms	**Translation**
plant propagation	การขยายพันธุ์พืช
sexual propagation	การขยายพันธุ์พืชโดยอาศัยเพศ
asexual propagation	การขยายพันธุ์พืชโดยไม่อาศัยเพศ
marcotting	การตอนกิ่ง
air layering, Chinese layering, pot layering, circumposition, marcotage, gootee	การตอนบนอากาศ
simple layering	การตอนกิ่งโดยวิธีง่ายๆ
tip layering	การตอนกิ่งโดยวิธีใช้ยอด
compound or serpentine layering	การตอนกิ่งแบบซับซ้อนหรือแบบงูเลื้อย
mound or stood layering	การตอนกิ่งแบบสุมโคน
grafting	การต่อกิ่ง
Inarching	การทาบกิ่ง
budding	การติดตา
cutting	การตัดชำ
adventitious roots	รากพิเศษ
rootstock, understock, stock	ต้นตอ
scion, cion	กิ่งพันธุ์ดี
Inosculation	การเชื่อมติดกันของเนื้อเยื่อลำเลียงระหว่างต้นตอกับกิ่งพันธุ์ดี
whip or tongue grafting	การต่อกิ่งแบบเข้าลิ้น
spliced grafting	การต่อกิ่งแบบฝานบวบ

ใบเตรียมการสอน	หน่วยเรียนที่ 2
	คาบที่ 1

Vocabulary/Technical Terms	**Translation**
bark grafting	การต่อกิ่งแบบเสียบเปลือก
inlay grafting	การต่อกิ่งแบบอินเลย์
saw-kerf or notch grafting	การต่อกิ่งแบบบาก
saddle grafting	การต่อกิ่งแบบเข้ากับเดือย
cleft or wedge grafting	การต่อกิ่งแบบเสียบลิ่ม
side veneer grafting	การต่อกิ่งแบบวีเนียร์
side grafting	การต่อกิ่งแบบเสียบข้าง
bridge grafting	การต่อกิ่งแบบเชื่อมสะพาน
modified spliced approach grafting	การทาบกิ่งแบบฝานบวบดัดแปลง
modified side veneer approach grafting	การทาบกิ่งแบบวีเนียร์ดัดแปลง
modified side approach grafting	การทาบกิ่งแบบเสียบข้างดัดแปลง
T - or shield budding	การติดตาแบบตัวทีหรือแบรูปโล่
inverted T-budding	การติดตาแบบตัวทีหัวกลับ
patch T-budding	การติดตาแบบแพทธ์หรือแบบแปะ
plate or forkert budding	การติดตาแบบเพลท
flute budding	การติดตาแบบฟลูท
I - or window budding	การติดตาแบบตัวไอหรือแบบหน้าต่าง
chip budding	การติดตาแบบชิพ
softwood cutting	การตัดชำกิ่งอ่อน
semi-hardwood cutting	การตัดชำกิ่งอ่อนกิ่งแก่
hardwood cutting	การตัดชำกิ่งแก่
mallet cutting	การตัดท่อนของกิ่งแก่กว่าเป็นท่อนสั้นๆ ติดโคนกิ่งไปด้วย
heel cutting	การตัดให้ส่วนของกิ่งที่แก่กว่าติดโคนไปด้วย
wounding cutting or straight	การตัดโดยไม่มีชิ้นส่วนของกิ่งที่แก่กว่าติดไปด้วย
leaf cutting	การตัดชำใบ

Vocabulary/Technical Terms	Translation
meristematic tissues	เนื้อเยื่อเจริญ
leaf bud cutting	การตัดชำใบที่มีตาติด
callus	เซลล์พื้นฐาน

2.2 Definition and Importance of Plant Propagation

Plant propagation is defined as the process of creating new plants from a variety of sources such as seeds, cuttings and other plant parts. Plant propagation can also refer to the natural or artificial dispersal of plants. While the importance of plant propagation is as follows: 1) Produce quality and healthy plants on commercial basis; 2) Improve the characteristics and quality of the plants; 3) Protect the plant species which are in danger of extinction and; 4) Multiply the different species in large quantity (NIOS, 2013).

2.3 Types of Plant Propagation

Plants are propagated by two types: 1) Sexual propagation or seed propagation (For examples: rice, wheat, sunflower, sorglum, etc) and; 2) Asexual or vegetative propagation (Examples: parts like roots, stem, leaf etc.).

2.3.1 Sexual propagation or seed propagation

This very famous reference tells us the importance of seeds in agriculture. Seeds are the complete new progenies those are the new plant lives start with the simple seeds and those are the plant propagation. Seeds are defined as a dormant plant which develops into a complete plant when subjected to required environmental conditions. Seeds are very important for living things in the world then let's see how seeds are germinated. Seed germination as the seed absorbs water and oxygen. Absorbed oxygen causes the seed to swell and increase in size. The seed secretes enzymes that convert insoluble starches into soluble sugars. Soluble sugars dissolve in the

absorbed water and are used as food by the plant embryo so events in seed germination Kumar (n.d.) (Figure 2.1).

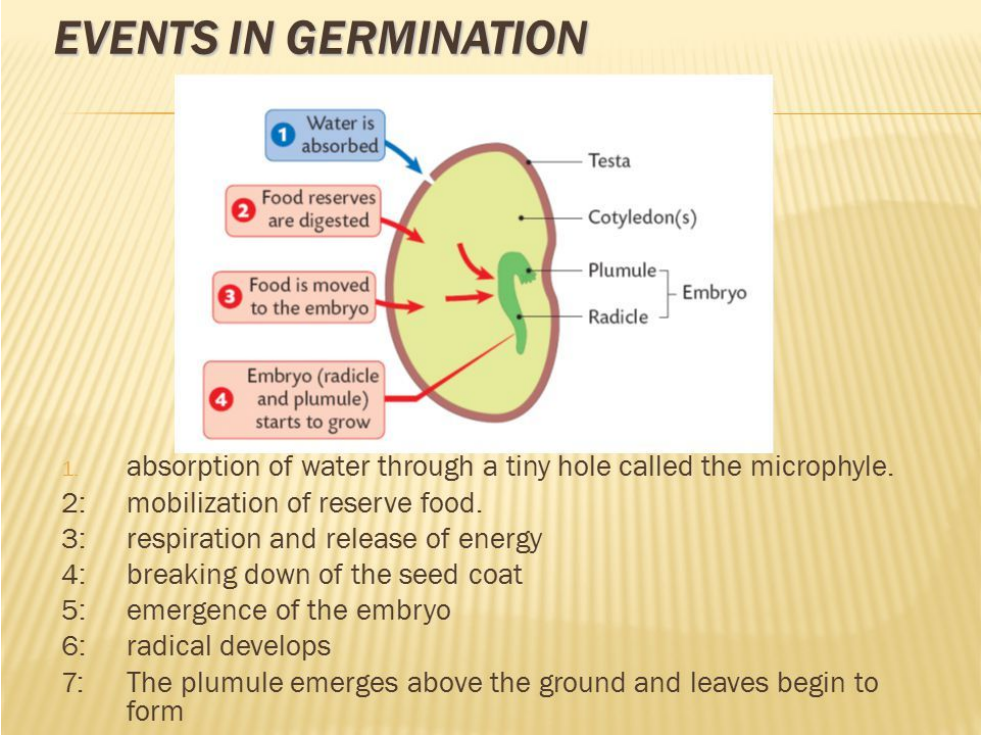

Figure 2.1 Events in seed germination.
Source: Kumar (n.d.)

There are advantages and disadvantages of sexual propagation (Table 2.1).

Table 2.1 Advantages and disadvantages of sexual propagation.

Advantages	Disadvantages
a) Sexual method can develop hybrid seeds.	a) Plants raised through seeds have long juvenile period so it takes long time to fruiting.

Table 2.1 Continued...

Advantages	Disadvantages
b) Sexual propagation is the only method that can develop new varieties of crops.	b) Intercultural practices like spraying, harvesting are difficult for plants propagated by sexual method because plants grow very high.
c) Sexual method can raise root stocks for budding and grafting.	c) Seedling characteristics propagated by sexual method are not genetically real to type to that of their mother plant.
d) The plants propagated by sexual method can be resistant to water stress and are long lived.	d) The plants which have no seeds cannot be propagated by sexual method. For example Jasmine, Banana, Rose etc.
e) Sexual method can prevent transmission of viruses.	e) Many genotypes of plant species are naturally made.
f) Some species of trees, ornamental annuals and vegetables which cannot be propagated by asexual means should be propagated by this method. For example Okra, Tomato, Roselle, Marigold etc.	
g) Some species of trees, ornamental annuals and vegetables which cannot be propagated by asexual means should be propagated by this method. For example Okra, Tomato, Roselle, Marigold etc.	

Table 2.1 Continued...

Advantages	Disadvantages
h) Sexual method can transport and store seeds for longer time. i) This propagation method is very simple and easy.	

Source: Samiksha (n.d.)

2.3.2 Asexual or vegetative propagation

New plants can grow from parts of the parent plant as production of new individuals from a selected plant having all the characters of the original one. Vegetable propagations include: marcotting, grafting, inarching, budding, and cutting. There are tools for asexual propagation of plants and are showed in Figure 2.2.

Figure 2.2 Tools for asexual propagation of plants.

Source: Te Kura-a Tuhi (n.d.1.)

2.4 Marcotting Methods

Marcotting is a method of propagating new plants from stems still attached to the parent plant. The stem is wrapped with moist medium to encourage adventitious roots to form. Marcotting has a number of propagation methods such as air layering, tip layering, simple layering, compound or serpentine layering, and mound or stood layering. Air layering is easily performed with less skill and is just a little different from other methods of layering such as tip layering, simple layering, compound or serpentine layering, mound or stood layering. In all these methods, root development is usually induced by wounding the part of the plant to be rooted. In this layering method, roots are induced to form on the part of the plant while it remains aerial (aboveground), therefore the term air layering. But in other layering methods, the same plant part is rooted on the ground with stem usually by bending it downward (Bareja, 2010). Common procedure in marcotting and various marcotting methods are air layering or Chinese layering or pot layering or circumposition or marcotage or gootee, simple layering, tip layering, compound or serpentine layering, and mound or stool layering.

2.4.1 Air layering, Chinese layering, pot layering, circumposition, marcotage, gootee

Propagate a plant by girdling or cutting part way into a stem or branch and packing the area with a moist medium, as sphagnum moss, stimulating root formation so that the stem or branch can be removed and grown as an independent plant. The procedure of air layering is done by the stem is girdled to induce root formation above the cut. The girdled stem is covered with damp moss. Plastic sheeting or aluminum foil is wrapped around the moss and tied at both ends (Figure 2.3). This cover is removed about 2 months after tying or when the roots can be seen (Grant, 2018).

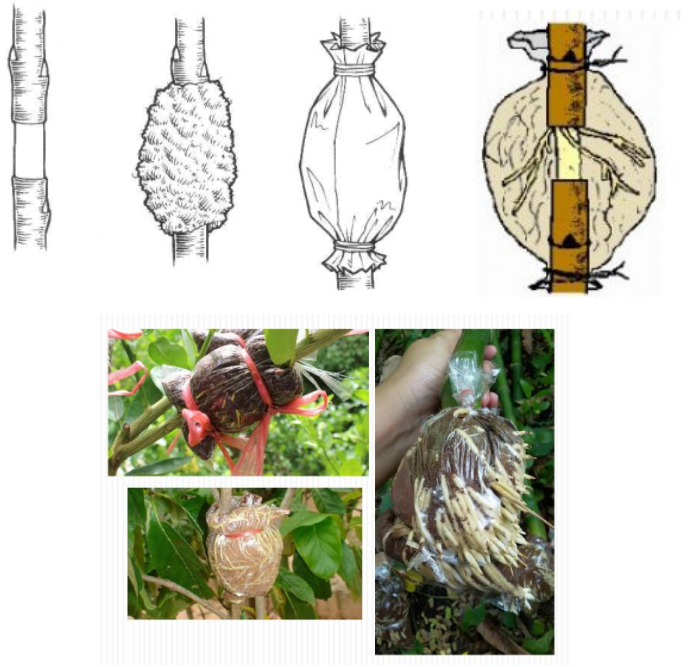

Figure 2.3 Air layering.
Source: Google Image (n.d.1.)

2.4.2 Simple layering

Simple layering can be accomplished by bending a low growing, flexible stem to the ground. Cover part of it with soil, leaving the remaining 6 to 12 inches above the soil. Bend the tip into a vertical position and stake in place (Figure 2.4). The sharp bend will often induce rooting, but wounding the lower side of the bent branch may help also. Simple layering can be done on most plants with low-growing branches. Examples of plants propagated by simple layering include climbing roses, forsythia, rhododendron, honeysuckle, boxwood, azalea, and wax myrtle (Evans and Blazich, 1999).

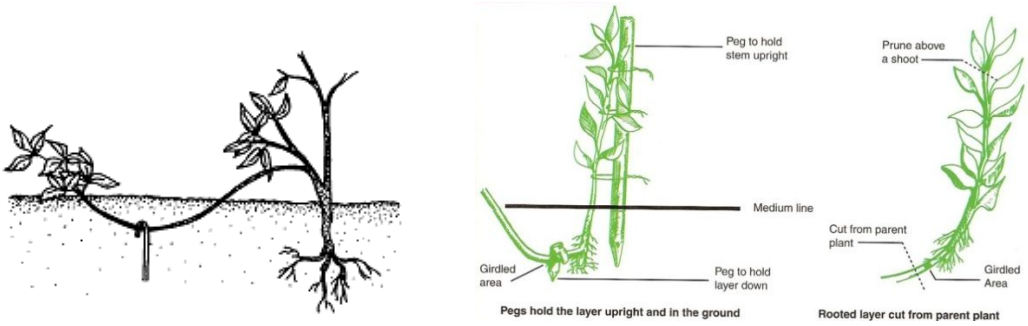

Figure 2.4 Simple layering.
Source: Google Image (n.d.2.)

Simple layering can be done in early spring using a dormant branch, or in late summer using a mature branch. Periodically check for adequate moisture and for the formation of roots. It may take one or more seasons before the layer is ready to be removed for transplanting. Muscadine grapes are often propagated by simple layering—placing soil over the mid-portion of new shoots in late June or early July, leaving the shoot terminal exposed. Roots will form where the vine is covered with soil. These rooted layers can be removed from the mother plant during the dormant season and transplanted. If a number of plants are desired, take an entire fruiting arm of the muscadine vine and lay it in a shallow trench in late June or July. Cover it with 4 to 5 inches of soil and leave the tips of all the growing shoots uncovered. Most of these shoots will root and form new plants. In the winter, remove the soil and cut the rooted shoots from the mother plant (Evans and Blazich, 1999).

2.4.3 Tip layering

Tip layering is similar to simple layering and happens naturally with plants such as black raspberry and trailing blackberries. The tip of a branch touches the ground and roots form (Figure 2.5). Tip layering simply mimics

this natural process. Trailing bramble plants often tip layer naturally late in the season. The terminal of the vigorously growing bramble canes will grow into the soil (Figure 2.6) and form a mass of roots. These rooted tip layers can be dug in the winter (Figure 2.7) and planted in the desired location (Ferree and Krewer, 2012).

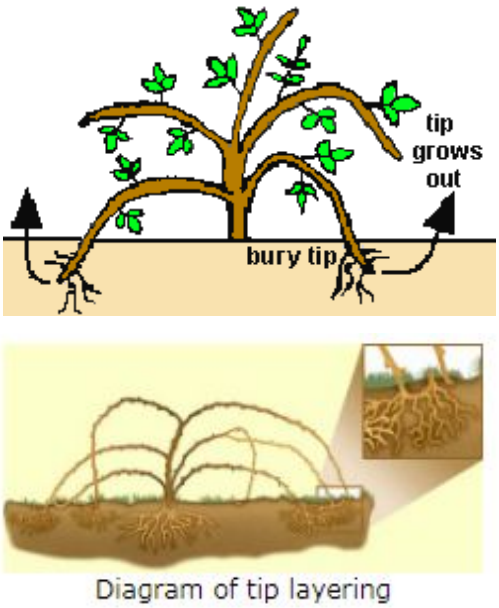

Figure 2.5 Tip layering.

Source: Google Image (n.d.3.)

Figure 2.6 Bramble canes.

Source: Ferree and Krewer (2012)

Figure 2.7 Rooted tip layers.

Source: Ferree and Krewer (2012)

To tip layer, dig a small hole several inches deep, insert the tip of a current season's shoot or cane, and fill around it with soil. The tip will turn and grow upward, while the bend of the stem that stays in the soil will grow roots. Care for the layered plant is the same as that used for simple layering (Ferree and Krewer, 2012).

2.4.4 Compound or serpentine layering

Compound (serpentine) layering is similar to simple layering, but several layers can result from a single stem. Bend the stem to the rooting medium as for simple layering, but alternately cover and expose sections of the stem. Each section should have at least one bud exposed and one bud covered with soil. Wound the lower side of each stem section to be covered (Figure 2.8). This method works well for plants producing vine-like growth such as heart-leaf philodendron, pothos, wisteria, clematis, and grapes (Evans and Blazich, 1999).

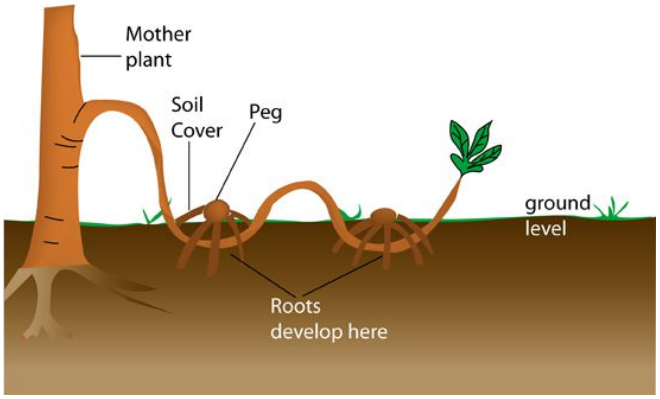

Figure 2.8 Compound or serpentine layering.

Source: Google Image (n.d.4.)

5. Mound or stool layering

Mound (stool) layering is useful with heavy-stemmed, closely branched shrubs and rootstocks of tree fruits. Cut the plant back to 1 inch above the soil surface in the dormant season. Dormant buds will produce new shoots in the spring. Mound soil over the new shoots as they grow (Figure 2.9). Roots will develop at the bases of the young shoots. Remove the layers in the dormant season. Mound layering works well on apple rootstocks, spirea, quince, daphne, magnolia, and cotoneaster (Evans and Blazich, 1999).

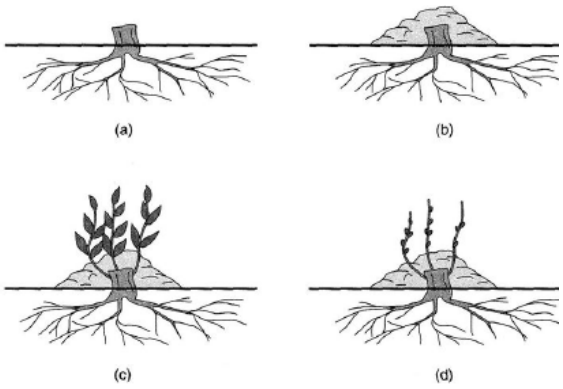

Figure 2.9 Mound or stool layering.

Source: Google Image (n.d.5.)

2.5 Grafting Methods

Grafting or graftage is one of the asexual propagation methods whereby tissues of plants are joined so as to continue their growth together. The lower part is called the rootstock while the upper part of the combined plant is called the scion (Figure 2.10). The success of this joining requires that the vascular tissue grow together and such joining is called inosculation. In general, one plant is selected for its roots and this is called rootstock or stock or understock. The other plant is selected for its leaves, stems, flowers or fruits and is called the scion or cion. The scion contains the desired genes to be duplicated in future production by the stock/scion plant. In bud grafting, a dormant side bud is grafted onto the stem of another stock plant, and when it has inosculated successfully, it is encourage to grow by pruning off the stem of the stock plant just above the newly grafted bud. In stem grafting, a selected shoot, desired plant genotype is grafted onto the stock of another type. In successful grafting, the vascular cambium tissues of the stock and scion plants must be placed in contact with each other. Both tissues must be kept alive until the graft has taken, usually a period of a few weeks. Successful grafting only requires that a vascular connection take place between the grafted tissues (Hottes, 1925).

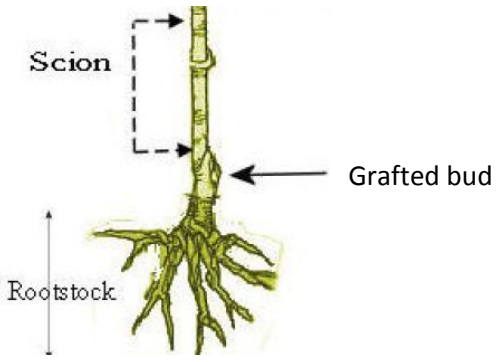

Figure 2.10 Rootstock, grafted bud and scion.
Source: Google Image (n.d.6.)

The different grating methods consist of whip or tongue grafting, spliced grafting, bark grafting, inlay grafting, saw-kerf or notch grafting, saddle grafting, cleft or wedge grafting, side veneer grafting, side grafting, and bridge grafting, and their common procedures are follows:

2.5.1 Whip or tongue grafting

This propagation method can be done by the first cut is a long sloping diagonal as much as 1 to 2 inches long (Figure 2.11). The second cut begins about 1/3 of the way down from the top of the first cut. It begins vertically, and then slowly becomes nearly parallel to the first cut surface, to create the "tongue". Complementary (identical)cuts are made in both stock and scion. The scion should be preferably the same diameter as the stock, but if it is smaller, it is important the scion be placed over to one side of the stock, rather than centered, so that the vascular cambium like up. Stock and scion should fit together without the overlap (Jauron, 2004).

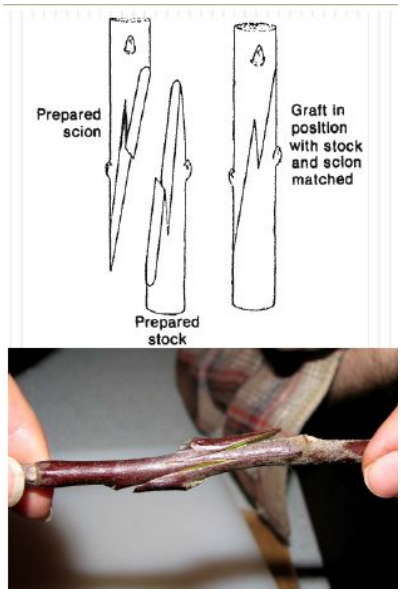

Figure 2.11 Whip or tongue grafting.

Source: Google Image (n.d.7.)

2.5.2 Spliced grafting

This method can be made by cutting the ends of the rootstock and scion completely across and obliquely, in such a manner that the sections are of the same shape, then lapping the ends so that the one cut surface exactly fits the other, and securing them by tying or otherwise (Figure 2.12).

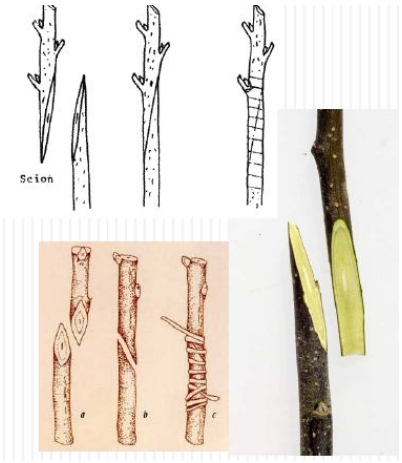

Figure 2.12 Spliced grafting.
Source: Google Image (n.d.8.)

2.5.3 Bark grafting

The rootstock and trunk will provide a good understock for a future orchard, the grafting stock and the parent trees are free of injurious viruses and fire blight bacteria. Bark grafting method can be implemented by cut 1/2" from bottom of each scion (Figure 2.13). Finished scion will have three buds, the lowest bud will be the outside bud. Make outside diagonal cut a little below and opposite the outside bud then make inside diagonal cut little below and opposite the outside bud. Remove excess scion wood by slightly angled cut 1/4" above top bud. Slitting or slipping the bark of the stock and

inserting the scion beneath it and used especially in topworking and frameworking where two or more scions are inserted in the end of each truncated branch of the rootstock and securing them by tying (Smith, n.d.).

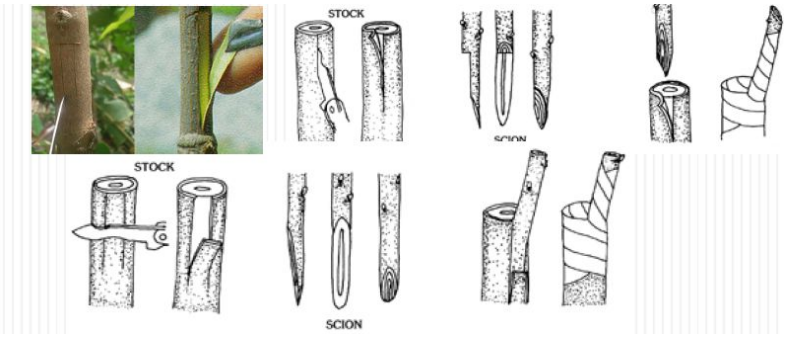

Figure 2.13 Bark grafting.
Source: Google Image (n.d.9.)

2.5.4 Inlay grafting

This method can be made by preparing a stock that should not be over 3 l/2 inches in diameter and scions should be 3/8 to 1/2 inches in diameter (Figure 2.14). The scion is the stem collected from the desired genotype which will become the upper portion of the tree. The stock is the root and trunk portion of the tree upon which the scion is grafted by inserting a scion to a stem of a less desirable tree (stock) of the same specie then securing them by tying (Gustafson, 1982).

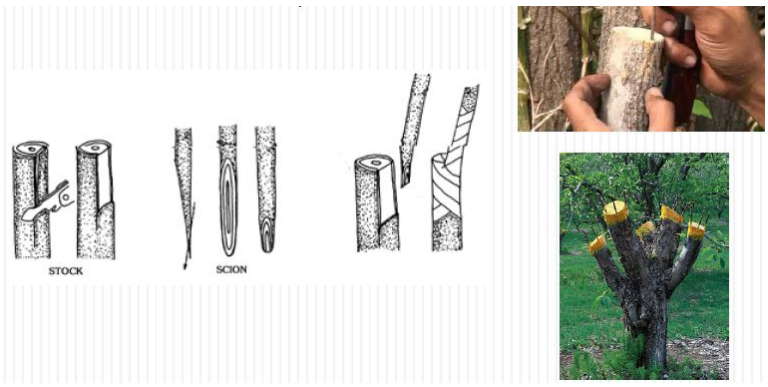

Figure 2.14 Inlay grafting.

Source: Google Image (n.d.10.)

2.5.5 Saw-kerf or notch grafting

A cut with thin-bladed, fine-toothed saw is made into the stock for each scion. This cut should extend 1 to 1 1/2 inches toward the center of the stock and about 4 inches down the side of the stock (Figure 2.15). Then, using a very sharp "round knife," the grafter widens this saw cut to fit the scion. The knife should be placed at the bottom of the saw cut and brought upward and inward to cut out thin slices of wood. Care should be taken not to get the cut in the stock too wide for use with the available scions. Then, insert the scion into each stock branch (Hartmann and Kester, 1975; Hartmann et al., 1996).

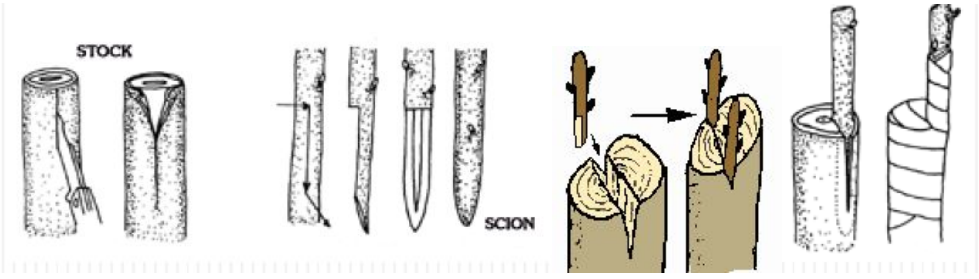

Figure 2.15 Saw-kerf or notch grafting.

Source: Google Image (n.d.11.)

2.5.6 Saddle grafting

The stock and scion are selected in similar diameter so that the two cambiums are in contact (Figure 2.16). Cut the prepared stock with sharp secateurs to 1 ½ - 2 inches above the soil surface then make a wedge shaped cut into the top. The scion should be prepared from well-ripened shoots of the previous year's growth, about 4 inches long and with a fat bud at the top. Cut the base in a 'V' to match the stock. Push the scion onto the stock to make a tight secure joint with the two faces in good contact with each other. This is important for the graft to be successful. Wrap and tie raffia or plastic grafting tape around the wound making sure that the scion is held in place firmly. Keep under black slan until the scion is growing well (Hartmann and Kester, 1975; Hartmann et al., 1996).

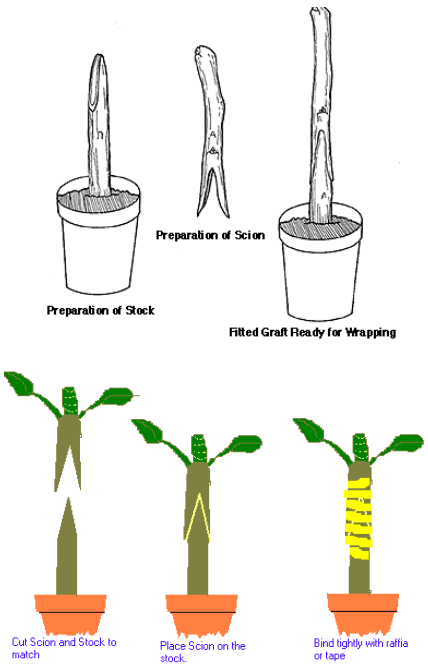

Figure 2.16 Saddle grafting.

Source: Google Image (n.d.12.)

2.5.7 Cleft or wedge grafting

This method was made by removing the terminal portion of the stock plant with a horizontal cut (Figure 2.17). Stock is split vertically, about 1-2 inches deep. Scion cut into a "V" shaped wedge. Scion is inserted into the stock, with care to align cambia. Stock and scion are tied together with plastic strip or a budding rubber. Scion and upper portion of stock are bagged to maintain high humidity, and grown on under shade to avoid overheating (Hartmann and Kester, 1975; Hartmann et al., 1996).

Figure 2.17 Cleft or wedge grafting.
Source: Google Image (n.d.13.)

2.5.9 Side grafting

Prepare a stock that should be vertically cut at about 1-3 inches long in the wood of the stock (Figure 2.18). The prepared scion is placed on the side of the prepared stock, the cuts are made and matching done so that the prepared scion arises at about a 30º angle from the vertical stem of the prepared stock. This leaves a portion of stock stem that is referred to as the "sap drawer". The purpose of the sap drawer is to regulate the flow of sap past the union, preventing in this way the sap accumulation with the consequently loss of the graft by "flooding of the union" (Hartmann and Kester, 1975; Hartmann et al., 1996).

Figure 2.18 Side grafting.

Source: Google Image (n.d.14.)

2.5.9 Side veneer grafting

The stock should be a 1-3 year old seedling, with a stem of approximately pencil-thickness (Figure 2.19). It is cut back to 12 inches, and then a sliver of wood is removed from the stem. This is done by making a small cut at a 45°angle of towards the base of the stem approximately 3 inches above soil level. A second cut is made 1- 1 1/2 inches above the first cut, then sliced downwards to meet the bottom of the first incision. The scion should be a one year old vigorous shoot with some mature wood, of similar diameter to the stock. It is trimmed to about 5-8 inches. A sloping cut of 1- 1 1/2 inches is made at the base of the scion, with a small angled cut on the other side, so that it matches the shape cut into the stock.The scion and the stock are then placed together and bound into position using clear plastic tape. The tape may be removed when the two pieces have successfully grafted (usually after about five weeks), and the newly formed plant gradually hardened off (InterGardening, 2018).

Figure 2.19 Side veneer grafting.
Source: Google Image (n.d.15.)

2.5.10 Bridge grafting

Trim loose and dried bark from the tree (Figure 2.20). Reshape the girdled area so as to leave a smooth edge. It does not have to be straight across the tree but can be gently curved to follow the shape of the wound. Mark two parallel cuts in the tree bark about two inches long and the width of the scion. Remove about 1 1/2 inches of the bark leaving a small flap. Repeat the process on the opposite side of the girdled area. To prepare wound for grafting, trim loose and dried bark from the tree. Reshape the girdled area so as to leave a smooth edge. It does not have to be straight across the tree but can be gently curved to follow the shape of the wound. Mark two parallel cuts in the tree bark about two inches long and the width of the scion. Remove about 1 1/2 inches of the bark leaving a small flap. Repeat the process on the opposite side of the girdled area. Shaping the scion, make a long, smooth, slanting cut 1 1/4 to 1 1/2 inches long on one end of the scion and then a short, slanted cut on the opposite side. Repeat the procedure on the other end of the scion. The finished scion should be 1/4 to 1/2 inch longer than the height of the girdled area plus four inches. Do not allow the cut surfaces to dry out on the scion wood. Placing the scion, place the long cut of

the scion against the wood, slipping the end under the flap. It is very important that the scion be placed with the buds in an upright position. Inverted scions will not take. Fasten the scion in place using the brads. Nails are too thick and are apt to split the scion. Put one brad through the flap to secure it to the scion and the other through the scion. The bridge is completed by repeating the process on the other side. Place the dowel or piece of wood near the midpoint of the scion, bend the scion over it and slip the scion into place. The bow is necessary to prevent the grafts being pulled out when the tree sways. Remove the dowel after the scion is tacked in place. Scions are placed about two inches apart over the wounded area. When all the scions in place, cover the grafts with grafting wax or a water-base asphalt emulsion dressing to prevent them from drying out. Check the scions during the growing season and rub out any buds that sprout (Hartmann and Kester, 1975; Hartmann et al., 1996).

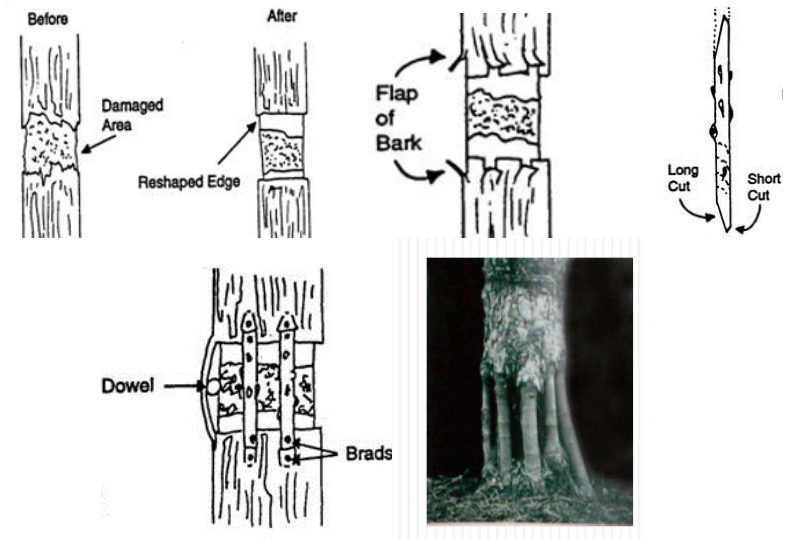

Figure 2.20 Bridge grafting.

Source: Google Image (n.d.16.)

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		เวลา 180 นาที

ชื่อบทเรียน 2.6 Inarching Methods

2.7 Budding Methods

จุดประสงค์การสอน

2.6 เข้าใจวิธีการขยายพันธุ์พืชโดยการทาบกิ่ง

2.6.1 อธิบายวิธีการขยายพันธุ์พืชโดยการทาบกิ่ง

2.7 เข้าใจวิธีการขยายพันธุ์พืชโดยการติดตา

2.7.1 อธิบายวิธีการขยายพันธุ์พืชโดยการติดตา

2.6 Inarching Methods

Inarching is a graft (a plant) by connecting a growing branch (scion) without separating it from its parent stock. Three popular types of inarching are as follows (Hartmann and Kester, 1975; Hartmann et al., 1996; Toogood, 1993):

2.6.1 Modified spliced approach grafting.

Six to eight months old seedlings are normally used as stocks; these may be either selected seedlings or vigorous clonal genotypes. The seedlings are raised in polyethylene bags. They should be watered regularly and fertilized at monthly intervals. The stock and scion, preferably of equal size, are sliced deeply with flat cuts to match; these cuts may be up to 8 or 10 centimeters in length (Figure 2.21). The cut must be perfectly smooth and as flat as possible to ensure close contact of the cambium layers. The cut surfaces are placed together and very firmly tied taking care that the upper and lower ends of the cuts coincide and that tying presses,

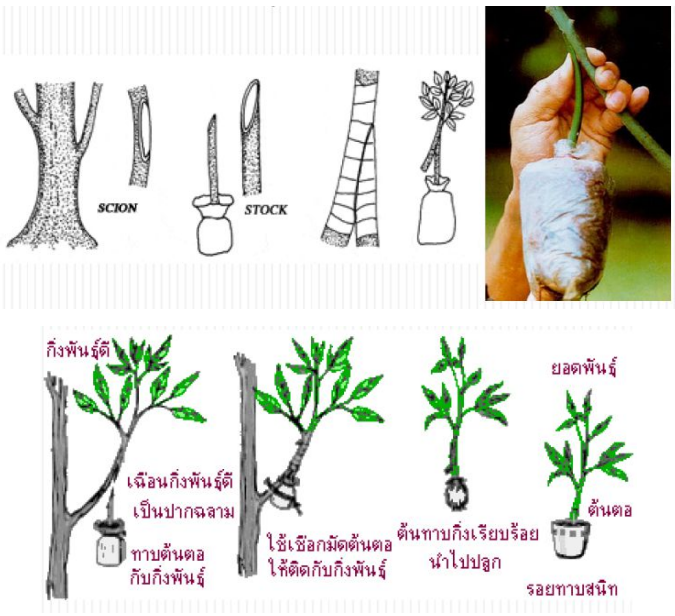

Figure 2.21 Modified spliced approach grafting.

Source: Google Image (n.d.17.)

particularly hard at these points. Sealing, preferably using grafting wax or tying with polyethylene tape, is done so it can complete the operation. The tying materials can be removed after 4-6 weeks. The graft is detached from the parent tree and the unwanted stock shoot is removed by pruning.

2.6.2 Modified side approach grafting

The scion and stock preparation, the scion stem is prepared by cutting at a 45° angle of towards the shoot of its scion stem approximately 1-2 inches long (Figure 2.22) then the stock is cut into wedge to ensure close contact of the cambium layers. The next steps do it the same with its steps for modified spliced approach grafting and modified side veneer approach grafting.

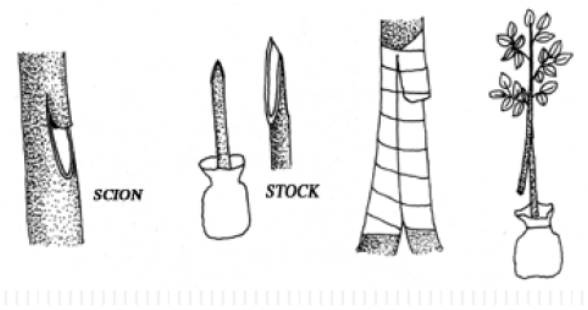

Figure 2.22 Modified side approach grafting.
Source: Anonymous (n.d.1.)

2.6.3 Modified side veneer approach grafting

This type of propagation is similar to that of modified spliced approach grafting. But the modified side veneer approach grafting is done by making a cut at a 45° angle of towards the shoot of the scion stem approximately 1/4 inches deep in its diameter (Figure 2.23). The stock is cut perfectly and has a suitable shape to ensure close contact of the cambium layers. The cut surfaces of the scion and stock are placed together and very firmly tied, taking care

that the upper and lower ends of the cuts coincide and that tying presses particularly hard at these points. Sealing by tying with polyethylene tape or using grafting wax so it can complete the operation. The tying materials can be removed after just about 4-6 weeks. The graft is detached from the parent tree and the unwanted stock shoot is removed by pruning.

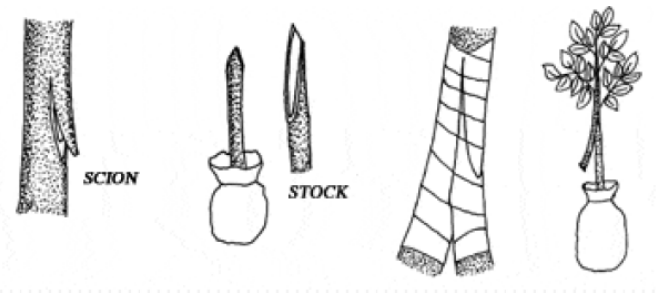

Figure 2.23 Modified side veneer approach grafting.
Source: Google Image (n.d.18.)

2.7 Budding Methods

Budding is propagated by bringing a bud of a good cultivar (scion) to place on the stem of the rootstock. The wood attaching to the bud can be removed or not depending on the plant species. The budding method can be also called "bud grafting" (Bareja, 2011). The procedure of budding is illustrated in Figure 2.24.

Figure 2.24 Budding procedure.
Source: Google Image (n.d.19.)

There are different budding methods and are as follows (Bareja, 2011):

2.7.1 T-or Shield budding

A plant propagated by this method is done by cutting the T-shaped on the stem of the rootstock and then slashing of the shield bud (Figure 2.25). Remove the wood out of the shield bud then inserting this shield bud into the prepared wound on the rootstock. Tying with polyethylene tape can complete the operation. The tying materials can be removed after just about 6 weeks as the new shoot emerged from the shield bud. The unwanted rootstock shoot above the new emerged shoot from the selected bud is removed by pruning.

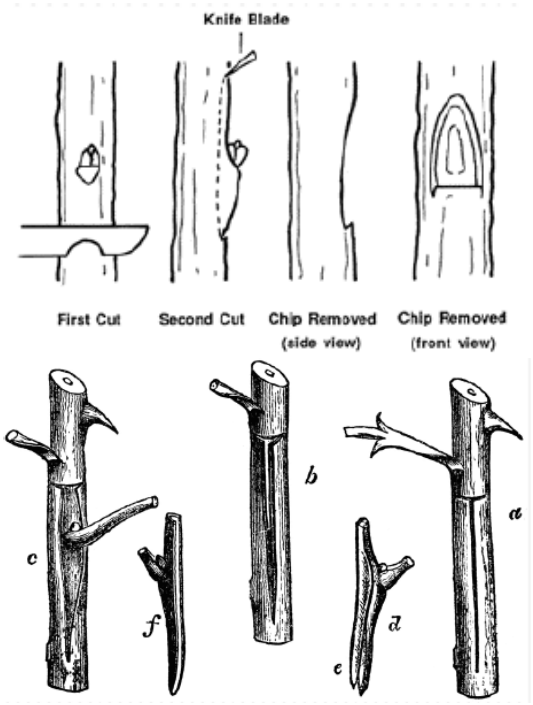

Figure 2.25 Procedure of T-or shield budding.

Source: Google Image (n.d.20.)

2.7.2 Inverted T- budding

A plant propagated by this technique is similar to the T-budding but instead cutting the inverted T-shape on the rootstock. Insert the shield bud upward to prevent trapping of water or latex of the rootstock. The procedure of the inverted T- budding is showed in Figure 2.26.

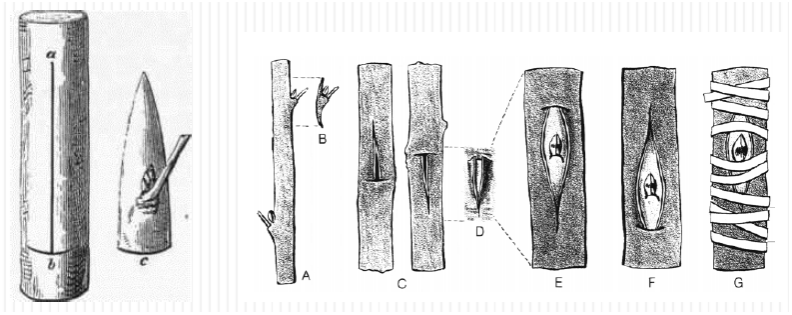

Figure 2.26 Procedure of the inverted T-budding.

Source: Google Image (n.d.21.)

2.7.3 Patch T- budding

This propagation technique is made by cutting a rectangle shape on the stock and also cutting the same shape to obtain the scion (bud patch) on the bud stick with the equal or a little smaller size than that of the wound on the stock (Figure 2.27). Insert the bud patch on the prepared wound of the stock to ensure close contact of the cambium layers. Tie with polyethylene tape can complete the operation. The tying materials can be removed after about 6 weeks as the new shoot emerged from the bud of the good cultivar. The unwanted stock shoot above the new emerged shoot from the selected bud is removed by pruning.

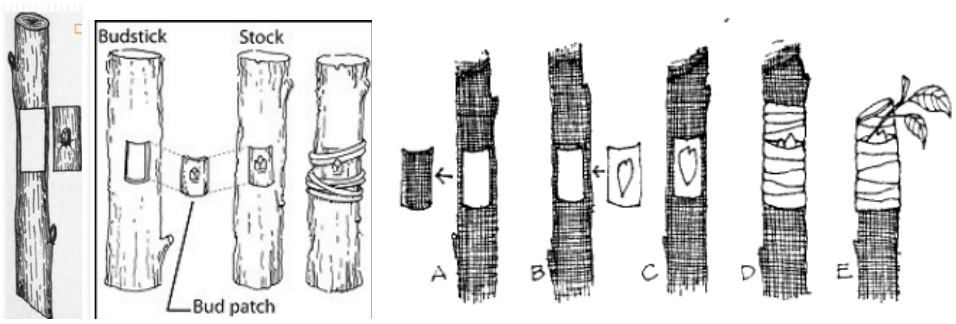

Figure 2.27 Procedure of patch T- budding.

Source: Google Image (n.d.22.)

2.7.4 Chip budding

A plant propagated by this method is used in cases where the bark and wood cannot be peeled off from each other. The preparation of the stock is similar to that of the side veneer grafting method but the difference is that the good scion has only one bud for chip budding (Figure 2.28).

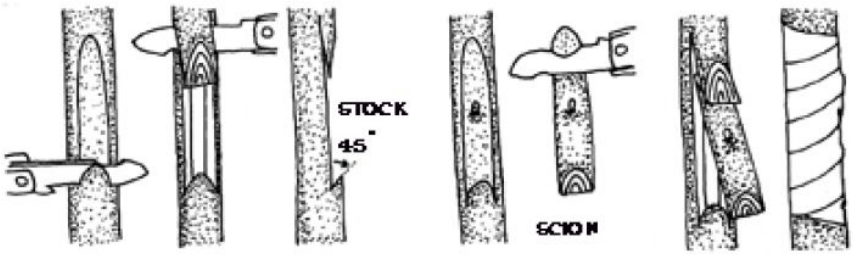

Figure 2.28 Procedure of chip budding.

Source: Google Image (n.d.23.)

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		เวลา 180 นาที

ชื่อบทเรียน 2.8 Cutting Methods

จุดประสงค์การสอน

2.8 เข้าใจวิธีการขยายพันธุ์พืชโดยการตัดชำ

2.8.1 อธิบายวิธีการขยายพันธุ์พืชโดยการตัดชำ

2.8 Cutting Methods

Cuttings are part of the plant that is cut off of the parent plant (Figure 2.29). Shoots with leaves attached are usually used. New roots and leaves will grow from the cutting. The shoot is cut at an angle. A growth promoter may be used to help with the growth of the roots (Relf, 2009).

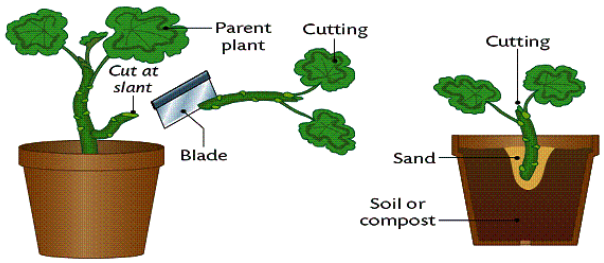

Figure 2.29 Parent plant for cutting.
Source: Google Image (n.d.24)

Following is a list of the different cutting methods.

2.8.1 Root cutting

New plants can grow out of swollen, modified roots called tubers. Buds can develop at the base of the stem and then can grow into new plants (Figure 2.30). Root cutting can be done only in some plants. The roots can be cut to lengths of 2-9 inches and then places in a moist planting medium. Keep the planting medium gets moist all the time by watering. The roots and shoots will emerge from the adventitious bud and develop into a new plant. Fruit trees that can be propagated in root cutting technique include jackfruit, guava, apple, raspberries, breadfruit, etc (Relf, 2009).

Figure 2.30 A new plant developed from root cutting.

Source: Google Image (n.d.25.)

2.8.2 Stem cutting

Runners (side stems) are stems that can grow horizontally above the ground (Figure 2.31). They have nodes where buds are successfully formed. These buds can grow into a new plant (Relf, 2009).

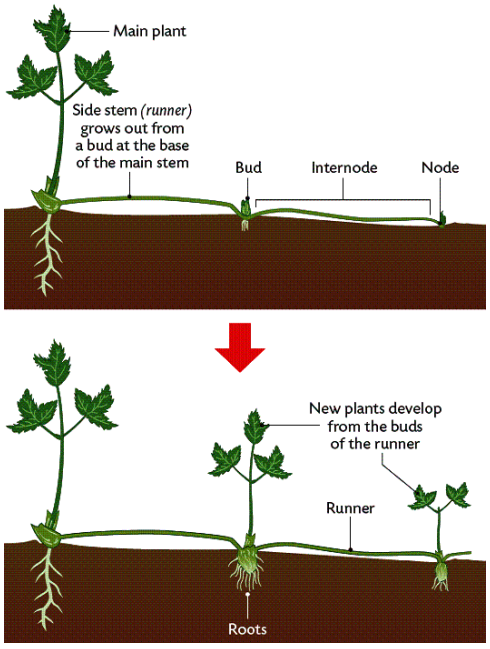

Figure 2.31 A new plant developed from stem cutting.

Source: Google Image (n.d.26.)

Stem cutting is divided into 3 types and they are as follows:

2.8.2.1 Softwood cutting

The branches are newly woods that just grew (Figure 2.32). These branches are soft and succulent. For successful softwood cutting is that the food supply and hormones in the shoots are not so an important factor because the food accumulates in that parts are inadequate. The importance is that the food must be obtained by photosynthesis and that can be used to create the roots. For this reason, the leaves are still attaching with the branches before and after cutting (Te Kura-a Tuhi, n.d.2.; Dirr and Heuser, 1987). Some of fruit trees that can be propagated by softwood cutting technique such as peach, guava, orange, apple, plum, and santol. The procedure of softwood cutting is showed in Figure 2.33.

2.8.2.2 Semi-hardwood cutting

A branch used in this technique is fully developed and its wood is starting to be hard (Figure 2.34). The old leaves or the lower leaves attached with the branch used for cutting must be detached but remained the fully developed leaves and top leaves for about 4-5 leaves. For suitable fruit trees can be propagated in semi-hardwood cutting technique such as jackfruit, orange, guava, etc (Te Kura-a Tuhi, n.d.2.; Dirr and Heuser, 1987).

2.8.2.3 Hardwood cutting

Most fruit trees are propagated by cutting old branches. The following important points must be considered and complied for the selection of branches in hardwood cutting. The branches are in a dormant stage for the temperate trees, and cross-season branches or cross-year branches for tropical trees. These branches have enough food to be used to root and grow for leaves. The branches should be from the

healthy and vigorous trees. The branches are too long or the branches are in the bush should be avoided (Te Kura-a Tuhi, n.d.2.; Dirr and Heuser, 1987). The procedure of hardwood cutting is showed in Figure 2.35.

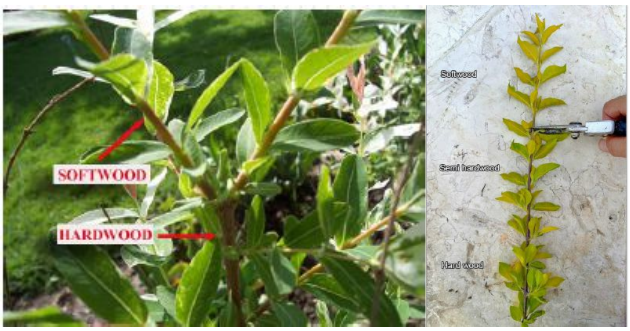

Figure 2.32 Characteristics of soft wood and hard wood.

Source: Google Image (n.d.27.)

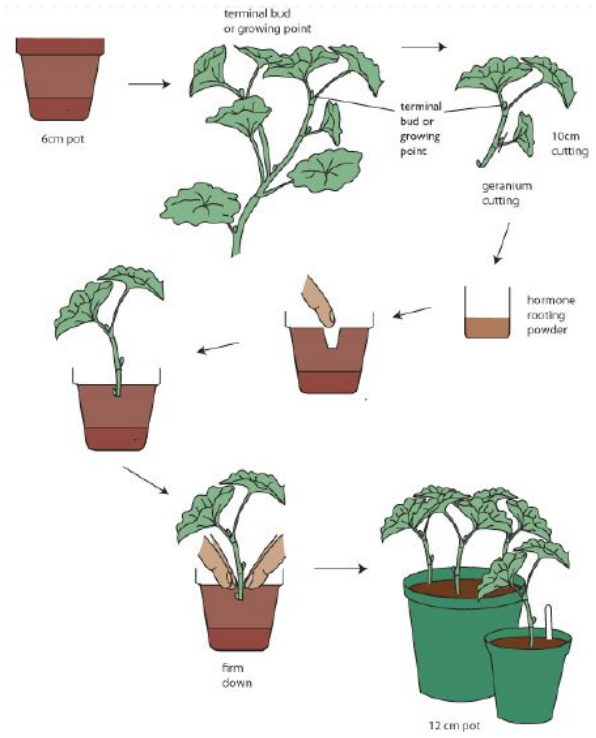

Figure 2.33 Soft wood cutting procedure.

Source: Google Image (n.d.28.)

Figure 2.34 Characteristics of softwood, semi-hardwood, and hardwood.

Source: Google Image (n.d.29.)

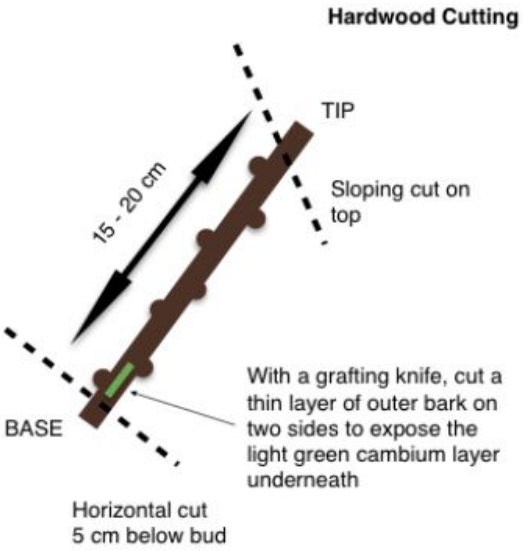

Figure 2.35 Hardwood cutting technique.

Source: Google Image (n.d.30.)

There are three types of hardwood cutting and are as follows (Figure 2.36):

1. Mallet cutting

This type is done by cutting the old branch into a short part and it is still attaching with the base of the selected branch for hardwood cutting.

2. Heel cutting

This type is made by attaching a part of older branch with the base of the selected branch for hardwood cutting.

3. Wounding cutting or straight

This type propagated by removing all the older branch from the selected branch for hardwood cutting.

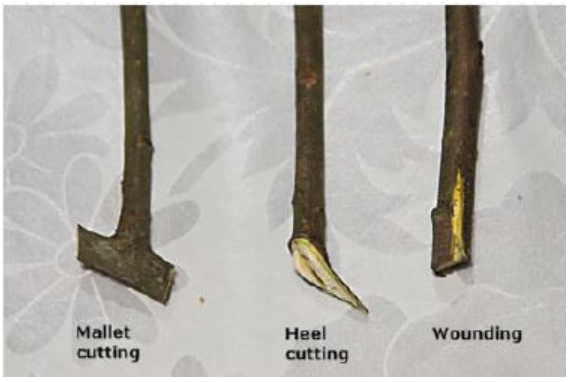

Figure 2.36 Characteristics of the older branch and the selected branch for mallet cutting, heel cutting, and wounding cutting.

Source: Google Image (n.d.31.)

The procedures of hardwood cutting are as follows (Figure 2.37):

1. Prepare the selected branch with 4 to 30 inches in length for about 6-9 inches. The selected branch size is about 1/4 to 1 inch in diameter depending on the plant spices.
2. The selected branch must have nodes at least 2-3 nodes per branch.
3. The base of a selected branch is cut as a "V" shape under node just a bit.
4. Place the prepared branch in the planting medium at 3/4 deep of the branch length with a 45° angle.
5. The branches used to propagation may do have or do not hove leaves attached depending on the plant species.

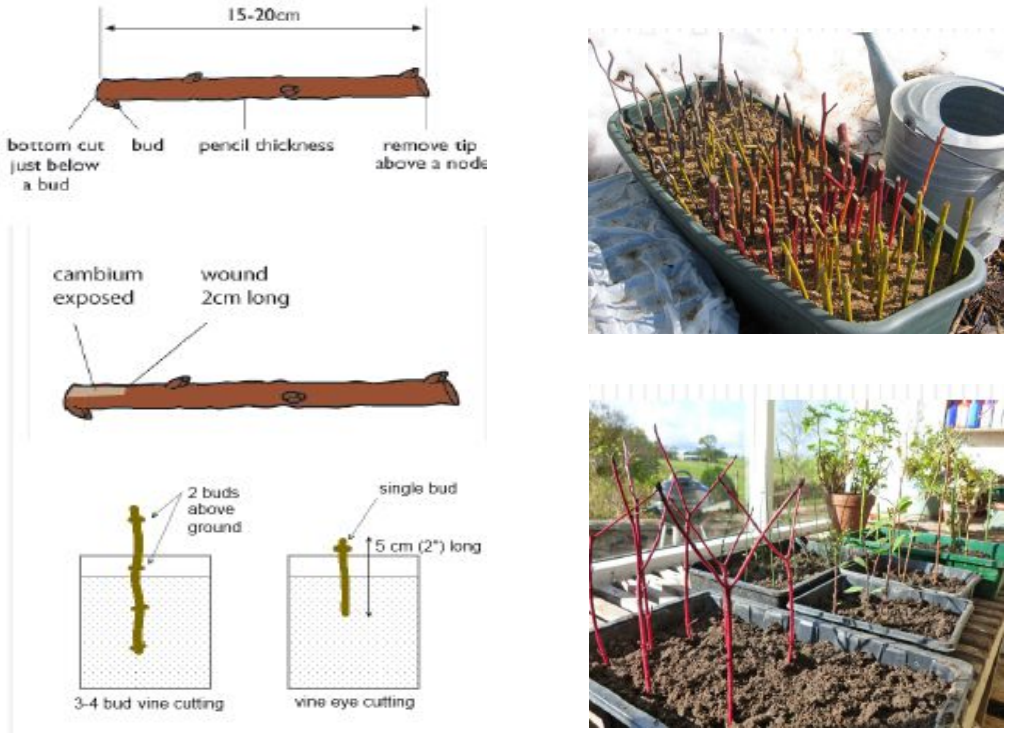

Figure 2.37 Procedures of hardwood cutting.

Source: Google Image (n.d.32.)

2.8.3 Leaf cutting

Leaves of some plants can grow into a new plant as they become detached from the parent plant. Other plants can grow small plants called plantlets on the edge of their leaves (Bryant, 1995; McMillan Browse, 1978). Leaf cutting is often used in many kinds of ornamental plants. The leaves can produce roots and new shoots. A plant propagated by leaf cutting, the leaf must be cut through the vascular bundles and also the leaf cutting area must be the meristematic tissues. The cut area develops into callus cells and then these cells develop into roots as stimulated by hormones, auxin and cytokinin. This leaf cutting technique is showed in Figure 2.38.

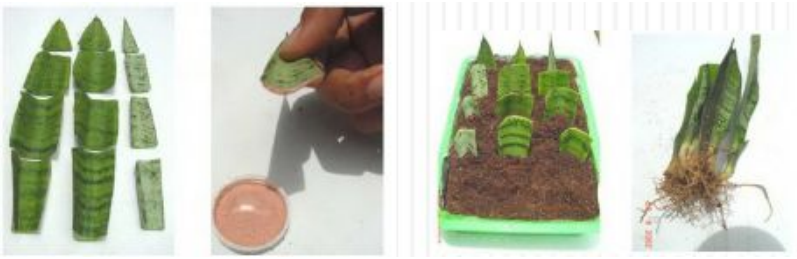

Figure 2.38 Leaf cutting procedure.
Source: Banlua (2010)

2.8.4 Leaf bud cutting

The leaf blade including the petiole and the bud at the base of the stem is used for propagating. In case of the parent plant limited, the cutting is made by placing it at a deep of 1/2-1 inch. For fruit trees that can be done by leaf bud cutting such as lemon and blackberry. As a time passed by, it is observed that there is a plant callus germinates at the base of the stem. This callus is a growing mass of unorganized plant parenchyma cells which are germinated by young age cells. First root emergence sometimes comes out from the callus (McMillan Browse, 1978). With this observation, it makes

belief that the callus is important for roots' emergence. The structure of a leaf and the procedure of leaf bud cutting are as showed in Figures 2.39 and 2.40, respectively.

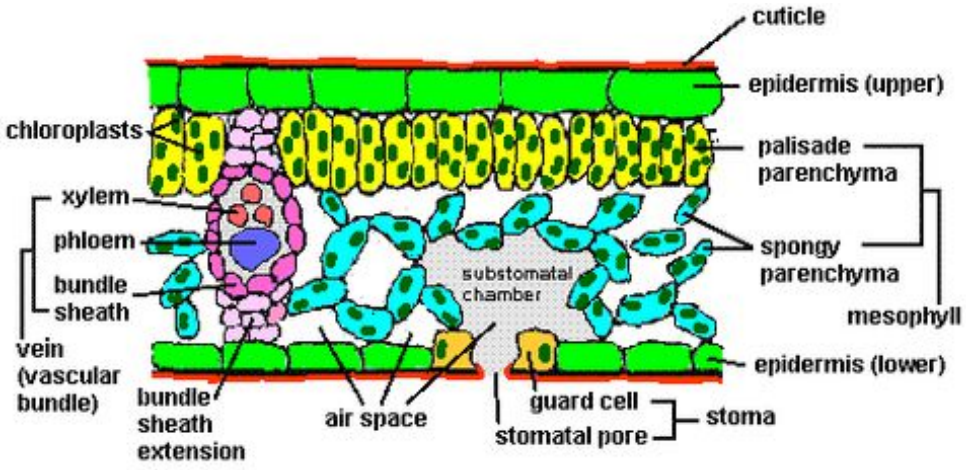

Figure 2.39 Leaf structure.

Source: Google Image (n.d.33.)

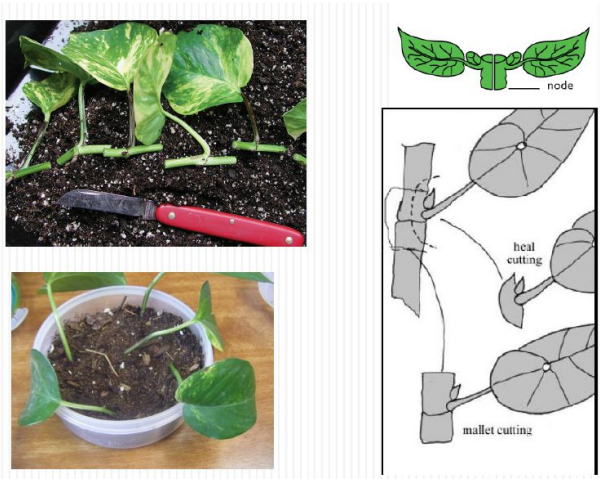

Figure 2.40 Procedure of leaf bud cutting.

Source: Google Image (n.d.34.)

ใบเตรียมการสอน	แบบฝึกหัดท้ายหน่วยเรียนที่ 2
	หลังจบหน่วยเรียน

Exercise 1: Translate the given vocabularies from English to Thai.

Vocabulary/Technical Terms	**Translation**
forkert budding	
marcotting	
heel cutting	
hardwood cutting	
scion	
budding	
plant propagation	
adventitious roots	
rootstock	
inarching	
asexual propagation	
tongue grafting	
saw-kerf grafting	
side grafting	
tip layering	
patch T-budding	
chip budding	
inlay grafting	

Exercise 2: Answer the following questions.

1) What is plant propagation?

_____

2) What is the importance of plant propagation? Describe its significance.

_____

3) What types of plants are usually propagated by sexual propagation?

_____

4) What types of plants are usually propagated by asexual propagation?

_____

5) What plants can be propagated by stem cutting?

_____

6) Describe the process of the following plant propagations:

a) Marcotting

_____

b) Grafting

_____

c) Inarching

_____

d) Budding

_____

e) Cutting

_____

7) Plant can be divided in two types as per their propagation methods as _____ and _____.

8) A plants reproduce by seeds is called as _____propagation.

Exercise 3: Choose the correct answer that best describes each sentence.

1) This grafting method uses stock that should be a 1-3 year old seedling, with a stem of approximately pencil-thickness.

2) It is the lower part of grafting.

3) This grafting method can be made by cutting the ends of the rootstock and scion completely across and obliquely.

4) This grafting is done by trimming loose and dried bark from the tree.

5) This method uses stock and scion that are selected in similar diameter so that the two cambiums are in contact.

6) This grafting method can be done by cutting½ inches from the bottom of each scion.

7) This method can be made by preparing a stock that should not be over 3 ½ inches in diameter and scions should be 3/8 to 1/2 inches in diameter.

8) It is the upper part of the combined plant.

9) This grafting method needs uses thin-bladed and fine-toothed saw to cut into the stock for each scion.

10) This method is made by removing the terminal portion of the stock plant with a horizontal cut.

11) This grafting is done by preparing a stock that should be vertically cut (1-3 inches long) in the wood of the stock.

12) It is one of the asexual propagation methods whereby tissues of plants are joined so as to continue their growth together.

13) This propagation method is with a first cut that is a long sloping diagonal (1 to 2 inches) cut.

bridge grafting	side grafting	cleft grafting
saddle grafting	graftage	whip grafting
side veneer grafting	rootstock	spliced grafting
tongue grafting	wedge grafting	bark grafting
saw-kerf grafting	grafting	scion
inlay grafting	notch grafting	grafting method

Exercise 4: Choose one method of plant propagation and demonstrate to class.

เอกสารอ้างอิงท้ายหน่วยเรียนที่ 2

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ft+wood+&gs_l=img.3...258824.258824.0.259209.1.1.0.0.0.0.0.0..0.0....0...1c.1.64.img..1.0.0....0.jegbMtVePg4#imgrc=95GZqPyyUmbB7M: (April 5, 2018).

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ใบเตรียมการสอน	สรุปกิจกรรมการสอน หลังจบหน่วยเรียน

วิธีสอนและกิจกรรม	1. สอนแบบบรรยายและถามตอบ 2. ให้นักศึกษามีส่วนร่วมในการเรียน การสอน 3. สรุปเนื้อหา	
สื่อการสอน	**เอกสารอ้างอิง**	เอกสารอ้างอิงหมายเลข 5,10-12,17,26,28,31,39-72,104,108,110,111,113,114,117,120,132,139, 148, 150,155,159,160 และ 163
	เอกสารประกอบ	-
	วัสดุโสตทัศน์	สไลด์หน่วยเรียนที่ 2 ทำด้วยโปรแกรม MS PowerPoint
งานที่มอบหมาย	1. Exercises 1, 2, 3 and 4 2. ให้นักศึกษาค้นคว้าเพิ่มเติม	
การวัดผล	1. สังเกตความสนใจ ซักถามรายบุคคล 2. พิจารณางานที่มอบหมาย	

หมายเหตุ

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สัปดาห์ที่ 5	แผนการสอน	รหัสวิชา 03-31-426
Plant Physiology		หน่วยเรียนที่ 3
		เวลา 180 นาที

ชื่อบทเรียน 3.1 Definition and Importance of Plant Physiology
3.2 Other Definition and Its Role to the Plants
3.3 Concerning Issue of Physiology
3.4 Plant Anatomy or Phytotomy

จุดประสงค์การสอน

3.1 รู้ความหมายและความสำคัญของสรีรวิทยาของพืช
3.1.1 บอกความหมายของสรีรวิทยาของพืช
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3.3 รู้ปัญหาที่ส่งผลกระทบต่อกระบวนการทางสรีรวิทยาของพืช
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3.4 รู้กายวิภาคของพืช
3.4.1 บอกกายวิภาคของพืช

ใบเตรียมการสอน	หน่วยเรียนที่ 3
	คาบที่ 1

เนื้อหา

3.1 Definition and Important of Plant Physiology

3.1.1 Definition of plant physiology

Plant physiology is defined as a sub-discipline of botany concerned with the physiology, or functioning, of plants – the dynamic processes that account for plant life. It encompasses plant growth, metabolism, and reproduction. Plant structures at cellular, tissue, and organ levels govern plant functions (Alfonso-Alejar and Dionisio-Sese, 1999). Or physiology is the scientific study of the functions and mechanisms which work within a living system. Fundamental processes such as photosynthesis, respiration, plant nutrient, and plant hormone functions.

3.1.2 Importance of plant physiology

Plant physiology is important to contribute to agricultural production only to the extent that they engage with breeding, agronomy and farming system research. Plant physiology gathered from many years of laboratory and field experimentations and therefore provides an effective means for investigating crop responses to climate change and alternative management scenarios. Understanding plant physiology is the key to successful agriculture (Andrade et al. 2015; Reddy and Patil, 2015).

3.2 Other Definition and Its Role to the Plants

Physiology is the study of all the processes happening in living organisms, such as respiration, excretion and in the case of plants, photosynthesis, transpiration etc. In case of crops, their genetic make-up and environmental factors play a significant role in regulating their growth. In other words, the environmental

variations and genotype of the crops act through physiological processes to control the growth of the crops. Thus, physiological processes of crops are the machinery through which both genetic potentialities and the environment operate to produce the quantity and quality of crop which we call yield. Once the breeder understands the physiology of crops they are trying to cultivate, it becomes easy for them to deal with problems such as environmental stress as well as insect invasions. It is the knowledge of genetics and environment and their effects on crops that made it possible for scientists to develop breeds of crops that can give yield with good quality and quantity (Kamath, 2018).

3.3 Concerning Issue of Physiology

The environment is not always in favour of crops, as there are multiple ways through which environment causes adverse effects on the crops. These unfavourable environmental factors affect the growth of crops by altering their physiological processes. For example, drought results in stunted growth due to water deficiency that causes closure of stomata and decreased photosynthesis. Nutrient deficiencies also have adverse effects on growth because they are essential for overall development of crops. Defoliation caused by insect attacks are lethal for plants as it reduces the leaf surface which performs the function of photosynthesis. Lastly, root damage impairs transport of nutrients and water, resulting in the reduced development of growing crops. The only way plant cultivators can achieve higher yielding varieties is by designing genotype that has the combination of best physiological processes resulting in crops that are structurally and physiologically more effective in a particular environment. Thus, plant physiology plays a central role in specifying features for which plant breeders must select the crop (Kamath, 2018; Xu et al. 2010).

3.4 Plant Anatomy or **Phytotomy**

It is the general term for the study of the internal structure of plants. Originally it included plant morphology, the description of the physical form and external structure of plants (Figure 3.1), but since the mid-20th century plant anatomy has been considered a separate field referring only to internal plant structure. Plant anatomy is now frequently investigated at the cellular cell, and often involves the sectioning of tissues and microscopy (Raven et al. 2005; Hagemann, 1992; Evert and Esau, 2006).

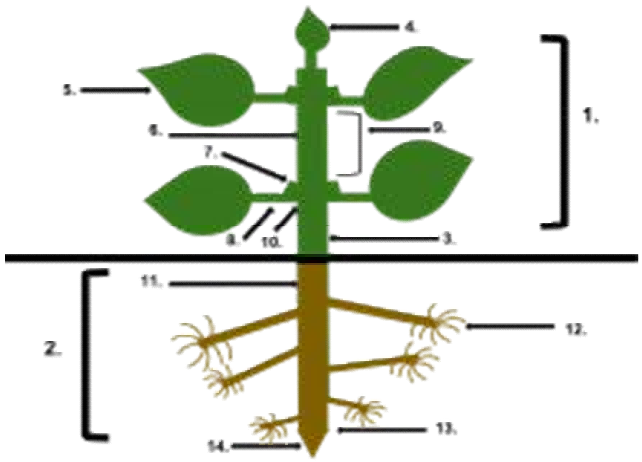

Figure 3.1 The anatomy of a plant with labels of structural parts of the plants and the roots. 1) the shoot system 2) the root system 3) hypocotyl 4) terminal bud 5) leaf blade 6) the internode 7) axillary bud 8) node 9) stem 10) petiole 11) tap root 12) root hairs 13) root tip 14) root cap

Source: Craig and Vassilyev (2010)

สัปดาห์ที่ 6	แผนการสอน	รหัสวิชา 03-31-426
Plant Physiology		หน่วยเรียนที่ 3
		เวลา 180 นาที

ชื่อบทเรียน 3.5 Photosynthesis
3.6 Respiration
3.7 Transpiration

จุดประสงค์การสอน

3.5 เข้าใจกระบวนการสังเคราะห์ด้วยแสงของพืช

3.5.1 อธิบายกระบวนการสังเคราะห์ด้วยแสงของพืช

3.6 เข้าใจกระบวนการหายใจของพืช

3.6.1 อธิบายกระบวนการหายใจของพืช

3.7 เข้าใจกระบวนการคายน้ำของพืช

3.7.1 อธิบายกระบวนการคายน้ำของพืช

3.5 Photosynthesis

Photosynthesis in green plants is classically defined as a process occurring in the chloroplast where, in the presence of light, CO_2 is assimilated to form carbohydrates and oxygen (Alfonso-Alejar and Dionisio-Sese, 1999). It can be written as follows:

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O_6 + 6O_2$$

It is also defined as a process that converts electromagnetic energy in the visible region of the solar light spectrum into chemical energy, in the form of nicotinamide adenine dinucleotide phosphate (NADPH) and adenosine triphosphate (ATP), which is subsequently utilized by a sequence of enzymatic reactions that convert CO_2 into organic molecules. The overall reaction in the photosynthetic process is an oxidation-reduction reaction: oxidation of water [$2H_2O$ → 4 electrons (e) + protons (H^+) + O_2] and reduction of CO_2 (through the transfer of e^- from donor to acceptor molecule) to form organic compounds. Photosynthesis is the sole mechanism of energy input in the living world. In the biosphere, photosynthesis and aerobic respiration are mirror images that balance out. Both processes generate usable chemical energy stored in the form of ATP. The net result is the transformation of light energy to heat energy (Alfonso-Alejar and Dionisio-Sese, 1999).

Growth requires a net gain of energy. In plants, photosynthetic energy gain must exceed respiratory energy loss. The total energy produced or fixed CO_2 is called gross photosynthesis (PG). The energy difference between PG and respiration (RD) is called net photosynthesis (PN). In short, PG = PN + RD. The amount of carbon assimilated by the plant minus the amount of carbon it lost through respiration is called the net productivity of the plant. A plant exhibits zero growth

when PG = RD. The rate of photosynthesis can be measured as: (1) moles of CO_2 fixed or absorbed; (2) moles of O_2 evolved; or, (3) amount of dry matter produced per unit area per unit time. The amount of carbon annually fixed by plants vary in different ecosystems. This ranges from 1,000 to 3,500 g m^{-2} for tropical forests and from 100 to 3,500 g m^{-2} for cultivated land. For extreme deserts, sands or ice lands, the estimate ranges from 0 to 10 g m^{-2}. The global amount of carbon annually fixed by plants is estimated to range from 7 to 12 billion metric tons. Photosynthesis, as carried out by plants vary furnish food for mankind, forage for animals, fibers for clothing, wood for shelter and furnishings, medicines for the alleviation of most ailments, and O_2 for breathing (Alfonso-Alejar and Dionisio-Sese, 1999).

In addition, photosynthesis is a process used by plants and other organisms to convert light energy into chemical energy that can later be released to fuel the organisms' activities (energy transformation) (Figure 3.2). This chemical energy is stored in carbohydrate molecules, such as sugars, which are synthesized from carbon dioxide and water — hence the name *photosynthesis*, from the Greek, *phos*, "light", and *synthesis*, "putting together". In most cases, oxygen is also released as a waste product. Most plants, most algae, and cyanobacteria perform photosynthesis; such organisms are called photoautotrophs. Photosynthesis is largely responsible for producing and maintaining the oxygen content of the Earth's atmosphere, and supplies all of the organic compounds and most of the energy necessary for life on Earth (Bryant and Frigaard, 2006). Although photosynthesis is performed differently by different species, the process always begins when energy from light is absorbed by proteins called reaction centers that contain green chlorophyll pigments. In plants, these proteins are held inside organelles called chloroplasts, which are most abundant in leaf cells, while in bacteria they are embedded in the plasma membrane. In these light-dependent reactions, some energy is used to

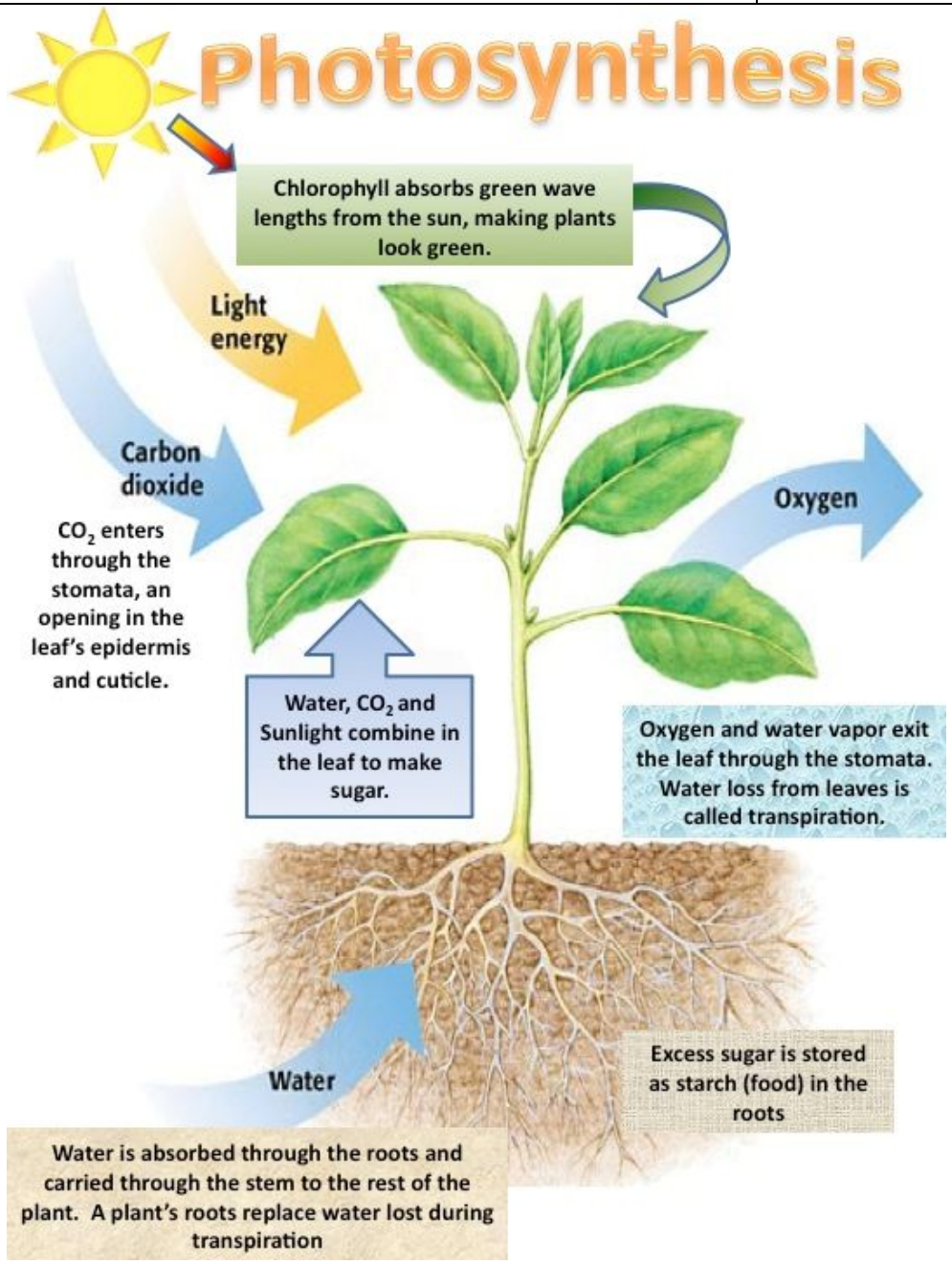

Figure 3.2 The process of photosynthesis.

Source: Google Image (n.d.35.)

strip electrons from suitable substances, such as water, producing oxygen gas. The hydrogen freed by the splitting of water is used in the creation of two further compounds that serve as short-term stores of energy, enabling its transfer to drive other reactions: these compounds are reduced NADPH and ATP, the "energy currency" of cells. In plants, algae and cyanobacteria, long-term energy storage in the form of sugars is produced by a subsequent sequence of light-independent reactions called the Calvin cycle; some bacteria use different mechanisms, such as the reverse Krebs cycle, to achieve the same end. In the Calvin cycle, atmospheric carbon dioxide is incorporated into already existing organic carbon compounds, such as ribulose bisphosphate (RuBP). Using the ATP and NADPH produced by the light-dependent reactions, the resulting compounds are then reduced and removed to form further carbohydrates, such as glucose (Olson, 2006). Photosynthetic organisms are photoautotrophs, which mean that they are able to synthesize food directly from carbon dioxide and water using energy from light. However, not all organisms that use light as a source of energy carry out photosynthesis; photoheterotrophs use organic compounds, rather than carbon dioxide, as a source of carbon. In plants, algae, and cyanobacteria, photosynthesis releases oxygen. This is called *oxygenic photosynthesis* and is by far the most common type of photosynthesis used by living organisms. Although there are some differences between oxygenic photosynthesis in plants, algae, and cyanobacteria, the overall process is quite similar in these organisms (Bryant and Frigaard, 2006).

There are also many varieties of anoxygenic photosynthesis, used mostly by certain types of bacteria, which consume carbon dioxide but do not release oxygen. Carbon dioxide is converted into sugars in a process called carbon fixation; photosynthesis captures energy from sunlight to convert carbon dioxide into carbohydrate. Carbon fixation is an endothermic redox reaction. In general outline, photosynthesis is the opposite of cellular; in the latter, glucose and other compounds

are oxidized to produce carbon dioxide and water, and to release chemical energy (anexothemic reaction) to drive the organism's metabolism. The two processes, reduction of carbon dioxide to carbohydrate and then later oxidation of the carbohydrate, are distinct: photosynthesis and cellular respiration take place through a different sequence of chemical reactions and in different cellular compartments. Therefore, photosynthesis has supplied the energy for food, feed, and fossil fuels that power electrical generating plants and many machines. A study of crop physiology soon leads to the discovery that the yield of crop plants ultimately depends on the size and efficiency of this photosynthetic system. Crop management practices proceed from this assumption (Bryant and Frigaard, 2006). The photosynthesis is important because it is the cornerstone of crop production, it is important to be aware of the energy available to drive photosynthesis and to consider how the anatomical and biochemical processes in the plant interact to capture and store radiant energy.

3.6 Respiration

Plant respiration couples the synthesis of ATP to the complete oxidation of photosynthesis-reduced carbon, proteins, and lipids. The process involves a series of enzyme-specific catalyzed reactions composed of about 30 steps. In aerobic respiration, the last intermediate reduced compound donates its electron to O_2 to form water, and releases energy as ATP and heat. The simple reaction is:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + ATP + heat$$

The standard free energy change in this reaction is the release of about 2,880 kilojoules (kJ) or 686 kilocalories (kcal) per mole (180 g) of glucose. This regulated release of free energy and its coupling to ATP synthesis is the primary function of

respiratory metabolism in plants. Plant respiration also provides carbon skeleton for a large number of plant products — amino acids for proteins; nucleotides for nucleic acids; carbon precursors for fats, sterols, porphyrin pigments, carotenoids, and aromatic compounds like lignin; etc. The products of plant respiration are distributed and utilized for two purposes: plant growth and maintenance. In growth respiration, energy in the form of ATP, reductants in the form of reduced nicotinamide adenine dinucleotide phosphate (NADPH) and reduced NAD (NADH), and structural building blocks in the form of carbon skeletons are used for the synthesis of new plant biomass. In maintenance respiration, the products are used for the repair and maintenance of existing structural systems (e.g., membrane proteins) and for ion gradients which keep mature cells in viable state. This usually takes precedence over growth respiration during tissue maturation and towards senescence. The biochemistry of plant respiration requires a clear understanding of the cell organelle where respiration takes place — the mitochondrion. The mitochondrion consist of a circular DNA containing the genetic information needed to produce its enzymes. It is formed through the division of preexisting mitochondria, which are individually surrounded by a double membrane that has an extensive inner membrane system (Alfonso-Alejar and Dionisio-Sese, 1999).

In addition, cellular respiration is a set of metabolic reactions and processes that take place in the cells of organisms to convert biochemical energy from nutrients into ATP, and then release waste products. The reactions involved in respiration are catabolic reactions, which break large molecules into smaller ones, releasing energy in the process, as weak so-called "high-energy" bonds are replaced by stronger bonds in the products. Respiration is one of the key ways a cell releases chemical energy to fuel cellular activity. Cellular respiration is considered an exothermic redox reaction which releases heat. The overall reaction occurs in a series of biochemical steps, most of which are redox reactions themselves. Although cellular respiration is technically a combustion reaction, it clearly does not resemble

one when it occurs in a living cell because of the slow release of energy from the series of reactions. Nutrients that are commonly used by animal and plant cells in respiration include sugar, amino acids and fatty acids, and the most common oxidizing agent (electron acceptor) is molecular oxygen (O_2). The chemical energy stored in ATP (its third phosphate group is weakly bonded to the rest of the molecule and is cheaply broken allowing stronger bonds to form, thereby transferring energy for use by the cell) can then be used to drive processes requiring energy, including biosynthesis, locomotion, or transportation of molecules across cell membranes (Bailey, 2017).

3.7 Transpiration

Transpiration is the process of water movement through a plant and its evaporation from aerial parts, such as leaves, stems and flowers. Water is necessary for plants but only a small amount of water taken up by the roots is used for growth and metabolism. The remaining 97–99.5% is lost by transpiration and guttation (Sinha, 2004.). Leaf surfaces are dotted with pores called stomata, and in most plants they are more numerous on the undersides of the foliage. The stomata are bordered by guard cells and their stomatal accessory cells (together known as stomatal complex) that open and close the pore (Cummins, 2007). Transpiration occurs through the stomatal apertures, and can be thought of as a necessary "cost" associated with the opening of the stomata to allow the diffusion of carbon dioxide gas from the air for photosynthesis. Transpiration also cools plants, changes osmotic pressure of cells, and enables mass flow of mineral nutrients and water from roots to shoots. Two major factors influence the rate of water flow from the soil to the roots: the hydraulic conductivity of the soil and the magnitude of the pressure gradient through the soil. Both of these factors influence the rate of bulk flow of water moving from the roots to the stomatal pores in the leaves via the xylem (Taiz, 2015).

สัปดาห์ที่ 7	แผนการสอน	รหัสวิชา 03-31-426
Plant Physiology		หน่วยเรียนที่ 3
		เวลา 180 นาที

ชื่อบทเรียน 3.8 Mechanism Driving Water and Mineral Movement in Plants

จุดประสงค์การสอน

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3.8 Mechanic Driving Water and Mineral Movement in Plants

Water is the most limiting abiotic (non-living) factor to plant growth and productivity. If water is so important to plant growth and survival, then why would plants waste so much of it? The answer to this question lies in another process vital to plants — photosynthesis. To make sugars, plants must absorb carbon dioxide (CO_2) from the atmosphere through small pores in their leaves called stomata. However, when stomata open, water is lost to the atmosphere at a prolific rate relative to the small amount of CO_2 absorbed; across plant species an average of 400 water molecules are lost for each CO_2 molecule gained. The balance between transpiration and photosynthesis forms an essential compromise in the existence of plants; stomata must remain open to build sugars but risk dehydration in the process (McElrone et al., 2013). Following is a list of mechanic driving water and mineral movement in plants.

3.8.1 Mechanism driving water movement in plants

Unlike animals, plants lack a metabolically active pump like the heart to move fluid in their vascular system. Instead, water movement is passively driven by pressure and chemical potential gradients. The bulk of water absorbed and transported through plants is moved by negative pressure generated by the evaporation of water from the leaves (i.e., transpiration) — this process is commonly referred to as the Cohesion-Tension (C-T) mechanism. This system is able to function because water is "cohesive" — it sticks to itself through forces generated by hydrogen bonding (Figure 3.3). These hydrogen bonds allow water columns in the plant to sustain substantial tension (up to 30 MPa when water is contained in the minute capillaries found in plants), and helps explain how water can be transported to tree canopies 100 m above the soil surface. The tension part of the C-T mechanism is generated by transpiration. Evaporation inside the leaves occurs predominantly from damp cell wall surfaces surrounded by a network of air spaces. Menisci form

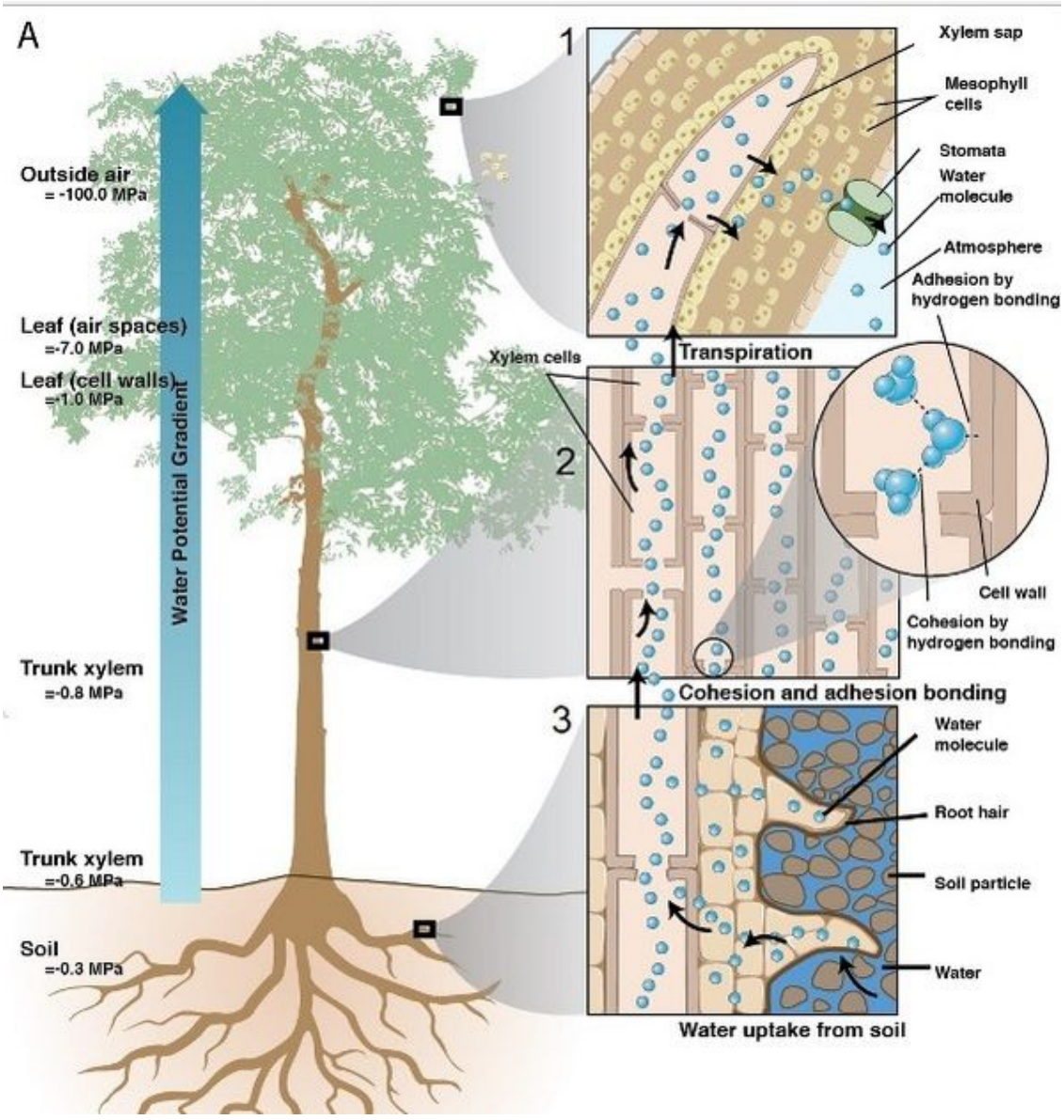


Figure 3.3 Continuous water transport pathway the Soil Plant Atmosphere Continuum (SPAC).

Source: Google Image (n.d.36.)

at this air-water interface, where apoplastic water contained in the cell wall capillaries is exposed to the air of the sub-stomatal cavity. Driven by the sun's energy to break the hydrogen bonds between molecules, water evaporates from menisci, and the surface tension at this interface pulls water molecules to replace those lost to evaporation. This force is transmitted along the continuous water columns down to the roots, where it causes an influx of water from the soil. Scientists call the continuous water transport pathway the Soil Plant Atmosphere Continuum (SPAC) (McElrone et al., 2013).

3.8.2 Nutrient transportation in plants

Plants continue to evolve as a species and sustain their life form by transporting water and minerals from the roots to all parts including tips of the leaves, while defying gravity. The food made out of photosynthesis is transported from leaves to the roots, the younger top regions of the plant, the flowers and fruits. The movement of food from leaves to other parts of the plant is called translocation. They use two different systems – xylem moves water and solutes from the roots to the leaves, phloem moves food substances from leaves to the rest of the plant. Both of these systems are rows of cells that make continuous tubes running the full length of the plant (BBC, 2014).

3.8.3 How water and minerals move up?

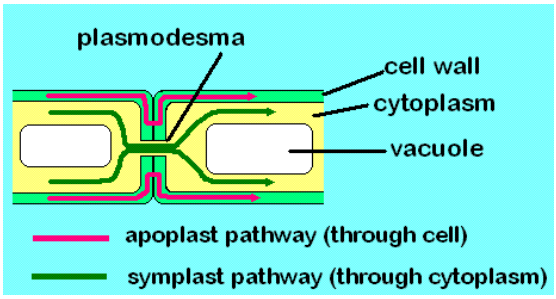
Plants do not have a metabolically active pump like the heart to move fluid in their vascular system. Water movement is passively driven by pressure and chemical potential gradients in plants through primary and secondary tissues. Water and minerals are mainly absorbed by roots, which goes upwards so as to replace water loss in transpiration and to be used in photosynthesis. Water and minerals enter through root epidermis, cross the cortex, pass into

the stele, and are carried upward in the xylem. Osmosis, the movement of particles from a higher concentration to a lower concentration across a semi-permeable membrane allows water to enter the cells of the root hairs. Water enters the root hairs if the concentration of water in soil is greater than the concentration of water in the root hairs. The root endoderm has the ability to actively transport ions in one direction because of a waxy layer called subrin. The movement of water continues across the root hairs, into the root cells, and then enters the xylem. The xylem acts as the vessels inside the plant that carries water and minerals from the root hairs to the stem and leaves. This upward movement of water from roots to leaves through stem against force of gravity is called ascent of sap (McElrone et al., 2013).

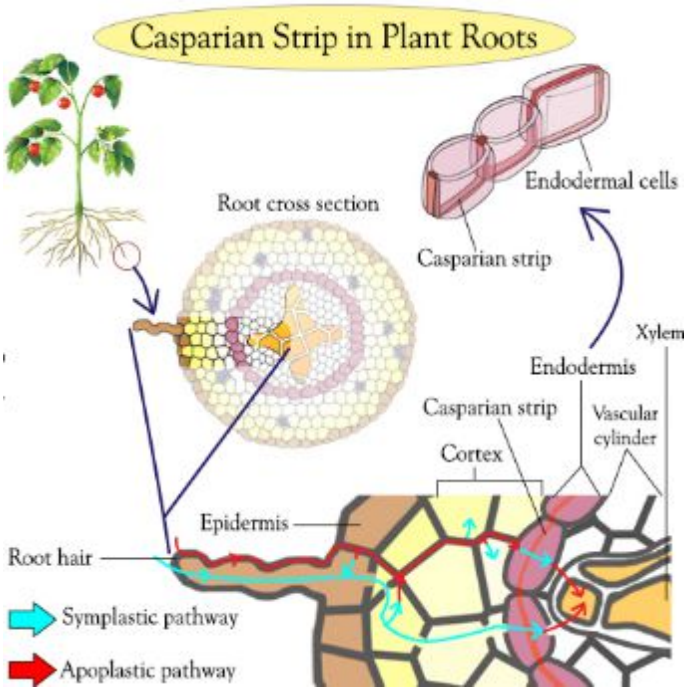
3.8.4 Water flow from roots to leaves

Water and minerals cross the cortex by way of Symplast and Apoplast. Symplast is the living continuum of cytoplasm connected by Plasmodesmata (Figure 3.4A). Apoplast is the nonliving matrix of cell walls. At the endodermis the apoplastic route is blocked by the Casparian strip which is a ring of suberin around each endodermal cell (Figure 3.4B). Here water and minerals must enter the stele through the cells of the endodermis. Water and minerals enter the stele via symplast, but xylem is part of the apoplast. Transfer cells selectively pump ions out of the symplast into the apoplast so that they may enter the xylem. Minerals enter the root by active transport into the symplast of epidermal cells and move toward and into the stele through the plasmodesmata connecting the cells. They enter the water in the xylem from the cells of the pericycle (as well as of parenchyma cells surrounding the xylem) through specialized transmembrane channels. In the xylem, water along with the minerals move up in the vessels and tracheids. The water can leave the xylem and pass laterally to supply the needs of other tissues. At the leaves, the xylem passes into the

petiole and then into the veins of the leaf. Water leaves the finest veins and enters the cells of the spongy and palisade layers. Here some of the water may be used in metabolism, but most is lost in transpiration (McElrone et al., 2013).



A



B

Figure 3.4 Water and minerals cross the cortex by pathway of Symplast and Apoplast.

Source: Google Image (n.d.37.)

3.8.5 Transpiration-adhesion-cohesion-tension (TACT) mechanism

Four important forces combine to transport water solutions from the roots, through the xylem and into the leaves. These TACT forces are: Transpiration, Adhesion, Cohesion and Tension (Anonymous, 2002).

- Transpiration involves the pulling of water up through the xylem of a plant utilizing the energy of evaporation and the tensile strength of water.
- Adhesion is the attractive force between water molecules and other substances. As water and cellulose (cell wall component of plants) are polar molecules there is a strong attraction for water within the hollow capillaries of the xylem.
- Cohesion is the attractive force between molecules of the same substance. Water has an unusually high cohesive force again due to the four hydrogen bonds each water molecule potentially has with any other water molecule. It is estimated that water's cohesive force within xylem give it a tensile strength equivalent to that of a steel wire of similar diameter. A combination of adhesion, cohesion and surface tension allow water to climb the walls of small diameter tubes like xylem and this is called capillary action.

Tension can be thought of as a stress placed on an object by a pulling force. This pulling force is created by the surface tension which develops in the leaf's air spaces. As water molecules leave the surface film by evaporating into the air spaces the remaining film forms menisci which become more and more concave. A meniscus has a tension that is inversely proportional to the radius of the curved water surface. "Tension is a negative pressure that pulls water from locations where the water potential is greater.

3.8.6 Water-balancing mechanisms

Water has strong adhesive and cohesive properties due to which loss of water is replaced by water clinging to the inside of the cell walls. This creates a

tension on the water in the xylem and gently pulls the water toward the direction of water loss. The cohesion of water is strong enough to transmit this pulling force all the way down to the roots. Adhesion of water to the cell wall also aids in resisting gravity. The water column in the tallest trees can be 100m as the tension created by evaporation of water coupled with the cohesive and adhesive forces is enough to support this column against the forces of gravity. At night, transpiration is almost none. However, the root cells continue to actively transport minerals into the root stele consisting of the xylem and the phloem. This active transport lowers the water potential within the stele and water flows into the roots, pushing the water up against gravity. Water that reaches the leaves is often forced out, causing a beading of water upon the leaf tips known as guttation. In most plants, however, root pressure is not the primary mechanism for transporting the xylem.

3.8.7 Food transport in plants

Leaves make food by the process of photosynthesis. The food made by leaves is in the form of simple sugar (glucose) while other types of substances called plant hormones are made in the tips of roots and shoots. The prepared food is transported from the leaves to the roots and all parts of the plant through phloem which translocates the food and other substances. Phloem consists of sieve tubes and companion cells. Sieve tubes are living cells which contain cytoplasm but do not have nucleus. So its function is supported by companion cell as each sieve tube has a companion cell next to it. Food, primarily sucrose is transported by the vascular tissue called phloem from a source to a sink. Unlike transpiration's one-way flow of water sap, food in phloem sap can be transported in any direction needed so long as there is a source of sugar and

a sink able to use, store or remove the sugar. The source and sink may be reversed depending on the season, or the plant's needs. Sugar stored in roots may be mobilized to become a source of food in the early spring when the buds of trees need energy for growth and development of the photosynthetic apparatus. Phloem sap (pH 7.2-8.5; 15-30% solutes) contains not only water and sucrose but also other organic molecules like plant hormones, amino acids, as well as inorganic ions are also transported. The movement of such substances in the plant is called translocation. The movement of water and dissolved minerals in xylem is always upward from soil to leaves, but the movement of food can be upward as well as downward depending upon the needs of the plants. Thus, this faultless transport system in plants is the product of an awesome design (Alfonso-Alejar and Dionisio-Sese, 1999).

สัปดาห์ที่ 8	แผนการสอน	รหัสวิชา 03-31-426
Plant Physiology		หน่วยเรียนที่ 3
		เวลา 180 นาที

ชื่อบทเรียน 3.9 Plant Hormones

จุดประสงค์การสอน

3.9 รู้และเข้าใจบทบาทของฮอร์โมนพืชในการเจริญเติบโตของพืช

3.9.1 บอกชนิดของฮอร์โมนพืชที่มีผลต่อการเจริญเติบโตของพืช

3.9.2 อธิบายบทบาทของฮอร์โมนพืชในการเจริญเติบโตของพืช

3.9 Plant Hormones

Plant hormones, known as plant growth regulators (PGRs) or phytohormones, are chemicals that regulate a plant's growth. According to a standard animal definition, hormones are signal molecules produced at specific locations, which occur in very low concentrations, and cause altered processes in target cells at other locations. Unlike animals, plants lack specific hormone-producing tissues or organs. Plant hormones are often not transported to other parts of the plant and production is not limited to specific locations. Plant hormones are chemicals that in small amounts promote and influence the growth, development and differentiation of cells and tissues. Hormones are vital to plant growth; affecting processes in plants from flowering to seed development, dormancy, and germination. Plant hormones regulate which tissues grow upwards and which grow downwards, leaf formation and stem growth, fruit development and ripening, as well as leaf abscission and even plant death. Plants produce hormones and other growth regulators which act to signal a physiological response in their tissues. They also produce compounds such as phytochrome that are sensitive to light and which serve to trigger growth or development in response to environmental signals. Following is a list of the most important plant hormones such as auxins, gibberellins, cytokinins, ethylene and abscissic acid (ABA), and though there are many other substances that serve to regulate plant physiology.

3.9.1 Auxins

The first of the 5 major types of plant hormones to be studied is auxin. It has lots of jobs but most importantly it stimulates growth, and if a plant doesn’t naturally produce auxin itself, it will die. The principal auxin in higher plants is indole-3- acetic acid or IAA, synthesized from the amino acid tryptophan. The highest concentrations of free auxin in living plants are in the apical meristem of shoots and in young leaves. Auxin levels are

controlled by its rates of synthesis and degradation (by IAA oxidase), and by its deactivation as it forms bound IAA (e. g., IAA-glucose) (Alfonso-Alejar and Dionisio-Sese, 1999). Auxin is involved in cell growth and cell expansion, so it is produced primarily in parts of the plant that are actively growing like the stem (specifically, the very tiptop of the stem). Auxin is transported in one direction in a plant – downward from the top to the bottom, like a one-way road from the stem tip to the roots. Therefore the concentration of auxin is highest at the top of the plant and decreases as you get closer to the roots, this controls the overall shape of the plant and helps keep the primary stem of a plant the leader. Auxin maintains apical dominance it prevents lots of lateral buds and branches from growing on the side of the stem. When you prune the primary stem of a plant, the source of the auxin is removed, then no single stem is dominant anymore – apical dominance is removed. Auxin will move to the shaded side of the plant stem and cause those cells to grow longer, while the cells on the sunny side of the plant stay the same size. That will cause the plant to bend to one side – toward the sun.

3.9.2 Gibberellins

Gibberellins (GAs) are isoprenoid compounds synthesized from mevalonic acid in tissues and seeds. Immature seeds contain relatively high levels of GA compared to its low levels in vegetative tissues (primarily in young leaves, buds and upper stem). Roots also synthesize GA. There are about 90 known GAs. All has GA_{12} aldehyde as basis. They are passively transported along the xylem or phloem (Davies, 1995; Alfonso-Alejar and Dionisio-Sese, 1999). Gibberellin causes some similar effects in plants as auxin. A fungus called *Gibberella fujikuroi* infected rice plants and caused them to grow too tall and fall over. The infectious fungus produced a

chemical that stimulated the growth in rice plants. The chemical was isolated and named Gibberellin after the fungus. It was later found that plants naturally produce variations of these chemicals. Gibberellins play an important role in several developmental stages in plants, but their claim to fame is making stems longer. Gibberellins promote stem elongation between nodes on the stem. A node is a place on a stem where a leaf attaches, so gibberellins elongate the internodes. It is easiest to see the absence of gibberellin in dwarf plants and rosette plants – there is very little space between nodes on a stem and the leaves are clustered toward the base of the plant.

3.9.3 Cytokinins

Cytokinins (CKs) are adenine or amino purine derivatives found in plant apical meristems and young organs. The root apex is the main site of CK production. From there it is transported to the shoot through the xylem as CK nucleotides. Zeatin is the naturally-occurring cytokinin in most plants. It was first discovered in immature corn endosperm (Alfonso-Alejar and Dionisio-Sese, 1999; Davies, 1995). Soon after, a substance that had the same biological effect as kinetin was found in plants, it stimulated plant cells to divide when in culture with auxin. The substance was named cytokinin and it is involved in cell division and in the making of new plant organs, like a root or a shoot. CKs are produced in the root apical meristems (very tip of the roots) and travel upward hitching a ride with water and traveling up the stem through the xylem. The movement of CKs is passive – it does not require energy. CKs are like the fountain of youth in plants. They delay senescence or the natural aging process that leads to death in plants. In the cell cycle, CKs promote the movement from the G2 phase to the M phase. In other words, they encourage cells to divide. CKs are involved in repair, too. If a plant becomes wounded, it can fix itself with the help of CKs and auxin. Well if the

concentration of auxin and cytokinin are equal, then normal cell division will take place. If the concentration of auxin is greater than cytokinin then roots will form. If the concentration of auxin is less than cytokinin then shoots will form.

3.9.4 Ethylene

Ethylene is a plant hormone that affects ripening and rotting in plants. It is a particularly interesting plant hormone because it exists as a gas. No other plant hormone is gaseous. Under physiological conditions, it is lighter than air. It can be oxidized to produce ethylene oxide, hydrolyzed to yield ethylene glycol, or completely oxidized to form CO_2. In higher plants, the amino acid methionine is the precursor of ethylene. The immediate precursor is 1-aminocyclopropane-1-carboxylic acid (ACC). Essentially all parts of plants produce ethylene. It can be easily released from tissues by diffusion. Ethylene biosynthesis is induced by stressed conditions such as drought, flooding, salinity, or wounding. The "stress ethylene" is involved in the onset of stress responses (e.g., abscission, senescence, and associated physiological acclimation to the stress) (Davies, 1995; Alfonso-Alejar and Dionisio-Sese, 1999). Ethylene can be produced in almost any part of a plant, and can diffuse through the plant's tissue, outside the plant, and travel through the air to affect a totally different plant. The formation of ethylene requires oxygen, and the agricultural industry has used this tidbit of information to their advantage. If you control the partial pressure of oxygen and carbon dioxide in a truck carrying produce (specifically low O_2 high CO_2) you can prevent ethylene synthesis and thus slow the ripening process. This is helpful when fruits and vegetables are grown in one region of the world and then shipped many miles away to be sold. Growers don't want their produce to go bad before you even have a chance to buy it.

3.9.5 Abscisic acid

Abscisic acid (ABA) is widely distributed in nature. It is a 15-C sesquiterpenoid synthesized from mevalonic acid in the chloroplasts and other plastids. It appears to act more as inhibitor rather than as promoter. The amount of ABA in a tissue depends on its biosynthesis, metabolism and transport. It is transported in both xylem and phloem (where it is more abundant) and in parenchyma cells outside vascular bundles. The distribution of ABA between compartments depends on pH. The more alkaline a compartment is, the more ABA is concentrated in that compartment. Therefore, it increases in the chloroplast under light and increases in the apoplast in the dark (Davies, 1995; Alfonso-Alejar and Dionisio-Sese, 1999). When a plant needs water, for example during a drought, it doesn't have too many options. Plants produce a chemical messenger, called abscisic acid, to alert the rest of the plant that it is water stressed. Abscisic acid is made in droughted leaves, droughted roots, and developing seeds and it can travel both up and down in a plant stem in the xylem or phloem sounding the alarm. Think back to transport in plants, how does water typically move through a plant? (Reminder: soil → roots → stem → leaves → air) Water molecules exit a plant through tiny pores in the leaves called stomata. Each stoma (singular) has two kidney bean shaped bodyguards on either side of the pore, whose job it is to open and close the stoma. When the guard cells are full of water, or turgid, the stoma is open. When water leaves the guard cells, they become flaccid, and the stoma is closed.

ใบเตรียมการสอน	แบบฝึกหัดท้ายหน่วยเรียนที่ 3
	หลังจบหน่วยเรียน

Exercise 1: From the word box, choose the correct word or phrases that best describes in each sentence.

1) It is the general term for the study of the internal structure of plants.

2) This is a set of metabolic reactions and processes that take place in the cells of organisms to convert biochemical energy from nutrients into adenosine triphosphate and then release waste products.

3) It is the water movement that there is an attractive force between water molecules and other substances.

4) This is the movement of food from leaves to other parts of the plant.

5) This is one of the nutrient transportation systems used where it moves food substances from leaves to the rest of the plant.

6) The food made by leaves in the form of simple sugar.

7) It is the movement of particles from a higher concentration to a lower concentration across a semi-permeable membrane allows water to enter the cells of the root hairs.

8) It is one of the key ways a cell releases chemical energy to fuel cellular activity.

9) It is a sub-discipline of botany concerned with the functioning of plants.

10) It is a process used by plants and other organisms to convert light energy into chemical energy that can later be released to fuel the organisms' activities.

11) It is the most common type of photosynthesis where algae and cyanobacteria release oxygen which will then be used by living organisms.

12) This is one of the nutrient transportation systems used where it moves water and solutes from the roots to the leaves.

13) This water movement involves the pulling of water up through the xylem of a plant utilizing the energy of evaporation and the tensile strength of water.

14) This water movement is the attractive force between molecules of the same substance.

15) This water movement is thought of as a stress placed on an object by a pulling force.

16) They are the plant growth regulators or chemicals that regulate a plant's growth.

17) The description of the physical form and external structure of plants.

plant hormones	cellular respiration	cohesion	phloem	translocation
xylem	adhesion	transpiration	plant physiology	
photosynthesis	glucose	plant anatomy	plant morphology	
tension	respiration	osmosis	oxygenic photosynthesis	

Exercise 2: Match the English words to its correct translation in Thai.

1) hormones	a) ออกซิเจน
2) sustain	b) พลังงานเคมี
3) light energy	c) ปัจจัยสภาพแวดล้อม
4) plant growth	d) ฮอร์โมน สารเคมีซึ่งร่างกายของสิ่งมีชีวิตสร้างขึ้น เพื่อกระตุ้นหรือควบคุมการทำงานของอวัยวะส่วนต่าง ๆ ให้เป็นไปโดยปกติ
5) abiotic factor	e) คาร์บอนไดออกไซด์
6) carbon dioxide	f) ปัจจัยของสิ่งที่ไม่มีชีวิต
7) oxygen	g) ธาตุอาหาร
8) chemical energy	h) รักษาไว้
9) nutrients	i) การเจริญเติบโตของพืช

10) convert	j) ความตึงเครียด
11) cultivate	k) สมบัติการยึดติด
12) environmental factors	l) พลังงานแสง
13) living organisms	m) การหายใจ
14) biochemical energy	n) สมบัติการเชื่อมแน่น
15) adhesive properties	o) เพาะปลูก
16) respiration	p) สิ่งมีชีวิต
17) tension	q) เปลี่ยนเป็น
18) cohesive properties	r) พลังงานชีวเคมี

Exercise 3: Answer the following questions as briefly as possible. (Group work)

1) How some hormones work together to affect plants?

_____

2) Have you ever noticed that if you put a really ripe, brown banana right next to a bunch of green bananas, the unripe bananas will ripen and turn yellow much faster? How does that happen?

_____

3) Now imagine a plant is thirsty. It hasn't rained in weeks and there is no moisture in the soil around its roots. The plant is running dangerously low on water. What can the plant do to prevent itself from losing any more precious water? How do plants do it?

_____

4) How water performs its gravity-defying act of moving upward from the roots to the leaves of a plant which is very tall? What kind of pumps these trees have? While answering these questions, we may note that it is quite a difficult job to raise

water up to heights of hundreds of meters and plants do not have circulation pump like heart in case of animals.

_____

5) Give one example of plant hormones, and explain its function to the plant.

_____

เอกสารอ้างอิงท้ายหน่วยเรียนที่ 3

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Horticulture		หน่วยเรียนที่ 4
		เวลา 180 นาที

ชื่อบทเรียน 4.1 Definition of Horticulture

4.2 Importance of Horticulture

จุดประสงค์การสอน

4.1 รู้ความหมายของพืชสวน

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เนื้อหา

4.1 Definition of Horticulture

Horticulture consists of two parts: “Hortus” means“garden” and “Cultura” means “cultivation”. Garden is a broad term. Garden is originated from the latin term Gyrdanϖ meaning “to enclose”. When fruits are grown in a definite area then that part is called as an “orchard” (Janick, 1972). Horticulture can also be defined as the branch of agriculture concerned with intensively cultivated plants (fruits, vegetables, flowers, and any other cultivar) directly used by man for food, for medicinal purposes or for aesthetic purposes (AgriInfo, 2015). It also includes plant conservation, landscape restoration, soil management, landscape and garden design, construction, and maintenance, and arboriculture. In contrast to agriculture, horticulture does not include large-scale crop production or animal husbandry (Lekhasre, 2018).

4.2 Importance of Horticulture

Horticulture crops are used in a living state while others like grains etc. are not used in a living state. Horticulture crops are comparatively more intensively cultivated than field crops. Horticulture crops have high water content and are highly perishable. Cultural operations like propagation, training, pruning and harvesting are skilled and specific to horticultural crops. Horticultural produce are rich source of vitamins and minerals and alkaloids (Hemla Naik and Thippesh, 2014). Following is a list of the different importance of horticulture.

4.2.1 Economic value

Vegetables can be grown 3 to 4 times each year giving the products all the time they are grown. More number of crops can be grown from same piece of land. Similarly, trees have a longer life and their production increases with advancement in age provided a proper care is taken. More profitable since the average income per unit area is more in horticulture crops

than agriculture crops. With the support of horticulture, many agro-industries can spring up in villages itself. In addition, plant growth regulators can improve the yield of some horticultural crops by increasing the number of flowers and fruits. Their real success, however, is correlated with their ability to modify quality and timing more effectively than other cultural alternatives. Another important reason for the successful development of plant growth regulants in horticulture is their ability to reduce labor costs associated with the production of high-value crops. Growth regulators which hasten or delay maturity allow greater labor flexibility at harvest. Concentrated maturity increases the efficiency of mechanical harvesters in once-over harvest producers. Expensive hand-labor operations, which are often used to maintain the form and shape of horticultural plants, can also be reduced with plant growth regulators (Mitlehner, 1977). It is an acceptable fact that horticulture can come in a big way to solve the problem of unemployment. Source of other industries e.g. rubber, oil, gum, dyes, chemicals etc. raw material for fruit and vegetable processing plants, hence becomes a solution to reduce unemployment. Employment is also generated in doing field operations like fruit picking/ harvesting, grading, packing, selling etc. The fruits and vegetables provide nutrients and minerals required for the human body as the food. The fruits and vegetables and their quality products such as mango, durians, can be a foreign exchange and make income for producers. Products like pickles, jams, jelly and so on are exported and similarly making them indigenously thus saving the foreign exchange minimizes the import of wines and other horticulture-based products.

4.2.2 Medicinal Purposes

Drugs, germicides, chemicals, and insecticides are made by using the parts like of the plants e.g. stems, leaves, flowers, roots and fruits of

horticultural plants. For example rose water is used to cure eyes ailments. Neem water for skin irritation and allergies. Citrus fruit like sweet lime is used for liver ailment. Rind of pomegranate and pectin from guava used for stomach upset. Vallarai (*Centella asiatica*) is a perennial, prostrate aromatic herb flourishing on water and damp areas of tropical regions. It is generally applied on the cure of leprosy, skin diseases, diahhorea, antitumour and antiulcer activity. It is also reported to possess insecticidal properties. Vallarai is used as a nerve tonic for improving memory and in insanity (Rajamani, 2015).

4.2.3 Diet

Fruits and vegetables are the main sources of vitamins, minerals, carbohydrates, fats, proteins that are recognized as protective foods as they are necessary for the maintenance of human health. The deficiency of any vitamin from the diet for considerable period may lead to diseased state or disorder conditions. Human body requires vitamins, minerals, proteins and energy for its health. All these are supplied by horticultural crops. A person should consume at least 120 g of fruits per day. Deficiency of any minerals and nutrients is depicted by the human body by giving typical symptoms. The great majority of people obtains most of their carbohydrates and proteins from cereals and pulses but their diets must also contain significant amount of fruits to ensure that they get the vitamins which are not provided by the staple cereal foods.

4.2.4 Environment

Mental piece is given to the humans who enjoy fresh air and natural beauty, sheds of tension making them fresh in the orchards, gardens or places well planted with flowerbeds. On the other hand, horticultural production, in comparison to other agricultural sectors, occupies a small land area but due to

its intensity of production its environmental impact can be relatively greater. Access to, and management, of water resources is the aspect of greatest concern since loss of water with resources, deterioration of water quality and pollution of surface water with pesticide residues, nitrates and phosphates are detrimental to the wider environment (Likkywhite, 2014).

4.2.5 Aesthetic value

Religious importance and aesthetic value is the unique factor distinguishing it from agricultural activities. Banana leaves and stems are used for religious functions on a day of Loy Krathong festival as a Siamese festival celebrated annually throughout the Kingdom of Thailand. The plantation of banana tree in the court yard is said to bring prosperity as per Hindu religion. This aspect of horticulture has led to its universal popularity. Paradise means garden. Similarly, horticultural plants are always liked throughout the cultures due to their wide variety of colors and flavors whether these are encountered as foods or desserts or in any recreational parks their aesthetic value is always at the top than economics. Flowers being the first for creating aesthetic essence, they are use in landscaping, home gardens, parks, recreational places etc. In history fruit gardens were planted in huge palaces for kings who basically use these places for spending leisure time (Gardens and Gates, 2018).

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		เวลา 180 นาที

ชื่อบทเรียน 4.3 Conversation Regarding a Very Big Farm

4.4 Vegetables

4.5 Fruits

4.6 Nutritional Values of Some Fruits and Vegetables

จุดประสงค์การสอน

4.3 เข้าใจบทสนทนาภาษาอังกฤษทั่วไปเกี่ยวกับฟาร์มขนาดใหญ่

4.3.1 อธิบายบทสนทนาภาษาอังกฤษทั่วไปเกี่ยวกับฟาร์มขนาดใหญ่

4.4 รู้ผัก

4.4.1 บอกชื่อผักบางชนิดที่คนไทยส่วนใหญ่นิยมรับประทาน

4.5 รู้ผลไม้

4.5.1 บอกชื่อผลไม้บางชนิดที่คนไทยส่วนใหญ่นิยมรับประทาน

4.6 รู้คุณค่าทางโภชนาการอาหารของผักและผลไม้บางชนิด

4.4.1 บอกคุณค่าทางโภชนาการอาหารของผักและผลไม้บางชนิด

4.3 Conversation Regarding a Very Big Farm (Gibson, n.d.)

A Very Big Farm

This week will be a very good week for Phanuwatt and Ratchapol. It will be a good week and it will be a busy week, too. This week, Phanuwatt and Ratchapol are going to visit a fruit farm. They are going together with their friends, the other students from their English class, and their English teacher. All the students think it will be a very interesting visit. They know that there are a lot of interesting things to see and do on a fruit farm. The teacher will tell the students the English names of all the things on the farm. He will tell them how to say the names and tell them how to write the names, too. When the students are at the farm, they will be very busy. They will look at everything at the farm. They will ask their teacher the names of everything, and they will write everything down in their books. Then, they will go back to the school and write more. The teacher thinks it will take two or three hours to look around and see everything at the farm. This farm is a very big fruit farm and a lot of people are working in it. The teacher knows some of those people, as those people are the teacher's friends. He says the students can ask questions to the people who work on the farm. Some of the students are already thinking about the questions they will ask. They want to ask good questions. They want to ask interesting questions. For some of the students, this will be their first time to visit a farm. Those students will want to know everything about the farm. Now, the teacher is very busy. He is very busy because he is getting everything ready for the visit to the farm. He wants to be sure that the students take everything they will have to use when they are on the farm. All the students will have to take their books, their pens, pencils, rubbers and other things with them.

Teacher: “Are you ready, Phanuwatt? Have you got everything?”

Phanuwatt: “Yes, I think so, Teacher. I think I've got everything.”

Teacher: “Are you sure? I don't want you to forget anything”.

Phanuwatt: “I won't forget anything. I always remember everything.”

Teacher: "Do you?"

Phanuwatt: "Yes, I do. I'm not like Ratchapol. He always forgets things."

Teacher: "Oh, really?"

Phanuwatt: "Yes. Sometimes, I think Ratchapol's not so clever."

Teacher: "Don't say like that, Phanuwatt. That's not a very nice thing to say!"

Phanuwatt: "I know it's not nice, but Ratchapol doesn't think about what he is going to do."

Teacher: "What do you mean?"

Phanuwatt: "I mean, he doesn't think about what he is going to do before he does it."

Teacher: **"**Oh, I see. Well, I sometimes forget things, too."

Phanuwatt: "Do you?"

Teacher: "Yes, I do. If I want to be sure I will remember everything, I usually have to write it down."

Phanuwatt: "Really?"

Teacher: "Yes. If I don't write things down, I always forget something."

Phanuwatt: "Oh. Now, I see it."

Teacher: "Well Phanuwatt. It's time to go. Get all your things together. And don't forget anything!"

4.4 Vegetables

Six favorite vegetables consumed by Thais are as follow:

4.4.1 Pakchoy

It is one of the popular very low-calorie leafy vegetables (Figure 4.1). Nonetheless, it is a very rich source of many vital phytonutrients, vitamins, minerals, and health benefiting antioxidants. It is one of the recommended vegetables in the weight-reduction programs falling under "zero calorie or negative calorie" category of food items, which when eaten would add no extra calories to the body but facilitate calorie (fat) burn and thereby bring a reduction in the body weight (Rudrappa, 2018).

Figure 4.1 Pakchoy.

Source: Google Image (n.d.38.)

4.4.2 Asparagus

It is a very low-calorie vegetable (Figure 4.2). Besides, its spears contain moderate levels of dietary fiber. Dietary fiber helps control constipation conditions, decrease bad (LDL) cholesterol levels by binding to it in the intestines and regulate blood sugar levels. Studies suggest that high-fiber diet help cut down colon-rectal cancer risks by preventing toxic compounds in the food from absorption. Its shoots have long been used in many traditional medicines to treat conditions like dropsy and irritable bowel syndrome (Rudrappa, 2018).

Figure 4.2 Asparagus.
Source: Google Image (n.d.39.)

4.4.3 Bamboo shoots

Bamboo shoots are one of the very low-calorie vegetables (Figure 4.3). Bamboo heart composes of moderate levels of soluble and non-soluble (NSP-non-starch carbohydrates) dietary fiber. Dietary fiber helps control constipation conditions, decrease bad (LDL) cholesterol levels by binding to it in the intestines. Bamboo hearts are also rich in the B-complex group of vitamins such as thiamin, riboflavin, niacin, vitamin B-6 (pyridoxine), and pantothenic acid those are essential for optimum cellular enzymatic and metabolic functions. Bamboo is useful in minerals, especially manganese and copper. Manganese utilized by the human body as a co-factor for the antioxidant enzyme, superoxide dismutase. Copper employed in the production of red blood cells. Iron is essential for cellular respiration and red blood cell formation. Bamboo shoots compose excellent levels of potassium. Potassium is an important component of cell and body fluids that helps controlling heart rate and blood pressure by countering effects of sodium (Rudrappa, 2018).

Figure 4.3 Bamboo shoot.
Source: Google Image (n.d.40.)

4.4.4 Immature pods of winged beans (Tender)

They are one of the very low-calorie vegetables (Figure 4.4). Mature winged bean seeds, however, compose relatively high protein content equivalent to that of soybean protein. Fresh, young bean pods are one of the finest sources of folates. Folate, along with vitamin B-12, is one of the essential components of DNA synthesis and cell division (Rudrappa, 2018).

Figure 4.4 Immature pod of winged bean.
Source: Google Image (n.d.41.)

4.4.5 Sweet potato

It is a root vegetable "tuberous root" (Figure 4.5). This is one of the

high-calorie starch foods. The tuber, however, contains no saturated fats or cholesterol, and is a rich source of dietary fiber, antioxidants, vitamins, and minerals than potatoes. Its calorie content mainly comes from starch, a complex carbohydrate. Sweet potato has higher amylose to amylopectin ratio than that in potato. Amylose raises the blood sugar levels rather *slowly* on comparison to simple fruit sugars (fructose, glucose, etc.) and therefore, recommended as a healthy food even in diabetes. The tuber is an excellent source of flavonoid phenolic compounds such as beta-carotene and vitamin-A. Vitamin-A and ß-carotene, a value which is the highest for any root vegetables**.** These compounds are powerful natural antioxidants. Consumption of natural vegetables and fruits rich in flavonoids helps protect from lung and oral cavity cancers (Rudrappa, 2018).

Figure 4.5 Sweet potato.
Source: Google Image (n.d.42.)

4.4.6 Bitter gourd or bitter melon

It is a vegetable that has a very low calories (Figure 4.6). Nevertheless, its pods are rich sources of phytonutrients like dietary fiber, minerals, vitamins, and anti-oxidants. Bitter melon notably contains phytonutrient, polypeptide-P, a plant insulin known to lower blood sugar levels. Also, it composes hypoglycemic agent called Charantin. Charantin increases glucose

uptake and glycogen synthesis inside the cells of the liver, muscle, and fatty (adipose) tissue. Together, these compounds may have been thought to be responsible for blood sugar levels reduction in the treatment of type-2 diabetes. Fresh pods are an excellent source of folates. Vitamin folate when taken by mothers during their early pregnancy time, would help reduce the incidence of neural tube defects in the newborn babies. Fresh bitter melon is an excellent source of vitamin-C. Vitamin-C is one of the powerful natural antioxidants which helps scavenge harmful free radicals from the human body (Rudrappa, 2018).

Figure 4.6 Bitter gourd.
Source: Google Image (n.d.43.)

4.5 Fruits

Like the charming people, exotic fruit greets you on almost every corner in Thailand. The country's fertile plains and hot tropical climate, as well as its more temperate northern regions, means that pretty much anything grows here. As a result, few places on earth can claim to have such a plentiful supply of gorgeous tasting fruit. Twenty amazing Thai fruits are presented as follows (Smith, 2018):

4.5.1 Mango (*Ma-Muang*)

One of the most well-known fruits in Thailand, there are many varieties of the delicious, refreshing mango and a few different ways

of eating it (Figure 4.7). When ripe, it can be halved and eaten with a spoon, while many choose to enjoy it with sticky rice and coconut milk (Khao Niew Ma-muang). Others like to eat it half-ripe and dip the crunchy slices in sugar. Also makes a wonderful juice.

Figure 4.7 Mango.
Source: Google Image (n.d.44.)

4.5.2 Mangosteen (*Mang-Kut*)

Little known outside Thailand, the Mangosteen is a bizarre looking fruit that contains in its round, deep purple shell a delicate, flavorful white flesh that is eaten in sections (Figure 4.8). The number of sections found inside match the number of petals found on the bottom of the shell. A delicious, distinctive flavour also makes it wonderful for juices.

Figure 4.8 Mangosteen.
Source: Google Image (n.d.45.)

4.5.3 Rambutan (*Ngor*)

Its name is derived from the malay word for rambut, meaning hair - a result of the fruits red and yellow spiky rind (Figure 4.9). Peeling this away reveals a firm, white, translucent flesh, something the Thais are especially adept at delicately carving away from its large seed.

Figure 4.9 Rambutan.

Source: Google Image (n.d.46.)

4.5.4 Durian (*Tu-Rian*)

Surely the most controversial fruit on earth, durian is to its fans a rich, unique tasting fruit, and to its critics, a putrid-smelling, lame duck of a fruit (Figure 4.10). Its extremely strong aroma - which some say resembles rotting fruit down a blocked drain - let alone its aggressive look, is enough to put many off tasting it altogether. Others, swear by it. Its the most expensive of all Thai fruits and actually banned, yes banned, from some public places, hotels and on planes.

Figure 4.10 Durian.

Source: Google Image (n.d.47.)

4.5.5 Pineapple (*Sapparod*)

The Kingdom is one of the largest producers of this flavourful, juicy fruit (Figure 4.11). Growing year round it is best planted in sandy seacoast soil, and grows on a low lying plant. It's an incredibly versatile fruit that finds its way into desserts, drinks and savoury dishes.

Figure 4.11 Pineapple.

Source: Google Image (n.d.48.)

4.5.6 Papaya (*Ma-La-Kaw*)

A delicious year-round fruit that is at its best between March and June, the papaya is oval in shape and cut lengthways to remove the small black seeds in the middle (Figure 4.12). When ripe the soft dark orange coloured meat is full of flavour. Thais like to shred unripe papaya and mix it with lemon juice, chillies, peanuts and dried shrimp (Som Tam) - one of Thailand's favourite salads.

Figure 4.12 Papaya.

Source: Google Image (n.d.49.)

4.5.7 Dragon fruit (*Gao Mung Gorn*)

The fruit of a cactus plant, the strange, unearthly looking dragon fruit has a lovely soft flesh that looks somewhat like that of a kiwi fruit and is typically eaten with a spoon (Figure 4.13).

Figure 4.13 Dragon fruit.

Source: Google Image (n.d.50.)

4.5.8 Guava (*Farang*)

Originally from Central America and the West Indies, Guava is now grown in many tropical countries and favoured especially for its fragrant, exotic taste (Figure 4.14). Available all year round, it makes a popular snack that can be eaten green and crunchy alongside salt, sugar and chilli, or when ripe. Tasty and highly refreshing, guava can also be made into delicious drinks, luscious ice creams or rich jams and jellies. It's Thai name, Farang, is also the term that foreigners are known by.

Figure 4.14 Guava.

Source: Google Image (n.d.51.)

4.5.9 Pomelo (*Som-O*)

Similar in size and taste to grapefruit, the meat of the pomelo is succulent and has a delicious sour-sweet flavour (Figure 4.15). Available all year round there are many varieties varying from pale yellow to orange or red.

Figure 4.15 Pomelo.

Source: Google Image (n.d.52.)

4.5.10 Rose apple (*Chom-Poo*)

With a shape much like a pear, the rose apple has a shiny skin that is either pink or green in colour (Figure 4.16). Extremely refreshing and with a crisp, crunchy taste it is often eaten in Thailand with salt and sugar.

Figure 4.16 Rose apple.

Source: Google Image (n.d.53.)

4.5.11 Jackfruit (*Khanoon*)

Available between January and May, the jackfruit is roughly the size of a large melon and packs a distinctive aroma and succulent taste (Figure 4.17). Divided into multiple sections, each of which contains a waxy textured meat surrounded by seeds, it is usually eaten raw, although some Thais like to fry it in batter.

Figure 4.17 Jackfruit.

Source: Google Image (n.d.54.)

4.5.12 Custard apple (*Noi-Na*)

Light green and about the size of a tennis ball, the flesh of this knobby textured fruit is, much like custard, best eaten with a spoon (Figure 4.18). The sweet tasting meat contains tiny black seeds.

Figure 4.18 Custard apple.

Source: Google Image (n.d.55.)

4.5.13 Langsat (*Lang-sard*)

Native to Thailand, the langsat is a small round seasonal fruit available between July and October (Figure 4.19). Use your fingers to prise open the thin, off white skin and you'll find a translucent, juicy flesh with a slightly tart flavour. An excellent thirst quencher, its flesh falls away into five segments and is best eaten raw.

Figure 4.19 Langsat.

Source: Google Image (n.d.56.)

4.5.14 Longan (*Lam-Yai*)

A lesser known sibling of the lychee and rambutan, the longan has a sweet, delicate flavour and grows in Northern Thailand in the Chiang Mai area, especially between June and August (Figure 4.20). The skin is pierced by the finger and the delicious, juicy flesh revealed by squeezing it out of its shell using the thumb and forefinger.

Figure 4.20 Longan.

Source: Google Image (n.d.57.)

4.5.15 Lychee (*Linjee*)

Covered by a red, roughly-textured rind that is inedible but easily removed, the inside of a lychee consists of a layer of sweet, translucent white flesh and has a texture somewhat similar to that of a grape (Figure 4.21). The centre contains a single glossy brown nut-like seed, that should not be eaten. This gorgeous fruit matures from July to October, about 100 days after flowering.

Figure 4.21 Lychee.

Source: Google Image (n.d.58.)

4.5.16 Sapodilla (*La-Mut*)

Rather deceptively, the dull and unattractive skin of this fig-like fruit masks the soft, succulent honey flavoured flesh to be found within (Figure 4.22). A knife is used to carve away the skin, and in Thailand you'll often find it carved into decorative shapes. A definite favourite.

Figure 4.22 Sapodilla.

Source: Google Image (n.d.59.)

4.5.17 Coconut (*Ma-Praow*)

Coconuts are just about the most versatile fruit there is – the juice is more hydrating than water, the soft flesh goes great in desserts, and the nut can be used to make adorable souvenirs (Figure 4.23). Just be careful when trying to open them!

Figure 4.23 Coconut.

Source: Google Image (n.d.60.)

4.5.18 Banana (*Gluay*)

You thought you knew bananas? Try again. There's 20 different types that grow in Thailand - ranging from small stubby ones to large fleshy types - each of which have different names (Figure 4.24). In Thailand you'll find them eaten any which way: pure, dried, boiled, fried, served in sweet coconut milk or, simply, enjoyed fresh.

Figure 4.24 Banana.

Source: Google Image (n.d.61.)

4.5.19 Snake fruit (*Sala or Salak*)

Snake fruit (Salak), the creepy name comes from pattern of the hard, brittle shell, but crack it open to reveal white lobes of flesh that deliver a burst of sweet and sour flavours, and a lot of acidity (Figure 4.25). The small seeds are inedible but can easily be eaten around.

Figure 4.25 Snake fruit.
Source: Google Image (n.d.62.)

4.5.20 Watermelon (*Tangmo*)

Thailand's rich soil imparts watermelons here with a delicious flavour (Figure 4.26). Found in a rich ruby-red and more unusually a golden yellow colour, they are often used as the centerpiece for fruit carving due to the intricate designs that can easily be made using the fruit's thick, green rind. You'll find that its thrown liberally into blenders to make delicious, refreshing drinks.

Figure 4.26 Watermelon.
Source: Google Image (n.d.63.)

4.6 Nutritional Values of Some Vegetables and Fruits

Vitamins are the essential constituents of vegetables and fruits and are very significant part of human diet. Although required in very little quantities, they are absolutely essential for the maintenance of health. Vegetables and fruits provide several vitamins and are as follows:

Vitamin A is important for cell growth and development, and for good vision. It protects cold and influenza and prevents night blindness. Its deficiency results in cessation of growth in young children, night blindness, drying up of tear glands in the eyes, eruption of skin (rashes on the skin) and brittleness of the teeth. Sources of vitamin-A are such as acorn squash, pumpkin, papaya, mango, jackfruit, walnut, etc. Vitamin B1 (thiamine) tones the nervous system and helps in proper functioning of the digestive tract. Its deficiency in human diet results in beriberi, paralysis, loss of sensitivity of skin, enlargement of heart, loss of appetite, loss of weight and fall in body temperature. Sources of vitamin B1 are such as orange and pineapple.

Vitamin B2 (riboflavin) is required for body growth and health of the skin. Its deficiency causes sore throat, anorexia cataract, and loss of appetite and body weight and also development of swollen nose. Sources of vitamin B2 are such as bael, papaya, lychee, banana, apricot, pomegranate, pear etc.

Absence or deficient in vitamin B6 (pyridoxin) can cause dermatitis, anemia, ulceration in oral cavity etc. fruits rich in vitamin B6 are chestnut, walnut, almond, apricot, apple, plum, etc.

Niacin deficiency can cause sour tongue, pellagra (a complex of diarrhea, loss of mental aptitude, and dermatitis), discoloration of skin of hands, feet and legs and under severe condition the mental balance may shift. Rich fruits of niacin are chestnut, walnut, almond, apricot, apple, plum etc.

Vitamin C (Ascorbic Acid) promotes general health and healthy gums. It also prevents scurvy disease which is characterized by pain in the joints and swelling of limbs (rheumatism), bleeding of gums, tooth decay and keeps the blood vessels in good condition. Sources of vitamin C are such as guava, citrus, strawberry,

pineapple etc.

Vegetables and fruits have effects on human wellness as showed in Table 4.1.

Table 4.1 Constituent, sources, and established effects on human wellness.

Constituent	**Sources**	**Established Effects on Human Wellness**
Calcium	Orange, papaya, raisins, almonds	blood pressure, teeth, osteoporosis, muscular/skeletal
Magnesium	Cashews, banana, nuts	immune system, teeth, osteoporosis, nervous system
Potassium	Dried fruits (such as prunes and apricots)	hypertension (blood pressure), arteriosclerosis, stroke
Fiber	most vegetables and fresh fruits, nuts, cooked dry beans and peas	heart disease, diabetes
Folate (folicin or folic acid)	dark-green leafy vegetables (such as butterhead lettuce, spinach, mustard greens, broccoli, brussels sprouts and okra), legumes (cooked dry beans, green peas, chickpeas and lentils),	nervous system, cancer, heart disease, birth defects
Vitamin K	Nuts	osteoporosis, synthesis of procoagulant factors
Vitamin E (tocopherols)	Almonds, pistachios, filberts, macadamias, pecans, cashew nuts, and walnuts	immune-system, heart-disease, LDL oxidation, cancer, diabetes

Source: Anonymous (n.d.2.)

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ชื่อบทเรียน

4.7 Durian Cultivation

จุดประสงค์การสอน

4.7 รู้และเข้าใจวิธีการปลูกทุเรียน

4.7.1 บอกสภาพภูมิประเทศที่เหมาะสมต่อการปลูกทุเรียน

4.7.2 บอกวิธีการใส่ปุ๋ยทุเรียน และดินที่เหมาะสมต่อการปลูกทุเรียน

4.7.3 อธิบายวิธีการปลูกทุเรียน

4.7.4 บอกวิธีการขยายพันธุ์ทุเรียน

4.7 Durian Cultivation

4.7.1 Location, climate and temperature for durian trees (Nirav, n.d.)

Durians are the king of fruits. The durian tree is ultra-tropical, a native of Southeast Asian equatorial rainforests (Figure 4.27). It requires much tropical warmth, adequate moisture, and full sunlight to thrive (except for the young trees' first year, when semi-shade is preferred – simulating rainforest conditions). In Thailand, one of the established commercial durian-growing areas is in the northern province of Uttaradit, not far from Chiang Mai province at 18 degrees north. In the Philippines, the upper elevation limit for growing durians is said to be 700 m; In Sri Lanka, 600 m; and in Malaysia, 800 m. Regarding altitude and climate, coconuts may be a good indicator as to the possibility of success with growing durians: if coconuts can grow and tolerate well in its micro-climate, except for seaside areas (durians are not salt-tolerant), durians may be possible too. Durian is surprisingly tolerant of relatively low mean temperatures for an ultra-tropical where durian is successfully grown that have a mean yearly normal temperature of just 23º C.

Figure 4.27 Durian-growing areas in Southeast Asian.

Source: Google Image (n.d.64.)

Some research has indicated that growth is limited below a mean monthly temperature of 22º C. The trees may survive occasional dips in temperature as low as 10º C but may drop their leaves. On the other end of the spectrum, durian trees in India sometimes successfully tolerate high temperatures up to 46º C. Durian trees requires adequate rainfall, or equivalent irrigation. In most areas of Asia where durians are grown, mean annual rainfall is greater than 2000 mm. The better production sites have developed in areas with annual mean rainfall totals of 3000 mm or more, well distributed throughout the year. There is no doubt, though, that drier areas can produce good crops with adequate irrigation. Established durian trees cannot withstand more than 3 months drought without suffering irreversible damage. Durians require three to four weeks of dry weather and relatively dry roots to stimulate flowering. Without a sufficient dry period, there will be no fruit that season. Rich soil conditions will help the tree grow well and fast. Consequently, four to five- year old trees can start to flower.

4.7.2 Organic fertilizer and soil types for durian trees (Nirav, n.d.)

Organic fertilizer will improve the soil by balancing the pH level. This will produce quality and quantity durians. Favorable terrain for good durian cultivation ranges from flat to steep. In Chanthaburi province, Thailand, which leads the world in quantity of annual durian production, many durian plantations are on relatively flat land. In contrast, on the island of Penang, which has the reputation for growing the finest connoisseur durians in Malaysia, all the durian farms are on tall hillsides and valley sides, many of them fairly steep. The root system of a durian tree is very sensitive to standing water, and good drainage is essential, which is well taken care of by such sloping situations. Durian trees grow best in a rich, deep, well-drained sandy clay or clay loam (deep alluvial or loamy soil), high in organic matter, pH range of 6 - 7. Heavy clay soils are not supportive of good durian tree growth

and health, as they do not drain well. Seedlings make more vigorous growth when potted into media that is light and sandy rather than high in clay content. In Thailand, it is commonly recommended that growers avoid using organic animal manure, as the most troublesome disease of durian trees there, the fungal *Phytophthora palmivora*, is encouraged by the moist fertile conditions at ground level around the trunk created by manure and mulch. It is not clear that such advice holds true for conditions elsewhere, however, and when using good organic tree planting practices. Traditional organic fertilizers are used with good results in Malaysia and elsewhere.

4.7.3 Planting of durian trees (Nirav, n.d.)

In equatorial regions, the most favorable time for planting is winter from November through mid-January (and not during the February-May dry season). In tropical areas far from the equator, early spring is probably best but is likely not too critical. In Malaysia, planting holes 0.6 m in diameter and depth are dug and allowed to weather for 2-4 weeks. (The Brunei Department of Agriculture recommends 0.5 m deep by 1 meter in diameter.) Organic matter or compost at the rate of about 5-10 kg is added to each hole, also about 200 gm of rock phosphate, and the young trees are planted with as little disturbance to the roots as possible. It's advisable to go further than this, and add rock dust (which enhances a plant's health and enriches the flavor of the plant's resulting food harvest) as well as other available organic amendments, and use standard organic tree planting techniques. In orchards, durian trees are commonly spaced 6-16 m apart, aiming for about 156 trees/hectare to 40 trees/hectare. T.S. Chang of Bao Sheng Durian Farm in Malaysia recommends 30 trees/hectare. At closer spacing, thinning will be necessary by the time the trees are 8 to 10 years old to reduce tree density and give remaining trees room for further growth. As grafted trees may start bearing at age 4-6, planting the trees more closely in the orchard's first decade is a way

to increase fruit production from a given piece of land. However, T.S. advises against this, saying from experience that few growers who plant more closely can bring themselves to cut down any 10-year old bearing durian trees of good quality to thin out the orchard, and most often allow them to remain. In the long term, this is unfortunate for the trees and the grower, as the trees compete for canopy sunlight in the increasingly cramped situation and eventually grow very tall and thin with less fruit bearing capacity. It's worth remembering that durian is a native of equatorial rainforests, eventually growing to the high canopy, and is at home amongst a mix of other plants and trees. As the Permaculture approach recommends, other useful plants can be grown among durian trees at ground level and lower levels. These can also provide needed shade during the durian trees' early life, as happens in the rainforest. The Brunei Department of Agriculture recommends interplanting durians with bananas and/or papayas. The bananas or papayas should be planted 6 months ahead of the durians, at a spacing of 3 x 3 meters. Eventually the durians will shade out the bananas or papayas, which can be trimmed and used as mulch and will also, of course, provide fruit harvest of their own. By the time the durians are fruiting, the banana or papaya plants should be removed, however, as their fruits will draw unwanted pest insects to the area. For trees that will remain interplanted among the durians indefinitely, in Malaysia, rambutan is a favored choice, as is nutmeg and chile pepper plants; but not mangos, mangosteen, citrus, starfruit, jackfruit, champedak, nor many others that can attract pest insects. The Brunei Department of Ag also suggests another alternative of interplanting with fast growing nitrogen-fixing-trees (there are a great many possibilities, including various species of Gliricidia, Sesbania, Leucaena, Albizia, Acacia, and others) which will provide shade, nutritious mulch, and soil improvement.

4.7.4 Propagation of durian trees (Nirav, n.d.)

Propagation of durian trees can be done through either seeds or by vegetative means. Unlike most seeds of temperate-climate plants, the big seeds of the ultra-tropical durian tree have a very short period of viability out of the fruit, especially if exposed even briefly to sunlight: only a few days at most. (However, if kept in ordinary cool storage, they can be successfully kept for a week, or as long as a month if surface-sterilized, placed in an airtight container and kept at 20º C. This high perishability of durian seeds no doubt has been a factor in preventing the durian tree's widespread dispersal far from its native territories. The seeds are best planted or sprouted within a day or so from removal from the fruit, sprout end pointed down, to a depth of half the seed with the other half above the soil surface. Healthy durian seeds sprout as quickly and vigorously as bean seeds, usually within a few days but possibly as long as a week. For transport or mailing, the seeds are best immediately placed in moist coconut fiber. Durian seedlings produce highly variable results. Their fruit may be better or worse than the parent tree, and it may be 10 to even 20 years before first fruit. In India, generally, they come into bearing 9 to 12 years after planting, but in South India they will not produce fruit until they are 13 to 21 years old. In Malaya, seedlings will bloom in 7 years; grafted trees in 4 years or earlier. Therefore, vegetative propagation, which is not difficult, is universally preferred and recommended for reproducing cultivars with known desirable traits. A large number of grafting methods are commonly employed. In Malaysia, Indonesia and the Philippines wedge (cleft), whip, approach, Forkert, and bud grafting of durian trees are all common. Propagation by airlayers and cuttings does not work. Wedge grafting and bud grafting are probably the most common techniques. As reported by the authors of Tropical Tree Fruits for Australia, growers in Thailand employ an unusual type of bottle graft with which many or most of their trees are grown. Durian seedlings that will serve as rootstocks are sown

in beds and dug up when approximately 300 to 600 mm (1 to 2 feet tall). The roots are packed with moist coconut husk fiber and sealed in a plastic bag. This rootstock seedling is then tied to a branch of the established durian tree that is desired to be reproduced, next to a lateral branch that appears suitable to serve a scion. The top of the young rootstock plant is then cut off, and the rootstock plant is inarched in a side-veneer graft to the branch/new scion. After the union is complete, the new scion is severed from the mother tree at about the level of the bottom of the seedling roots. The scion butt is also potted up and develops roots, so that the resulting grafted tree actually has two root systems, and is stronger and more vigorous as a result. Most durian growers regard any variety of durian as suitable for a rootstock as long as it is healthy and vigorous. In Thailand, the common vigorous Chanee variety is said to serve very well as a rootstock. There is also increasing use there of some wild Durio species such as *D.malaccensis, D.mansoni, and D.lowianus* for resistance to *Phytophthora palmivora*. In India, a relative of durian, *Cullenia excelsa* (native to Sri Lanka) is favored as a good vigorous rootstock which is said to also hasten the time of first fruiting.

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ชื่อบทเรียน

4.7 Durian Cultivation (continued)

จุดประสงค์การสอน

4.7 รู้และเข้าใจวิธีการปลูกทุเรียน

4.7.5 บอกวิธีการจัดการดูแลรักษาต้นทุเรียน

4.7.6 บอกวิธีการให้น้ำทุเรียน

4.7.7 บอกวิธีการควบคุมโรคและศัตรูของทุเรียน

4.7.8 อธิบายวิธีการเก็บเกี่ยวทุเรียน

4.7.5 Management for durian trees (Nirav, n.d.)

Following planting, young durian trees should be provided with temporary shade and complete wind protection for the first year, as in a shade cloth nursery structure or equivalent. The structure of the young trees and their leaves is such that strong winds can twist the leaves right off, a setback from which they are unlikely to ever fully recover. Proper pruning of the durian tree is said to be important to obtain a tree form that encourages early flowering and good yields. The pruning system commonly used in Southeast Asia includes:

- formative pruning resulting in a main leader; after about age 2 or 3 the interior is thinned out, removing all thin or dead branches and water shoots
- encouraging early branching to encourage early bearing
- topping to maintain a manageable tree height as the tree grows older
- general maintenance pruning contributing to a healthy and productive tree, removing dead, broken or diseased branches and water shoots, and allowing free circulation of air and plenty of sunlight throughout the canopy

In Southeast Asia, cut surfaces are routinely treated with a fungicide and bitumastic compound (use an organic equivalent). Durian growers in Thailand are often advised to keep the area under the tree and drip line area free of weeds, manure, and mulch, primarily so as to not create a microclimate suitable for the thriving of *Phytophthora palmivora* disease. (As previously mentioned, it is not clear if this is necessary or advisable in using strictly organic methods. Durian trees are otherwise benefited from manure and mulch, like many other trees). Likewise, for the same purpose, the trunk of the tree is kept free of any water shoots and weak branches up to a height of about 1 m (3 feet) above the ground. However, tropical legume cover crops between trees, such as perennial peanut, are recommended. Durian trees are surface

feeders, and if any weeding is necessary (with a cover crop like perennial peanut, there shouldn't be much), care should be taken to prevent damage to the roots. Durian trees remove a relatively low amount of nutrients from the soil. However, like many other fruit trees, it is a good idea to at least quarterly topdress the soil under the tree with a mix of organic fertilizers (preferably particularly rich in nitrogen and potassium) during the first five years. (Animal manures are favored in most places for this purpose, but not in Thailand, where chemical fertilizers are widely used in commercial production). T.S. Chang of Bao Sheng Durian Farm recommends placing topdressed fertilizer just beyond the edge of the root zone so that the trees' roots will chase after it and expand their reach in the process. The times a few months before flowering, during fruit development, and after harvesting are favored for fertilizing durian trees throughout Southeast Asia.

4.7.6 Water application for durian trees (Nirav, n.d.)

In Asia, areas with a dry season longer than 3 months are regarded as marginal for durian, unless adequately irrigated, in which case there is no problem. Micro-sprinkler or drip irrigation can be used. Durian trees are as incapable of withstanding any standing water around their trunks as papayas; they will simply die. In low-lying rainy areas, it may be advisable to construct surface drainage systems to prevent that possibility from ever occurring, or to plant only on sloped land, as is done in many areas of Southeast Asia. The times most critical for water for the durian tree are during flowering and fruiting. In equatorial regions, it needs at least three to four weeks of dry weather without rain to produce flowers to fill all branches. (Farther from the equator as in Hawaii, this may not hold true and day length and temperature may be the primary factors in inducing flowering). Like mango trees, heavy rains and wind during flowering can knock off many of the blossoms, decreasing or even eliminating fruit production that season. When blossoms

are forming, water is sometimes deliberately withheld to enhance flowering. To maximize flower and fruit production, after allowing a 3 to 4 week dry period, growers in Malaysia then begin applying irrigation. Topdressing the trees with organic fertilizer just before flowering also increases production. Various cultivars may have their own unique responses to dry weather and irrigation; for example, the common Malaysian cultivar D24 is sensitive even to short dry spells; the common Thai variety Chanee tends to drop flowers if watered as much as other varieties. An unseasonal drought may provoke durian trees to an out-of-season round of flowering and fruiting.

4.7.7 Pest and disease control (Nirav, n.d.)

As with any plant or tree, the best way to minimize damage of durian trees or fruit by pests or disease is to keep the soil and tree as maximally healthy as possible using modern organic methods. Except for usually light damage by local fruit borers, beetles, and leaf cutters in some areas, the tree and fruit tend to be relatively free of insect pests. *Phytophthora palmivora* is a dreaded fungus disease of durian trees in Southeast Asia. The organism is a primary parasite of durian roots. Symptoms are canker development on the trunk at or just above ground level, and an oozing of brownish-red gum at the collar of the tree, up the trunk and down to the roots, which can result in complete girdling and subsequent death of the tree. The organism gains access to the interior tissues of the tree suitable for its growth through natural or pruning wounds, thus hygienic pruning and using (natural) fungicides are very important to guard against infestation. Grafted trees are said to be particularly susceptible due to cracks that often form in the tree structure due to inherent grafting weaknesses. In Thailand, as previously noted, steps are taken to eliminate a moist microclimate at the base of the tree which might support the growth of *P. palmivora*, such as not using animal manures or mulch, and removing any branches starting to grow below about 1 m (3 feet) height.

Growth of *P. palmivora* in Southeast Asia is also controlled by using cultivars known to be resistant.

4.7.8 Harvesting durians (Nirav, n.d.)

Grafted cultivars generally start bearing at 4 to 6 years after planting in the ground; seedlings usually take from 7 to 10 years but have been known to wait as long as 13 to 21 years—powerful incentives to use vegetative propagation. Durian fruits vary in size and shape depending on variety and completeness of pollination, but most often are oblong and have an average mass slightly larger than a (U.S.-style) football. Fruit weights of 1.5-4 kg are common, but occasionally massive 8 kg (tribal-size) durians are produced. Of the weight of a typical whole durian, only about 15% to 25% is fruit pulp and about 20% is seeds, making it one of the most expensive fruits in the world in terms of its ratio of whole fruit to the part actually edible.

Depending on variety and climate conditions, it may require from about 85 to 150 days for durians to develop after flower pollination, and if not harvested, they will naturally drop from the tree over about a 10-week period. In areas near the equator where there are no defined wet and dry seasons, as in parts of Malaysia and Sumatra, individual trees commonly bear fruit twice a year, with the peaks in June and December. In these equatorial areas, durian trees do not start flowering in response to any seasonal changes in day length or temperature, but rather are stimulated to flower by periods of dry weather. In tropical areas with distinct wet and dry seasons, for example, India and eastern Java, flowering begins near the end of the dry season.

In tropical areas farther than 10º north or south from the equator, flowering normally starts in the spring months, with an annual harvest in mid-summer to autumn. There is a tendency with some trees to bear only every other year, even in areas where twice-a-year fruiting is possible. Initial yield may be 10 to 40 fruits for the first year of fruiting to about 100 fruits for the

sixth year. Yield of up to 200 fruits is common after the 10th year of fruiting. Well-grown, high-yielding cultivars may produce 10 to 15 tons per hectare of durian fruits per year by 10 to 15 years after planting. As durians command relatively expensive market prices even in the areas of Southeast Asia where they are plentiful, it is easy to understand that in that part of the world, people who have more than a few bearing durian trees are considered wealthy.

ใบเตรียมการสอน	แบบฝึกหัดท้ายหน่วยเรียนที่ 4
	หลังจบหน่วยเรียน

Exercise 1:Based on the lesson, briefly answer the following questions:

1) What is horticulture?

_____

2) Give one (1) importance of horticulture to the society. Discuss its importance to the class.

_____

3) Aside from the above-mentioned “favorite vegetables” consumed by Thai people, give additional five (5) vegetables that your group would likely to eat and discuss the benefits of each vegetable.

_____

4) What is the geographical condition suitable to durian cultivation?

_____

5) How can fertilizer be applied to durian trees?

_____

6) How can you grow durian trees?

_____

7) What method should you use to propagate durian trees?

_____

8) How can you apply water to durian trees?

_____

9) How can you care for durian trees?

_____

10) What method is used to control pests, insects, and diseases?

_____

11) How can you harvest durian fruits?

_____

Exercise 2: Based on a title of A VERY BIG FARM, answer these questions:

1. Will this week be busy for Phanuwatt and Ratchapol?

Answer: _____

2. What are they going to do this week?

Answer: _____

3. Who will they go with?

Answer: _____

4. Do they think the visit will be interesting?

Answer: _____

5. What will they do on the farm?

Answer: _____

6. Who always forgets things?

Answer: _____

7. How long will it take to see everything on the farms?

Answer:_____

8. What does the teacher do to help him remember things?

Answer: _____

Exercise 3: Based on the titles of Vegetables" and "Fruits", answer these questions.

1. They are just about the most versatile fruit there is – the juice is more hydrating than water, the soft flesh goes great in desserts, and the nut can be used to make adorable souvenirs.

Answer: _____

2. It has a red, roughly-textured rind that is inedible but easily removed, its inside consists of a layer of sweet, translucent white flesh and has a texture somewhat similar to that of a grape.

Answer: _____

3. The creepy name comes from pattern of the hard, brittle shell, but crack it open to reveal white lobes of flesh that deliver a burst of sweet and sour flavours, and a lot of acidity.

Answer: _____

4. The most controversial fruit on earth, it has a unique tasting fruit, and to its critics, a putrid-smelling, lame duck of a fruit.

Answer: _____

5. It has a high protein content equivalent to that of soybean protein. Fresh, young pods are one of the finest sources of folates.

Answer:_____

6. Its pods are rich sources of phytonutrients like dietary fiber, minerals, vitamins, and anti-oxidants.

Answer:_____

7. It has higher amylose to amylopectin ratio than that in potato.

Answer:_____

Exercise 4: Match the English word to its correct Thai translation.

1) propagation	a) ผลิตภัณฑ์
2) source (noun)	b) การว่างงาน
3) unemployment	c) แหล่งที่มา
4) economic value	d) พืชสวน
5) cultivation	e) อาหาร
6) diet	f) การเพาะปลูก
7) low-calorie	g) คุณค่าทางโภชนาการ

8) produce (noun)	h) การขยายพันธุ์พืช
9) orchard	i) สำคัญ
10) horticulture	j) มูลค่าทางเศรษฐกิจ
11) deficiency	k) การขาด
12) essential	l) สวนผลไม้
13) organic fertilizer	m) กิจกรรมทางการเกษตร
14) climate	n) ภูมิอากาศแถบอบอุ่น
15) agricultural activities	o) ปุ๋ยอินทรีย์
16) nutritional value	p) แคลอรี่ต่ำ
17) temperate-climate	q) ภูมิอากาศ

เอกสารอ้างอิงท้ายหน่วยเรียนที่ 4

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ใบเตรียมการสอน	สรุปกิจกรรมการสอน หลังจบหน่วยเรียน

วิธีสอนและกิจกรรม	1. สอนแบบบรรยายและถามตอบ 2. ให้นักศึกษามีส่วนร่วมในการเรียน การสอน 3. สรุปเนื้อหา	
สื่อการสอน	**เอกสารอ้างอิง**	เอกสารอ้างอิงหมายเลข 1,6,34,36,76-102,112,116,123,125,134,140,144, 149 และ 154
	เอกสารประกอบ	-
	วัสดุโสตทัศน์	สไลด์หน่วยเรียนที่ 4 ทำด้วยโปรแกรม MS PowerPoint
งานที่มอบหมาย	1. Exercises 1, 2, 3 and 4 2. ให้นักศึกษาค้นคว้าเพิ่มเติม	
การวัดผล	1. สังเกตความสนใจ ซักถามรายบุคคล 2. พิจารณางานที่มอบหมาย	

หมายเหตุ

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สัปดาห์ที่ 14	แผนการสอน	รหัสวิชา 03-31-426
Basic Knowledge of Soil Science		หน่วยเรียนที่ 5
		เวลา 180 นาที

ชื่อบทเรียน 5.1 Definition of Soil
5.2 Importance of Soils
5.3 Components of Soil
5.4 Types of Soil
5.5 Soil Profile and Soil Horizons
5.6 Relationships of Soils, Water and Plants

จุดประสงค์การสอน

5.1 รู้ความหมายของดิน
5.1.1 บอกความหมายของดิน
5.2 รู้และเข้าใจความสำคัญของดิน
5.2.1 บอกความสำคัญของดิน
5.2.2 อธิบายความสำคัญของดิน
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5.4 รู้ชนิดของดิน
5.4.1 บอกชนิดของดิน
5.5 รู้หน้าตัดของดิน (soil profile) และช่วงชั้นดิน (soil horizons)
5.5.1 บอกความหมายของหน้าตัดของดิน
5.5.2 บอกช่วงชั้นดิน
5.6 เข้าใจความสัมพันธ์ระหว่างดิน น้ำ และพืช
5.6.1 อธิบายความสัมพันธ์ระหว่างดิน น้ำ และพืช

ใบเตรียมการสอน	หน่วยเรียนที่ 5
	คาบที่ 1

เนื้อหา

5.1 Definition of Soil

Soil is defined as the upper layer of earth in which plants grow, a black or dark brown material typically consisting of a mixture of organic matter, minerals, water and air (Carter, n.d.). Or it is the material found on the surface of the earth that is composed of organic and inorganic material (Gillaspy, 2018). Or it is the loose surface material of the earth in which plants grow (MerriamWebster, n.d.).

5.2 Importance of Soils (eSchoolToday, 2017)

Soils are essential for life. They provide a medium for plant growth and development. They also are a habitat for many living things such as insects and other organisms, act as a filtration system for surface water, carbon store and maintenance of atmospheric gases.

5.2.1 Soils are important as the medium for plant growth and development, because:

1. Soils can hold water and maintain aeration for plant growth and development.
2. Soils can provide the essential minerals and nutrients to the plants.
3. Soils can provide air for gaseous exchange between roots of the plants and atmosphere.
4. Soil can support plant's roots and keep them upright for growth and development.
5. Soils can protect plants from water erosion and other destructive physical, biological and chemical activity.

5.2.2 Soils are important as a habitat for many insects and other organisms, because:

1. Soils are homes for many organisms such as insects to lay and hatch eggs and rodents to give birth to new offspring.

2. Soils are homes to a diverse range of organisms such as earthworms, ants and termites. Soils provide the needed moisture and air for breakdown of soil organic matter.

3. Soils are homes to insects and microbes (very tiny single cell organisms). These insects and microbes live in the soils depending on their food and air available in a specific soil.

5.2.3 Soils are important as a filtration system for surface water, because:

When the rain comes and/or snowmelts, water flows on the earth's surface to water bodies, but much of it soaks and gets infiltrated into the ground. As it continues its way downwards through the many soil layers in the ground, it is filtered from chemicals, dust and other contaminants. This is why underground water(aquifers) is one of the purest sources of water. Filtered water is clean and unpolluted that provides a better plant growth and development.

5.2.4 Soils are important as a carbon store and maintenance of atmospheric gases and are as follows:

Soils regulate atmospheric carbon dioxide (CO_2) by acting as a carbon store. Some organic matter breakdown do not occur completely during humidification (a process where soil organisms form complex and stable organic matter), especially in soils like peat, owing to its high acid and water content. On a global scale, soils contain about twice as much carbon as the atmosphere and about three times as much as vegetation. This results in the accumulation of organic matter in the soil which is high in carbon content. Many other nutrients

including nitrogen and phosphorus are stored, transformed, and cycled in the soil.

5.3 Components of Soil

The four main components of soil are:1) minerals (rocks), 2) air, 3) water and 4) organic material (leaves and decomposed animals) (Figure 5.1). The fifth component of soil, which is always not recognized, is the living world that exists under the ground -- the biological component (DeGomez, 2015). Rich garden soil is 45 percent rocks and minerals, 5 percent organic matter and 25 percent each air and water. All soils have some mixture of the five basic components, and most soils can be amended to improve that composition so it will be more suitable for plant life.

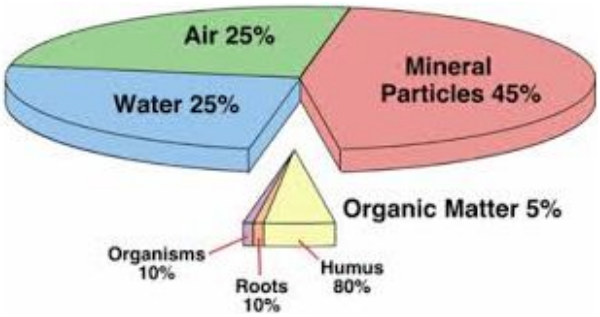


Figure 5.1 The four main components of soil.
Source: Morgan (2018)

5.3.1 Minerals

All soils are composed of sand, silt and clay. Rocks and minerals make up the largest amount of soil's composition. The rocks and minerals found in soil come from nonliving, inorganic materials. Sand comes from small fragments of quartz and other minerals, and by itself is not rich in the nutrients that plants need. Sand is the largest and coarsest of soil particles; water passes through sand more easily than other soil types. Silt is a combination of quartz and other rocks.

Silt particles are smaller than sand but larger than clay. Clay is the richest of soil minerals, containing nutrients like iron, potassium and calcium. The smallest soil particles come from clay, which can become very dense and hard to work (DeGomez, 2015).

5.3.2 Air

Air is not solid or liquid, but a combination of gaseous elements that are found naturally in Earth's atmosphere. In soil, air pockets allow water to pass through the soil and into the plants growing above and below the soil line(DeGomez, 2015).

5.3.3 Water

Water in soil usually contains dissolved salts and other chemicals. Water is an essential part of soil; plants cannot survive without it. Some soils, like clay, retain water much better than others. When water lingers in soil instead of passing through it easily, the soil becomes more densely packed. Some plants cannot grow in heavy, moisture-rich clay soils (DeGomez, 2015).

5.3.4 Organic and biological materials

Decayed plants and animals provide the organic materials found in soil. Through decomposition, organic materials are broken down and turned into nutrients that plants can use. Mineralization also occurs through decomposition, and through this process organic materials become inorganic. The fifth element of soil, the biological world, provides these important organic elements that are so essential. Plants and animals, when they die, become part of the ground once more -- and so the cycle continues. Soil gives life; life gives itself back to the soil (DeGomez, 2015).

5.4 Soil Profile and Soil Horizons

5.4.1 Soil profile

When using a shovel and dig a hole, about 50-70ft vertically downwards into the ground, you will notice that you would have cut through various layers of soil types. A look at the layers from distance gives one a cross-section view of the ground (beneath the surface) and the kinds of soils and ricks it is made up of. This cross-section view is called a soil profile (Figure 5.2).

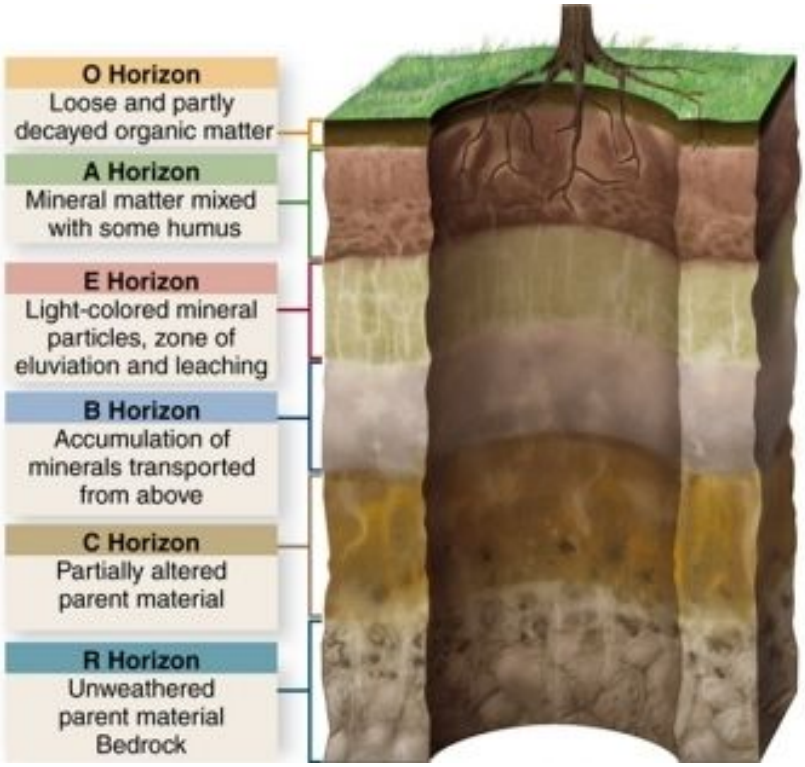


Figure 5.2 Soil profile, each layer of a soil profile is a soil horizon.
Source: Anonymous (n.d.3.)

5.4.2 Soil horizons

The soil profile is made up of layers; each layer of a soil profile is referred

to as a soil horizon. Each horizon may be slightly or very different from the other above or below it. Each horizon tells a story about the makeup, age, color, texture, structure, thickness, as well as its chemical compositions. Thus soil profile differs from soil samples based on its color, texture, structure, thickness, and other soil characteristics. The soil horizons are identified by letters. Most soils have three major horizons. These are A, B and C horizons. Aside these three, there are also the O, E and R horizons. The characteristics of each soil horizon are described as follows (SSSA, n.d.):

O horizon

It is very common in many surfaces with lots of vegetative cover. This layer made up of organic materials such as twigs and fallen trees, dead leaves including surface organisms. It is a layer of loose and partly decayed organic matter.

A horizon

The A horizon is known as the topsoil. This horizon may be seen in the absence of the O horizon. Typically, the A horizon is the top layer soil made of mineral matter mixed with some humus, sand, silt, clay with high amounts of organic matter thus it is the root zone layer and good for many grasslands and agricultural lands. However, this layer is vulnerable to wind and water erosion.

E horizon

The eluviation and leaching always occur in this layer. Eluviation is the transport of soil material from upper layers of soil to lower levels by downward precipitation of water across soil horizons, and accumulation of this material in lower levels. Leaching refers to the loss of water-soluble plant nutrient from the soil due to rain and irrigation. Thus it has usually

the light-colored mineral particles.

B horizon

This horizon is formed below the O, A, and E horizons and contains high concentrations of iron, aluminum, carbonates and silicate clay. It is also called the illuviation zone due to the accumulation of minerals. The B horizon is the layer in which the roots of big trees may end.

C horizon

This horizon lacks all the characteristics of the layers above it. It has no organic material and it is mainly made up of broken bedrock - cemented sediment and geologic material. There is little activity here although additions and losses of soluble materials may occur. The C horizon is also known as saprolite. This is a chemically weathered rock.

R horizon

This horizon is bedrock, material, cemented and compacted by the weight of the overlying horizons. Rock types including granite, basalt and limestone found here. The R horizon is the unweathered parent material.

5.5 Types of Soil

There are three basic types of soil: sand, silt and clay (Figure 5.3). But most soils are composed of a combination of the different types. The characteristics of each soil type are as follows:

5.5.1 Sand

Sandy soil or sand is actually small particles of weathered rock (Figure 5.4A). It is gritty feel. Its degree of aeration depends on the sizes of the particles,

which vary a lot in size. It is usually formed from the weathering or disintegration of bedrock such as shale, limestone, granite and quartz. Sand is fairly coarse and loose so water is able to drain through it easily. Sand is the largest of the soil particles. Each particle is just a small piece of gravel ranging in size from 2.00mm down to 0.05mm (Figure 5.5). Since sand is just small gravel it drains like gravel and does not do a good job of holding nutrients or water (Grover, A. 2017).

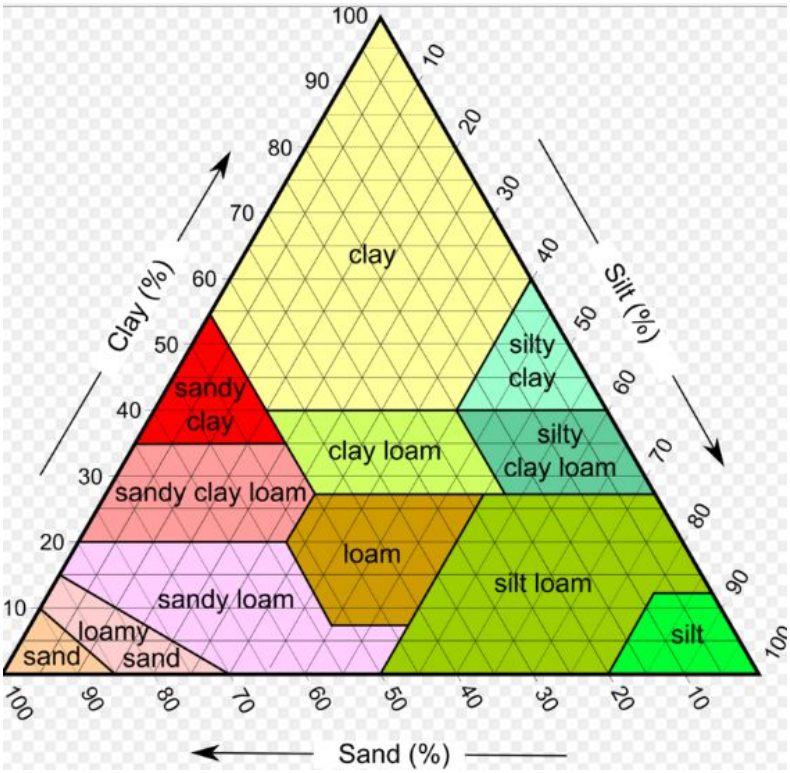


Figure 5.3 Soil types by clay, silt and sand composition as used by the United States Department of Agriculture.

Source: USDA (2011)

A B C D

Figure 5.4 Soil types: A. Sand; B. Silt; C. Clay; D. Loam.

Source: Google Image (n.d.)

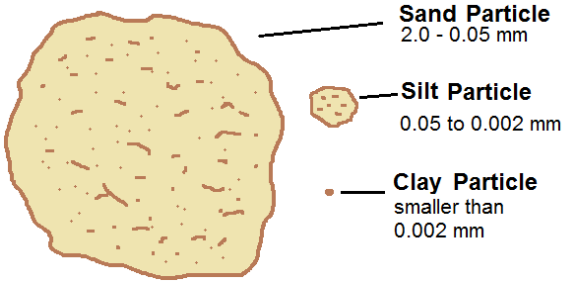


Figure 5.5 Soil particle size for sand, silt and clay.

Source: Google Image (n.d.)

5.5.2 Silt

Silty soil or silt is finer, smoother in texture and hold water better than sandy soil (Figure 5.4B). It is formed when fine sediments (dust, organic matter and debris) are carried by water or ice and deposited. Silt is a medium sized particle ranging from 0.05mm down to 0.002mm (Figure 5.5). If you were to hold a handful of dry silt in your hand, it would feel almost like flour. If you were to add water to the silt in your hand, it would do a fair job of holding the water and feels slick and smooth. It also holds up nutrients and make it better

for crop cultivation. Silty soil is heavier than sandy soil, and almost midway between the properties of sandy and clay soil (Grover, A. 2017).

5.5.3 Clay

Clay soil or clay is very fine-grained soil and it binds very well (Figure 5.4C). It has very little air spaces as its particles are even smaller than silt. Therefore, clay does not drain well or provide space for plant roots to flourish. If you were a farmer, you would not want your field to be mostly clay. However, if you were a potter, you would think clay was the best type of soil. When moisture is added to clay, it can be molded into shapes, such as a pottery bowl or a building brick. Clay is the smallest of the soil particles and usually has a unique shape. Most clay has a flat shape that is more like a piece of paper or sheet metal. This special shaping gives it a huge amount of surface area for nutrients and water to stick to, making clay one of the best soils to grow plants in. Since clay is smaller than 0.002mm (Figure 5.5), water drains out very slowly. Clay particles are also linked in the soil in very convoluted patterns making it even more difficult to drain, but even so, many clay soils still have good drainage and don’t cause problems with the plants (Grover, A. 2017).

5.5.4 Loam

Loamy soil or loam is considered as a fourth type of soil, even though it is really a combination of sand, silt and clay (Figure 5.4D). Loam will vary depending on how much of each component is present, but generally if you are a gardener, this is the type of soil you want because it holds moisture, but also allows for good drainage. If you were to hold loam in your hand, you could mold it into a ball, but the ball would easily crumble when disturbed. Loamy soil is high in calcium, aeration and ideal for most crops and vegetables. It is the soil all farmers dream of, as it is full of nutrients from decomposed organic material. It

is soft and easy to cultivate (Finch et al., 2014).

5.6 Relationships of Soils, Water and Plants

There are many ways of water loss from soils and plants. Soil water lost by percolation, seepage, drainage, and evaporation including the plants absorbed water from the soil and so on. Whereas water loss from the plants though a process of transpiration. Percolation (P) is the vertical flow of water from the ponded water layer to below the root zone to the water table. Seepage (S) is a lateral subsurface flow. Drainage (D) is defined as field is drained during the late maturity stage of crop to facilitate the grain filling, maturity and lodging reduction, and the field is over flow due to heavy rain. Evaporation (E) is defined as the 'unproductive' loss of water from the soil surface to the atmosphere. Transpiration (T) is defined as the 'productive' loss of water by the plants to the atmosphere through stomates. Quite frequently the terms E and T are put together. The sum of T and E is called evapotranspiration, as it is quite troublesome to separate E and T when measuring the balance in the field. Only E takes place during land preparation, whereas both E and T occur during the crop growth period. During early growth stage, canopy is not dense and sufficient to cover the ground and soil is exposed to radiation which results in high E and low T. Amount of E decreases with time because soil is covered with crops when T increases with increasing leaf area index (LAI). During senescence, E increases again along with reducing of T, and finally only E takes place after harvest.

Soil texture has also a strong effect on soil fertility level and water productivity in irrigated rice ecosystems. The higher the clay content of the soil, the greater the soil fertility and water availability because light-textured soils are characterized by higher water and nutrient losses through percolation. Similarly percolation in clay and sandy soils varied from 1 – 4 mm and 24 – 29 mm per day, respectively (Gunawardena, 1992). Thus higher soil fertility, soil moisture and crop yields were observed in the lower positions of the toposequence as compared with those in the higher positions.

Soil texture has strong influence on the magnitude of seepage and percolation losses. The total daily water consumption including evaporation (ET)were of 27 mm/day on sandy soils, clay loam (15mm/day) and of clay (13 mm/day). Total water use of 10,14,17,23, and 27 mm/day for clay, clay loam, loam, sandy loam, and sandy soils, respectively. Percolation is assumed to be the main component in sandy soils, and seepage dominates in clay and clay loam soils. Percolation losses are successively smaller for sandy soils, sandy loams, and heavy clay soils (Gupta and Bhattacharya, 1963).

Water input can be reduced by reducing ponded water depths to soil saturation or by alternate wetting/drying. Water savings under saturated soil conditions were on average 23% (±14%) with yield reductions of only 6% (±6%). Yields were reduced by 10-40% when soil water potentials in the root zone were allowed to reach -100 to -300 mbar. In clay soils, intermittent drying may lead to shrinkage and cracking, thereby risking increased soil water loss, increased water requirements and decreased water productivity. Water productivity in continuous flooded rice was typically 0.2 – 0.4g grain per kg water in India and 0.3-1.1 g grain per kg water in the Philippines. Water-saving irrigation increases water productivity, up to a maximum of about 1.9g grain per kg water, but decreases yield. It therefore does not produce more rice with less water on the same field. Field-level water productivity and yield can only be increased concomitantly by improving total factor productivity or by raising the yield potential. Total rice production can be increased by using water saved in one location to irrigate new land in another. If this is not done, a strategy of saving water at the field level potentially threatens total rice production at large.

It is clear that soil water movement is often not purely seepage or percolation, but a combination of both. There are many aspects of soils that influence the S and P rates of soil beyond the root zone (the top 25 to 30 cm of soil in most lowland conditions). Soil structures like prismatic, blocky**,** and columnar have macro soil porosity. Therefore, downward movement of water (or percolation) and seepage are

higher in those soils. Similarly, soil structures like granular, massive soil and single grain soils have micro soil porosity. Therefore, downward movement of water (or percolation) and seepage is lower in those soils. Thus, the effects of structure in wet soils are closely associated with porosity which is affected by the puddling of the soil.

Drying and shrinking of many puddled soils causes cracking. High percolation losses are expected when cracked soils are first flooded. In clay soils, the development of cracks is strongly affected by drying temperature, and their width and depth are linearly related to temperature (Fujioka and Sato, 1968a,b). Some soils containing substantial clay and organic colloids have great expansion and contraction capacity. Surface cracks formed during water shortage results in sudden increase in the percolation as the number and size of cracks increase. In the absence of tillage, cracking is irreversible, thus cracks that develop after the crop is planted do not usually disappear because lines of cleavage remain intact (Goto and Kobayasi, 1960).

Increased bulk density reduces percolation losses of water through non-puddled soils and through puddled soil with compacted subsoils (Ghildayal and Satyanarayana, 1965). Bulk density increase from 1.46 to 1.68 g cm^{-3}, percolation decreased from 110 to 14 mm day^{-1} and hydraulic conductivity decreased from 2.05 to 0.16 cm hr^{-1} on non-puddled lateritic sandy clay loam soils in India (Pande, 1976).

The lattice structure of clays has an important effect on the extent of soil puddling, and therefore on the seepage and percolation rate. Kaolinite (1:1 type clay), which swells relatively little and therefore has little change in interaggregate cohesion upon flooding, is difficult to puddle thoroughly (Buehrer and Rose, 1943) and it also allows for higher S and P losses. Montmorillonite exhibits substantial inter layer swelling when wet, which tends to decrease interaggregate cohesion. Such soils can be puddled more thoroughly, which contributes to reduced seepage and percolation losses. Sodium saturated clays are easier to puddle than calcium saturated clays, which affects water movement (McGeorge, 1937).

It is generally believed that the addition of organic matter improves soil structure and increases percolation in lowland soils. An increased aggregation in rice soils with organic manuring (Biswas et al., 1970). No effect of organic matter alone on the degree of aggregation, but significantly greater aggregation with organic matter and subsurface drainage. A decrease in aggregate stability with increased soil depth and explained it by a reduction in organic matter content at greater soil depths (Kawaguchi and Kita, 1958a). Contrary to those findings, as that addition of fresh organic matter have neutral or detrimental effects in regenerating structure in puddled soils.

To maintain yield, alternate wetting and drying irrigation system (AWD) appears to be promising because of its high water productivity with the lowest penalty to grain yield. In trials conducted in China and the Philippines, reported savings in water for AWD range from 13% to 30%, with no significant reduction in yield (Cabangon et al., 2001; Belder et al., 2002). Two major factors, the use of inappropriate rice genotypes and inadequate weed management, appear to be responsible for yield loss under AWD (Tabbal et al., 1992; Shi et al., 2002). The water productivities of hybrid rice genotype (IR78386H) under conventional continuous flooding (CF) irrigation method were 1.36, 1.04, 0.30, 0.40, and 0.39kg grain m^{-3} water while for the inbred (PSB Rc80) were 1.35, 1.03, 0.24, 0.32, and 0.46kg grain m^{-3} water in clay loam, clay, loam, sandy loam, silt loam soils, respectively. The water productivity under alternate wetting and drying irrigation method when the perched water table is 20cm below the soil surface (AWD20) were higher than CF in sandy loam and loam soils. Grain yield under AWD20 increased by 7.3% and water productivity increased by 78% due to the reduction in water used by 38.4% in sandy loam soil. The irrigation water use under AWD20 to produce 1 kg of unmilled rice was 2140L. The inbred genotype was more adapted to AWD20 irrigation method than the hybrid genotype. Savings in water use under alternate wetting and drying irrigation method when the soil moisture tension at 15cm below soil surface reaches 30

kilopascal (AWD30) were about 53% in sandy loam and 40% in silt loam soil textures but grain yields of 2 rice genotypes decreased by 40% under sandy soil condition and reduced by about 50% in silt loam. AWD30 irrigation method is not advisable to be adopted by rice farmers in the light-textured soils (Wiangsamut et al., 2013).

Exercise 1: Work with a group and briefly answer the following questions:

1) 1) Define “soil”.

_____

2) Why is soil important? Enumerate three (3) importance.

_____

3) Define a “soil profile”.

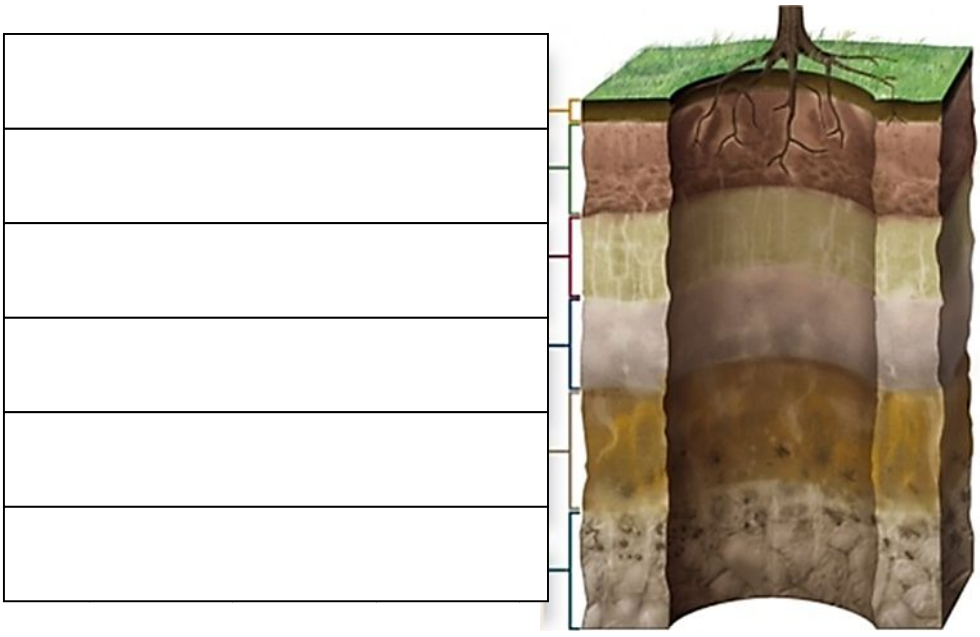
_____

4) What is soil horizon?

_____

5) In your own native language, identify and explain the different layers of a soil horizon.

_____



6) Explain the relationships of soils, water and plants.

_____

Exercise 2: Identify the correct word or phrases that best describes each sentence.

1) Components of soil that are composed decayed plants and animals that provide the organic materials in the soil.

_____

2) Components of soil that is not solid or liquid, but a combination of gaseous elements that are found in Earth's atmosphere.

_____

3) Components of soil that is all soils that are composed of sand, silt and clay.

_____

4) Components of soil that is the most essential; plants cannot survive without it.

_____

5) The soil layer that has the light-colored mineral where eluviation and leaching always occur.

_____

6) The soil layer that is bedrock, material, cemented and compacted by the weight of the overlying horizons; also known as the unweathered material.

_____

7) This soil layer is made up of organic materials such as twigs and fallen trees, dead leaves including surface organisms; commonly found in surfaces with lots of vegetative cover

_____

8) This soil layer is known as saprolite; it has no organic material and it is mainly made up of broken bedrock - cemented sediment and geologic material.

_____

9) The soil layer known as the topsoil; made of mineral matter mixed with some humus, sand, silt, clay with high amounts of organic matter.

_____ _____

10) The soil layer that is formed below the O, A, and E horizons and contains high concentrations of iron, aluminum, carbonates and silicate clay.

_____

Exercise 3: Match each English word to its correct Thai translation. Choose the correct answer from the boxes below.

1) mineralization -	9) filtration system -
2) composition -	10) layer (noun) -
3) dig (verb) -	11) component -
4) clay -	12) gaseous element -
5) Earth's atmosphere -	13) particles (noun)
6) loamy -	14) sandy -
7) texture -	15) soil -
8) hole (noun)	16) silt

a) ชั้นบรรยากาศของโลก	i) ธาตุที่มีสถานะเป็นแก๊ส
b) องค์ประกอบ	j) ขุด
c) ชั้น	k) ส่วนประกอบ
d) ทราย	l) ระบบการกรอง
e) การเปลี่ยนเป็นแร่ธาตุ	m) อนุภาค
f) ดินร่วน	n) ดินเหนียว
g) เนื้อดิน	o) ทรายแป้ง
h) หลุม	p) ดิน

เอกสารอ้างอิงท้ายหน่วยเรียนที่ 5

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ใบเตรียมการสอน	สรุปกิจกรรมการสอน หลังจบหน่วยเรียน

วิธีสอนและกิจกรรม	1. สอนแบบบรรยายและถามตอบ 2. ให้นักศึกษามีส่วนร่วมในการเรียน การสอน 3. สรุปเนื้อหา	
สื่อการสอน	**เอกสารอ้างอิง**	เอกสารอ้างอิงหมายเลข 7,14,15,18-20,25,27,32,33,35,37,38,103,105-107,119,131,133,136,142,152,156,157,167 และ 168
	เอกสารประกอบ	-
	วัสดุโสตทัศน์	สไลด์หน่วยการเรียนที่ 5 ทำด้วยโปรแกรม MS PowerPoint
งานที่มอบหมาย	1. Exercises 1, 2 and 3 2. ให้นักศึกษาค้นคว้าเพิ่มเติม	
การวัดผล	1. สังเกตความสนใจ ซักถามรายบุคคล 2. พิจารณางานที่มอบหมาย	

หมายเหตุ

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สัปดาห์ที่ 15	แผนการสอน	รหัสวิชา 03-31-426
Reading Academic Sources		หน่วยเรียนที่ 6
		เวลา 180 นาที

ชื่อบทเรียน 6.1 Definition of Academic Sources
6.2 Types of Academic Sources
6.3 Tips and Instructions for Reading
6.4 Types of Reading Skills

จุดประสงค์การสอน

6.1 รู้ความหมายของแหล่งข้อมูลทางวิชาการ
6.1.1 บอกความหมายของแหล่งข้อมูลทางวิชาการ
6.2 รู้ประเภทของแหล่งข้อมูลทางวิชาการ
6.2.1 บอกประเภทของแหล่งข้อมูลทางวิชาการ
6.3 รู้เคล็ดลับและคำแนะนำในการอ่าน
6.3.1 บอกเคล็ดลับและคำแนะนำในการอ่าน
6.4 รู้และเข้าใจประเภทของทักษะการอ่าน
6.4.1 บอกประเภทของทักษะการอ่าน
6.4.2 อธิบายประเภทของทักษะการอ่าน

ใบเตรียมการสอน	หน่วยเรียนที่ 6
	คาบที่ 1

เนื้อหา

6.1 Definition of Academic Sources

An academic (or scholarly) source is defined as the quality of a work of writing which seeks to clarify, explain and extend concepts belonging to the topic and discipline. When researching a topic for a university assignment, 'academic' sources are preferred over other types of writing. They carry more weight and authority, and are likely to be more convincing (Monash University, 2017). To identify an academic source, one must look into its qualities such as:

Authoritative - academic sources identify the qualifications and expertise of the writer. A source written by a recognised expert in a field is more likely to be trustworthy;

Sourced - academic writing is careful to credit the origins of information and ideas, usually by means of a reference list or bibliography;

Peer-reviewed - other academics have read the source and checked it for accuracy. Before publication in an academic journal, for example, an article is checked by a panel of referees. Academic books are checked by editors and other reviewers;

Objective - academic sources aim to examine a topic fairly. This does not mean that they never take a side, but that the source does not ignore alternative positions on the topic;

Written for academics - academic sources target university lecturers, students, and professionals interested in the theoretical side of a topic.

6.2 Types of Academic Sources (Massey University, 2012)

The most common forms of academic sources are:

1. books
2. journal articles

3. published reports

Sources such as newspaper articles, magazine articles and trade journals, newsletters, opinion pieces, journals published weekly or more frequently, articles that have no bibliography and websites are not commonly academic, although there are some exceptions.

Academic journals are very different from popular magazines, although they bear several similarities. To identify an academic source, apply the criteria listed above:

- What are the qualifications of the author? Academic authors are likely to come from a university or institute, and academic writing is often published by a university press.
- Are sources listed? Look for a reference list or bibliography.
- Has the writing been peer-reviewed? Peer-reviewed journals will have an editorial board or committee listed, or will provide instructions to authors that describe a standard peer review.
- Is the writing objective? Sources that are blatantly one-sided are unlikely to be academic.
- Who is the target audience? Consider the style of the writing, the presence of advertising, and where you found the source (Massey Library has a more comprehensive selection of academic sources than public libraries, for example).

It can help to consider the purpose of the source. Academic writing aims to inform. It does not aim to sell something or present one person's opinion independent of evidence or logic.

In order to correctly reference material, you first need to identify the type of source (Massey University, 2014): is it a book, a journal, or something else?

Books

Books are printed and bound documents on a particular topic or set of topics. Most books are written by either one person or a small group of people, but there are exceptions to this such as: edited books (books containing writing by several different authors), conference proceedings (books that collect many different presentations and papers from an actual meeting, conference, or symposium), encyclopedias, and dictionaries (collections of a number of small articles or definitions often on a single topic).

Journals

Journals are periodically published collections of articles on a particular subject, similar to a magazine or newspaper. However, the target audience of a journal is usually academic, professional, or technical. Journals represent the cutting edge of research in a field: pioneering studies and analyses are published here first. When writing an assignment, journal articles are more likely to be comprehensive and useful than general magazine articles. Many academic journals are available online, either directly or through the library's article databases.

Published reports

These refer to publications that you are less likely to find in a library: institutional reports, brochures, press releases, etc. They are usually more difficult to access than books or journal articles, and are less likely to be useful for academic assignments.

6.3 Tips and Instructions for Reading

Reading is an important part of learning English, but many students find it difficult. Below are tips that will help improve reading by using skills anyone uses in his/her own language (Pappa, 2015).

6.3.1 Read for gist

Gist is the main idea/s. Read the text for the first time. Don't stop. Read to understand the main ideas, and don't look up for new words. You'll be surprised that you can usually understand the general idea of the story.

6.3.2 Use context

Context refers to words and situations that are around a word you don't understand. Look at the example sentence:

"I went to the Chowking to buy some chitia for dinner."

*What's 'Chowking'? - - It must be a store because you bought something there.

*What's 'chitia'? - - It must be food because you are going to eat it for dinner.

6.3.3 Use your own language

One of the best tips on improving reading is to think about how you read in your own language. Start by thinking about how you read different documents. How do you read the newspaper? How do you read novels? How do you read train schedules? And so on. Taking time to think about this will help give you clues on how to read in English - even if you don't understand every single word. Ask yourself this question: Do I read every word in my own language when I am reading a schedule, summary, or other outlining document? The answer is most definitely: No!

Reading in English is like reading in your native language. This means that it is not always necessary to read and understand each and every word in English. Remember that reading skills in your native language and English are basically the same.

6.3.4 Understand the different reading skills

Here is a quick overview of the four types of reading skills used in every language:

a. Skimming –reading rapidly for to understand the "gist" or main idea;
b. Scanning –reading rapidly to find a particular piece of information;
c. Extensive reading –reading a longer text for pleasure and general understanding;
d. Intensive reading –reading a short text accurate reading for detailed information.

6.4 Types of Reading Skills (McDonald, 2012)

6.4.1 Skimming

Skimming is used to quickly gather the most important information, or 'gist'. This skill is also called “gist reading”. To apply this reading skill, run your eyes over the text, noting important information. Use skimming to quickly get up to speed on a current business situation. It's not essential to understand each word when skimming.

Examples of Skimming:

- The newspaper (quickly to get the general news of the day)
- Magazines (quickly to discover which articles you would like to read in more detail)
- Business and travel brochures (quickly to get informed)

6.4.2 Scanning

Scanning is used to find a particular piece of information. Run your eyes over the text looking for the specific piece of information you need. Use scanning on schedules, meeting plans, etc. in order to find the specific details

you require. If you see words or phrases that you don't understand, don't worry when scanning.

Examples of Scanning:

- The "What's on TV" section of your newspaper.
- A train / airplane schedule
- A conference guide

6.4.3 Extensive reading

Extensive reading is used to obtain a general understanding of a subject and includes reading longer texts for pleasure, as well as business books. Use extensive reading skills to improve your general knowledge of business procedures. Do not worry if you understand each word.

Examples of Extensive Reading:

- The latest marketing strategy book
- A novel you read before going to bed
- Magazine articles that interest you

6.4.4 Intensive reading

Intensive reading is used on shorter texts in order to extract specific information. This skill is also known as “narrow reading.” It includes very close accurate reading for detail. Use intensive reading skills to grasp the details of a specific situation. In this case, it is important that you understand each word, number or fact.

Examples of Intensive Reading:

- A bookkeeping report
- An insurance claim
- A contract

Exercise 1: Identify the words being described in each sentence. Choose the correct answer from the box on the next page.

1) It is a reading technique that is sometimes referred to as gist reading; or to know what the text is about at its most basic level.

2) These refer to publications that are less likely to find in a library and are usually more difficult to access than books or journal articles.

3) It is defined as the quality of a work of writing which seeks to clarify, explain and extend concepts belonging to the topic and discipline.

4) It is a reading skill that is quick and focusing on locating specific information.

5) They are printed and bound documents on a particular topic or set of topics.

6) They are periodically published collections of articles on a particular subject, similar to a magazine or newspaper but the target audience is usually academic, professional, or technical.

7) This reading skill is sometimes called "narrow reading" and involves reading selections by the same author or several texts about the same topic.

8) It is a reference list, or a list with all of the names of all authors.

9) This reading skill is known as “pleasure reading” with aims to build reader’s confidence and enjoyment.

10) It is the skill or activity of getting information from written words.

11) A skill to read to understand the main ideas, and not look up for new words.

12) This refers to words and situations that are around a word you don't understand.

13) One of the best tips on improving reading.

read for gist	skimming	published reports
intensive reading	bibliography	using your own language
academic source	books	scanning
reading	author	collection
journals	use of context	extensive reading

Exercise 2: Match the English word to its Thai translation.

1) objective (adj)	a) ที่อยู่บนพื้นฐานของความเป็นจริง ไม่ลำเอียง ยุติธรรม
2) website	b) หน้าเว็บเพจหลายหน้า ซึ่งเชื่อมโยงกันผ่านทางไฮเปอร์ลิงก์ ส่วนใหญ่จัดทำขึ้นเพื่อนำเสนอข้อมูลผ่านคอมพิวเตอร์ โดยถูกจัดเก็บไว้ในเวิลด์ไวด์เว็บ
3) reading skills	c) ทักษะการอ่าน
4) sourced (adj)	d) ซึ่งอ้างอิงแหล่งข้อมูลได้
5) researchers (noun)	e) นักวิจัย
6) peer-reviewed (adj)	f) ซึ่งได้รับการควบคุมและตรวจสอบคุณภาพ
7) (to) research (verb)	g) ทำการวิจัย
8) gist reading	f) การอ่านเพื่อจับใจความสำคัญ
9) journals	h) วารสาร
10) author (noun)	i) ผู้เขียน
11) academic (adj)	j) เชิงวิชาการ
12) narrow reading	k) เลือกอ่านเฉพาะที่ตนเองสนใจ
13) authoritative (adj)	l) ซึ่งเชื่อถือได้
14) published (adj)	m) ซึ่งถูกตีพิมพ์
15) gist (n)	n) ใจความสำคัญ

เอกสารอ้างอิงท้ายหน่วยเรียนที่ 6

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ใบเตรียมการสอน	สรุปกิจกรรมการสอน หลังจบหน่วยเรียน

วิธีสอนและกิจกรรม	1. สอนแบบบรรยายและถามตอบ 2. ให้นักศึกษามีส่วนร่วมในการเรียน การสอน 3. สรุปเนื้อหา	
สื่อการสอน	**เอกสารอ้างอิง**	เอกสารอ้างอิงหมายเลข 127-129,135 และ 143
	เอกสารประกอบ	-
	วัสดุโสตทัศน์	สไลด์หน่วยเรียนที่ 6 ทำด้วยโปรแกรม MS PowerPoint
งานที่มอบหมาย	1. Exercises 1 and 2 2. ให้นักศึกษาค้นคว้าเพิ่มเติม	
การวัดผล	1. สังเกตความสนใจ ซักถามรายบุคคล 2. พิจารณางานที่มอบหมาย	

หมายเหตุ

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สัปดาห์ที่ 16	แผนการสอน	รหัสวิชา 03-31-426
Reading Academic Articles		หน่วยเรียนที่ 7
		เวลา 180 นาที

ชื่อบทเรียน 7.1 Definition of Academic Articles
7.2 Importance of Academic Articles
7.3 Guideline in Reading Academic Articles

วัตถุประสงค์การสอน

7.1 รู้ความหมายของบทความทางวิชาการ
7.1.1 บอกความหมายของบทความทางวิชาการ
7.2 รู้ความสำคัญของบทความทางวิชาการ
7.2.1 บอกความสำคัญของบทความทางวิชาการ
7.3 รู้หลักเกณฑ์ในการอ่านบทความทางวิชาการ
7.3.1 บอกหลักเกณฑ์ในการอ่านบทความทางวิชาการ

ใบเตรียมการสอน	หน่วยเรียนที่ 7
	คาบที่ 1

เนื้อหา

7.1 Definition of Academic Articles

An article is defined as a piece of writing that is published in a newspaper, magazine, or other publication such as research articles, books and book chapters (Towson University, 2015). A book means an author wrote the entire book, and then provided a reference for the whole book. Book chapter, on the other hand, means the chapter comes from a book where each chapter is written by different authors (and the whole thing is put together by an editor), then provide a separate reference for each chapter that readers used (Lee, 2011). A research article is a written paper that illustrates an outcome of scientific research with supporting experimental data. Academic (or scholarly) articles are defined as articles that have been peer-reviewed before they are published. This means that experts in the field of study will review and approve the article before the journal will publish it such as the research articles (University of Reading, n.d.).

7.2 Importance of Academic Articles

The purpose of articles published is to share authors' findings or new knowledge with others. These findings or new knowledge were utilized by the teachers at schools and universities for teaching their students in a classroom where students could sit around a table with a teacher who would talk with them and instruct them by a sort of tutorial or conference method, where each student would feel encouraged to speak up. This would be a real revolution in methods. The students sit around the table, with the teacher among them, but in no ‘prime’ position. All students can make eye contact with each other, and for much of the lesson they lead the discussion with the teacher contributing at key moments to add structure and direction. Importantly, the students come to the lesson having completed ‘prep’ in advance: they do the work independently, and then they share. Others learn, including the teacher. The shared

aims of this partnership is to offer school-to-school support, both for staff and students, to spread good practice, to use technology in a meaningful (and cost-effective way), to use evidence-based research to underpin approaches to teaching and learning, and fundamentally, to learn from each other (James, 2013).The importance of articles submitted to journals usually appears in print faster than books or book chapters, and continue to be accorded greater influence in promotion and tenure decisions within academia than alternative means of distributing information. Articles published in peer reviewed journals are likely to remain very important means of distributing research findings for the foreseeable future (Thyer, 2018). Magazines and newspapers are articles but not considered as academic articles. Academic journals (also known as periodicals or serials) publish the world's most recent research in all disciplines. Magazines are primarily designed to entertain as well as inform. Newspapers are also primarily designed to inform and also entertain. Following is a list of the difference between academic journals, magazines and newspapers (Table 7.1).

Table 7.1 Difference between academic journals, magazines and newspapers.

Academic Journals	**Magazines or Newspapers**
Each article is peer-reviewed (critically evaluated by a board of experts in the discipline) before publication. Note: Book reviews are not peer reviewed.	Articles are not peer-reviewed.
Usually published by professional organizations and societies, or large publishers that specialize in academic publications.	Informative in a general manner and are published by commercial organizations for broad audiences.

Table 7.1 Continued...

Academic Journals	**Magazines or Newspapers**
Articles are usually structured and may include sections such as abstract, literature review, methodology, results and conclusion.	Articles do not usually follow a particular structure.
Articles are all written by scholars in a particular discipline who have done extensive research in their field. The language of the article is geared towards other scholars in the same field.	Articles are written by staff writers or freelance journalists. The authors make no assumptions about the background knowledge of the reader and the language is non-technical.
Every article contains cited references: footnotes or bibliographies, reference lists or works cited.	Articles typically do not contain cited references.
Journal articles report actual research findings and/or review key principles and assumptions.	Articles report briefly on news items or subjects of interest to the general public.
Appearance is very formal and serious-looking and often contains graphs and charts and no glossy pictures.	Magazines: Appearance is eye-catching and full of glossy images (e.g., photographs, cartoons, advertisements). Newspapers: Appearance is eye-catching and full of images (e.g., photographs, cartoons, advertisements) but usually printed on matte newsprint, not glossy paper.

Source: MacOdrum Library (2018)

Nowadays, academic journals are often divided into two categories: 1) the so-called international journals, typically published in English, and 2) national and local journals, published in a language other than English. The international journals are important for worldwide people can retrieve the information as English is the central language for people in the world; while it is only the native people in each country can understand their own national and local journals (Lariviere, 2014).

7.3 Guidelines in Reading Academic Articles

Reading a scientific article as academic article is a complex task. Readers have to take notes and read it multiple times, and probably go look up other articles in order to understand some of the details. Reading a single article may take readers a very long time at first but be patient with yourself. The process will go much faster as readers gain experience. In case, readers are interested to read a research article, they should be able to answer the following questions:

7.3.1 What is a research article?

When students have found an article on their topic, it is useful for them to evaluate the article. For instance, has it been published in a scholarly publication? A research article is a written paper that illustrates an outcome of scientific research with supporting experimental data as earlier abovementioned. This differs from other types of informative articles, such as research papers or magazine features, which typically address the topic in a general scope as a means of introduction. A research article, on the other hand, is written by and for researchers for the purpose of making specific findings known to the scientific community at large (WiseGeek, 2018). In fact, rather than appearing in a consumer or industry publication, a research article is found exclusively in a peer-reviewed scientific or agricultural journals, such as The International Journal of Agricultural of Technology, *ISHS (International Society for Horticultural Science) ActaHorticulurae*, for example.

Another key difference between other papers and a research article is that the latter strictly presents facts, rather than serve as a letter of opinion or a summary of the existing scientific literature. However, most scientific journals simultaneously publish such letters, as well as reviews of the body of existing research methods and findings (WiseGeek, 2018).

7.3.2 Where can you find a research article?

You can find a research article in a library's computers that generate article lists, based on the search criteria.Most articlescan be found published in a bound journal that is located on the shelves of a library (the library will have a list of journals it holds). Simply find the right volume on the shelf and go to the correct page. Most researchers like to photocopy the entire article, but taking notes is an easier method. Be sure to record page numbers and other information needed for citations. Articles can be accessed via interlibrary loans (a process where a printed copy of any article can be requested) as the library may hold a number of bound journals, but no library contains every journal published. Libraries buy subscriptions to articles that they think their visitors will be most interested in finding. If you discover an article that exists only in printed form, but it is not in your own library, you are still OK. A library official will help you by contacting another library and ordering a copy. This process takes a week or so, but it is a lifesaver (Cornell University Library, 2018).

Another great way to access academic papers is through “Google Scholar”. It is a search tool via an internet connection that finds scholarly articles - academic journals, patents, theses/dissertations, court proceedings, and more. Google Scholar displays how many times an academic piece of literature was cited, which is a rough numerical indicator of how influential the research was. Google Scholar also has link under each posting to help you find related articles such as a research article as well. To use it, enter the topic and the word

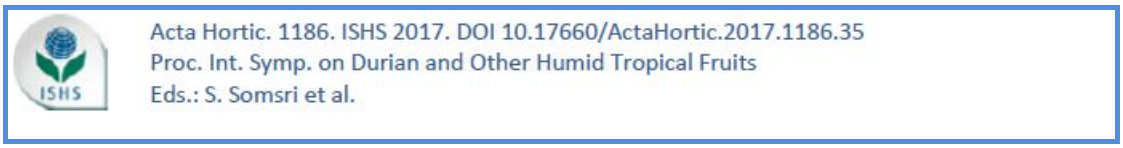
"journal" in the search box; enter the word journal to avoid getting research from books (University of South Australia, 2018).

7.3.3 What to Look for in a Research Article.

As mentioned above, a research article will usually include the: abstract, literature review (the section reviews literature related to the focus of the article which provides a background to the area of research and also shows how other work in the field informs the paper), methodology, results, discussion of the results, conclusion, and bibliography or reference list.

7.3.4 Identify the parts (structures) in a research article.

Below is an example of a research article from an online agriculture publication "ActaHorticulturae", an international society for horticultural science researches (Wiangsamut et al., 2017).



a) Title

The title should be specific and indicate the problem the research project addresses using keywords that shall be helpful in literature reviews in the future. Typically, the title of the article is concise and informative. It is written clearly and concisely describing the contents of the research.

A survey of information on producers, production and marketing systems of salak fruit in Chanthaburi Province, Thailand

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[1]Faculty of Agro-Industrial Technology, Rajamangala University of Technology, Klung, Chantaburi, Thailand; [2]Chanthaburi Horticultural Research Center, Klung, Chantaburi, Thailand.

b) Abstract

The abstract should be used by readers to quickly review the total content of the paper. The abstract should be written as a single paragraph, typically strict word limits on abstracts, such as 200 or 300 words, making them a challenge to write. The abstract should provide a complete synopsis of the research paper. It should introduce the topic and the specific research question, provide a statement regarding methodology and should provide a general statement about the results and the findings. Because it is really a summary of the entire research paper, it is often written last.

Abstract

Information on salak fruit (or snake fruit) producers was gathered from Mueang, Khlung, Tha Mai, Na Yai Am and Khao Kitchakut districts in Chantaburi. Each district comprised about 10 producers, totalling 50 producers. Only the districts of Mueang, Khlung and Tha Mai are certified for good agricultural practice (GAP) while Na Yai Am and Khao Kitchakut are not. Producers of about 94.4 ha were surveyed using questionnaires. The most popular salak cultivar for the producers was 'Noen Wong', followed by 'Sumali' and 'Mo'. Salak planting was integrated with that of other plants. Plant spacing was mostly 4×4 m, followed by 5×5 and 6×6 m. Most producers use sprinkler irrigation, applied organic and chemical fertilizers and used pesticides for insect and disease control on their salak farms. Pruning of leaf stalks was mostly done once a year. The clusters of salak fruits were also pruned with between 6 and 10 clusters branch^{-1} retained, followed by 11-15 clusters branch^{-1} and then 5 clusters branch^{-1}. Based on the survey, the highest abundance of salak fruits was in May-July, while fruit was rare in February-April. The pollen of rakam (*Salacca wallichiana* Mart.) was mostly used for pollination. The most commonly used artificial pollination

method was the flower sack shaking method. After salak fruit harvest, about 64% of the producers used a brush to clean up the fruits, while 36% used fresh water. About 68% of the producers brought the salak fruits to the market and sold them themselves, while only 32% of producers had middlemen to buy fruit from their farms. The average cost of production was about 2852 USD year^{-1} for each of the 'Noen Wong' and 'Mo' cultivars, while it was 2402 USD year^{-1} for the 'Sumali' cultivar.

Keywords: snake fruit, good agricultural practice, artificial pollination, pollen

c) Introduction

The introduction begins by introducing the broad overall topic and providing basic background information. It then narrows down to the specific research question relating to this topic. The statement of problem or research finding, should avoid a detailed literature survey or a summary of the results, it should be able to explain how to identify the problem with references cited. It provides the purpose and focus for the rest of the paper and sets up the justification for the research.

INTRODUCTION

Salak is a shrub plant (scientific name *Salacca edulis* Reinw.) in the family *Arecaceae*. Three popular cultivars of salak are 'Noen Wong', 'Sumali' and 'Mo', all grown in Chanthaburi province. 'Noen Wong' was bred in Bang Ka Ja sub-district in Mueang district (Board of Chanthaburi Salak Producer Union, 2001). The stem of 'Noen Wong' is smaller than that of 'Rakam'. Its leaf sheath has a golden brown colour. It has a long leaf tip, and white, unopened and soft thorns on its fruit, which is a long and spindle shape. The thorn tips of 'Noen Wong' fruit bend towards the tail of the fruit. The flesh of the fruit is creamy yellow, like honey in colour, soft and thick, sweet, or sweet and sour in taste, and aromatic with small seeds (Department of Agriculture, 2009). 'Sumali' is a new salak cultivar bred in Bo Phu sub-district in Tha Mai district in 1992. Its stem is similar to that of 'Rakam'. Green-yellow leaves that are wide, big and long are characteristic of the 'Sumali' plant. Its leaf tip is shorter than that of 'Noen Wong'. Thorns on the shoot are unopened and have a light orange colour. Its flowers have a long peduncle, grow in big clusters and bear fruit easily. Its fruit has a short-round shape, and its flesh is similar to that of 'Rakam' but thicker, and thinner than that of 'Noen Wong'. It has a unique sweet taste, has better growth and is more tolerant of full sunlight than 'Noen Wong' (Academic Team of Chanthaburi Horticultural Research Center, 1996). 'Mo' has a small stem. It has a golden-brown leaf sheath that is darker than that of 'Noen Wong'. It also has narrow and short nodes on the leaf stalk, and long, smaller thorns

on its fruit that are apparently softer than those of 'Noen Wong'. 'Mo' also has a long inflorescence and bears fruit more easily than 'Noen Wong'. Its fruits are similar to those of 'Rakam'. The husk of the fruit is dark red. The fruit flesh has brown stripes and is thick but loose. It has a sweet taste, unique smell and small seeds. 'Mo' is more tolerant of full sunlight than 'Noen Wong'. Salak is an important economic crop that has a unique sweet taste and is popular among take-home goods for visitors and tourists. It has a rapid growth and in return can be quickly sold commercially with good agricultural practice, correct managment and proper timing of the production factors (Anonymous, 2012). Salak is a fruit crop that has a five-star ranking in Chanthaburi province. It can be sold domestically and internationally, which generates many millions USD year^{-1} as profits for both the province and the country (Nankaset, 2010). For good agricultural practice in salak production, good quality fruit is of high importance. Hence, a survey collecting information on producers, production and marketing systems of salak fruit in Chanthaburi province was conducted. The purpose of this research was to determine the procedures used for salak production and production factors including the hauling of salak fruits to the market. This research could help potential producers to have a better understanding of the factors that comprise salak production and could also suggest good alternatives for effective and efficient production.

d) Methodology (Materials and Methods)

The methodology section will describe the experimental design, treatments, replication and statistical analysis. Methodology used to complete to the study must be stated for each experimental parts. Time and place of research should be stated. The general rule is that readers should be provided with enough detail to replicate the study.

MATERIALS AND METHODS

Questionnaires were used as a tool in this research. Target groups were determined from five districts (Na Yai Am, Khao Kitchakut, Mueang, Khlung and Tha Mai) where there are salak plantations in the province of Chanthaburi, Thailand. Samplings were made in each target group: 10 producers per district, totalling 50 producers. These producers were classified into two groups: the producers who were registered for good agricultural practice (GAP) from the Department of Agriculture, comprising three districts, namely Mueang, Khlung and Tha Mai; and the producers from the other two districts, namely Na Yai Am and Khao Kitchakut, who were not. This research was conducted from 1 July 2014 to 24 October 2014; sample producers were contacted directly by phone for an appointment. After the phone calls, materials and questionnaires were then prepared for the survey. The questionnaires had three parts: 1) general information about the producers such as gender and age; 2) salak planting information such as salak cultivar and number of growing areas, and salak farm features including salak planting space, labour use, irrigation application

system, application of chemical and organic fertilizers, insect and disease control management, pruning of salak leaf stalks, pruning of salak fruit clusters, profitable age of salak fruit harvested for sale, salak fruit distribution, artificial pollination methods and techniques in efficient fruit production, harvest and postharvest, and marketing of salak fruits; and 3) production cost per year composed of fertilizer, chemical and labour costs. The quantitative data analysis was done in terms of frequency and percentage, and descriptions for some items.

สัปดาห์ที่ 17	แผนการสอน	รหัสวิชา 03-31-426
Reading Academic Articles		หน่วยเรียนที่ 7
		เวลา 180 นาที

ชื่อบทเรียน 7.3 Guideline in Reading Academic Articles (continued)
7.4 Step-By-Step Instruction in Reading Academic Articles
7.5 How to Write a Curriculum Vitae (CV) for a Job
7.6 Activity

วัตถุประสงค์การสอน

7.3 เข้าใจหลักเกณฑ์ในการอ่านบทความทางวิชาการ (ต่อ)
7.3.2 อธิบายหลักเกณฑ์ในการอ่านบทความทางวิชาการ
7.4 รู้และเข้าใจคำแนะนำแต่ละขั้นตอนในการอ่านบทความทางวิชาการ
7.4.1 บอกคำแนะนำแต่ละขั้นตอนในการอ่านบทความทางวิชาการ
7.4.2 อธิบายคำแนะนำแต่ละขั้นตอนในการอ่านบทความทางวิชาการ
7.5 รู้วิธีการเขียนประวัติย่อสำหรับการสมัครงาน
7.5.1 บอกวิธีการเขียนประวัติย่อสำหรับการสมัครงาน
7.6 รู้และเข้าใจกิจกรรม
7.6.1 บอกชื่อกิจกรรมประจำทุกปีของมหาวิทยาลัยเทคโนโลยีราชมงคลตะวันออก วิทยาเขตจันทบุรี
7.6.2 อธิบายลักษณะกิจกรรมประจำปีของมหาวิทยาลัยเทคโนโลยีราชมงคลตะวันออก วิทยาเขตจันทบุรี
7.6.3 บอกประวัติย่อของตนเองโดยจัดทำรายงานเป็นภาษาอังกฤษและนำเสนอหน้าชั้นเรียน

e) Results and Discussion

The results of the analysis are presented in this section. Results must be explained clearly with statistical analysis by writing the output of the experiments, model or computation in each part. This section should present the results, but not discuss opinion or interpretation or their significance. This section should focus only on results that are directly related to the research or the problem. Charts, graphs, equations, and tables should only be used when there is too much data to efficiently include it within the text. Pictures are rare unless they relate directly to the research presented in the article.

RESULTS AND DISCUSSION

Information on producer groups

The producers of salak fruit (or snake fruit) were from the five districts of the province of Chanthaburi, Thailand, namely Mueang, Khlung, Tha Mai, Na Yai Am and Khao Kitchakut. Each district comprised 10 producers, totalling 50 producers. Only the districts of Mueang, Khlung and Tha Mai are registered for good agricultural practice (GAP) while Na Yai Am and Khao Kitchakut are not. Producers with about 94.40 ha were surveyed. Owners of snake fruit farms were about 52% female, with ages between 42 and 67 years; male owners comprised about 48%, with ages between 42 and 72 years. Labourers that were members of the family ranged from about two to five people for the said two gender groups.

Salak planting information and salak farm features

The 'Noen Wong' cultivar accounted for 75% (71.04 ha) of the growing area for salak due to it being the most popular cultivar in the past, with plant ages of 20-30 years old. This was followed by the 'Sumali' cultivar grown on an area of 20.80 ha (22%), due to its popularity as a new cultivar; the price of its seedlings was costly 7-10 years ago, and thus producers opted to grow it less. At present, the seedling price is lower (12.75-14.16 USD seedling^{-1}) and producers now tend to grow more 'Sumali' since an increasing number of consumers prefer this cultivar. Moreover, 'Sumali' fruits yield a higher profit than those of the other two cultivars. It was noted that the three cultivars at the same age had a similar yield. Selling price for the 'Sumali' fruits was higher, at 1.98-2.27 USD kg^{-1}; much higher than the selling price of 'Noen Wong' and 'Mo', which was only 0.85-1.13 USD kg^{-1}. Lastly, the growing area for the 'Mo' cultivar was only 2.56 ha (3%) due to a low preference from consumers. Most producers (68%, or 34 people) practised integrated farming, where salak was grown together with other fruits such as rambutan, mangosteen, durian, langsat, rambai and banana. Salak was grown in the available space on the farms of the above-mentioned fruits. About 16 producers (32%) practised salak-monoculture farming. These producers had made a decision to only grow salak to obtain high yields through high-density planting.

Salak planting space and labour use in salak production

About 33% of salak producers preferred to grow salak with a planting space of 4×4 m, followed by about 30% of producers with a 6×6 m planting space, and about 14% grew their plants in a 5×5 m planting space. These optimal planting spaces were in agreement with those of the Board of Chanthaburi Salak Producer Union (2001). About 23% of salak producers used other planting spaces, e.g., 3×3, 4×3, 6×8 and 10×10 m. This was due to salak plants being grown together with the other fruits on old farms, or being replanted on the empty areas where durian trees had died (e.g. producers had grown durian trees with a planting space of 10×10 m; however, some durian trees had died so producers had replaced these trees with salak plants). Twenty-one producers, or 42%, had permanent labourers. Their main duties were pollination, fertilizer application, pesticide spraying, fruit harvest and leaf stalk pruning. Their wages ranged from 5.67 to 8.50 USD day^{-1}. Two to three labourers worked in a salak growing area of 1.6-2.4 ha; 4-5 labourers worked in growing areas of 3.2-4.8 ha; and 6-7 labourers worked in a salak growing area of more than 4.8 ha. Seventeen producers (34%) had temporary labourers, hiring 2-3 laborers at a time with a wage of 8.50-14.16 USD day^{-1} during salak pollination and harvest, working out to 1-2 times per month. Twelve producers (24%) had labourers from their own family, 2-3 labourers per family, due to having small farms with a lower number of salak plants.

Irrigation application system and application of chemical and organic fertilizers

Most salak producers (76%) with integrated farms had a rotary sprinkler system with a size of 2/3 inches for irrigation where the water sprinkled equally all over the growing area. The irrigation application varied, e.g., 15 min on 2 days, 20-30 min on 3 days, 30-45 min on 4 days and 60-90 min on 5 days. About 89% of the producers applied the commonly used 16-16-16 and 15-15-15 fertilizers for growth of stems, leaves and roots in salak production. These chemical fertilizer application rates depended on the frequency of fertilizer application, e.g. application of 0.5 kg $hill^{-1}$ was done every 20 days, application of 1 kg $hill^{-1}$ was made every 1-2 months or application of 1.5 kg $hill^{-1}$ was completed every 3 months. About 11% of the producers applied 17-17-17 chemical fertilizer due to other fruit trees planted on the same farms, e.g., mangosteen and durian, to reduce the use of more fertilizers. About 44% of the producers used 13-13-21 chemical fertilizers for development of salak flowers and fruits to enhance their quality. Application rate was about 1-1.5 kg $hill^{-1}$ $month^{-1}$ interval. Alternately, they applied 15-15-15 or 16-16-16 chemical fertilizer with a rate of 1-1.5 kg $hill^{-1}$ $month^{-1}$ interval. Some producers applied these fertilizers when the salak fruits had reached their 6th month, before harvest. Organic fertilizers were also used in salak production: 61% of the producers used chicken dung because it was cheaper. The rate depended on its application frequency, e.g. 10 kg $hill^{-1}$ every 3 months, 15 kg $hill^{-1}$ every 6 months or 30 kg $hill^{-1}$ once a year. Producers who used swine dung represented 36%, while 13% used cow dung.

Insect and disease control management

Producers used chlorpyrifos, an organophosphate insecticide, to control insects like fruit-boring caterpillar, coconut rhinoceros beetle, weevil and other insects that are harmful to the plants and trees. Cypermethrin is a synthetic pyrethroid insecticide used to control flower and fruit caterpillar. Producers also used this insecticide at 20 mL 20 L^{-1} water sprayed on the flower, fruit and stem during outbreaks and then stopped at 15 d before harvest. The producers controlled fungal diseases using fungicides such as carbendazim, mancozeb, metalaxyl and phosphenic acid. The application rates of fungicides were 15-30 mL 20 L^{-1} water applied on the flowers and fruits during the rainy season when fungal disease infection is high.

Pruning of salak leaf stalk and pruning of salak fruit clusters

Most producers (74%) pruned leaf stalks once a year, due to labour shortage. Dried leaves, yellow leaves, leaves with diseases and lower leaves attached to the harvested fruits were cut off. All the cut leaves were piled in the middle of inter rows on the farm, or those leaves were chopped up and then brought back to the farm to be used as an organic fertilizer. Some producers (20%) pruned leaf stalks every 6 months, while some (6%) did it every 3 months, due to being small farms with fewer numbers of salak plants. Most producers (78%) preferred to prune and retain the clusters of salak fruits on the plant at between 6-10 clusters branch^{-1} with 0.5-1.0 kg cluster^{-1}, a desirable weight for consumers agreed upon with the Board of Chanthaburi Salak Producer Union (2001). Some producers (16%) had a preference for 11-15 clusters branch^{-1} with 0.5-1.0 kg cluster^{-1} due to labor shortage and/or the farm owners needing the heavier weight of branches. Having sufficient labourers, some producers (6%) pruned and retained the clusters of fruits on the plant at 5 clusters branch^{-1} with 0.8-1.5 kg cluster^{-1}, which yields good quality fruit.

Profitable age of salak fruit harvested for sale

'Noen Wong' and 'Mo' cultivars were harvested in the ninth month (counted from the days of pollination up to harvest) by the majority of the producers (90%) because of their fruits' flavour desired by consumers, while a minority of the producers (10%) harvested the fruits in the seventh month, as they would be processed into syrup called "salak loi gaew", a dessert. Fruit of the 'Sumali' cultivar was harvested in its eighth month by 94% of the producers due to the flavour desired by consumers; while 6% of the producers harvested the salak fruits in the seventh month, also to be processed into syrup called salak loi gaew.

Salak fruit distribution

There was a lot of salak fruit collected in the months of May to July because the producers had artificially pollinated (September to November) prior to collection, when male flowers were abundant, and this time is at the end of the rainy season when the labourers can work better. However, there was less fruit collected during the months of February to April as producers had artificially pollinated from May to July, or during the rainy season when there were fewer or insufficient male flowers for the said pollination. Moreover, work at the farm was difficult due to rain resulting in fungal infection of the pollinated flowers that would soon be rotten.

Artificial pollination methods and technique in efficient fruit production

One of the types of male flower (pollen) that had been used to pollinate the female salak flowers was rakam (*Salacca wallichiana* Mart.), used by 69% of the producers due to its availability in the salak growing areas. About 19% of the producers used the pollen of the salak 'Mo' cultivar; only 9% of the producers used pollen of the 'Noen Wong' cultivar; while just 3% of the producers made use of the 'Sumali' cultivar for pollination. Five artificial pollination methods were performed during the day, from 8 am until 5 pm. For the artificial pollination method, 51% of producers mostly used the flower sack shaking method (Figure 1). The fully opened male flowers were collected, as observed from the light yellowish pollen, and cut lengthwise using a cutter. These cut male flowers (about 200-300 g) were placed in a plastic bag, 17.78 cm wide × 27.94 cm long. The bag containing the cut male flowers was then used to cover at least 50% of the opened female flower (which should have turned a dark red colour with the petal fully opened showing three lobes). The plastic cover was shaken gently 3-4 times to make sure the pollen stuck to the stigma. After that, the pollinated flower was fully covered by a leaf of the salak plant and secured with its thorn to prevent the pollen from being washed off during the rainy season. Thirty percent of producers performed pollination using the flower brushing method, where the open male

practices, 64% of the producers used a brush or coconut leaf stalks to clean up the salak fruits. Using water to clean up the salak fruits could remove fruits from their rachises or branches by the time of transportation, which will shorten the storage time for sale due to fungal infection that may infect the fruits. However, 36% of the producers used fresh water to clean up the salak fruits.

Figure 3. Flower-to-flower method. Male and female flowers locked together with a salak plant thorn, without brushing.

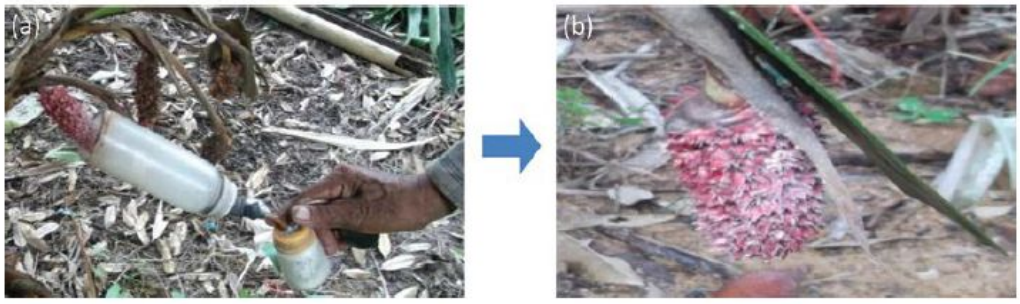

Figure 4. Flower spraying method. (a) Spraying the mixture of instant pollen + talcum powder onto the female flower. (b) The female flower after spraying the mixture of instant pollen + talcum powder.

Marketing of salak fruits

Sixty-eight percent of producers sold their salak fruits by themselves, due to having fewer salak fruits on hand or their farms not being near the buying market. The other 32% of producers had their salak fruits purchased by buyers from their farms; producers either had large farms with greater numbers of fruits or producers of small-scale farms gathered together to sell their fruits in one place. In Tha Mai and Na Yai Am districts, producers would sell their salak fruits at Nong Kla market, which is near their farms; the producers in Mueang and Khlung districts would sell their salak fruits at Pak-Sang market; the producers in Khao Kitchakut would sell their salak fruits at Khao Rai Ya market. It should be noted that the distances from the farms of these producers to the market do not exceed 40 kilometers; hence, the producers look for the nearest market to sell their own salak fruits.

Production cost of salak

'Noen Wong' and 'Mo' cultivars had the same production costs of 2852 USD year^{-1}; 54% (1540 USD year^{-1}) of the production cost was spent on chemical and organic fertilizers; 42% (1198 USD year^{-1}) was spent on labour; and 4% (114 USD year^{-1}) was spent on other chemicals. The 'Sumali' cultivar had a production cost of 2402 USD year^{-1}; 54% (1298 USD

year^{-1}) of the production cost was spent on chemical and organic fertilizers; 42% (1008 USD year^{-1}) was spent on labour; and 4% (96 USD year^{-1}) was spent on other chemicals. At present, producers have increased the growing of the 'Sumali' cultivar. Lower production cost was observed for the 'Sumali' cultivar compared with those of the 'Noen Wong' and 'Mo' cultivars due to the average age of 'Sumali' plants being just about 5-10 years old while the average age was about 12-20 years old for 'Noen Wong' and 'Mo'. The requirements of chemical and organic fertilizers including water use for salak plants are directly in relation to age and size; thus, there were higher production costs for 'Noen Wong' and 'Mo' cultivars.

f)Discussion and or Conclusions

This section should be a discussion of the results and the conclusions on the field, as well as other fields. The hypothesis should be answered and confirmed by the interpretation of the results. This section should also discuss how the results relate to previous research mentioned in the literature review, by comparing the results that as same as others or contradict to the other with references cited. Discuss any cautions about the findings, and potential for future research.

CONCLUSIONS

Most of the producers were female, and their ages were between 42 and 67 years old, while the males were 42-72 years old. Labourers from members of the family represented around 2-5 people. The 'Noen Wong' cultivar had the largest growing area, followed by 'Sumali' and 'Mo' cultivars. Most of the producers grew salak on integrated farms. The preferred planting space was 4×4 m, followed by 6×6 m, then 5×5 m. The irrigation system used mostly was a rotary sprinkler with a size of 1.9 cm. The 15-15-15 and 16-16-16 fertilizers were mostly used for plant growth, followed by the 13-13-21 fertilizer, which was applied for flower and fruit development. Chicken and swine dungs were the organic fertilizers used. Pruning the leaf stalk was mostly done once a year. Pruning of salak fruit clusters was done by removing clusters of unfilled and rotted fruits and then retaining about 6-10 clusters branch^{-1} plant^{-1}. The proficient age for salak fruit harvest for sale in the market was 9 months old for 'Noen Wong' and 'Mo' cultivars, while this was 8 months old for the 'Sumali' cultivar. The fruits of 'Sumali', 'Noen Wong' and 'Mo' cultivars were harvested at 7 months old for the purpose of processing the fruits to be made into syrup (salak loi gaew). Most producers (68%) marketed their harvested fruits by themselves by bringing the fruits to a nearby market. Only 32% of the producers had buyers come to their farms to buy their fruits. Production costs for 'Noen Wong' and 'Mo' cultivars were the same, at 2852 USD year^{-1}. The 'Sumali' cultivar had a production cost of 2402 USD year^{-1}.

g) References or Bibliography

Most papers provide a list of references at the end of the article.

Each reference listed there corresponds to one of the citations provided in the body of the paper. The research paper is not complete without the list of references. This section should be an alphabetized list of all the academic sources of information utilized in the paper. The format of the references will match the format and style used in the paper.

Literature cited

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7.3.5 Is it too advanced?

Furthermore, students need to consider if the article is at an appropriate level for their project. Is it at a popular level or is it too advanced for their purposes? A review article may be appropriate for their level and one way to find these is by searching the Library catalogue, or other resources, for publication titles beginning “Progress in.. (fill in the chosen topic). or “Advances in...(fill in the chosen topic)”

Tips to remember:

To form a truly educated opinion on a scientific subject, readers need to become familiar with current research in that field. And to be able to distinguish between good and bad interpretations of research, readers have to be willing and

able to read the primary research literature for yourself. Reading and understanding research papers is a skill that every single doctor and scientist has had to learn during graduate school. Readers can learn it too, but like any skill it takes patience and practice. Before readers begin reading a paper, take note of the authors and their institutional affiliations. Some institutions are well-respected; others may appear to be legitimate research institutions but are actually agenda-driven. Also take note of the journal in which it's published. Be cautious of articles from questionable journals, or sites like Natural News, that might resemble peer-reviewed scientific journals but are not.

7.4 Step-By-Step Instructions in Reading Academic Articles (Anonymous, n.d.4.)

Following is a list of step-by-step instructions and its details for reading academic articles:

1. Begin by reading the introduction, not the abstract. Readers should always read the abstract last, because it contains a succinct summary of the entire paper, and readers are concerned about inadvertently becoming biased by the authors' interpretation of the results.

2. Identify the big question. Not "*What is this paper about*?" but "What problem is this entire field trying to solve?" This helps readers focus on why this research is being done. Look closely for evidence of agenda-motivated research.

3. Summarize the background in five sentences or less. What work has been done before in this field to answer the big question? What are the limitations of that work? What, according to the authors, needs to be done next? Readers need to be able to succinctly explain why this research has been done in order to understand it.

4. Identify the specific question(s).What exactly are the authors trying to answer with their research? There may be multiple questions, or just one. Write them down. If it's the kind of research that tests one or more null hypothesis,

identify it/them.

5. Identify the approach. What are the authors going to do to answer the specific question(s)?

6. Read the methodology section. Draw a diagram for each experiment, showing exactly what the authors did. Include as much detail as readers need to fully understand the work.

7. Read the results section. Write one or more paragraphs to summarize the results for each experiment, each figure, and each table. Don't yet try to decide what the results mean; just write down what they are. Readers will often find that results are summarized in the figures and tables. Pay careful attention to them. Readers may also need to go to supplementary online information files to find some of the results. Also pay attention to: The words "significant" and "non-significant." These have precise statistical meanings. For graphs, do they have error bars on them? For certain types of studies, a lack of confidence intervals is a major red flag. The sample size, has the study been conducted on 10 people, or 10,000 people? For some research purposes a sample size of 10 is sufficient, but for most studies larger is better.

8. Determine whether the results answer the specific question(s).What do readers think they mean? Don't move on until readers have thought about this. It's OK to change readers mind in light of the authors' interpretation — in fact, readers probably will if readers are still a beginner at this kind of analysis — but it's a really good habit to start forming readers own interpretations before readers read those of others.

9. Read the discussion/interpretation/conclusion section. What do the authors think the results mean? Do readers agree with them? Can reader come up with any alternative way of interpreting them? Do the authors identify any weaknesses in their own study? Do readers see any that the authors missed? (Don't assume they are infallible.) What do they propose to do as a next step? Do readers agree with

that?

10. Go back to the beginning and read the abstract. Does it match what the authors said in the paper? Does it fit with readers interpretation of the paper?

11. Find out what other researchers say about the paper. Who are the (acknowledged or self-proclaimed) experts in this particular field? Do they have criticisms of the study that readers have not thought of, or do they generally support it? Do not neglect to do this. But do it last, so readers are better prepared to think critically about what other people say.

7.5 Curriculum Vitae

A curriculum vitae (often shortened CV, resume or vita) is a written overview of a person's experience and other qualifications for a job opportunity. A CV is typically the first item that a potential employer encounters regarding the job seeker and is typically used to screen applicants, often followed by an interview. CVs may also be requested for applicants to post secondary programs, scholarships, grants and bursaries. In the 2010s, some applicants provide an electronic text of their CV to employers using email, an online employment website or using a job-oriented social-networking-service website, such as LinkedIn. Following is an example format of a curriculum vitae (CV) for a job application.

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BANCHA WIANGSAMUT, PhD

Education	**April 2010** **University of the Philippines Los Baños, Los Baños, Laguna, Philippines** Doctor of Philosophy in Agronomy Minor in Soil Science Dissertation entitled **"Water Saving Method in Irrigated Rice Fields in Tarlac, Philippines".** This dissertation was financially supported by the International Rice Research Institute (IRRI). **November 2005** **University of the Philippines Los Baños, Los Baños, Laguna, Philippines** Master of Science in Agronomy Minor in Development Management Thesis entitled **"Growth Dynamics and Yield of Rice Genotypes Grown in Transplanted and Direct-Seeded Fields**". This thesis was financially supported by the International Rice Research Institute (IRRI). **April 1997** **Khon Kaen University, Khon Kaen, Thailand** Bachelor of Science in Horticulture
Professional experience	**September 2010-2011 Lecturer** **The Office of the Commission on Agricultural Resource Education (OCARE) CHULALONGKORN UNIVERSITY** Henri Dunant Rd., Khet Patumwan, Bangkok, Thailand 10330 **2001-2002** **Mitr Phol Sugarcane Research Center Co., Ltd., Khon Kaen, Thailand** Head of the company farm ▪ Consultant of the company farm (Phu Vieng) ▪ In-charge with farm management

Professional experience (continued)	**1997-2001** **Mitr Phol Sugarcane Research Center Co., Ltd. Khon Kaen & Suphanburi, Thailand** Extension Officer ▪ Consultant of the company farm In-charge with the farmers' training and farm demonstration
Publications	**"Effect of Various Planting Media on Growth of Thao Yai Mom (*Tacca Leontopetaloides* Ktze.)" (2016).** International Journal of Agricultural Technology 12(4): 797-810. **"Biomass Accumulation and Sink Regulation in Hybrid Rice: Consequences for Breeding Programs and Crop Management" (2010).** *Accelerating hybrid rice development.* Eds. F. Xie and B. Hardy. International Rice Research Institute, Los Baños, Laguna, Philippines, 2010. p. 463. **"Leaf Elongation Rate, Agronomic Traits and Grain Yield of Three Transplanted Rice Genotypes" (2008)**. Journal of Agricultural Technology 4(1): 205-217. **"Response of Leaf Elongation to Water Temperature – Determining the Base Temperature of Contrasted Rice Genotypes" (2008).** ICSC 2008.2008.4 **"Rice Response to Direct Seeding – Are Available High-Yielding Genotypes Adapted?"(2008).** ICSC 2008. 2008.4: 16-17. **"Growth Dynamics and Yield of Rice Genotypes Grown in Transplanted and Direct-Seeded fields" (2006).** Journal of Agricultural Technology 2(2): 299-316. *Presentation:* **"Enhancing Crop Performance: The Challenge of Integrating Crop Establishment Strategies with Effective Plant Traits"** November 17, 2005 International Rice Research Institute, Los Baños, Laguna, Philippines

Trainings	**"Capability Development of The New Batch of Lecturers at Chulalongkorn University, Thailand**". April 25 – 29, 2011 Springfield@Sea Resort & Spa, Cha-Am District, Phetchaburi, Thailand May 2 – 6, 2011 Amari Orchid Pattaya Hotel, Pattaya, Thailand **"Analysis of Experimental Data Using The SAS System"** May 28 – June 11, 2007 International Rice Research Institute, Los Baños, Laguna, Philippines **"English for Agricultural Workers"** (Translator) http://rkb.irri.org/EA/preliminary%20pages/eng~about.htm **"English Training 1 Course"** July 5 – August 11, 2005 International Rice Research Institute, Los Baños, Laguna, Philippines **"Intensive English A (Basic Communication Skills)"** June 9 – July 23, 2003 College of Education, University of the Philippines - Diliman, Quezon City, Philippines **"Intensive English C (Basic Oral Interaction)"** April 25, 2003 College of Education, University of the Philippines - Diliman, Quezon City, Philippines **"Intensive English Program"** January 31, 2003 Faculty Center, University of the Philippines Campus - Diliman, Quezon City, Philippines **"Intensive English B (Intermediate Written English)"** January 8 – February 20, 2003 College of Education, University of the Philippines - Diliman, Quezon City, Philippines

Languages	Thai, English, Lao, Philippine
Interests and activities	Faming System (rice-based, sugarcane-based, ornamental plants) Recreational sports (Judo, Football, Tennis)
References	**Teodoro C. Mendoza, PhD** (Professor 12, Scientist 2) **Rodrigo B. Badayos, PhD** (Professor 12, Agricultural Systems Cluster Director) **Pompe C. Sta. Cruz, PhD** (Associate Professor) **Oscar B. Zamora, PhD** (Professor 12, Graduate School Dean) *College of Agriculture* *University of the Philippines - Los Baños* *College, Los Baños, Laguna,Philippines* **Amnuay Kamtoe, PhD** (Associate Professor) *Faculty of Agriculture* *Khon Kaen University* *Khon Kaen, Thailand*

7.6 Activity

7.6.1 Group work

1) Choose your group.

2) Choose a topic to present from the following:

a) Rajamangala Orchid Festival (ราชมงคลรักษ์เหลืองจันท์),

b) Students' orientation day activities of the university campus

c) the university's commencement activities,

d) volunteer activity at the university campus,

e) Buddhist candle making ceremony and candle procession of the university campus

3) Find relevant information of your group's chosen topic.

4) Present the information in powerpoint format to the class.

7.6.2 Individual work

1) Write your own curriculum vitae (CV) and then present it to the class.

ใบเตรียมการสอน	แบบฝึกหัดท้ายหน่วยเรียนที่ 7
	หลังจบหน่วยเรียน

Exercise 1: Answer the following questions, as briefly as possible.

1) What does an academic article mean?

_____

2) Why are articles important?

_____

3) What is the difference between academic journals, magazine, and newspaper?

_____

4) What are the guidelines in reading academic articles?

_____

5) What are the step-by-step instructions in reading academic articles?

_____

Exercise 2: Based on the given sample research article ("A survey of information on producers, production and marketing systems of salak fruit in Chanthaburi province, Thailand"), answer the following questions:

1) Who are the authors of the research article?

_____

2) What is the objective of the research article?

_____

3) What is the research article about?

_____

4) Summarize the background of the research article in five sentences or less.

_____

5) What exactly are the authors trying to answer with their research?

_____

6) What did the authors do to get all data in the methodology section?

_____

7) How many sampling producers of salak were conducted in this study?

_____

8) What kind of data did the authors gather in this study?

_____

9) Did the results answer the objective of the study?

_____

10) What do the authors think the results mean?

_____

11) Do the readers agree with them?

_____

12) Do the readers see any that the authors missed?

_____

13) What do they propose to do as a next step? Do the readers agree with that?

_____

เอกสารอ้างอิงท้ายหน่วยเรียนที่ 7

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ใบเตรียมการสอน	สรุปกิจกรรมการสอน หลังจบหน่วยเรียน

วิธีสอนและกิจกรรม	1. สอนแบบบรรยายและถามตอบ 2. ให้นักศึกษามีส่วนร่วมในการเรียน การสอน 3. สรุปเนื้อหา	
สื่อการสอน	เอกสารอ้างอิง	เอกสารอ้างอิงหมายเลข 8,21,115,121, 122,126,162,164-166,169 และ 170
	เอกสารประกอบ	-
	วัสดุโสตทัศน์	สไลด์หน่วยเรียนที่ 7 ทำด้วยโปรแกรม MS PowerPoint
งานที่มอบหมาย	1. Exercises 1 and 2 2. ให้นักศึกษาค้นคว้าเพิ่มเติม	
การวัดผล	1. สังเกตความสนใจ ซักถามรายบุคคล 2. พิจารณางานที่มอบหมาย	
หมายเหตุ		

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