COCOA TEACHING RESOURCE BOOK

FOR

GRADES 6 - 8

TEACHERS IN PAPUA NEW GUINEA SCHOOLS

Cocoa Coconut Institute
Papua New Guinea

Department of Education

First Edition

2013

Written and Developed by the Cocoa Coconut Institute (CCI) Ltd of Papua New Guinea,
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Cocoa Curriculum Consultant

Cover Page: Kamanakam Primary School Students in the School Cocoa Plot

CONTENT

MESSAGE FROM THE SECRETARY OF EDUCATION

Cocoa growing is a major cash crop for Papua New Guinea (PNG). It is a crop that earns a lot of foreign currency for the country. As a sustainable and renewable industry, it offers great potential for school leavers to take up cocoa farming as an entrepreneurial activity and live a sustain life in the communities. These are some of the reasons the Education Department is pleased to partner with a major commodity crop sub-sector such as the cocoa industry to develop relevant and appropriate curriculum to impact our school leavers in the rural communities of the country. The Education Department beliefs in integral human development and strengthening the rural population therefore such a relevant curriculum and partnership arrangement with a major commodity crop is encouraged and promoted.

Cocoa is a rural and community based cash crop and the knowledge, skills and attitude of cocoa production, processing and marketing will go a long way in promoting and enhancing community living. This is why cocoa units are approved for use by teachers and schools to teach such subject matter at upper primary classes in the primary school. These cocoa units will be taught as units of Making a Living (MAL) curriculum and it is highly recommended to teachers and schools.

The MAL curriculum for upper primary classes was designed to teach students with the process skills of identifying community based learning opportunities for school leavers linking the community. Therefore the cocoa units to be taught units of MAL are to promote community based teaching and learning.

Through the cocoa units of MAL, the students will learn about the economics of cocoa and its importance to the community and the country. It will teach them about the cultural, social and the economic importance of the crop. The management of the cocoa and generation of income will support life in the communities. One of the new units of cocoa in MAL introduces students of the importance of the crop and this unit is intended to create the motivation needed amongst student to take up cocoa as an entrepreneurial activity to sustain their livelihood in the community.

It is my honor and privilege to commend and approve this Cocoa Units as units of MAL to be taught in the Upper Primary Schools in the lowlands regions of PNG.

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DR. MICHAEL TAPO (EdD)
Secretary for Education

MESSAGE FROM THE CHIEF EXECUTIVE OFFICER, CCI PNG LTD

This cocoa curriculum provides the fundamental knowledge, skills and attitude of cocoa farming for grades 6-8 classes at upper primary level of education in the country. It has been developed by the Cocoa Coconut Institute (CCI) of Papua New Guinea (PNG) in consultation with the National Department of Education. With our major partner, the National Department of Education, we have development this curriculum for the benefit of the future cocoa farmers at an early age of their education. We certainly hope that learning cocoa production, processing and marketing knowledge, skills and attitude will enable them to take up cocoa farming as an entrepreneurial activity when they leave school as school leavers.

Cocoa is major lowland crop and is central to the economic, social, cultural and political fabric of the lowland communities in Papua New Guinea. It is through cash income that is derived from cocoa that contributes to the wealth and status of farmers and communities that grow cocoa as a means of earning cash income. It is for this reason, the cocoa curriculum has been developed so that youth with to gain maximum benefit from growing cocoa.

Like many commodity crops that a dependent on the international demand and supply situation which highly impact cocoa price and the resultant cash the farmer receives, from cocoa farming is a very challenging enterprise. These coca production challenges include: the difficult terrain in which rural farmers live, infrastructural problems prevent efficient marketing, farmer attitude for growing cocoa, competing opportunities in other crops and livestock, cocoa farming has been badly impacted in recent times by the incursion of Cocoa Pod Borer. This has significantly reduced cocoa production in some communities. It is therefore the CCI's duty to consolidate current research and extension programs while engaging new and innovative ways to increase production. One such opportunity to increase and maintain high production is to skills our youth to take cocoa production seriously through formal education and training programs.

An estimated 50, 000 students that leave school each year to go to the communities. It is important to appropriately skills them so that they can have cocoa farming as a better alternative than to engage in anti-social and criminal activities. For these reasons the CCIPNG is keen to assist the school better prepare the youth for life in the villages. I feel strongly that the cocoa curriculum offers great potential to youth to be enterprising and productive members of the community. Therefore with the Education Department's approval, I have much pleasure in recommending cocoa entrepreneurship learning opportunity in schools as a viable alternative to encouraging the students to take up cash income opportunities as the school leavers enter the communities, while in turn helping to our economy grow.

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DR. EREMAS TADE, (PHD)
Acting Chief Executive Officer

INTRODUCTION

The cocoa curriculum is a collaborative and partnership effort between the Cocoa Coconut Institute (CCI) and the National Department of Education (NDOE). The NODE is responsible for the curriculum in schools and the CCI is responsible for cocoa development so the partnership brings together both the Education Department and the Cocoa industry to promote skills development while preparing the youth for life in the communities after they leave school

The cocoa curriculum is developed following the recent successful development of the coffee curriculum. This first edition is a trial edition. The cocoa curriculum trail edition will be trialled in five schools in the ENBP at all levels of schooling. Adjustments will be made to the content and the educational components after the field test of the curriculum. A second edition with the field experiences included in the context will be prepared and published in 2014.

The package (the teacher's resource book) is developed and packaged for grades 6-8 classes in the cocoa growing regions of the country. The package is designed for grades 6-8 classes as units of the Making a Living Curriculum (MAL). The specific components of MAL to be used to teach the cocoa curriculum are Managing Resources and Community Development. It is envisioned that the teaching of how to manage resources entrepreneurially and for living in the community will foster and promote purposeful and meaningful lives in the communities.

The cocoa units for MAL will offer the foundational knowledge and skills of growing cocoa as an entrepreneurial crop in the communities. Students will learn about the cocoa tree, its origin, the parts and functions and the basic managerial knowledge and skills. Using these knowledge and skills, the student will proceed to learning about the more advanced topics in graders 9-12 classes and beyond.

Cocoa is grown in about 14 Province in PNG. There are some new growth areas in some minor crop growing Provinces such as Gumine in the Simbu Province, parts of Gulf, the Jimi area of Jiwaka, parts of Enga that are close to the East Sepik Province and Maiyer River areas of the Western Highlands. These new growth areas are being investigated by the CCI and the Cocoa Board of PNG. If growing cocoa in these regions is viable cocoa will become an alternative cash crop in these areas.

The cocoa curriculum should see, over a period of time, the introduction of quality skills-based education for the students while helping to increase the yield and improve the quality of cocoa exported from PNG. It is for these reasons the partnership endeavour is conceived. Such collaborative public and private partnership should be beneficial to the organisations and the country.

TEACHING AND LEARNING

How the students learn

What I hear I forget
What I hear, see I remember a little
What I hear, see and discuss I begin to understand
What I hear, see discuss and do, I acquire knowledge and skills
(Active Learning Credo Statement by Silberman, 1996)

In support of these are the findings that we remember:

- 20% of what we hear
- 40% of what we see
- 90% of what we see, hear say and do so or what we discover for ourselves

A student-centred approach to learning

Different student learn in different ways. Some students learn best by writing, others by talking and discussing, others by reading and others by listening. Most students learn by using a combination of these. All learn skills through practicing and repetition. You need to use a variety of teaching strategies to cater for the different ways your students learn.

Teaching and Learning Strategies

To assist and encourage students to learn, you perform certain tasks. These are referred to as teaching strategies. You need to engage students directly in learning but there are times when you to take charge of the learning in the class and teach particular concepts ort ideas. These teaching strategies include:

- Group work
- Role Play/Drama
- Skills practice
- Direct assignment, research/inquiry
- Class discussion/debate
- Problem solving activities
- Teacher-talk – Instructions, explanations, lectures or reading aloud
- Direct question and answer sessions
- Audio Visual presentations
- Textbooks or worksheets
- Demonstrations and modelling
- Guest speakers/Resources persons
- Field trip
- Classroom displays

Using groups as a teaching and learning strategy

Using groups is an important strategy in agriculture as students learn from each other, not just from the teacher. Groups work encourages students to participate in achieving a shared goal and collaborative learning in deciding whether to use group or not, you need to consider

- Your intended outcomes
- The extent to which the outcomes can be achieved by the group
- The lesson content
- The time allocated for the completion of tasks
- The classroom setting
- The materials and resources available
- The structure of the groups based on gender, ability, cultural background and student preferences

Groups work well when:

- The groups decides upon their goals, timeline and tasks
- Students realise that success depends on the achievement of the whole group and not just individuals
- The task is broken into subtask which must be finished to successfully complete the overall task
- The whole class is involved in the activity
- Everyone has a role to play, e.g. field trips
- Membership of small groups is changed regularly to provide a variety of learning experiences for all students

Strategies for organising and managing groups:

- Mixed-ability groups – the more able leaners in the group can help the others to master the work so that you need not teach some parts
- Same ability groups – the teacher can leave the groups of faster learners to get on with the work on their own. You can give extra help to individual leaners in a slower group of learners.
- Using group leaders/monitors – you appoint faster, more able learners as group leaders or monitors who can help slower learners.

DEVELOPING SKILLS

Principles and procedures

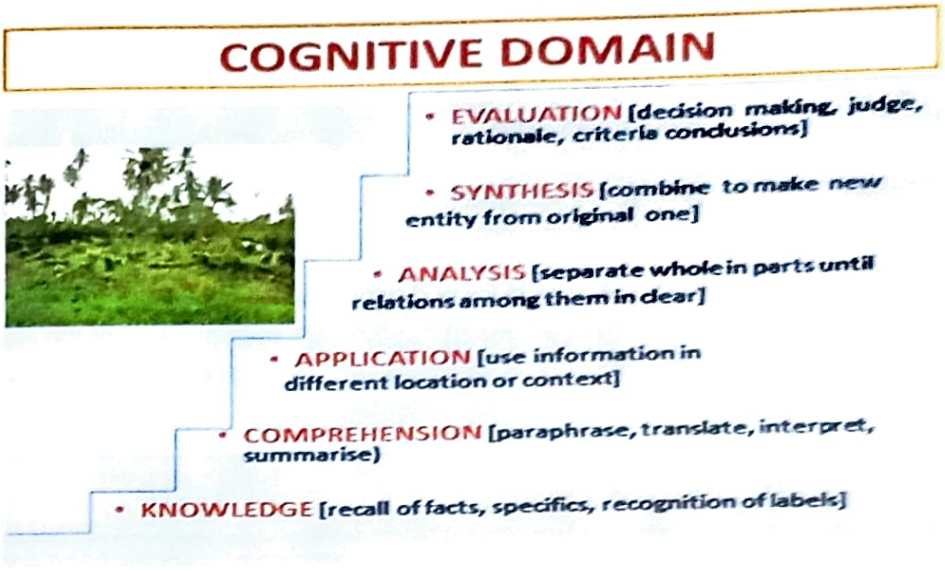
Students need to develop skills to help them learner. Skills development should happen as a part of a student's experience and the learning and practising of skills needs to occur in the context of units being taught.
Skills learning tend to be most effective when:

- Students go from the known to the unknown
- Students understand why it is necessary to gain mastery of specific skills
- Skills are developed sequentially at increasing levels of difficulty
- Students identify the components of the skill
- The whole skill and the components of the skills are demonstrated
- There are frequent opportunities for practice and immediate feedback
- Students are encouraged to record and diagnose their performance
- The skill is used in a range of contexts

To teach skills effectively you need to include learning activities that span the range from teacher-centred learning to using different groups of different sizes ranging from th e whole class to small groups and use a range of teaching strategies which use higher order skills as your students progress.

Blooms taxonomy (hierarchy) of theory skills

Blooms taxonomy is a way to classify skills, activities, or questions (or objectives/outcomes) as they progress in difficulty. The lower level questions require less in the way of thinking skills. As you move up the hierarchy, the skills or activities require higher level thinking.

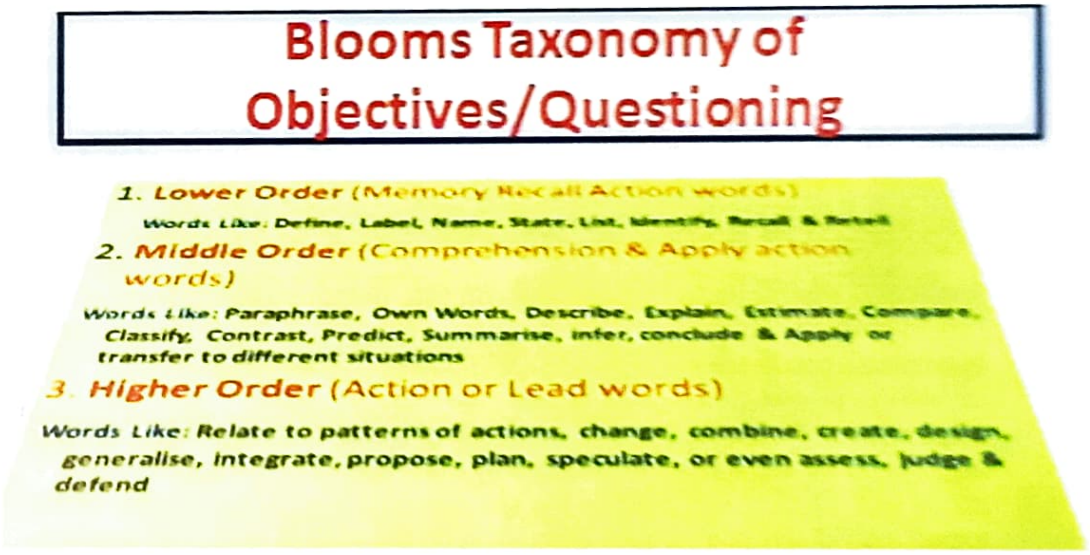


Recommended levels of learning

For students in grades 6-8, teachers are recommended to use teaching skills at the low and middle levels skills and activities. Teachers should teach student to learn at knowledge, comprehension and application levels of learning. (see Blooms cognitive domain levels of questioning above).

Examples of cognitive level of learning key words

The following is a further subdivision of Blooms taxonomy of questions into lower, middle and higher order questions to assist teachers in preparing and to teach the cognitive domain effectively.

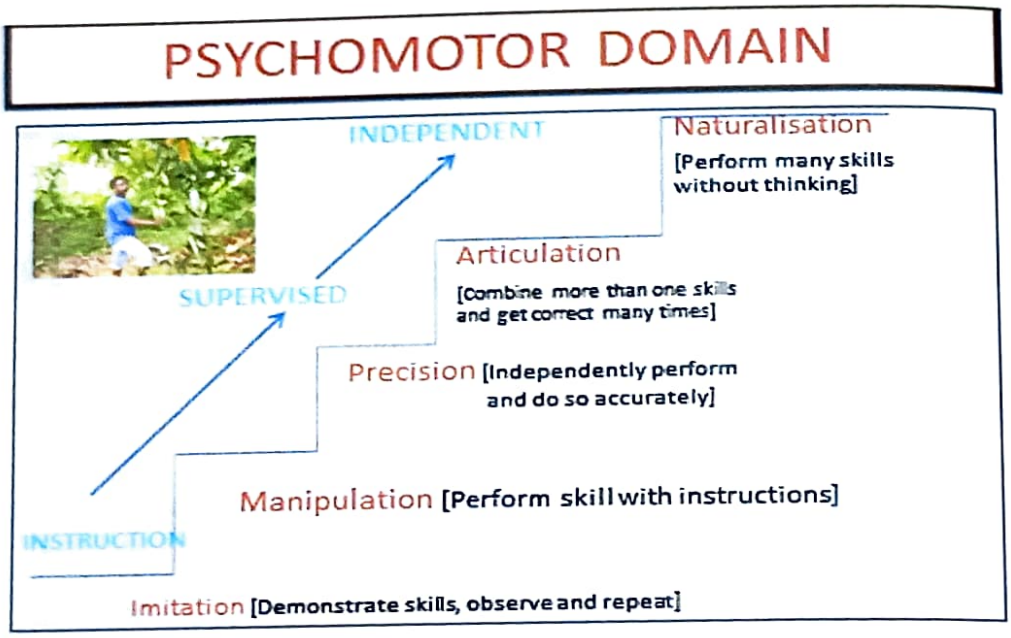


Teachers are recommended to use key works in the upper end of the middle order performances and the higher order key performances to prepare and teach students. As seen from the taxonomy of outcomes or questions in Blooms hierarchy of

questions, teachers should adapt their teaching according to the appropriate levels of learning for their students. Some of these outcomes are presented in each unit of learning in this teacher's resource book but teachers should feel free to adapt them for the class's ability to learn these skills.

Major Categories (hierarchy) of practical skills

The major categories of the practical skills and activities are shown in the diagram below. There are: imitation when demonstrating the skill, manipulation of the skill by the students until precision, articulation and the eventual naturalization of the skill.



Student at grade 6-8 levels of schooling need a lot of teacher guidance to perform the practical skills. The above diagram shows major categories or levels of student learning according to Krathwont, Bloom & Masia (1964). This is important for practical subjects like agriculture. There are three categories:

- **Imitation - instructions through appropriate demonstration**: Teacher should prepare skills well and provide demonstrations to the student on an appropriate cocoa skills

- **Supervision:** Following the demonstration of a skill, teachers should provide opportunity for supervised experience by the students of the appropriate cocoa skill. Student can practice the skill demonstrated by the teacher or the expert individually or in groups depending on the level of resources available.
- **Independent practice:** Independent practice is the next step up and without this step the students will not gain mastery or be an expert. Teachers must prepare for and allow independent practice in the school cocoa garden or in

their own family cocoa plots or in the communities. Practice makes perfect the skill being demonstrated and taught.

Language skills for Agriculture

Students need to learn how to speak, read and write, view and observe carefully all the cocoa skills being taught and demonstrated. Students can learn oral language skills through, for example:

- Discussions
- Oral and written reports
- Interviewing opportunities

Provide opportunities for your students to listen and record information accurately. Guest speakers or teachers can, talk during the field trips or excursions, tapes, radio, television, CDs, videos, stories, and concepts about agriculture while students listen and record using listening resources. When students come to expect a listening experience as a regular part of their classroom routine, their ability to attend to details in what they hear about agricultural concepts is quite likely to improve.

Place of Vernacular in Agriculture

Maintenance of the student's language is something that continues at lower levels of secondary school as stated in the Department of Education's language policy in all schools. At all times, it will be appropriate to use vernacular, Motu and tok pidgin to explain concepts or ideas. Vernacular can be sued to describe and illustrate those things that do not have English translations. For example, it would be appropriate to use Vernacular, Motu or Pidgin when finding information from the community or selling agriculture produce in the local farmers market.

Writing Skills

Students must be able to choose the right words to get the agriculture message across and be able to put words together in a way that makes sense to the reader. The ability to write well and use appropriate vocabulary and agriculture terms in order to impart agriculture messages takes a lot of practice. Writing skills and techniques should be emphasized in agriculture lesson activities.

Thinking and Questioning skills

Agriculture lesson activities assist students to analyze and think critically about information they come across. By processing information rather than rote learning, students are more likely to understand and retain what they have learnt. Students must be involved in the process of thinking instead of simply accepting the end

products of someone else's thoughts. The ability to think critically can be taught effectively by asking the types of questions listed below:

- What do you notice/see/find?
- What difference do you see...?
- What similarities do you...?
- Which one belongs together? Why?
- Why don't these belong to this group?
- What could have happened if...?
- What would...be like if...?
- How would you...?
- What explanation would you give for...?
- Is this always so?
- Does evidence of....change the original explanation?
- How can this be tested or checked?
- Suppose...what would happen?
- What makes your think this would happen?
- What would be needed for that to happen?
- Is there a different explanation?
- If...happened, what would happen next?

Teaching and Learning Strategies for Agriculture

Here are teaching and learning strategies which can be used to make learning more meaningful and interesting in Agriculture. You should vary your lessons by using different teaching strategies, making sure that the ones you use for the lesson are suitable for your lesson outcomes. Many of these strategies work together, for example developing consequence charts during class discussions helps students make realistic decisions.

Problem Solving

- Brain storming
- Situation/Problem needs analysis
- Identify strategies to solve problems
- Research
- Investigation
- Jigsaw groups
- Class meetings
- Discussions
- Questionnaires

Field Applications

- Research
- Field work
- Classroom display

- Guest Speakers
- Interviews
- Photographs
- Questions and Questionnaires
- Cultural activities
- Presentations

Multimedia

- Photos
- Pictures
- TV
- Classroom displays
- Radio
- Internet
- Power point presentations

Decision Making

- Consequence charts
- Diagrams
- Mapping
- Matrix
- Questions and questionnaires
- Tables and Figures
- Graphs
- Presentations

Evaluation

- Questions and questionnaires
- Reflections
- Tables of evaluation results
- Graphs of evaluation results
- Discussions
- Presentations
- Classroom displays
- Value reinforcement

Assessing Agriculture

Assessment is an important part of teaching and learning. Assessment is used to:

- Evaluate and improve teaching and learning
- Report Achievement
- Provide feedback on student on their learning

Assessment in Agriculture measures student's achievement of the units learning outcomes described in the syllabus. It is an ongoing process of identifying, gathering and interpreting information about students' achievement of the learning outcomes and can be integrated into the students' normal learning activities

Assessment for Learning

Assessment for learning is often called formative assessment (evaluation of competencies) and is assessment that gathers data and evidence about student learning n the learning process. It enables you to see where the students are having problems and to give immediate feedback which will help your students to lean better. It also helps you to plan programs to make students learning and your teaching more effective. Often it is informal and students can mark themselves or by their friends. An example is a quick class quiz to see if students remember the important points of the previous practical or theory lesson.

Assessment of Learning

Assessment of leaning is often called summative assessment. It is used to obtain evidence and data that shows how much learning has occurred, usually at the end of the term or unit. End of the year examinations are examples of summative assessment. It is usually done for formal recording and reporting purposes.

Assessing Cocoa Units

In the cocoa units, the units learning outcomes which link to the broad learning outcomes are assessed through specified assessment tasks using a range of assessment methods. Assessment criteria for each unit outcomes provide clear indications of how, and to what extent, the achievement of the learning outcomes may be demonstrated. Performance standards, making guides and assessment criterion b help you with the making process and ensure that assessment is consistent across all schools.
Students must complete the assessment tasks for all the units. You will expand each task and provide clear guidelines to students for how the task will be completed and how the criteria will be applied.

When you set a task make sure that:

- The requirements of the task are made as clear as possible to the students
- The assessment criteria and performance standard are provided to the students so that they know what it is that they have to do
- Any sources or stimulus material used are clear and appropriate to the task
- Achievement is measured in terms of more than one outcome

- Instructions are clear and concise
- The language level is appropriate for the grade
- It does not contain gender, cultural, or any other bias
- Material and equipment needed are available to students
- Adequate time is allowed for completion of the task

Feedback

When you assess the task, remember that feedback will help he students understand why he/she received the result and how to do better next time.

Feedback should be:

- Constructive so that students feel encouraged and motivated to improve
- Timely so that students can use it for subsequent learning
- Prompt so that student can remember what they did and thought at the time
- Focused on achievement and not effort. The work should be assessed, not the student
- Specific to the unit learning outcomes so that assessment is clearly linked to learning

Feedback can be:

- Informal or indirect – such as verbal feedback in the classroom to the whole class, or person to person
- Formal or direct – in writing, such as checklist or written commentary to individual student either in written or verbal form
- Formative – given during the topic with the purpose of helping the student know how to improve
- Summative – given at the end of the topic with the purpose of letting the students know what they have achieved

Tests

A test is a formal and structured assessment of student achievement and progress which the teacher administers to the class.
Tests are an important aspect of the teaching and learning process if they are integrated into the regular class routine and not treated merely as a summative strategy. They allow students to monitor their progress and provide valuable information for you in planning further teaching and learning activities.

Tests assist students learning if they are clearly linked to the outcomes. Evidence has shown that several short tests are more effective for

student progress that one long test. It is extremely important that tests are marked at the earliest opportunity and that students are given feedback on their performance.

There are many different types of tests. Tests should be designed to find out about student knowledge of content and about the development of thinking processes and skills. Open questions provide more detailed information about achievement than a question to which there is only one answer.

Principles of designing classroom test

Tests allow a wide variety of ways for student to demonstrate what they know and can do. Therefore:

- Student need to understand the purpose and value of the test
- The test must assess intended outcomes
- Clear direction must be given to reach section of the test
- The test questions should vary from simple to complex
- Marks should be awarded for each section
- The question types (true/false, fill-in the blank, multiple choice, extended response, short answer, matching) should be varied

Test should:

- Be easy to read (and have space between questions to facilitate reading and writing)
- Reflect an appropriate reading level
- Involve a variety of tasks
- Make allowance for student with special needs
- Give students some choice in the questions they select
- Vary the level of questions to include gathering, processing and applying information
- Provide sufficient time for all students to finish

Who assesses?

Teacher assessment

Assessment is a continuous process. You should:

- Always ask questions that are relevant to the outcomes and content
- Use frequent formative tests or quizzes
- Check understanding of the previous lesson at the beginning of the next lesson through questions or a short quiz

- Constantly mark/check hew students' written exercises, class tests, homework activities
- Use appropriate assessment methods to assess the tasks

Frequency of assessment

You should schedule the specified assessment tasks to fit in with the teaching of the content of the unit that is being assessed. Some assessment tasks might be programmed to be undertaken early in the unit, others at the end of the unit. You should take care not to overload classes with assessment tasks at the end of the term.

Judging student performance

Student achievement is recorded and reported against standards. You must use the performance standards provided in each unit of the teachers' guide when making a decision about the achievements of your students in relation to the unit of learning outcomes. The performance standards describe the level at which the student has to be working to achieve a particular standard or mark.

Student should always have access to a copy of the assessment criteria and the performance standards so that they know what it is they have to know and be able to do to get a good mark in a particular task. The performance standards will help you in your marking and will help the student improve their performance in the future. They are useful when providing feedback to students as they explain what it is the student needs to do to improve.

Moderation

To ensure that you are interpreting the performance standards correctly when assessing your students, it is important to undertake subject moderation of student work within your school and with teachers of nearby schools.

To moderate student work, a common assessment task must be used and a marking scheme developed so that all students complete the same task under the same conditions, and all teachers use the same making scheme. Teachers can compare (moderate) the students' work and come to a common understanding of the performance standards and the requirements for a particular level of achievement.

Moderation enables you to be sure that your understanding of the required standards for levels of achievement is similar to the understanding of the other teachers and that you are assessing students at the appropriate level.

Self-assessment and peer assessment in Agriculture

Self and peer assessment helps students to understand more about how to learn. Students assess their own work (self-assessment) or th4e work of others (peer assessment). Students should be provided with opportunities to assess their own learning (self-assessment) and the learning of others (peer assessment) according to the set criteria. Self and peer assessment:

- Continues the learning cycle by making assessment part of learning
- Shows students their strengths and areas where they need to improve
- Encourages students actively in the assessment process
- Enables students to be responsible for their learning
- Helps students understand the assessment criteria and performance standards

Managing assessment tasks in Agriculture

Usually, the marking of assessment tasks is done by the teacher. To reduce the amount of work it is necessary to develop a strategic approach to assessment and develop efficiencies in marking.

In Agriculture there are a number of assessment tasks that may be new to teachers and students. Below are some suggestions on how to manage some of these tasks to minimize marking or presentation time

Developing efficiency in marking

Clarify assessment criteria: Plan the assessment task carefully, and ensure that all students are informed of the criteria before they begin. Discuss the assignment and the criteria in class, giving examples of what is required. Distribute a written copy of the instructions and the criteria or put them on the board. Make the assessment criteria explicit, speeds marking and simplifies feedback.

Supply guidelines on what is required for the task: This reduces the amount of time wasted evaluating students work that is irrelevant.

Use attachment sheets such as marking guides: An assignment attachment sheet which is returned with the assessed work rates aspects of the task with a brief comment. Such a system enables each student's work to be marked systematically and quickly. The strategy can be applied to assignments and projects.

Assess in class: Use class time to carry out and to assess tasks. Oral presentations and multiple choice tests marked in class enable instant developmental evaluation and feedback. On-the-spot reports on the

projects or practical work, takes less time to mark and are useful, because they give immediate feedback to students on their projects.

Feedback to the whole class: Feedback to the whole class can cut down on the amount of individual feedback required. On returning assessed work,

Shift the responsibility

Introduce self and peer assessment: Develop in students the skills to evaluate their own work and that of their peers. Help the Students' use the performance standards, marking guides and assessment criteria against which work is judged. Self-assessment increase the amount of feedback students get .It can supplement teacher assessment.

Treat each task differently

Every piece of work need not be evaluated to the same degree. A mark needs to be the outcome in every case; and every piece of student work need not contribute to the final grade. Assessment is designed to enhance the teaching and learning experience for the teacher learner, not just to accredit students.

Use observation sheets and spotlighting

You might record student achievement while observing your students by using observation sheets. The most common observation sheets are individual student checklists and whole class grids. They can be used for all the project s that students undertake.

Spotlighting uses individual student checklists. This method can be used to focus on a few selected aspects of student performance, such as planning for a project. It is best to focus on five to six students at a time. Systematically work through the class over time. Focused questioning you can gain a deeper awareness as to whether or not students understand the concept being taught.

Portfolios

Portfolios provide evidence for judgments of student achievement for a range of projects. In the option units students are required to present a portfolio for assessment purposes. It contains a specific collection of student work or evidence. This collection of work provides a fair, valid and informative picture of the student's accomplishments.

How to minimize marking times of portfolios:

- Specific the pieces of work and keep the number low
- Mark as you go – ask that one of the pieces of work be completed at the end of week 3 and mark it then. Do not

leave the assessment of the whole portfolio until the end of term
- Use self-assessment-the student can self-assess some of the work.

The portfolio does not have to be a folder or binder; it can be in the form of an exercise book with the student marking the pages they want to have marked as part of their portfolio.

Reports

Reports are an authentic form of assessment. They encourage students to develop observation and recording skills, and require organization skills in both collecting and analysing information and communicating information clearly.
Reports in Agriculture can be oral, written or in graphic form or a mixture of these. Duration of reports vary according to the task. Reporting in groups is a common strategy used in bi classes however each student should be allowed a turn at reporting during the year.

Experiments

There is a great deal of time involved in marking experiments and projects. However, the end result is that you have a better picture of what `students truly know, understand, and are able to do. To help you, generic performance standards and checklists are provided for assessing experiments.

Planning and programing units

The main purpose of planning and programming is to help you to arrange the presentation of the unit in an organized manner. This will help you to know what to teach and when to teach it. It is strongly recommended that you plan with the other teachers who teach the same grade. By planning together, you will all have better lessons and make better use of your limited resources.

Points to consider when programming

- Which unit learning outcomes are students working towards?
- What is the purpose of this unit/topic/learning experience?
- Which learning experiences will assist students to develop their knowledge and understandings, skills, and values and attitudes in the subject?
- What are the indicators of student learning that you would expect to observe?
- How can the learning experiences be sequenced?

- How do the learning experiences in the unit relate to student's existing knowledge and skills?
- How individual learning is needs to be catered for?
- What are the literacy demands of this unit/learning experience?
- What authentic links can be made with the content of other subjects?
- How can school events and practice be incorporated in to the program?
- Do the assessment methods address the unit learning outcomes and enhance the learning?
- How can the assessment be part of the teaching and learning program?
- Which options and projects can be done to make best use of the school's resources?
- How can a balanced program be developed?

The planning process

In this teacher guide, ideas for programming and organising each unit have been provided. These have been arranged in steps to help you teach the unit. The steps follow the thinking processes involved in the outcomes approach.

Steps 1 – Interpreting the unit learning outcomes

The first step is to read the unit description in the syllabus and then study the unit learning outcomes to determine what students will know and be able to do by the end of the unit.

You need to look at the action verb, concept and context of each learning outcome. This will help you see what skills and knowledge are embedded in the outcomes. Remember the unit learning outcomes link to the broad learning outcomes.

This teacher guide gives you a brief description of the main requirements of each learning outcome.

Step 2 – Planning for assessment

It is necessary to study the assessment requirements of the unit early in you planning to ensure that you teach the content and skills students need to achieve the unit learning outcomes.

The assessment tasks are described in the syllabus. They indicate what specific knowledge and skills students will need to demonstrate that they have achieved the unit learning outcomes.
You will have to decide when to schedule the assessment tasks to allow yourself time to teach the required content and time for students to develop the necessary skills. You will also need time to mark the task and provide

feedback. Practical tasks may, for example, be broken into a series of stages that are marked over several weeks as students' progress with making their product. It is not appropriate to leave all the assessment until the end of the unit.

This teacher guide provides the performance standards and / or marking guide which you must use when you are marking the tasks. This is to ensure consistency with marks awarded to students in all schools in Papua New Guinea. However you must develop clear and detailed instructions for completing the task yourself and ensure all students know exactly what they have to do.

Step 3 - Programming a learning sequence

This step requires you to develop a program outlining a sequence of topics and the amount of time spent on each topic. You may follow the topics in the order they are listed in the syllabus or you may cover the topics through integrated activities or a thematic approach. If the unit involves a project for example, you may plan to teach some theory at appropriate stages during the project, rather than teaching all the theory before the students start the project.

To develop your program you need to study the topics listed in the syllabus and to think about the learning activities that will best provide students with the opportunity to learn the content and practice the appropriate skills, and how long the activities will take. You will have to think about some major activities that last several weeks and smaller activities that may be completed in a single lesson.

Once you have completed your unit plan you will have to consider each topic in more detail. For example, if you have allocated two weeks for a topic that means you have ten lessons available (five lessons per week). You will have to develop a plan for each topic that includes in more detail what you will cover in each lesson. Your topic plan must include a sequence of student activities and teaching points that contribute to the overall achievement the unit outcomes. Your topic plan should include what you think your students will do in each lesson, but you must remember that the individual lessons must flow logically, one from the previous and must be adjusted according to how students are processing through the topic. You may develop outcomes for the topic and for each lesson, but these must be related to the unit outcomes.

The teacher guides provides a sample program for each unit. It does not provide individual lessons plans.

Step 4 – Elaboration of content and activities

Once you have mapped out your program for the term you must then develop more detailed plans for each topic in the unit. All units require students to be actively engaged in learning, not just copying from the board. Make sure you develop a range of activities that suit all learning needs-some reading and writing, some speaking and listening, some observing and doing.

Browse through the text books and teaching resources you have access to and list chapters, pages or items that you will use for each topic in your program. The text books should also provide you with ideas for activities related to the topic. You may have to collect or develop some resources for yourself.

Once you have sorted out your ideas and information you can then develop your more detailed weekly program and daily lesson plans.

This teacher guide gives examples in each unit of some activities you might like to use to ensure active learning. It also gives background information on some of the content.

Remember that option cocoa units should be taught alongside the core units in both Grade 9 and Grade 10 Agriculture and Grade 11 and 12 Natural Resource Management frame work.

Essential resources/equipment for Cocoa units	
All units that involve crop production	Land for cocoa gardens or nursery; soil samples; seeds and / or seedlings; cocoa plants; tools and machinery for planting , tilling and harvesting coffee beans; fertilizers; weed and pest control products;
Specialist options e.g. farm technology	Equipment and resources to driers and equipment

Guide to Planning and Programming Agriculture

Individual Units

In Agriculture, how you program the core units together with the option cocoa units will depend on the crop that your students grow, or the animals they raise for their project. There will be times when the students are very busy in the field, garden or orchard preparing the ground, planting, weeding etc., and other times when the crop is growing where they are not so busy outside.

Collaborate with Design and Technology teachers to construct animal or plant housings in order for you and your students to have more time for actual growing or looking after animal activities. There will be other times when your students will be very busy looking after young animals, and other times when they are not so busy with outside activities. You need to look at the growth cycle or life cycle calendar of the project crop, fruit or animals and plan your cocoa crop program around it.

It is possible that you will decide that the students could run two projects simultaneously – such as cocoa and animal project together - and then your program will be for four terms. It is also possible that you could combine a long term schools project, such as growing such as cocoa, coffee, oil palm or vanilla, with a short term class project such as growing a crop of tomatoes or cabbage. The short term project will enable students to experience the satisfaction of successfully undertaking and completing a small project while contributing to the long term school project.

As outlined in the syllabus document, each core unit is integrated over twenty weeks with and option unit to allow sufficient time to complete the project.

A project

It is important to teach students how to plan when they are undertaking class or individual activities such as projects. Students can apply knowledge and skills from Business Studies and Design & Technology to Agriculture. The process which students undertake when planning and undertaking a project is:

Planning

Research

- What to-do for the project? - decide on what plants or animals or type or simple farm machinery or equipment to produce
- Special requirements of the plant or animal or type or simple farm machinery or equipment chosen
- Time needed to complete the project
- Possible markets for the products
- Possible risks and problems
- Possible sources of help and support

Decide on the goals

- What and how much to produce?
- Timelines

Physical planning

- Select site
- Determine facilities needed
- Determine infrastructure needed e.g. housing, equipment, etc.

Financially planning

- Start-up costs
- Sources of funding
- Estimates of profit
- Estimates of cash flow
- Determine how records would be kept

Implementation

When implementing the project students

- Organize the necessary tools or equipment
- Obtain the required seeds/plants/animals
- Learn and practice the appropriate skills
- Undertake the activities required to grow the crop or raise the animal over the required length of time
- Undertake the activities required to harvest and market the product
- Clean up the area, and dispose of, or use waste appropriately.

UNIT 1 - INTRODUCTORY TO COCOA IN RURAL GROWTH AND DEVELOPMENT

Introduction

This unit lays a foundation for discussions on the importance of cocoa and the wide range of issues surrounding this lowlands rural based cash crop. It is reflected in income generation as cocoa growing families' living standards are raised with their accumulation of wealth. The change in life style increases as people are able to purchase goods and services to fulfil their needs and wants. Thus, a cash economy at the family level is created. The cocoa growers contribute to their local communities and the national economy as cocoa is a renewable resource and the third largest Agricultural cash crop commodity earner for Papua New Guinea. In additional, Papua New Guinea cocoa is special in the world as it is premium cocoa where it is used to flavour bulk cocoa from other major producing countries. Therefore, PNG cocoa gives high purchasing power to ordinary people.

Therefore, the unit briefly discusses

1) Cocoa as a crop
2) The growth of cocoa
3) Development of the cocoa industry
4) Politics
5) Economy
6) Social
7) Culture
8) Environment issues
9) Other major challengers in cocoa production

Learning Outcomes

At the completion of the unit, the students will:

A. Describe what is cocoa
B. Explain Growth in rural living standard in relation to cocoa cultiva
C. Explain cocoa benefits and Development in relation to the cocoa
D. Define Economy
E. Define Social
F. Define Politics
G. Define Culture
H. Define Environment
I. Outline challengers in to cocoa production in the rural areas

Content

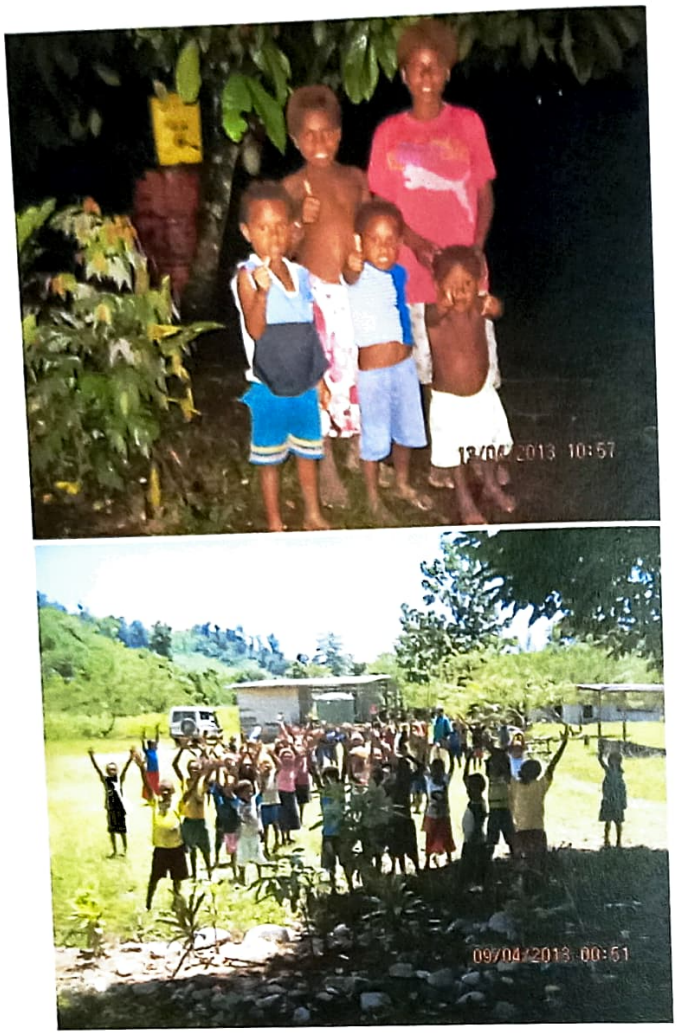


Figure 1.1& 1.2: Happy cocoa growing families' children giving a thumps up for cocoa and its benefits as cash crop

Note Figure 1.1: A Cocoa tree and a cocoa block input equipment/ tools and material in the back ground

Figure 1.2: School children from Warakindam Elementary School (Lassul, ENB). A major cocoa producing area

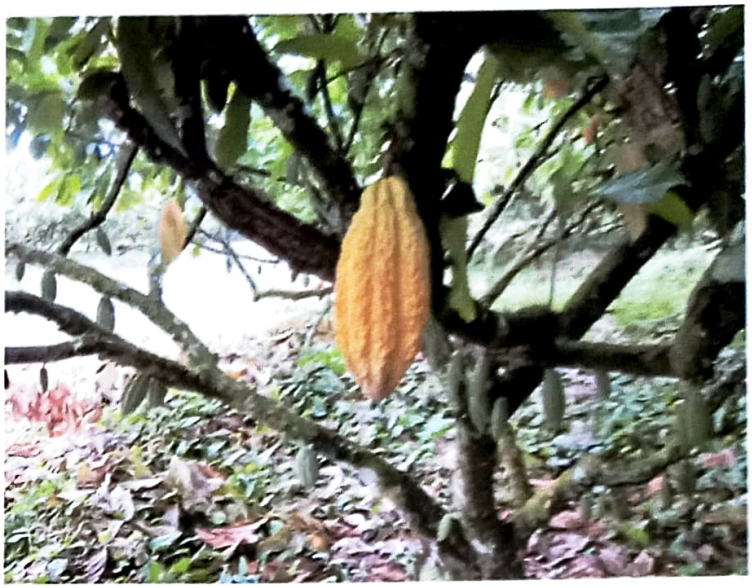


Figure 1.3: Showing ripe cocoa pod. Figure 1.4: Harvesting & breaking cocoa pods

Cocoa

Cocoa is produced by a cocoa plant. The fruit/pod develops from flowering, pollination and fertilization through to pod formation. In these pods cocoa seeds/beans are contained. These are then being harvested as cash crop.

Cocoa and political activities

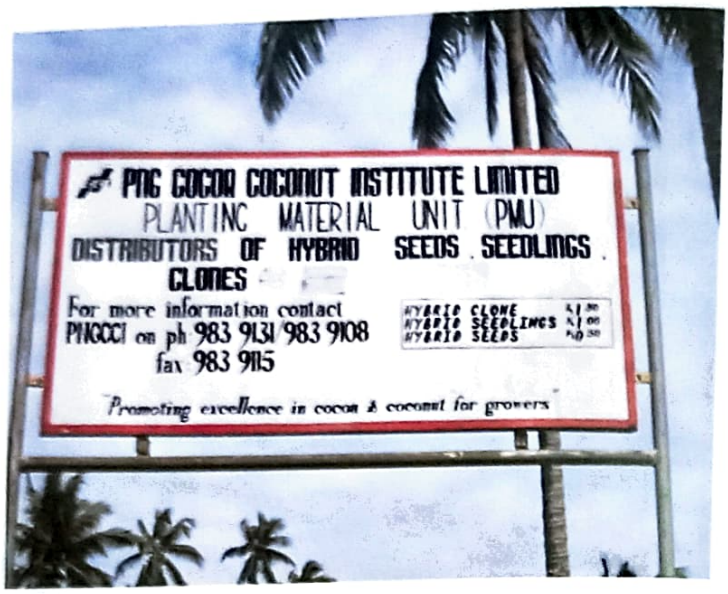
Political activities are mainly referred to as decision making process. In National Vision 2050 the government plans at all levels with the aim to achieve a population which is Healthy, Educated, Wealthy and Wise. It plans to empower people the use the environmental resources to partner the government, private and NGO and

churches mainly to bring growth and development in all relevant sectors. In the Agriculture sector, Cocoa is a strategic crop to drive income generation for cocoa growing entrepreneurs and especially rural families.
Therefore, the Department of Agriculture and Livestock regulates on it through our National Politicians on the floor of our National Parliament. It is a national function

Figure 1.5, 1.6, 1.7 & 1.8: DAL Minister, CCI CEO, Cocoa Board CEO, Dignitaries and Delegates at the launch of the ten CPB tolerant cocoa varieties at CCI headquarters- Tavilo, ENB. The gathering of high profile people shows how important cocoa is to the economy and the country.

Research and Cocoa Breeding

Research work at Tavilo is being supported by the National Budget annually and international donor agencies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Promoting excellence in cocoa & coconut for growers

Figures 1.9, 1.10 & 1.11: Showing Location of Research and Breeding Programmes at Tavilo and the Lunched CPB tolerant cocoa varieties

Cocoa Industry and growth and development

Growth of the cocoa industry can be measured in the increased supply of goods and services. Goods are mainly referred as the material wealth in the household. Services provided are in various forms to enable goods and services delivery

Cocoa and economic activities

Economic activities are mainly money making activities

Figures 1.12: A typical small holder mother with dry cocoa to sell Figure 1.13: Small holder families selling their cocoa produce

Figure 1.14 & 1.15: Market is an indicator of the cocoa cash follow in rural communities.
Informal common road side market 1.14 and formal Digicel co-operate sales- 1.15 are examples

Cocoa and social activities

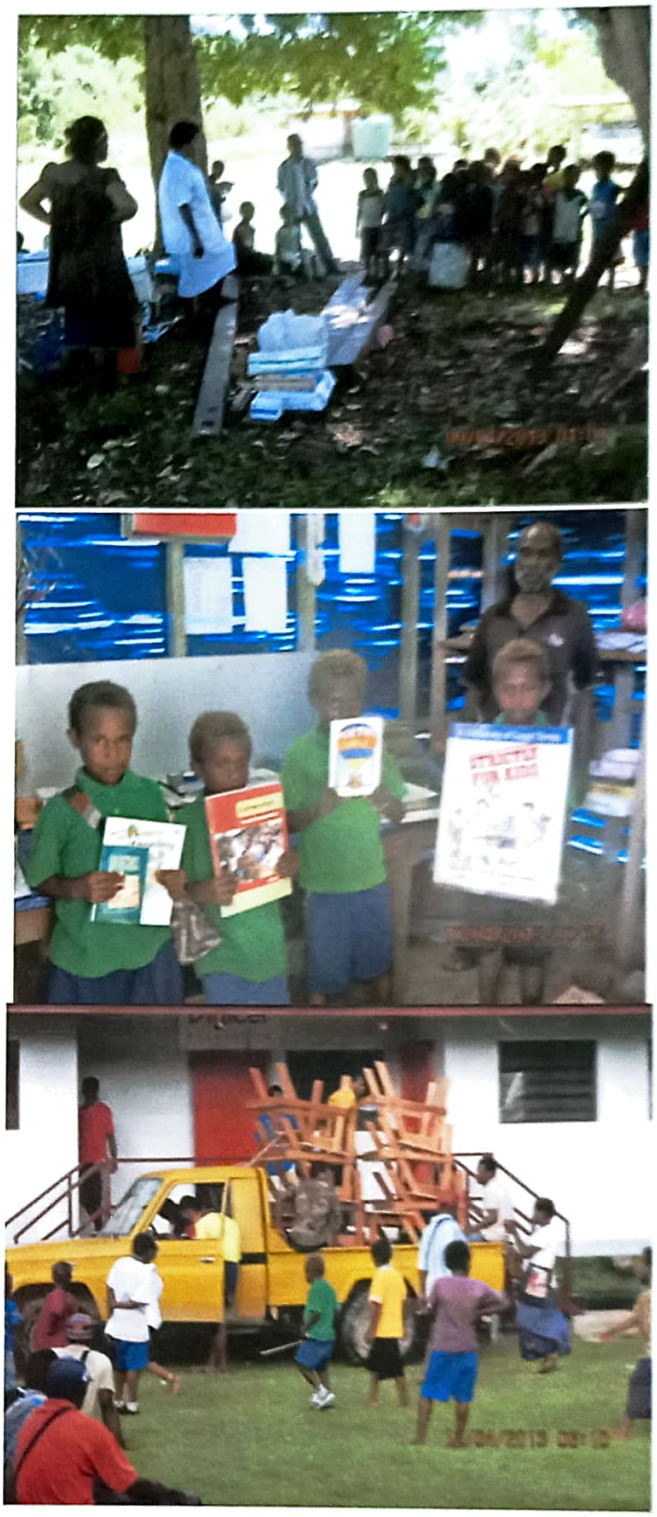
Social activities

There are wide ranges of social activities carried out by different sectors and cocoa stakeholders. This section briefly discusses the following:

Government Service delivery

Figures 1.16, 1.17 & 1.18: Showing one of the sites for the Cocoa Curriculum pilot project.

A Project targeting the new generation of cocoa growers



Figures 1.19, 1.20, 1.21 & 1.22: Showing Health and Education roll out programmes such as SLIP

Private Sector

Figures 1.23 & 1.24: Digicel Foundation donating a modernized double classroom to rural Kamanakam Primary School- ENB

Third Sector/ NGOs

Figure 1.25: Church building make from cocoa earnings. Figure 1.26: Rural aid post serving people make of cocoa income

Cocoa and cultural activities

Cultural activities refers to the activities people in societies practice as part of their living

In past and today about 80% of the people continue to live in the rural areas. There were some forms of trade like the bata system and free exchanges of goods. When modern cash money was introduced some societies and ethnic keep their cultures and traditions which are unique, thus promoting the nation in the tourism industry

Figures 1.27, 1.28, 1.29 and 1.30: Showing the value of money in the famous shell money/ "tambu" in ENB during cultural activities

In the "Tolai" societies as other in Papua New Guinea, cocoa plays an important role in customary obligation and in funding traditional activities

Cocoa and environment

Environment is the surroundings around us. People in rural areas always take from the environment. After a hard day's work in the cocoa blocks, families have access to fresh clear water, forest for building material, rich land for cocoa and food

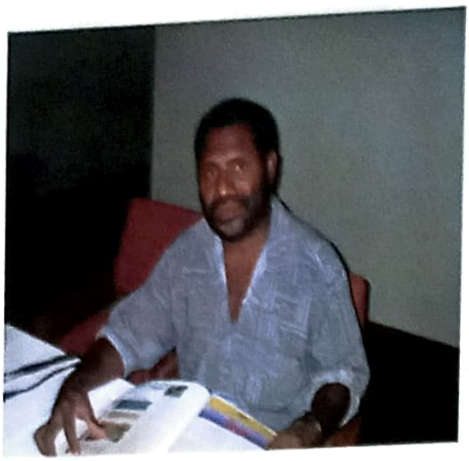
Figures 1.31, 1.32 and 1.33: Sound rural environment is a bonus to cocoa income for healthy living. Water is essential for living where families, especially children in rural areas have access to fresh clean water

Cocoa and People

Employment

The cocoa industry is the third largest Agricultural commodity. Thus, it is one of the largest primary industry sector employers both formally and informally. Through cocoa income rural families are employees of cocoa enterprises are able to meet their cost of living. These include paying for basic services such as education, health, transport, clothes, proper shelter, improved diet, etc.

Living standards



Figures 1.34 &1.35: Showing rural families members benefiting from cocoa income for Schools/ study fees and an improved living standard

Figures 1.36, 1.37 & 1.38: Showing how people live and sustain themselves, types of buildings built and innovative baking etc are examples of spin off activities from income generation from cocoa

Community activities

Figure 1.39: Women fellowship meeting Figure 1.40: School P&C meeting and Work Figure 1.41: Fishing material from cocoa income

Families in rural cocoa producing communities enjoy a sound living standard from income cocoa income that provides much needed services such as road infrastructures, better prices, better extension programmes, etc, to boast the atmosphere surrounding cocoa production

Challenges in rural cocoa production

Needed Basic Services such as Health and Education

Like in most rural areas of PNG, the topography of the land is a barrier to reaching much basic services such as Health and further Education

Pest and diseases

The infestation of economical pest and diseases such as Cocoa Pod Borer and Vascular Streak Die Back are a threat to the cocoa industry.

Infrastructures

Weather patterns and climatic changes

Damages to road and infrastructures due to weather, lack of regular maintenance and poor workmanship are really a burden to small cocoa entrepreneurs. Such damages is reflected in the high costs to run and maintain vehicles and this increased the burden on ordinary people to transport goods and services to and from the rural areas.

Figure 1.44, 1.45, 1.46 and 1.47: Showing the Soil Erosion, washed away bridges, bad roads and over loading to off vehicles is becoming unavoidable bring cocoa for sell to towns

Energy crises

In today's world, producers use fuel to power machineries to boast production. However, Fuel prices go up every now and then causing a strain on cocoa growers' budget

The prices

Our cocoa prices are controlled by the demand of consumers of cocoa products in the world. Therefore, cocoa price is determined on the international level. Prices of goods and services too, go up every now and then limiting the buying power of cocoa producers.

Land tenure system

About 97% of the lands in Papua New Guinea are customarily owned. There are government programmes to help people but unless land is registered, these programmes will not reach the ordinary families and support other programmes such as the women and youth, church, etc...

Inter-industrial/Agro-systems

Cocoa is a crop that is environmentally friendly. Families have the option to diversify with other food and cash crops unlike other crops like oil palm. Therefore, cocoa can be easily mixed cropped with other crops.

Figure 1.48, 1.49 & 1.50: Showing different site clearance for Oil palm- 1.48, Cocoa clearance inter-planted with peanut- 1.49 and 1.50- cocoa clearance inter-planted with food crops

Law and order

Law and order problems can disrupt and obstruct cocoa development. Cocoa growers have experienced armed hold ups, stealing or are being cheated and robbed of their earning. It is the government's duty to control crime.

TEACHING STRATEGIES

A) Introduction

Teacher to lead discussions and get students to brain storm ideas on

1) What is cocoa
2) Description of cocoa
3) Importance of cocoa

B) Body

Teacher to provide notes for students to correctly

1) Define cocoa
2) Describe cocoa features
3) State the importance of cocoa to the rural cocoa growing families
4) Importance of cocoa to the rural local economy
5) Importance of cocoa to the country's economy
6) Describe why cocoa is said to an industry
7) Explain how politics is important in the cocoa industry
8) Give examples of social benefits cocoa industry brings to the rural families
9) Provide reasons as to how cocoa plays a role in the culture of people in the rural areas
10) Demonstrate how the sound rural environment enhance to cocoa industry to be a success
11) Outline challengers facing the cocoa industry

C) Closure

Teacher to appoint groups presenters to

1) Description of cocoa
2) Explain the benefits of cocoa
3) Give an over view of the cocoa industry
4) State and describe challengers facing the cocoa industry

STUDENT ACTIVITIES

1. Describe cocoa in your own words

2. List the types of benefits cocoa brings to the rural areas

3. Describe why cocoa is said to be an important industry

4. Explain political, economic, social, cultural and environmental impacts on the cocoa industry

5. State and explain some challenges that affect cocoa production in the rural areas

UNIT 2: HISTORY OF COCOA

Introduction

This unit gives a review on the history of cocoa. The discussions include the following:

- The origin of cocoa
- Early cultivation
- The consumption
- The growth of consumption
- Developments and Spread of Cultivation
- History of cocoa in PNG
- Introduction of planting material into PNG
- Development of Cocoa Processing and Marketing in PNG
- History of Cocoa Research in PNG
- Notable features of the Cocoa Research Program over the years

Learning Outcomes

At the end of the unit, the students can:

A) Locate on the map the origin of Cocoa
B) Explain the cultivation of Cocoa in the early days
C) Describe the consumption of cocoa in the early days
D) Explain the growth of consumption of Cocoa in the world
E) Descried the developments of cocoa in Papua New Guinea
F) Describe the history of cocoa in PNG
G) Explain the introduction of planting material in Papua New Guinea
H) Explain the process of processing cocoa in Papua New Guinea
I) Describe marketing of cocoa in Papua New Guinea
J) Briefly describe the history of cocoa research in Papua New Guinea

Content

A) Origin of cocoa

Cocoa originated from the Amazon basin and tropical areas of South and Central America. It belongs to the genus Theobroma found in the Amazon basin. Theobroma, a Creek name meaning 'Food of the Gods"' has 20 species. Only Theobroma cocoa is widely cultivated. It has two main sub-species – Criollo and Foresterio

These species of cocoa are thought to have originated from the forest of the Amazon basin and early cultivation took place in Central America in Mexico and other Central America countries of Panama, Costa Rica, Honduras, Nicaragua, and others. The origin and cultivation of Theobroma species is shown in the maps below

Figure 2.1: World map showing the origin of cocoa

Main Cocoa Breeds

1.1 Cocoa belongs to the genus Theobroma
1.2 Has 20 species while only Theobroma cocoa is widely cultivated
1.3 Has 2 main subspecies. The Criollo and Foresterio

B) Early Cultivation

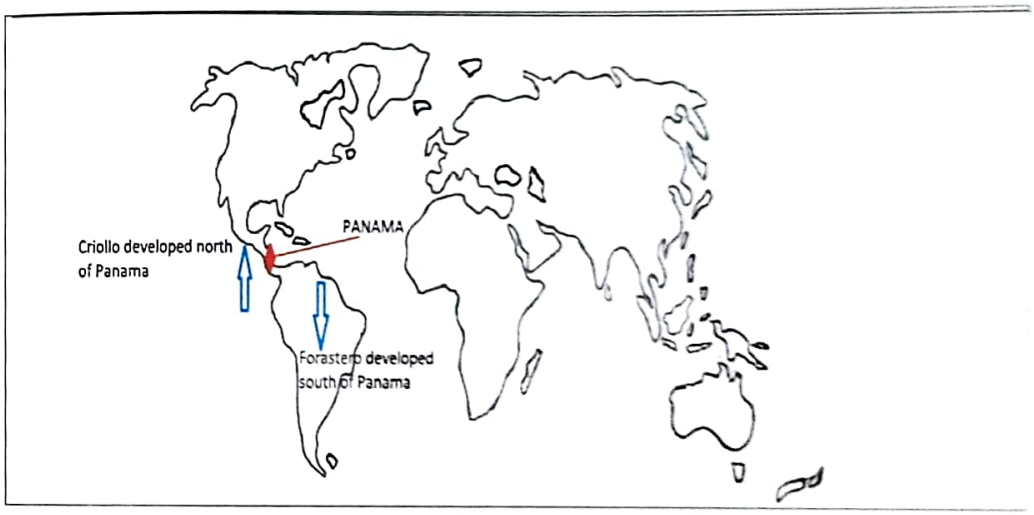


Figure 2.2: Showing the Sequence of events in cocoa development

1) In 1502 Columbus first saw cocoa begin traded in Central America
2) Spanish explorer Cortes discovered Mexico City in early 16th century found Aztecs
3) Aztec king Montezuma and his court consume large quantities of "chocolatl" but did not cultivate cocoa
4) Criollo developed North of Panama
5) Foresterio developed South of Panama

6) Consumed as early as the 6th century believed to be by Malay Indians
7) Varieties cultivated in Mexico and Central America is Criollo

Two reasons for cultivating Criollo

1) Criollo gives a palatable drink with little or no fermentation before-hand while,
2) Foresterio beans require several days for fermentation

C) Early Consumption of cocoa

1) Sent or paid as a tribute to the Aztecs by Maya Indians and others living in areas suitable for cocoa cultivation
2) Using cocoa beans to prepare a drink called "Chocolate". Was a luxury in Mexico City
3) Consumed by many classes of people in the growing areas
4) Used as currency to buy gold, slaves, clothing, food and even "public women"
5) Has medicinal properties and aphrodisiac properties
6) Other social and official ceremonies

Steps to mix

1) Roast cocoa beans
2) Grind cocoa beans
3) Mix with maize, vanilla and chilli
4) Stir the thick drink mixture with a special whisk

D) Growth of Consumption of cocoa

Figure 2.3 Consumers at a Kerevat (ENB) shop with Cocoa products

1) Spaniards found Aztec "chocolate" unpalatable. They mixed with cocoa paste with sugar and seasoning it with cinnamon and other spices
2) The drink became popular in Europe. In Spain, later Italy, France and England
3) First reported in England in 1652, 17th and 18th centuries consumption in London confined to chocolate houses frequented by the wealthy
4) Early 19th century, import duties were reduced and consumption increased, rising in Great Britain
   to 500 tons annually during the 1820s. Navy used half of this to replace rum
5) Chocolate drink was the only cocoa product in England till 1828 when Coenraad Van Houten pressed to remove some cocoa butter. A powder produced made it easier to prepare and digest which led to the range of products today
6) The milk chocolate was developed in 1875 in Switzerland by David Peter. He used condensed milk made by his friend Henri Nestle and first introduced in 1876. The spread in popularity of this product formed the base for today's world chocolate industry

E) Developments and Spread of Cultivation

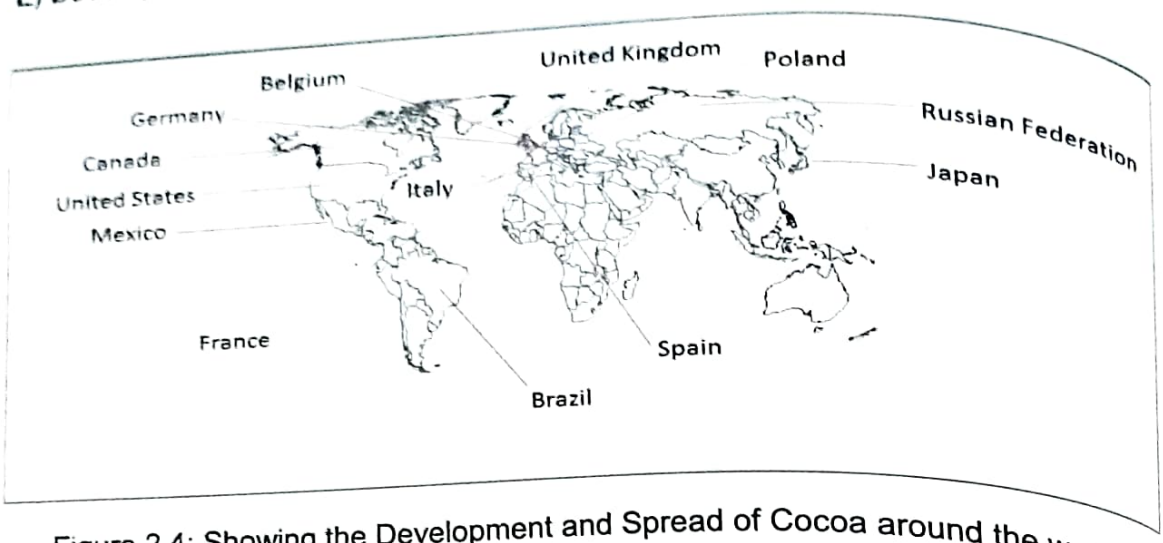


Figure 2.4: Showing the Development and Spread of Cocoa around the world

Sequence of Events in cocoa consumption

1) Cultivation spread to parts of South America, Venezuela and Caribbean, as Jamaica and Trinidad.
2) In the 1600s was taken to the Philippines and Spread to Java and India
3) In the 16th and 17th centuries, the cocoa Criollo varieties were cultivated
4) In the 18th century, Brazil and Ecuador started producing Forasterio cocoa
5) After Brazil's Independence, Amelonado type cocoa from Brazilian area of Bahia to Sao Tome and Principe Island of the coast Central America
6) In 1855 was taken to Fernando Po (Malabo) an island off the coast of West Africa
7) Later in the century it spread to Ghana and Nigeria to form the basis of cocoa growing
8) In West Africa, now the World's largest cocoa producing area

F) History of cocoa in PNG

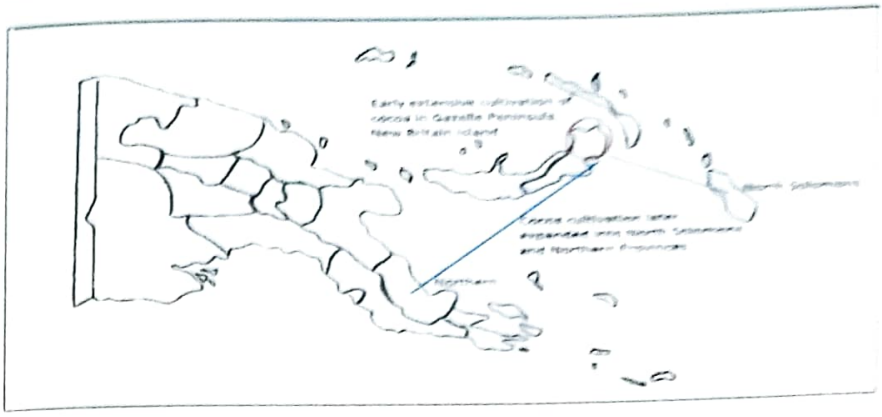


Figure 2.5: Map of PNG showing cocoa establishment

1) Up till the Second World War, the cocoa crop was primarily grown on plantations
2) In early 1950s it initially developed on plantations in New Britain, Bougainville and
3) Oro while smallholder cocoa based smaller land settlement schemes were established at Vudal (East New Britain) and Oro
4) Early extensive development was in Gazelle Peninsula of New Britain
5) Figures for PNG from 1964 and 1965 indicated about 45 500ha of cocoa crop on plantation and 12, 750ha on small holders. About half of this in East New Britain

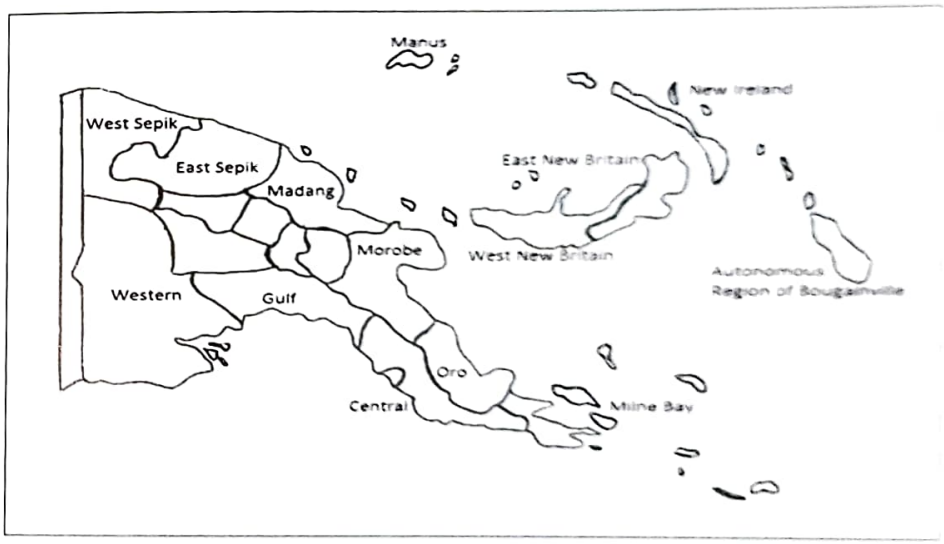
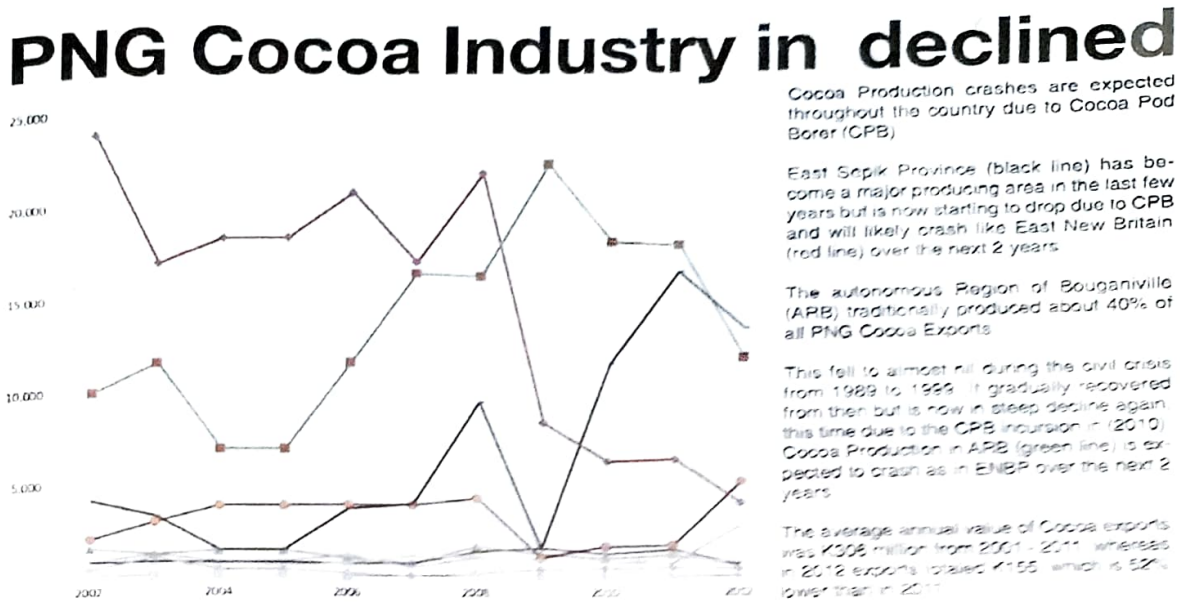


Figure 2.6: Cocoa growing provinces of Papua New Guinea

Table 2.1 Provinces Cocoa Production Figures

Province	Annual Production by Provinces										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
East New Britain	20,522	15,003	23,882	16,920	18,241	20,626	19,027	16,930.00	21,640	8,279	6,207
North Solomons	4,073	5,447	9,995	11,525	6,881	11,559	13,071	16,305.00	16,144	22,414	17,945
New Ireland	1,295	1,105	1,512	1,191	1,380	984	1,185	710.00	1,628	1,223	979
West New Britain	722	435	769	783	763	698	803	708.00	1,362	1,564	1,251
Manus	13	13	21	10	7	3	1	-	8	9	7
Madang	1,731	2,801	2,045	4,443	3,826	3,877	3,181	3,884.00	4,257	2,049	1,641
Morobe	203	539	840	1,157	831	1,141	779	530.00	1,020	931	745
East Sepik	1,176	1,468	4,125	3,291	1,426	3,676	3,438	3,936.00	9,411	14,296	11,445
West Sepik	312	203	153	599	545	756	892	1,107.00	1,059	932	746
Oro	109	215	361	1,019	331	177	22	44.00	172	-	421
Milne Bay	-	1	3	5	-	3	5	-	1	5	4
Central	-	-	-	-	-	-	-	-	-	-	-
Gulf	-	1	1	-	-	-	-	-	-	-	-

The table shows cocoa production figures by Provinces from the period 2000 to 2011. The most significant information from the table from 2000 to 2008, cocoa production by ENBP ranged from 15, 000 to 23,000 tons per year but after the CPB invasion this production dropped to only 1/3 of the production to about 8,000 tons per year. The ENBP which was the biggest producer of cocoa dropped while Bougainville rose from the civil war destruction to be the top producer of cocoa followed by ESP. This production figures show how devastating CPB can be to destroy cocoa production and reduce the rural population that relies on cocoa to misery.



The figure shows the cocoa industry in PNG on the decline due to the cocoa pod borer incursion. Generally major producers like the ENBP showed major decline while ESP and North Solomon show an increase and these are not affected by the cocoa pod borer incursion yet.

G) Introduction of planting material into PNG

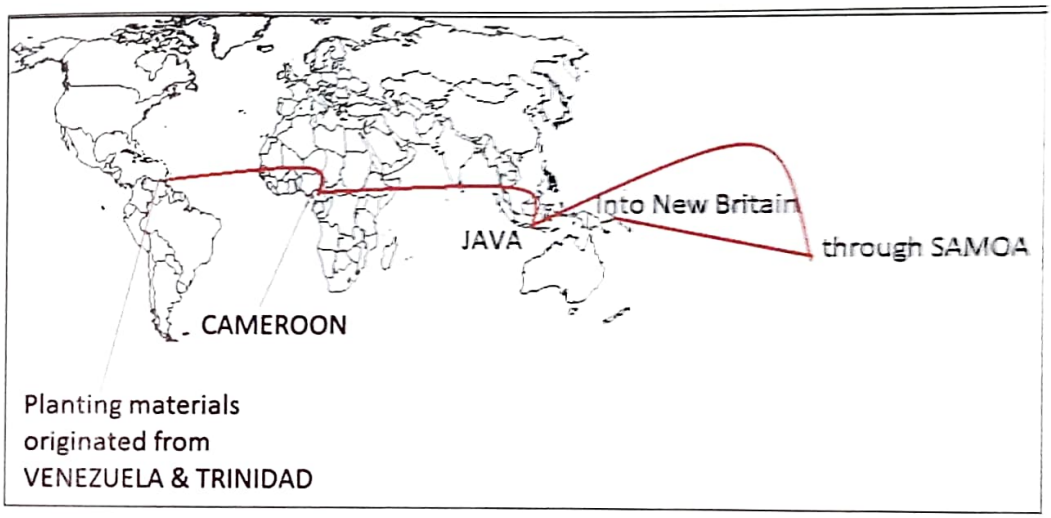


Figure 2.7: Asia/Pacific Map showing the spread of cocoa

1) Most likely our cocoa came from Samoa
2) Most material originated in Trinidad and Venuezuela, came via Java, Ceylon and Cameroons
   to Samoa then PNG
3) The Germans annexed New Guinea in 1884 and took large numbers of labourers to work on the Germans' plantations in Samoa. By 1900 well

established shipping communications between the two countries and likely transported cocoa seedlings back to New Guinea
4) There was a subsequent introduction to PNG from Java in 1932

The 1960s introductions included:

1) Seeds of Upper Amazonian material, comprising Na 32x Pa 35 crosses and a wide range of crosses within Nanay, Parinari, Scavinia and IAC groups- some of the parents of our present hybrids
2) Open pollinated seed from ICS (Imperial College Selections) clones from Trinidad.
2) Seed of West African Amelonado from Malaysia
3) Further introductions of ICS clones and Amelonado material from Malaysia via the Solomon Islands in the mid 1980s

I) Development of Cocoa Processing and Marketing in PNG

1) The cocoa Ordinance of 1951 officially discouraged village plantings, however, the Tolai people of East New Britain actively planted cocoa
2) The Administration developed a marketing organization- known as the Tolai Cocoa Project which later became the New Guinea Islands Produce Company (NGIP), backed by DPI through the Local Government Council System
3) Rural progress societies were set up on co-operative lines in areas that first planted village cocoa such as Siwai Co-operative (Bougainville), Karkar Company (Madang), Akua Society (Finschhafen), Lamington united Cocoa Limited (Oro) and East Sepik. Most failed while some are still major wet bean buyers. These were managed by DPI field officers and later Department of Commerce
4) In mid 1970s, PNG Cocoa Board started to regulate the expanding Industry and administer a price stabilization scheme

J) History of Cocoa Research in PNG

1) In 1911 the production was only about 40 tonnes from a total of 400 hectares, much was immature plantings
2) War in 1914 to 1918 resulted in the loss of many trees
3) Planting of cocoa did not increase and production in 1923 was approximately 80 tonnes
4) Inter planting cocoa under coconuts was popular in the 1930's and 1200 hectares were established by the end of that decade
5) The Australian Government encouraged the industry to expand by passing The New Guinea Bounties Act of 1926 and the Customs Tariff (Papua New Guinea Preference) Act of 1926
6) Cocoa was one of first crops planted when Demonstration Plantation at Keravat was opened in 1928
   The demonstration plantation provided advice to growers and supply seeds from selected trees at reasonable prices

   a) Additional breeding material was introduced from Java in 1932
   b) Pre war research was concerned with seed selection and vegetative propagation
   c) A spacing trail was planted in September in 1935
   d) Cocoa weevil Pantorhytes caused problems in 1940 and a serious problem in many parts of PNG today. Therefore, spraying and banding tests were initiated
   e) War outbreak in the Pacific halted work and Papua New Guinea cocoa producing fell dramatically. Export in 1936 to 1940 period averaged about 200 tonnes per year
   f) In 1946 to 1947 only 48 tonnes exported
   g) Figures increased gradually to 730 tonnes in 1953 to 1954. Large scale plantings
      i) followed and resulted in that exports totalled 10 000 tonnes in 1961 to 1962,
      ii) 20 000 tonnes in 1964 to 1965. The peak export year was 1989 when 48 000 tonnes exported
      iii) In 1990 the Bougainville crisis interrupted production there Smallholders now produce about 64% of the Country's annual crop
7) After the war in 1948 and 1949, trees were selected from Keravat demonstration Plantation, Lowlands Agriculture Experiment station (LAES) now NARI. From remains of bombed out Rabaul Botanic Gardens and Asalingi Plantation pods from trees used to plant up a number of progeny trails on LAES
8) From 1952 to 1957 research expanded. A selection and breeding program initiated, spacing and fertilizer trails laid down, cocoa processing researched, vegetative propagation by cutting examined
9) Papua New Guinea Trinitario cocoa is very heterogeneous. It is derived originally from crosses between Criollo and Forastero types. First crossing programme in 1958 for possibility of obtaining improved Material by crossing extreme of parents being based on pod and bean characteristics. This was partly successful

10) In early 1960s, a significant problem occurred. The Vascular Streak Dieback disease (VSD) was in many parts of the country including Gazelle Peninsula. It was first recorded on LAES in clone K1-102 in clone Testino Series III in early 1961. Proposed hybrid breeding programme was postponed as several years were spent on researched into this disease. Experimental work was not resumed till 1969

11) First Trinitario x Amazonian hybrid breeding programme expanded in 1980 to combine high yields with disease resistance. This was done by the Cocoa Industry Company, which became the Cocoa and Coconut Research Institute 1986 using Information collected by DAL research staff on yields and resistance. Improved hybrid seed gardens were established in 1986 and improved seeds (SG2) became available to growers in 1988.

Notable features of the Cocoa Research Programme over the years have been:

A) Agronomy

1) Shade, spacing and fertilizer trials were conducted from the late 1950s to 1970s
2) Studies and trials of suitable soils for cocoa, suitable shade species, and pruning techniques
3) Planting cocoa under coconuts became standard practice in many areas of PNG after trial work in New Ireland in the 1940s and 1950s
4) A study of propagation techniques started in the 1930s, using seed, cuttings, and bud grafting methods. The change from cuttings to bud grafting as a more effective method of cloning gave rise to commercial bud grafting, which began in August 1976, and the transition from cuttings were completed by September 1977
5) Selection and cloning of VSD-resistant and high-yielding material for distribution to growers
6) Development of more efficient spraying machinery and techniques for pest control

B) Breeding

1) Selection of Trinitario material introduced in the early 1900s and the establishment of collections in 1948
2) The importation of Amazonian and Amelonado material and its evaluation in the 1960s
3) The importation of selections from Puerto Rico and Ghana in the early 1970s
4) Introductions of material from Kew Gardens and Reading University collections and USDA
    i. Miami collections commenced in 1975
    ii. Introductions of Amelonado material from the Solomon Islands in 1985

5) The success of the hybrid breeding programme (Trinitario x Amazonian) in 1980 and the establishment of hybrid seed gardens and distribution of hybrid seed for redevelopment in 1982 (SG1s)
6) The development of new improved hybrids (SG2s) and the establishment of seed gardens between 1982-1987,for commercial production in 1988

C) Entomology

1) Identification of *Pantoryhtes* weevil as the major insect pest of cocoa in many provinces of PNG, and the development of control methods including biological control using Crazy Ants
2) Study of the Giant African Snail, a devastating pest of cocoa nurseries and young cocoa plantings, which was introduced by the Japanese during the war, and the adaptation of Gonaxis snail for biological control
3) Research on the biology and control of a wide range of cocoa and shade tree pests which are constraints to cocoa production (e g. Psyllid)

D) Plant Pathology

1) Detection of Vascular-Streak Dieback (VSD) disease, which caused a virtual cessation of breeding and agronomy work between 1962 and 1969
2) Identification of the causal organism of VSD: the development of control measures and of a quarantine screening technique for planting material entering VSD- free areas of PNG
3) Development of improved spraying techniques and machinery for Black Pod control from 1979 to 1985, and a series of field experiments to investigate the potentials and the limitations of cocoa Black Pod (*Phytophthora*) pathogen control measures
4) Development of a trunk injection technique using Phosphorus Acid
5) Identification of various minor diseases of cocoa, (root diseases, Pink Disease, etc.) and recommended control measures

E) Processing

Studies and trials on fermentation of cocoa and drying techniques conducted in the 1950s and 1960s, resulting in recommendations to growers on commercial and efficient methods of processing.

Teaching Strategies

A. Introduction

1. Ask students to state the origin of Cocoa
2. Show a World Map and ask to locate origin
3. Descried Cultivation and Growth of Consumption in the world through to PNG
4. Show PNG Map and ask to Locate Cocoa cultivation areas
5. Describe briefly the introduction and spread of Cocoa
6. Explain processing and marketing of Cocoa
7. Give brief history of Cocoa Research in PNG

B. Body

1. Use history notes, Give correct origin.
2. Use a World map to show correct location.
3. Using history notes, describe Cultivation and Growth of Consumption in the World through to PNG.
4. Use PNG map, Locate Cocoa cultivation areas.
5. Use PNG map and notes to describe the introduction and spread of Cocoa.
6. Use notes and field trip/visit/exposure, explain processing and marketing of Cocoa.
7. Use notes and field trip/visit/exposure, describe and explain Cocoa Research in PNG.

C. Closure

1. Orally ask students to:
    a) Give origin
    b) b) Show locations on the map.

2. Short test on origin, cultivation, consumption, growth and spread, processing and marketing and Research in PNG.

3. Mark (1 or 2) and evaluate student performance

Student Activities

1. State the origin of Cocoa

2. List Locations of early Cultivation of cocoa

3. Describe early Consumption cocoa.

4. Explain the Growth of Consumption leading to cocoa industry today

5. State a range of cocoa products

6. Describe the spread of cocoa through the world to PNG

7. Explain introduction of planting material to PNG

8. Write a page on the processing and marketing in PNG

9. Describe briefly the Cocoa research in PNG

Practical/Experiential Activities

1. Teachers are encouraged to organize for resource people to come and discuss historical experiences

2. Teachers to arrange and organize field trips to cocoa plots as appropriate.

UNIT 3: CLIMATE FOR GROWING COCOA

Introduction

After soil and nutrient requirements, climate is the most important determinant of the growth of cocoa. Climate is made up of a complex inter- relationship of factors such as temperature (largely determined by altitude in the tropics), rainfall, humidity, cloud cover, sunlight and wind-speed.

Evaluation of the quantity and distribution of rainfall and temperature is usually sufficient to set limits within which cocoa growing could be successful. In this unit the student will basically learn the climate factors effects and have a feel of instruments/equipment for measuring different climatic factors. Therefore, it covers:

1. Altitude
2. Temperature
3. Rainfall
4. Latitude
5. Sunlight requirement
6. Effect of sunlight on cocoa
7. Winds
8. Other effect of climate

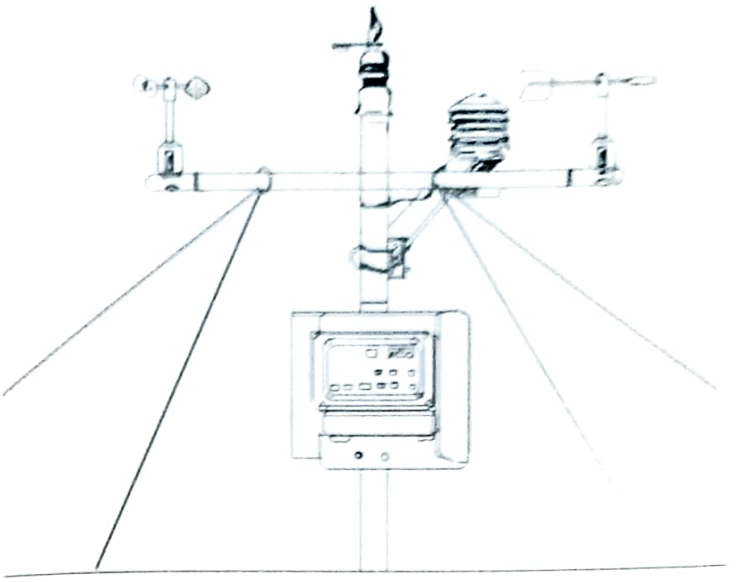
Learning Outcomes

At the completion of the unit, the students can:

A) Describe the altitude where cocoa is grown
B) Give required temperature ideal for cocoa growing
C) State range of rainfall vital for cocoa growing
D) Identify the latitude where cocoa is grown
E) Define sunlight requirements conducive for cocoa growing
F) Explain winds requirements necessary for cocoa growing
G) Refer to other aspects of climate important for cocoa growing

Content

Figure 3.1: An ideal Weather Station and weather instruments at CCI PNG LTD



A weather station is where weather and other climatic conditions are recorded and monitored for a particular area. At the station are various climatic factors instruments are installed as shown and discuss below

The climate

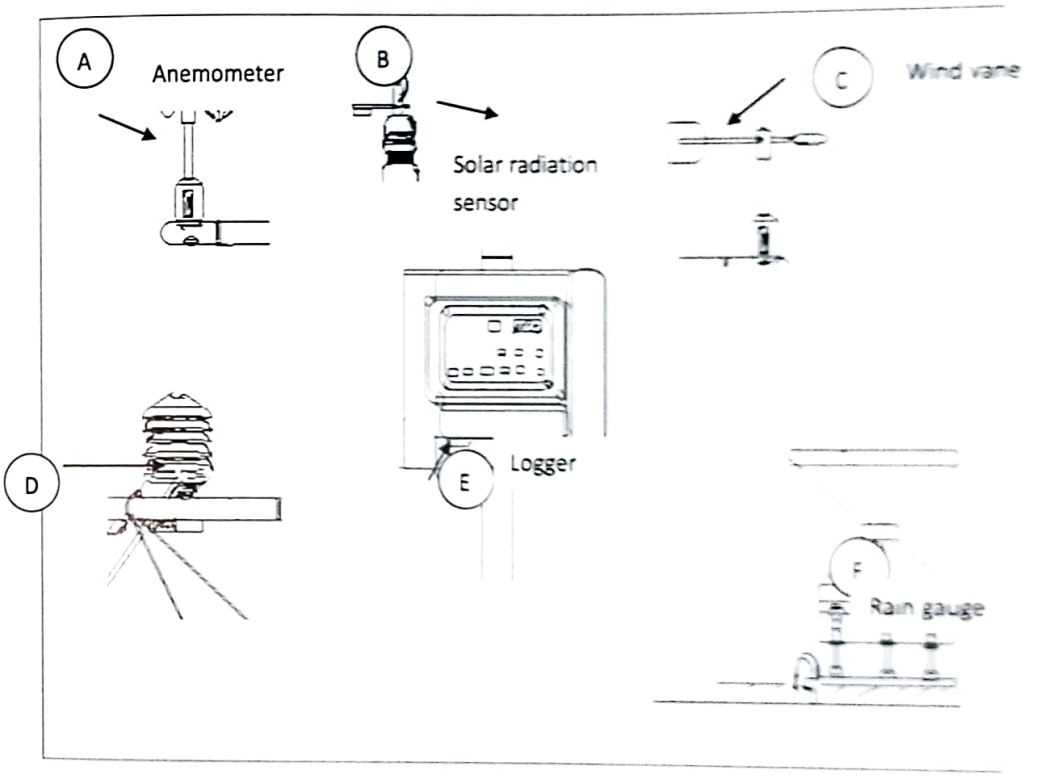


Figure 3.2: Showing the weather station and weather factors instruments

Altitude

1. Cocoa can be grown from sea level to 600 meters above sea level in Papua New Guinea
2. Above 600 meters, diurnal range can be greater that 9 *C and mean annual temperature less than 25.5*C
3. Common occurrence of mist and cloud in hilly coastal lowlands increase the risk of fungal diseases
4. Therefore, cocoa cultivation not recommended
5. In Papua New Guinea cocoa growing are in places where the mean minimum temperature not less than 21*C and mean maximum temperature not more than 31*C

Temperature

Instrument for measuring temperature is the relative humidity and air temperature sensor

1. Temperature conditions favouring cocoa growing are where seasonal variations are small and the diurnal (daily) range is most constant throughout the year
2. Mean annual temperature most suitable for cocoa is 25.5*C with a monthly mean minimum of 15*C, a mean maximum of 30*C and daily range of 9*C
3. This order of daily temperature is necessary for initiating bud-bursting
4. If the daily range exceed 9*C, leaf- flushing can be excessive especially where maximum temperature rises above 28*C
5. Flower formation appears inhibited at mean annual temperatures below 25.5*C
6. All coastal areas in Papua New Guinea are considered to satisfy these temperature conditions

Rainfall

Figure 3.3: Flooded river after a lot of rain fall. Figure 3.4: Lots of rain water run offs damage road infrastructures to rural areas

Instrument for measuring rainfall is the rain gauze

1. Most cocoa growing areas in the world have annual rainfall of 1500 to 2500mm.
2. Careful selections of soils and good management enable cocoa to be grown successfully in areas with annual rainfall as low as 1150mm, e.g. parts of Nigeria where rainfall is less than 1250mm while four months of the year are dry, such seasonal climates appear to have little or no effect on yield apart from producing peak cropping periods
3. The severity and duration of " dry season" cocoa can tolerate will depend on available water- holding capacity of the soil
4. It is widely accepted that the loss of water by evapo- transpiration from area planted with cocoa is about 100 to 125mm a month implying a similar mean minimum monthly rainfall is desirable
5. Areas with rainfall more than 4000mm are undesirable as are liable to nutrient losses through excessive leaching, soil erosion and increased incidence of fungal diseases
6. Cocoa production needs rainfall evenly distributed throughout the year ideally no month less than 100mm
7. In Papua New Guinea, three months in a row with less than 100mm of rain is unsuitable for cocoa
8. A total annual rainfall not less than 1500mm to not more that 4000mm is considered satisfactory as average annual rainfall is about 2500mm is well distributed throughout the year with a short dry season is preferred
9. Cocoa grown in areas of Papua New Guinea with rainfall greater than 4000mm with free- draining soils e.g. Buin (4100mm) and Lea (4600mm), fungal diseases can occur
10. Good cocoa growing conditions is associated with high humidity, the lower relative humidity of dry season accelerates water loss from tree transpiration
11. Mean minimum relative humidity of about 70% preferred

Latitudes

Cocoa can be grow between latitudes of 20 *S and 20 *N but most world's cocoa is produced between 10 *S and 10 *N where Papua New Guinea lies within this band

Sunlight Requirements

1. Response of cocoa to shade indicate amount of sunlight falling on cocoa trees can affect yield
2. Relationship between tree growth and interaction between amount of radiant energy intercepted by tree and soil fertility
3. Soil fertility is not limiting factor as trees will be able to be productively use more sunlight and will require less shade
4. Cocoa in infertile soils may do very poorly under similar low shade as nutrient level are inadequate to maintain higher degree of metabolic activities induced by more sunlight
5. In Papua New Guinea an average of about 5.5 hours sunlight per day is preferred although this varies from 4.5 per day in Buin and to 6.1 per day at Madang. In other parts of the World averages 7.3 hours per in Trinidad to as low as 2.6 hours per day in Ecuador

Effects of sunlight on cocoa

The transference of the sun's radiant heat through the air and the soil is essential to plants

Thermal effects

Three important plant process directly affected by the temperature of air and soil

a) Growth of plant tissues closely correlated with air temperature and truck growth where soil water supply is abundant and regular but not where distinct wet and dry seasons cause irregularity in soil water supply

b) Metabolism involves enzymes activity is accelerated by rises in temperature. Found that pod ripening is generally more rapid during the hotter months of the year

c) Leaf temperature may be as high as 18 *C to 20 *C higher due to exposure to direct sunlight and corresponding increased rate of transpiration may be two to three times as great than cocoa leaves in the shade

2. Illumination effects

Three important plant processes depend on the effects of direct illumination (light)

a) Photosynthesis. Light is essential where carbohydrate is produced in illuminated leaves from carbon dioxide and water
b) Movement of stomata about 35 000 to 60 000 per square meter. Wide open under direct sunlight in the early morning and thus allow free entry of carbon dioxide gas, water and oxygen outs
c) Enlargement of cells of certain plant tissues. Late in the day, effect of light intensity on turgidity of guard cells which regulate the size of the apertures or loss of water from leaves by transpiration, enhanced by a reduction in the water supply of the soil

Winds

Instrument for measuring wind direction is wind vane

Strong winds can

1. Adversely affect cocoa. Leaves has short petiole and can be damaged by movement of steady winds
2. In dry season decrease the relative humidity in a block and increase evapo-transpiration, if persists trees die
3. Bring salt spray from the sea to defoliate trees. Difficult to grow cocoa close to the sea

Other Aspects of Climate

1. Low temperature and high humidity as in wet season in Papua New Guinea favours the spread of fungal disease such as black pod, canker and vascular streak die back (VSD)
2. Wet season is ideal for cocoa development in Papua New Guinea while at the same time is ideal for disease build up
3. Wet Africa harvest and ferment during dry season and good quality cocoa is produced by small holders using sun drying

Teaching Strategies

A) Introduction

1. Ask students to list climatic factors of Cocoa
2. State importance of temperature
3. Give the range of rainfall for cocoa growing
4. Describe the importance of sun light
5. Explain the process of transpiration
6. Explain importance of photosynthesis

B) Body

1. Use notes, Give correct climate factors for cocoa growing
2. Refer to a weather station, identify instrument for measuring each climatic factor
3. Using notes, describe the process of transpiration
4. Demonstrate the process of transpiration
5. Conduct an experiment on photosynthesis

C) Closure

1. Orally ask students to
   a) Give climatic factors
   b) State measuring instrument for climatic factors
2. Short test on climatic factors and importance to cocoa production
3. Mark (1 or 2) and evaluate student performance

Student Activities

1. State the climatic factors that affect Cocoa Production

2. Describe the effect of temperature on cocoa

3. State the range of rainfall required for cocoa growing

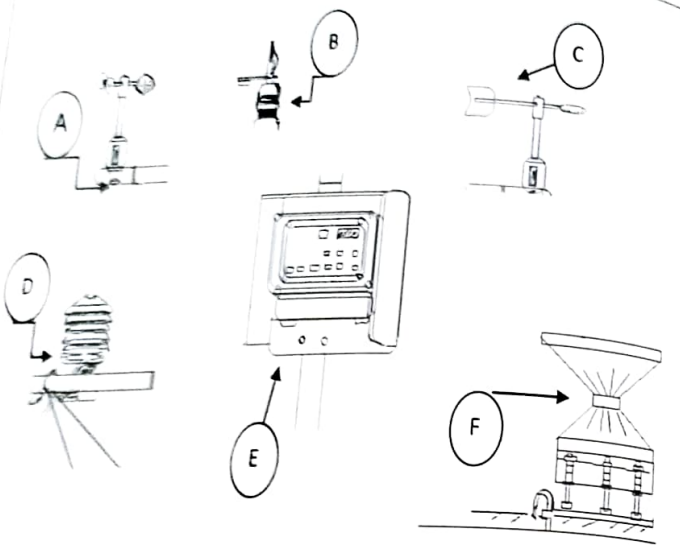
4. Identify the latitude ideal for cocoa growing

5. Describe other factors needed for cocoa growing

6. Explain the effects of winds

7. Write a page on the effect of low temperature and high humidity on cocoa

8. Describe briefly the importance of rainfall in cocoa growing areas



9. Identify, label and discuss each weather instrument of a weather station
10. State the function of different instrument of a weather station

Practical/Experiential Activities

1. Teachers are encouraged to organize for resource people to come and discuss climate and weather patterns

2. Teachers to arrange and organize a visit to a weather station nearby

3. Identify instrument for measuring climatic factors and discuss each factors impact on Cocoa production

UNIT 4: NURSERY

Introduction

Planting material is propagated either sexually or asexually (from vegetative plant parts). Sexual production involves flowering, sexual union from female and male flowers parts and fruits that produce seed in pods.

Trees from seeds are a combination of genetic material from the parent tree(s) and so will be distinct individual that vary from either parent. It is unpredictable if the genetic variation will make a tree grown from seed better or worse at producing cocoa than its parent(s). Cocoa seedlings grown from seeds collected from the same tree can vary in their performance in terms of growth vigour, yield quality and pest and disease resistance. Trees grown from seeds are known as, 'hybrids' which are said to be sexually propagated planting material and will be heterozygote (or mixture of genes).

Vegetative propagation is growing of new trees using vegetative parts of existing plants and not seeds. Vegetative propagated planting material will produce a clone form the tree which the material is taken and will demonstrate homozygote. Clone are genetically identical to (i.e. exactly the same as) its 'parent' in every way. If trees are cloned from parents that are high yielding, resistant to pests and diseases have pods which are large and have many large seeds, they too will show these characteristics.

Using clone cocoa planting material minimizes variability therefore performance of a tree is predictable. It promotes uniform growth and increases cocoa yields of the desired quality, provided the selected clones are well screen and well managed. Clones should be used as planting material when available/possible. When not available, recommended hybrid seeds should be planted. Propagation of clones requires seedlings grown from seed to provide rootstock for the material to be grafted onto. Cloned planting material and hybrid seeds have to be source from CCI nurseries as specialized skills needed to produce them. Therefore in this unit, students will learn and appreciate the following out comes.

Learning Outcomes

At the completion of the unit, the students can:

A. Definite nursery
B. State the reasons for having a nursery
C. Discuss site preparations procedures
D. Describe general nursery management
E. Other aspects of nursery management
F. Explain types of nurseries structures
G. Describe how to fill the poly bags
H. Describe vegetative propagation process. budding, grafting and marcotting

Content

The Nursery

A nursery is where seeds are raised from seed to seedlings stage when they are ready for field planting. Cocoa seeds are expensive and valuable for special care should be taken to raise seedling until the seedling a mature enough to be transplanted onto the field.

Advantages of having a nursery

1. Raise own when not buying
2. Best to raise seedlings in a nursery
3. Seedlings easily looked after and protected in a small area
4. Possible to choose the best seedlings and plant at most suitable time
5. Whether seedlings are hybrid seedlings or raised as root stock to be grafted with clonal material, the approach to establish and running the nursery will be the same

Site selection

A good nursery site should have the following features

1. Well drain, very slightly sloping land is the best
2. Good water supply is essential
3. Not too far from the block where cocoa will be planted
4. Not near or under old cocoa trees to avoid diseases and insect pests that will harm the young seedlings
5. About at least 100 meters from the nearest mature cocoa trees
6. All weather road access is essential for rainy weather as the best time for planting cocoa
7. Good supply of good quality top soil
8. Plant wind breaks as young cocoa seedlings are very sensitive to continuous movement by steady winds

Site preparation

I. **Under brushing and felling, Clearing or weeding**
   1 Remove under growth and shabby plants
   2 Fell trees
   3 All material removed and completely burnt (basic sequence as clearing a block to plant cocoa

II. **Levelling**
   1 Gently slope site is ideal as it helps drainage after heavy rain
   2 Frame to support shade
   3 Poly bags
   4 Irrigation pipes laid properly
   5 Levelling done manually or front loader/ bulldozer depending on the size

III. **Drainage**
   1 Cocoa sensitive to water logging so essential that the nursery site drains quickly after heavy rain
   2 Main drainage channels should be dug in the direction of the steepest slope

IV. **Design and construction**
   1 Temporary nurseries
   Set up to establish one small to medium size cocoa block

   2 Permanent nurseries
   3 For plantations or commercial enterprises that supply seedlings to many growers

Nursery size depends on how many seedlings needed to plant the block

1. Calculate the number of seedlings required for field planting
2. Add 40% more to allow for Culls (30%)
3. Seedling bags containing non- germinators (10%)
4. Divide this number by 20 and will give the required size of the nursery in square meters
   a) Assume a planting density of 625- 722 trees per hectare,
   b) Approximately 43.75m2 – 50.5m2 of nursery space area will be needed to raise enough seedlings to plant out every hectare on a cocoa block,
   c) i.e. 625 trees x 1.4 (140%)
   d) 722 trees x 1.4 (140%)
   /20

   = 43.75m2 to 50.54m2

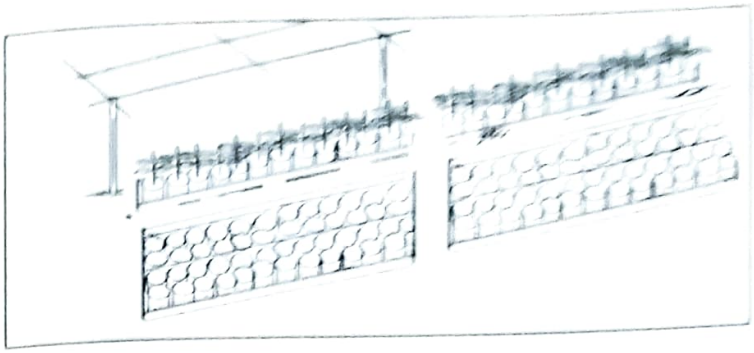


Figure 4.1: Cocoa poly bags Arrangements in a Nursery

Types of structures

a) Temporary nursery materials

Figure 4.2: Temporary Nursery (Bombom) Using Coconut Fronds for Shade

This type of a nursery is easy to make but will break down under weather condition rapidly. Bush materials will rot easily.

Steps

1. 2.5- 30 meter long hard wood/ kwila posts
2. Strips of split bamboo
3. Coconut or sago fronds
4. Black polythene seedlings bags size 35 cm x 18 cm
5. Live shade, one 1.5m long gliricidia stick for every shade tree is needed. Between 16 and 20 Gliricidia shade trees will be needed for every 50m2 of nursery space, depending on lay out whether square or rectangular shape
6. Empty 200 litter drums, for water storage and catchments if roofing nearby to provide water for the seedlings in dry weather

Figure 4.3: Semi - Permanent Nursery Using Gliricidia Trees

Semi-permanent materials are easily to construct by using already established shade trees or using some modern materials and some bush materials. They will not last long and will not provide good shade.

Steps in Construction

1. Plant Gliricidia (live shade) by putting the 1.5 meter long sticks in the ground at 2m x 3x spacing (i.e. 2m between trees within a row and 3m between rows) 9 months before you sow cocoa seed in the polybags. Trees need regular pruning to maintain the shade at suitable levels
2. Alternatively, coconut or sago fronds can be placed on frames held up by posts to provide shade of approximately 50%. As frond dry, they let in more light. This helps seedlings to harden naturally. When other materials are used, remove gradually starting 4 weeks before planting out
3. Seedling bag supporters made of stakes and bamboo splits are installed underneath the shade
4. These define seedlings bed rows, made 36cm wide to fit double rows of seedling bags (i.e. 2 x 18 cm wide bags).
5. Beds should be arranged in series of three
6. An access gap 25-40 cm wide between each bed (double row of bags).
7. Every third access gap should be slightly wider- 60 cm wide- to permit easy access for wheelbarrows and management operations
8. Lines can be continuous down the length of the nursery
9. A wire or piece of wood placed across the lines at 4.5m interval (i.e. 25th bag) down the row to mark out blocks of 50 seedlings i.e. 2 lines of 25 bags making it easy to count the seedling bags
10. In larger nurseries with longer rows it may be helpful to have one or two paths running across the nursery
11. Using these arrangements, every 100 bags will need total area in the range of 6.75- 7.5m2 depending on the width of the access gaps used

12. Place the 200 liter drums near the nursery and next to a roof to catch rain water or near a creek so easily be replenished by hand with a bucket

Figure 4.4: Permanent Nursery Made From modern materials

Permanent nursery is constructed using modern and durable materials. These types of nurseries are expensive to build but will last longer and adverse weather conditions as they are made of metal frames, and covered with modern shade clothes that are very effective in screening or shielding high sun light energy and radiation.

b) Permanent nursery material needed

1. Galvanized 2" pipes
2. 2.5- 3.0 meter long kwila or other hardwood posts
3. 8 gauge plain wire
4. 10 gauge tie wire
5. (Smaller nurseries) 4 empty 200 litter drums and some roofing iron for catchments and water storage
6. (Larger nurseries) materials and equipment such as pumps (generators), pipes, filters, and water storage tanks for the irrigation system
7. Black polythene seedling bags size 35 cm x 18 cm
8. Salon shade cloth
9. Some nails
10. Star pickets

Construction procedure for a permanent nursery

1. Erect 2.5 - 3.0 meter long pipes or hardwood posts to make the shade frame of the nursery.
2. The corner and intermediate posts should be placed in holes that are 0.5 m deep so that the shade frame will be 2.0 - 2.5 m. above the ground.
3. These posts should have adequate supporting cross-struts to hold the frame and shade material up.
    a. Assemble the shade frame according to the planned dimensions of the nursery structure.
    b. Attach the Salon shade cloth to the frame by looping the shade cloth over the frame
4. Sewing it back on itself by threading tie wire through the shade cloth and around the frame pipe in a looping spiral.
5. Lift up the shade frame and attach it to the support posts.
6. Cut the star pickets into 50cm lengths with a hacksaw.
7. Drive these into the ground where the seedling beds are to be located to a depth of 20cm, so that 30cm remains above the ground.
8. The dimensions and layout of the seedling bed rows are the same as for the temporary nursery.
9. String the plain wire between these star picket lengths to form the seedling bag supporters. As the rows are 36 cm wide, put in two pickets 36 cm apart at the end of the rows and then every4.5m along the rows.
10. Install the nursery irrigation equipment and materials. This will involve running a pipe from the water source to the pump and a pipe from the pump to the water storage. If the pump is not manual or driven by a windmill, it will require some engine and energy source for motive power.
11. Ideally the water storage should be installed on a raised platform to give the system some pressure to deliver the water to the seedlings.
12. The outlet from the storage can either be through a further series of pipes with micro sprinkler outlets in the nursery or by tap for filling watering cans. If such a system provides too little pressure between the storage and nursery, a further pump may be necessary.
13. In hillier locations, where the stream from which the water is taken, drops a considerable height in the vicinity of the nursery, a water race system can be used. This uses gravity to bring the water from its source to the nursery. This system will involve installing a diversionary pipe or channel upstream, which is operated by opening a simple value or using a syphon to fill a storage tank. The tank is installed lower than the take off point in the creek but higher than the delivery point in the nursery, to provide the necessary pressure.
14. Such a system will be cheaper to install and run, so is desirable if it is technically feasible. It is ideal for sloping land sites.

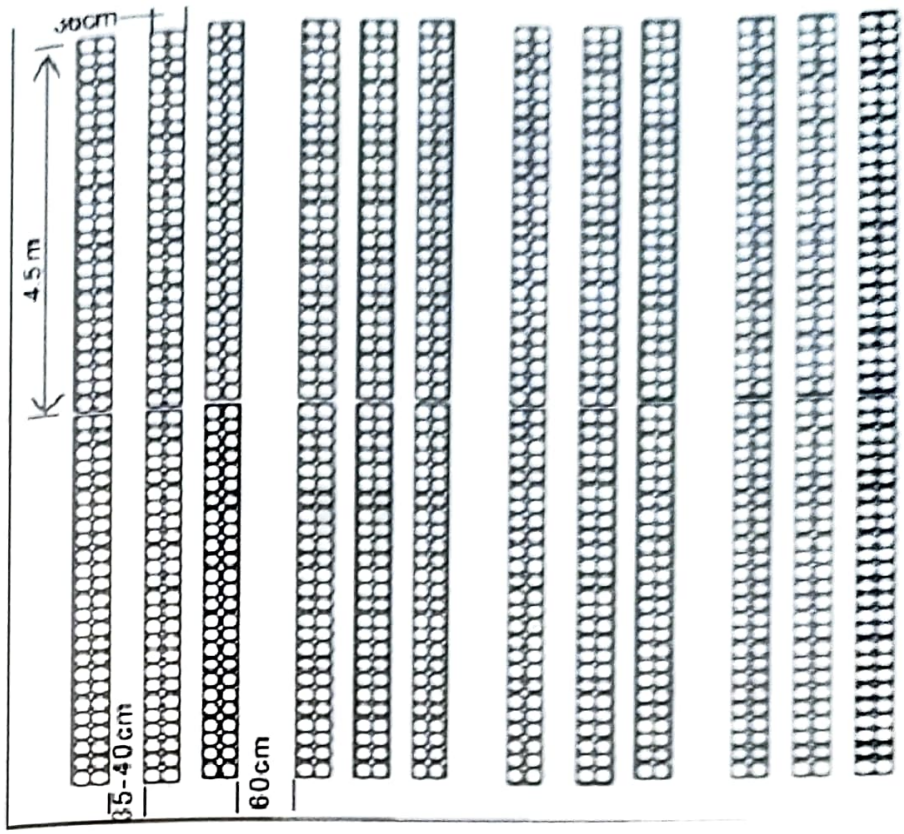


Figure 4.5: Overview of arrangement of seedling in poly bags in a nursery bed

Figure 4.6: Filling nursery bags with soil

Filling the seedling bags

The following points need to be remembered when filling the seedling bags with soil:

(1) Use black plastic planting bags of the proper size: 35cm high x 18cm across.
(2) Fill the planting bags with the best topsoil available.

2) Collect black topsoil that crumbles easily when it is dry.
3) You will need 1 cubic meter of soil (i.e. 1m long x 1m deep x 1m high) for every 500 bags to be filled.
4) On the basis that 1000 seeds will need to be planted in the nursery to obtain the 600 – 700 trees of sufficient vigour for planting out 1 hectare of a cocoa block,
5) 2 cubic meters of soil will be needed for every hectare that the nursery is to provide seedlings for.
6) This soil should be sifted through a 4mm sieve.
7) Do not use sandy soil or soil from old cocoa blocks.
8) Make sure the soil will clump together when wet, so that it will stick to the roots when the bag is removed at planting.
   a. Punch the bottom flap ends inward and fill the bags with soil right up to the top of the bag.
   b. After filling the bags, dump them twice to make the soil settle. However make sure the soil level
9) Is still high enough to stop the plastic at the top of the bag from curving inwards. If that happens
10) The water will not get into the bag when the seedlings are watered.
   a. Line the filled bags up in the beds marked out by the seedling bag supporters. Make sure that the bags are well positioned and firm in these support rows.
   b. Leave the bags filled there for two days before planting the seeds
11) If the weather is dry and no rain has fallen, do not plant unless you can hand-water the bags before planting, and at least once a day for the first two weeks after sowing and once every second day of the week

Figure 4.7: Seed Treatment.

At left, cleaned seed fungicide and a small amount of water; at right, seed, fungicide and clean sawdust well mixed and ready for packing

1. If SG2B hybrid seeds are not readily available, Trinitario seeds can be obtained from big trees with big pods on an established mature cocoa block.
2. Only seeds from fully ripened pods should be used
3. Over- or under-ripe pods should not be selected
4. If pods are selected or purchased, they must be broken, and the seeds soaked in fungicide before planting.
5. Pods should be broken with a blunt object like a stick (not a sharp knife) to avoid damaging the seeds inside.
6. When the seeds are extracted from the pods, the mucilage should be removed by rubbing them with sawdust and then washing them in
7. If the mucilage is not completely removed from the seed, the seed may not germinate because the mucilage contains a chemical that stops germination.
8. The seeds are then put in a bucket of water. Those that float should be discarded.
9. The seeds that sink to the bottom of the bucket of water are collected and soaked in a mixture of 10 grams of metalaxyl fungicide in 1 liter of water for 10 minutes.
10. Seeds that are flat, very small or germinated should also be discarded

Figure 4.8: Correct way to sow cocoa seeds

Note that the fatter end of the seed is at the bottom and the thinner end is at the top.

Planting Procedure

The following points need to be remembered when sowing the seed in the seedling bags

1. Do not pre-germinate cocoa seed, or let the seeds sprout before you plant them because there is a big risk the taproot will be damaged or bent by post-germination sowing.
2. The viability of cocoa seeds reduces quickly. Therefore the seed should be planted immediately after purchase.
3. If the seeds are taken from a pod they should be sown within two days of harvesting the pod.
4. The filled seedling bags should be thoroughly watered the day before sowing.
5. Cocoa seeds should be sown in the middle of the seedling bags.
6. Place the seed flat and press it into the planting bag soil.
7. Seeds should be planted no deeper than 2cm or the first joint of your forefinger.
8. If seeds that are being sown to grow rootstock are planted too deep there will not be enough space between the soil surface and the cotyledon to graft the bud.
9. The seedling bag should be watered as soon as possible after sowing.
10. To reduce weed management problems in the nursery, this water may usefully contain a selective pre-emergent herbicide such as Diuron (15 g in 100 litters of water).

B) Vegetative propagation

There are four methods for vegetatively propagating cocoa. They are:

1. Budding
2. Rooted- cutting
3. Grafting, and
4. Marcotting

Key Points

1 Of the four methods, budding is now the most commonly used because it is simple and convenient
2 To carry out, once the practitioner has acquired the necessary skills and experience.
3 The other three methods of vegetative propagation have major limitations and therefore have limited practical application.
4 Budding is described in detail and the other methods, which are not recommended

Types of bud wood for vegetative propagation

1. Bud wood can be taken from either
   a. fan branches or
   b. chupons
2. For all four methods of vegetative propagation a bud wood from chupons gives a better shaped tree.
3. fan branches are used more often, because they are more abundant.
4. The main difference between the two types of bud wood is their growth habit, which differs enough to need different management.
5. Fan branches grow plagiotropically (horizontal/sideways growth habit).
6. Some of the branches tend to droop, which gives the tree a bushy appearance.
7. Trees grown vegetatively from fan branch bud wood produce branches from ground level up, regardless of which propagation method is used.
8. Formation pruning is therefore needed in the establishment phase to produce trees with a suitable shape.

This is done for two reasons:

a) To increase air flow through the block and thus reduce the incidence of fungal diseases such as black pod, and
b) To make it easier to carry out block management operations such as weed control, fertilizing and harvesting.

The work needed to formation prune clones produced from fan branch bud wood increases the cost of managing them, especially when they are young. This increased cost should be recovered by higher yields from well-managed hybrid clones, compared to seedling hybrids.

Figure 4.9: Plagiotropic Growth Figure 4.10: Orthotropic Growth

In contrast to fan branches:

a) Chupons have an orthotropic growth habit and develop a jorquette, in the same way that trees grown from seed do.
b) Chupon bud wood is not generally available and
c) Chupon-budded trees tend to jorquette at a low height, which may require formation pruning to achieve a manageable canopy.
d) Bud-grafting is therefore most likely to be done with buds from fan branches.

Budding

It involves grafting single buds of scion wood onto rootstock raised from seeds of either open- or hand-pollinated trees. With budding, there are two options for grafting the bud (scion) on to the stock tree.

They are:

1. Inserted buds (referred to as bud-grafting, when the bud has a small amount of wood), and
2. Patched buds.

The types of budding described here are patch budding methods

Budding has these advantages over the other three methods of clone multiplication:

1. Only a single bud eye is used, more grafted trees can be produced from a single length of bud-wood.
2. Bud-wood is easily transported as long as the right preservative measures are used.
3. The strike (success) rate of the budding method is over 90 percent (and in most cases close to 100 %), with highly skilled and well practiced budders.
4. Budding can be done in the nursery for later field planting.
5. Trees produced by budding have proper tap root systems, which help them to withstand strong winds and long dry periods.
6. Budding can be done on rootstock of widely differing growth stages. Conventionally, buds are grafted on to rootstock in the nursery when the rootstock seedlings are 2-31/2 months old. However, buds can also be grafted onto juvenile (14-21 day-old) rootstock seedlings or even be field budded onto mature trees for block rehabilitation purposes.

Due to these advantages, budding is the main method used for cloning cocoa

Three types of budding

Figure 4.11: Normal Budding

Figure 4.12: Juvenile Budding

Figure 4.13: Field Budding

A) Normal Budding

1. 'Normal' or 'conventional' budding is the method used to bud rootstock that is two to three-and-a half months old.
2. At this age, the main stem of the rootstock is about the thickness of a pencil (8-10mm).
3. Either fan branch or chupon bud wood of about 8mm thickness can be used
4. Matching the size of the scion wood to the root stock is important. If the bud is too small or too big it will not fit the rootstock well and the budding may not be successful.
5. Care should also be taken to select bud wood that is green turning brown (semi-hard) and that has bud eyes ready to open.
6. Experienced budders should be able to do between 200 and 300 buddings in a day, of which at least 90 % should take place.
7. Slow workers often obtain a low take because the cambium of the stock dries out before the bud is attached.

If they are well cared for, the plants need a further three months after budding to develop sufficiently to be planted out in the block. Thus, it takes a minimum of 5 ½ - 6 months to raise buddings from the time the root stock seeds are sown to the time the budded trees are ready for field planting.

1. Either patch-budding or bud-grafting can be used in 'normal' or 'conventional' budding.
2. Of these two options, patch-budding is the technique most commonly used as it is more convenient than bud-grafting.
3. An 8 - 10 mm thick rootstock stem rarely has thick enough bark for the bud to be inserted and covered again with the bark before being taped, as is done with bud grafting.
4. Therefore, patch-budding is preferred for 2 – 3 month old root stock.

Hence 'normal' or 'conventional' budding is sometimes referred to as patch-budding.

The following tools and materials are needed for conventional bud-grafting:

1. Cocoa seedling rootstock,
2. Bud wood from CCRI's selected hybrid or Trinitario clones, or productive and disease resistant
3. Hybrid trees.
4. A budding knife, which must be kept sharp.
5. Budding tape.
6. Secateurs.

The conventional bud-grafting method consists of the following steps:

B) Root stock selection

1. Seedlings should be about 1cm thick below the cotyledon scar, or about the thickness of a pencil.
2. Dry rootstock cannot be budded successfully, so the rootstock must be watered and kept moist prior to budding. This will help the bark to peel easily and ensure that the stem has adequate moisture to hold the bud.
3. Only healthy rootstock should be used when budding. Up to 25% of seedlings in the nursery will be undersized or misshapen. These should be discarded to avoid budding on to genetically inferior rootstock.

C) Bud-wood selection

1. Bud wood is selected from semi-hard wood (wood that is turning from green to brown) sections of fan branches or chupons, about 8mm in diameter. Suitable bud sticks have visible bud growth at the base of each leaf petiole.

2. Budding should be done as soon as the bud is cut. Store bud-wood in wet hessian during the budding operation. If delay (to a maximum of 48 hours) is unavoidable, the cut petioles and bud-stick ends are dipped into molten paraffin wax. The bud-wood is stored in damp sawdust wrapped in hessian.

D) Budding

1. Make either a capital "T" or inverted capital "T" cut below the cotyledon scars.
2. This is where the bud will be put.
3. Budding below the cotyledon scars ensures that chupons do not develop later from the rootstock.
4. Any such chupons would have to be cut off, possibly setting the plant back.
5. The capital "T" cut is used more often than the inverted capital "T" cut, as it is easier to do.
6. After the cut has been made, the bark is peeled with the aid of the spatula on the budding knife.

7. The bud is then quickly extracted from the bud-stick (see Figure 7.13) and inserted into the opening.
8. If the patch-budding technique is being used, most of the peeled bark is cut off, leaving short flaps to hold the bud in place.
9. If the bud-grafting technique is used, the peeled bark is not cut off (see Figure 7.14).

Things to remember when inserting the bud:

Do not cut into the wood of the rootstock.
Avoid damage of any kind to the exposed surface (cambium of the seedling or budpatch).
Avoid introducing dirt into the union:

1. If the budding is done too slowly the cambium will start to dry out. Budding should be completed within 60 seconds, and preferably 30 seconds, to minimize the drying out of the cambium tissue.
2. Don't bud during rain. The budder can easily be disturbed and dirt and water introduced into the budding union that will cause it to rot.
3. In patch budding, a maximum of one-third of the circumference of the rootstock barks cut open.
4. In patch budding, a 1mm space between the sides of the bud patch and the window of the rootstock is needed to allow callus growth.

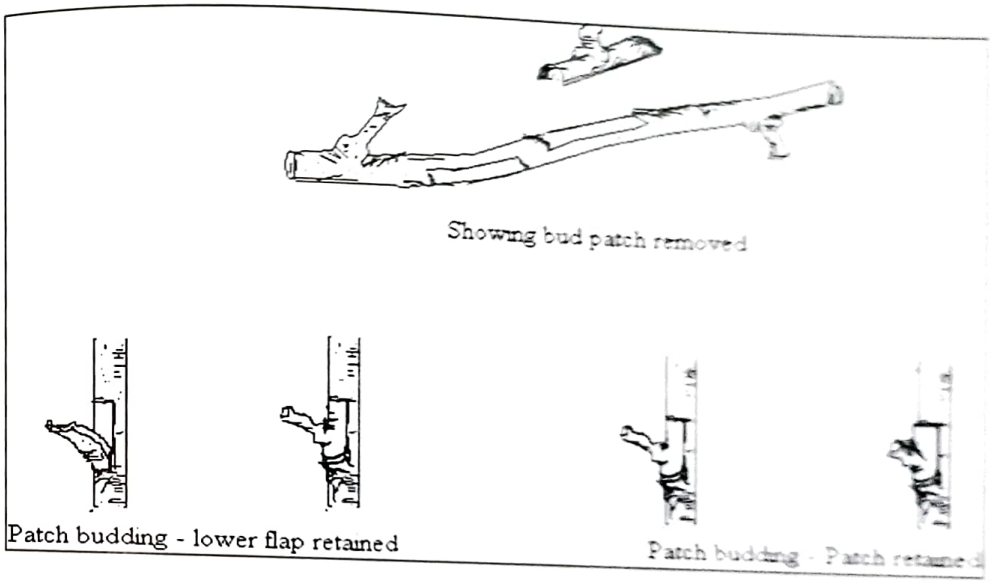


Figure 4.14: Patch Budding

E) Taping

After inserting the bud, it is evenly and firmly taped into position from the bottom to the top then tied firmly to prevent the entry of water (see Figure 7.15)

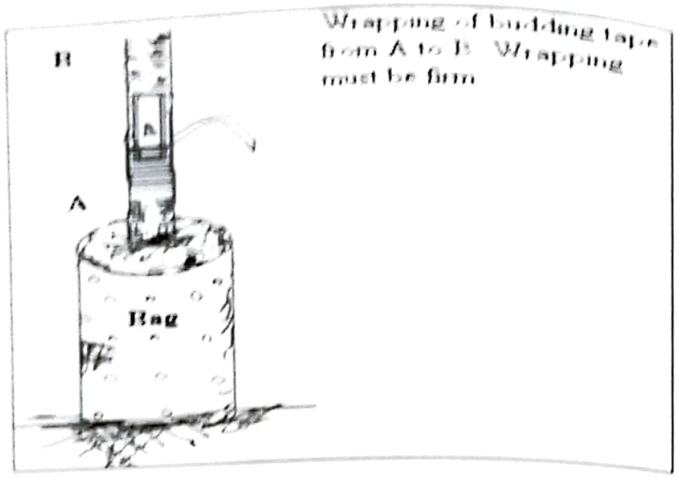


Figure 4.15: Taping the budding

After-care

1. Heavy rains, especially in the first week after budding, can lead to a reduction in the percentage of successful takes. Buddings should be retained under cover for this period
2. Budding tape is unwound 14 days after budding. The bud-grafter checks if the bud is green (i.e. still alive) or not.
3. If the bud is green, the top quarter (the apical shoot) of the root stock is cut off and only two or three leaves left at the top of the stem; lower leaves are removed.
4. Shoots which grow on the rootstock stem should be removed by hand as they emerge. If they are allowed to grow, they will compete with the developing bud for light, water and nutrition. If several shoots develop out of the budding, only the most vigorous one is kept and the rest are removed.
5. Six weeks after the tape is removed, most buds should have started growing if they are alive. If they have not, and they are still alive, they can be made to grow by notching the stem (cutting a small piece out of the root stock stem) 1cm above the bud-patch. Buds may not grow due to a dry period, incorrect pruning, or too heavy shade. Shade should be 30-50%.
6. The rootstock stem is cut off between the top of the budding union scar and below the cotyledon scars when the bud leaves have hardened and the base of the bud stem becomes semi-hard i.e. leaves get darker green and stems turning brown. By this stage the bud will have developed three flushes of leaves. Removing the cotyledon scars ensures that for the rest of the tree's life no more stock tree shoots will grow and that all the tree's resources are devoted solely to the budding (see Figure 7.16).

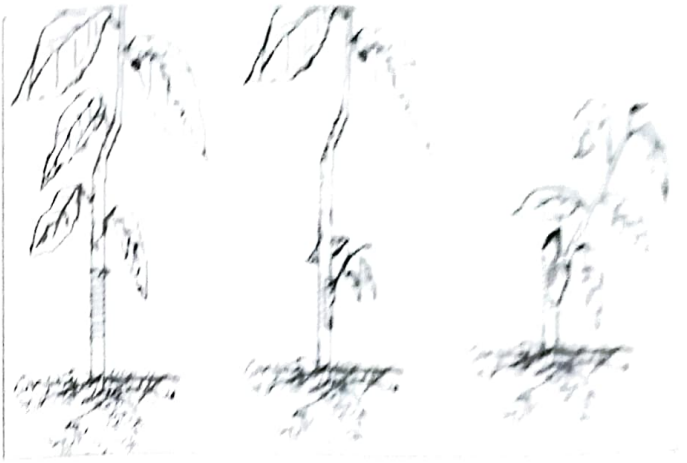


Figure 4.16: Stages of root stock growth

1. The budding is ready for the rootstock stem to be cut off when the bud shoot is about 15cm long. At this stage the budding is ready to be planted out in the field.
2. Under good nursery management, buddings should be ready for field planting two to three months after budding.

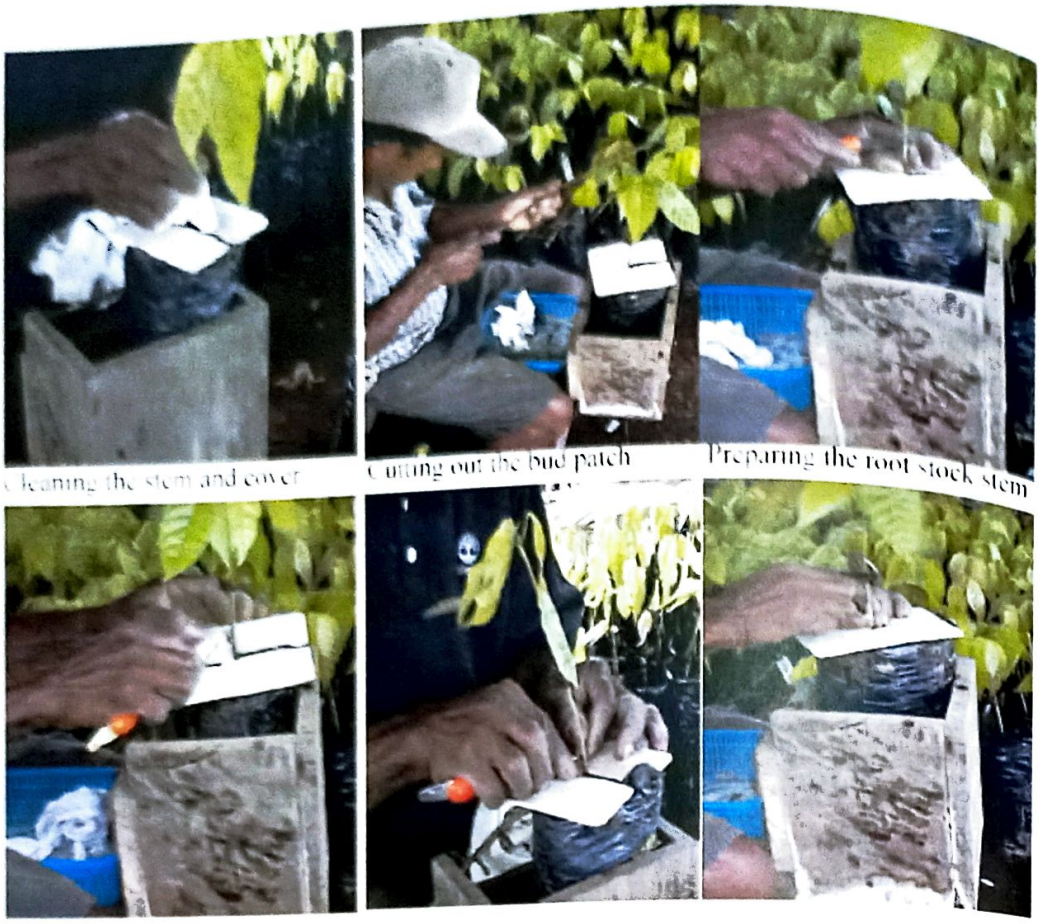
F) Juvenile budding

Juvenile budding is the budding of 14-21 days old rootstock in the nursery. This technique has recently been adopted by PNG CCI, based on work done in Malaysia. The main aim of the juvenile budding technique is to reduce costs and waiting time involved in raising buddings. After budding, it takes 3 months before the plants are ready for field planting. Like the normal budding,

some buddings may be ready as early as 2-2 ½ months after budding, depending on the type of bud-wood used and the management applied.

The technique however, requires a high level of skill. Nescofilm is used instead of normal budding tape, as this material is easily stretched and thus more convenient than the normal budding tape (see Figure 7.17). The technique requires that the whole budding operation (from the cutting of the rootstock, extraction of the bud through to the taping of the budding) is completed in less than 30 seconds and preferably in less than 25 seconds. Hence, care and speed are required, as the rootstock is very fragile and easily damaged. If the cambium tissue is exposed for longer than 30 seconds it will dry out. This technique demands a lot of practice to master the necessary skills.

Other precautions during the budding operation are the same as for normal budding. Smaller-sized bud-wood is used for juvenile budding to match the size of the younger rootstock.



Inserting the bud patch onto the root stock
Trimming off petiole from the bud patch and 'skin' from the root stock
Covering the graft with Nescofilm

Figure 4.17: Stages of Juvenile Budding

Only the capital "T" cut and patch-bud method (as opposed to the grafting method) is used in juvenile budding, as the rootstock is relatively undeveloped and because it is the easiest way to do the budding. Within the constraints imposed by the root stock seedlings being only 14 – 21 days old, it is best to bud using the biggest of the rootstock available. That is because:

1. The bark is easy to peel on bigger seedlings of that age,
2. Bigger seedlings of that age have more surface area for the scion to come in contact with, and
3. There is less chance of the root stock being damaged in the course of the budding operation.

However, smaller rootstock should not be discarded, especially if they are grown from hybrid seed. All hybrid seeds cost money (they have to be purchased) and so should all be used, where-ever possible. They can be used later for normal budding.

The budding operation starts:

1. By covering the soil surface with a dirt guard made of plywood or other hard and firm material.
2. The guard has a slot cut into it so that it fits around the seedling.
3. Done to minimize the risk of introducing soil or any other foreign matter into the budding union.
4. A horizontal cut that goes three quarters of the way around the rootstock is then made below the cotyledons.
5. It is important not to cut into the stem while making this cut.
6. The stem should not be bent too much in any way, as it is easily damaged.
7. After the horizontal cut, a vertical cut is made to form a capital "T" cut.
8. Using the spatula on the budding knife, the bark is peeled back.
9. The bud is then quickly taken from the bud wood and inserted into the opening.
10. Most of the peeled bark is cut off with just a little left to form flaps to keep the bud in place.
11. The budding is then taped in the same way as with normal budding, using Nescofilm as the taping material. Strips of Nescofilm 1.0-1.5 cm wide and 5-7 cm long are prepared before budding. A single strip is used for each budding.
12. All other considerations and procedures followed in normal budding such as watering rootstock before budding, keeping the bud site clear of dirt and not budding during wet weather also apply to juvenile budding.
13. The buds are able to break open the Nescofilm tape as they develop.
14. Nevertheless, it is still best to remove the tape 14 days after budding, to allow the buds full freedom to grow.

Aspects of nursery management such as shoot removal, weed control, pest and disease control measures, watering, fertilizing and shade management are the same after juvenile budding as they are after normal budding.

C) Field budding

Field budding involves grafting superior scion wood onto trees that are already growing in the block but which are not very productive. It is unlikely that new seedlings planted in amongst mature trees would ever catch up. Field budding also reduces the time it takes before production is resumed.

This technique is described in Section 6.2.2 of Chapter 6 - Block Rehabilitation.

Rooted cuttings

1. Involves placing either fan branch or chupon stems in a medium that will make the stems sprout roots.
2. Several ways of doing this, including spraying hormones on the rooting medium beds and using polythene sheets or closed bins.
3. These methods are difficult, costly and require special skills and conditions.
4. To root successfully, the cuttings must be kept at the right light intensity, temperature and humidity.

5. Further complicated by the need to vary the levels of these conditions according to the type of cocoa used for the cuttings, the age of flushes at which cuttings are harvested, the hormones used and the rooting medium.
6. Each cutting requires several bud eyes for each new tree.
7. A maximum of four cuttings can be taken from one length of bud-wood.
8. Therefore, the availability of bud-wood can be a limiting factor.
9. A bigger disadvantage is that trees grown from cuttings do not have a proper taproot.
10. As a result they are weaker and after field planting are more likely to suffer moisture stress during dry periods and to be blown over by strong winds.

For these reasons, vegetative propagation by rooted cuttings **IS NOT RECOMMENDED**

Grafting (side/stick grafting)

1. Involves grafting a stick of bud wood (scion wood) that consists of several bud eyes onto a rootstock – generally only a mature tree you want to improve.
2. Only used for rehabilitating unproductive mature trees because of low strike rates, the small number of clones that could be generated from each length of bud wood.
3. The rationale for stick grafting unproductive mature trees was because replanting a new seedling takes longer to produce pods, and the new tree may never catch up with the other trees in the block.

The grafting method has been used successfully in trials but in practice the union between the root stock tree and the scion wood is rarely strong enough and fails either due to wind or the weight of the new growth.

This causes total loss for the farmer and for this reason **STICK GRAFTING IS NOT RECOMMENDED**

Marcotting

1. Involves removing a 7.5 cm long strip of bark from a branch of a tree that is to be cloned covering the xylem with sawdust mixed with a growth hormone.
2. The branch is not cut off the tree at first.
3. A strip of polythene sheet carefully tied around the branch with a rope supports the sawdust.
4. The branch is cut off after roots have sprouted in the sawdust.
5. It is expensive and impractical for producing large numbers of trees.
6. As with rooted cuttings, plants struck from marcotting do not have a proper taproot system.
7. Easily destroyed by winds and long dry seasons.

For these reasons, Marcotting is not recommended

Teaching Strategies

A) Introduction

Teacher should introduce the unit by asking students:

1. What do you know by the term nursery?
2. What does not nurse do at the hospital?
3. Explain the nurse's job! "The nurse provides care for the patient who is the recipient of care.
4. Likewise, a Nursery" is a place where nursery workers care for the young cocoa seedling.

B) Body

1. Explain nursery establishment and take students through the process of nursery care and management. (Make linkage to the nurse taking care for the patient)
2. Describe vegetative propagation (show student vegetative planting materials)
3. Discuss budding, crafting, marcotting,
4. Take students to the nursery and show them the nursery, types of nursery, bud wood and grafting and marcortting

C) Closure

1. Orally ask students to:
   a) Give features of a temporary, semi-permanent and permanent nursery
   b) Show vegetative

2. Get students to write things to do as care providers in a nursery

3. Student Activities

Complete the table by searching the definitions of the terms listed

Terms	Definitions
Bud grafting	
Budding	
Vegetative Propagation	
Fan branches	
Jorquette	
Chupons	
Bud wood	
Marcotting	
Normal budding	
Juvenile budding	
Field budding	
Rood stock	

Fill in the table by using the words below to match the definitions in the table

Terms	Definitions
	Cocoa trees grown from the bud
	A very young plant
	Grow or start growing
	Producing/ making a new plant

Reproduction, Germination, Budding, Seedling,

Activities

Carry construction of a Nursery. Note: This should be carried out as Practical Assessment a list of Activities/ Criteria/ skills draw up and assessed

1. Temporary
2. Semi- Permanent.
3. Permanent.

Describe Vegetative propagation

UNIT 5: BLOCK PREPARATIONS AND ESTABLISHMENT

Introduction

This unit should be taught as practical, thus giving a real feel of the block preparation and establishment. Can be done in sessions as:

1. Surveying which can be done before or after clearing the block
2. Mapping out the block
3. Site clearance
4. Lining patterns preferred
5. Common lining/ shade combinations
6. Shades
7. Cocoa establishment
8. Inter- cropping with coconut
9. Planting patterns
10. Drainage

Learning Outcomes

At the end of the unit, the students can:

A) Site survey

B) Mapping

C) Site clearing

D) Lining

E) Shade

F) Cocoa establishment

G) Intercropping

H) Planting patterns

I) Drainage

Content

A) Site survey

1. Boundary

Boundary survey involves measuring distance around the block

Two methods

a) Chain and compass- more accurate
b) Tape measure- easier to get

Steps

B) Chain and compass

1. Clear 2.0m wide strip using grass and bush knives
2. Pull chain along a bearing established with compass
3. Points which bearing are established are called stations
4. Starting point is station **A** from which a bearing is followed
5. At the end of the line when a change of direction is made it is station **B**
6. A new bearing is taken and followed through to its end is **C**, the starting point of new direction or bearing
7. Stations are marked with pegs
8. The process is repeated back to the starting point

C) Tape measure

1. Clear 20m wide strip using grass and bush knives
2. Use a 50m or 100m tape measure
3. Starting point is the first squared station using a right angle triangle (with 3m, 4m and 5m long) are made along one boundary lines
4. When the end of the boundary line reached the adjoining boundary line is squared and followed to its end
5. Continue back to the starting point

Features of the Map

a) A sketch map is drawn as survey proceeds
b) Length of various boundaries be listed on this map
c) List features as creek swamps drains substantial or significant trees gardens block road roads and foot paths should be sketched on the draft map
d) Record the distance of these landmarks from the boundary line

Sub-division survey

1. Done similar to the boundary survey
2. Needed for large (10ha or more)
3. When some management aspect of the block calls for differentiation
4. To facilitate planning for additional improvements to the blocks like
   a. Roads for easy access
   b. Drainage
   c. On site nurseries
   d. Buildings

D) Mapping

1. Need to be neatly redrawn by surveyor after survey is complete
2. Special features like roads, tracks and drains should be on the maps
3. Clearly show the block name
4. Survey date
5. Surveyor's name
6. Whether drawn to scale or not, orientation of north (0°) on the map and a legend
7. Useful to attach notes on previous land use, land slope, vegetation and soil type

After maps are properly redrawn, they are used to calculate the area of the block

Done by dividing the area drawn

1. Into squares
2. Rectangles
3. Triangles, areas of which easily calculated
4. These are added up to get the total area of the block

E) Site clearing

Figure 5.1& 5.2 Kamanakam Primary school (ENB) students making a site clearance

Necessary so lining can be done and the block can be maintained more easily once planted. It is best done during in the dry season

1. **Under brush**

   i) Clear under growth/brush (grasses, herbs, shrubs and small trees)
   ii) Use bush knives and grass knives
   iii) Best done at the end of the wet season and beginning of dry season

2. **Felling**

i) Large trees are felled using axes and chainsaws
ii) Trees within 10 15 m of the block boundary should be cut down to avoid dead branches falling onto cocoa trees
iii) Trees are cut up after felling
iv) To prevent root rot, paint the cut surface of stump with a mixture of 20ml of Garlon and 30g of cuprous oxide in 1 liter of diesel
v) Where coconut is established, removed some to obtain a suitable level of shade

Clear felling

Is the removal of trees, logs and rubbish from the block for easy access and later stages of block development]

i) Trees and logs are cut up
ii) Allowed to dry out
iii) Are stacked and burned
iv) Alternatively, a chainsaw or wok about sawmill can be used to processed logs into sawn timber

Lining

1. Done soon after the block has been cleared
2. Gliricidia commonly used as the shade species
3. Lining techniques is the marking of where shade and cocoa trees are to be planted
4. Spacing (plant density) for the cocoa tree also set the spacing for the shade trees, is decided before lining

Common spacing is:

i) 4.0 m apart in a square pattern (giving a plant density of 625 trees/ha)
ii) 4.0 m apart in a triangular pattern (giving a plant density of 720 trees/ha)

Tree densities are calculated for the various planting patterns using the following formula:

Square Pattern

No. of trees/ha = 10 000 (distance between trees (m)) x (distance between rows (m))

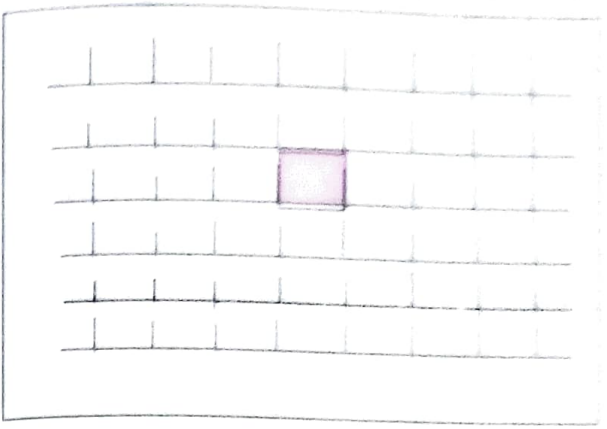


Figure 5.3: Insert Square lining and Planting

I. Triangular Pattern

No. of trees/ha = 10 000 (distance between trees (m)) x 1.155 (distance between rows (m))

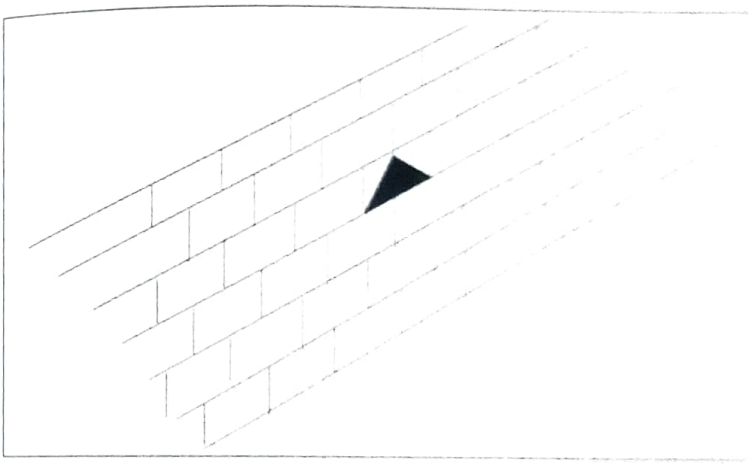


Figure 5.4: Insert Triangular lining and Planting

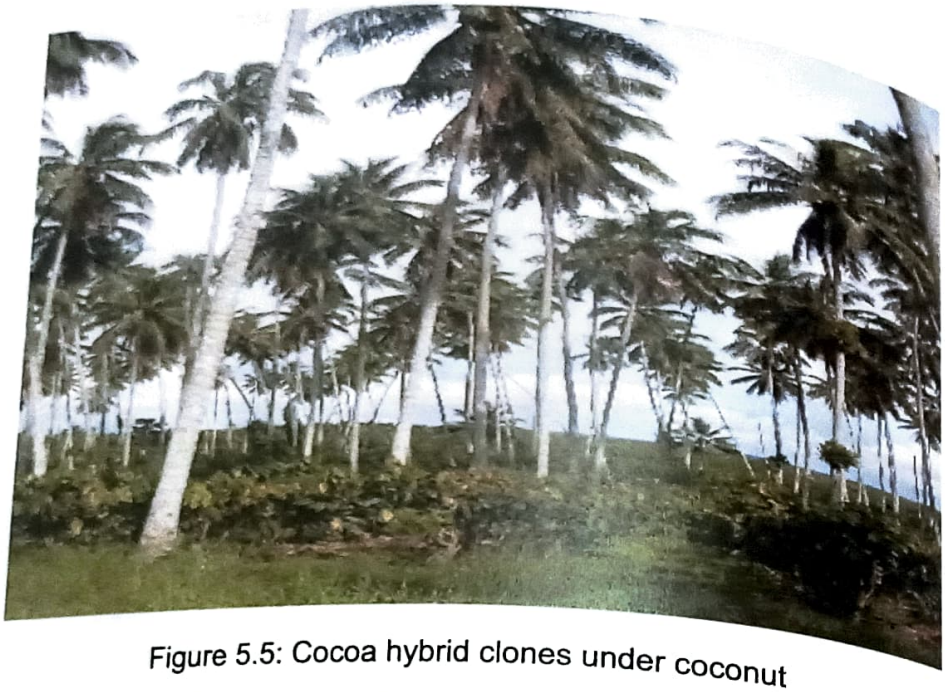


Figure 5.5: Cocoa hybrid clones under coconut

Figure 5.6: Cocoa hybrid clones under gliricidia and galip nut mixed with robusta coffee

Table 5.1: Shading Combinations

Permanent shade	Temporary shade	Rows of temporary shade	Comments
Coconut	Gliricidia	Can be in same rows as coconut	Gliricidia will be removed and cocoa will be in its own rows
Coconut	Pigeon pea	Same rows as cocoa	Pigeon pea dies and cocoa will be in its own rows
Gliricidia	Pigeon pea	Same rows as cocoa	Cocoa and gliricidia trees in own rows
Gliricidia	Banana	Same rows as shade trees	Cocoa and gliricidia trees in own rows after banana removed

Lining Process

1) Establishment of a baseline- usually made along a convenient part of the block such as block road, walking track or boundary, e.g. Lines of coconut trees can form the base line
2) Tape measure and compass technique used for boundary and sub-surveys also used. Compass ensure that rows are set out in perfectly straight lines
    a. The baseline is first squared by making a '3,4,5' triangular with tape measure
    b. Then pulled in the direction of the squared base line
    c. Pegged at every 4.0 m along the baseline
    d. Where the intended spacing is 4.0 m square, a seconded base line can be made forming a right angle (90°), since two base line are squared when squaring the first baseline
    e. For triangular, only one baseline is squared. Second baseline done during actual lining
    f. Tape measure not to be used to carry out actual lining as daytime heat and pulling cause stretch leading to inaccurate spacing
    g. Mark and cut out two 4.0 m long straight sticks from material as timber, bamboo or piping to use as markers

h. Where the second baseline for a square spacing not yet done, three 4.0 m markers will be needed
i. Four people are needed for the lining and pegging operation
j. The two marker sticks are carried end to end by three people-
k. One person holding two markers sticks where they meet in the middle
l. The other two at the ends of the two sticks
m. Person in the middle places the planting site pegs in the grounds where the ends of the two marker sticks meet
n. The fourth person checks that the pegs are properly lined up and positioned in their rows

F) Shade

1. Young cocoa trees are highly susceptible to dehydration and wind damage and must be raised under shade
2. Shade be gradually reduced (tinned or removed) to desired level starting when trees are about 18 months old
3. At this age, should have developed a good tree canopy and root system
4. The amount of shade that young cocoa trees need is affected by a number of variables, including rainfall, amount of cloud cover, soil fertility, the level of management applied to the block and age of the tree

1. Temporary shade

Needed if permanent shade not well established

- Shade establishment

Table 5.2: Advantages and disadvantages of different temporary shade species

Temporary shade	Advantages	Disadvantage	How to plant
Pigeon pea (Cajanus cajan)	1. Fast growing 2. Dies naturally after 18-24 months 3. Legume (fixes nitrogen)	1. Limited seed supply 2. Can spread pink disease to cocoa	1. Sow seed in block 1.0m apart, 3-6 months before cocoa 2. Start removing 6 months after cocoa planted
Gliricidia	1. Fast growing 6 to 9 months, easy to establish 2. Legume (fixes nitrogen) 3. Improves organic matter cycling 4. Provides firewood	1. High labour input to prevent over hading 2. Can harbour giant termites 3. Rotting stumps can provide breeding sites for Scapanes beetles	1. Plant freshly cut (one day) 1.5m long stakes with single diagonal cut at base. one third in ground 2. Space at 4m pattern same as cocoa
Bananas	1. Easy to establish 2. Provide economic crop	• Compete strongly with cocoa for water and nutrients	1. Plant 4 to 6 month old suckers (preferably diploid type) 2m apart between cocoa row 2. Start removing when cocoa 6 months old

Table 5.3: Approximate percentage shade needed for cocoa

Tree age	6 months	12 months	18 months	24 months	36 months	48 months/mature
Percentage shade needed	50%	50%	45%	40%	30%	20%

2. Permanent shade

Figure 5.7 & 5.8: Trainees of St: Benedict's, Danip- Madang establishing a coconut block before planting cocoa

c) Shade establishment

Figures 5.9: Showing combinations of coconut and gliricidia for cocoa shade

a) Coconut and gliricidia are main permanent shade trees
b) Local tall coconuts like Raulawat, Gazelle, Markham and Karkar are more suitable hybrids and dwarfs
c) Hybrids and dwarfs are more susceptible to attack by Rhinoceros Beetles (Scapanes australis or Oryctes centaurus) and Black palm Weevil (Rhyncophorus bilineatus).
d) Not tall enough to adequately shade cocoa trees
e) Planted in a 12.0 m square planting pattern giving a plant density of 69 palms per hectare
f) Young palms up to 12 months are planted in the field
g) Weeds are controlled every 4 to 6 weeks

Holing, Cutting off the bottom of the bag & Removing the plastic bag

Putting the seedling in the hole, Filling the hole with topsoil and Gently, firming the soil

Figure 5.10: Holing and planting

G) Cocoa establishment

- Seedlings and budding are planted the same way
- Seedlings when are about 3 to 4 months old (about 50 cm high or about the diameter of a pencil at their base).
- Only best seedlings should be planted out

1. **Holing**

Before planting holes are dug for cocoa seedlings, lining and marking is done in the same way as for shade
Recommended spacing for hybrid is a 4 meter square pattern
Large Sharp knife to cut the planting bags
Spade to plant seedlings
Dig 45 cm deep
Keep topsoil in a heap on one side o the hole and subsoil in another heap on the other side

2. **Field planting**

a) Planting can start when all holes have been dug and weather is suitable on a cloudy or rainy day
b) Take must be taken when handling seedlings
c) At planting place top soil in planting hole
d) In phosphorus – deficient soils, put 15-20 g of triple super phosphate TSP in the planting hole
e) Lay planting bag with seedling on its side and slice off the bottom 3 cm. This cuts off any twisted roots on the seedling and helps the plant to grow up straight
f) Make sure that the level of the soil in the bag is the same as the level of the soil around the hole
g) Forcing the bag into the hole will cause the root to grow sideways (bench root)
h) Make sure leaves do not get into the hole with the soil as this can also cause bench root

G) Intercropping

With Coconut

1. Coconut provide best option cocoa for shade
2. An economic crop grown together with cocoa
3. Tall varieties are recommended for intercropping with cocoa

H) Planting patterns

1. In square planting arrangements there will be 69 palms per hectare
2. In triangular planting arrangements there will be 80 palms per hectare
3. Within these planting arrangement, coconut trees are planted 12 meters apart between every third and fourth cocoa tree in a row
4. Palm are only planted within every third row of cocoa trees
5. If copra or other coconut products are the primary cash crop, a spacing of 7.5 m triangular (205 palms per hectare) for hybrids be used or 9 m triangular (143 palms per hectare for tall

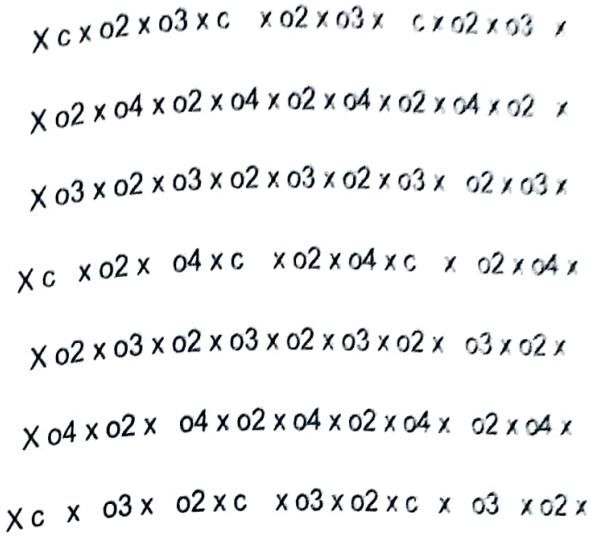


Figure 5.11: Planting arrangement

Key: x= Cocoa tree, c= coconut shade, o2= Gliricidia removed at 2 years, o3= Gliricidia removed at 3 years, o4= Gliricidia removed at 4 years

I) Timing of planting cocoa and coconut

Table 5.4: Schedule for planting and thinning shade, Planting permanent shade coconuts and hybrid cocoa. Details may vary to specific needs of different blocks.

Months	Season	Operation
Minus 20-18	End wet	Plant coconut poly bag nursery
Minus 15	Mid dry	Mark out block for individual planting sites of coconut and cocoa
Minus 12	Start wet	Plant out coconut with Gliricidia
Minus 3	Mid dry	Plant cocoa nursery
0	Start wet	Plant out cocoa seedlings in the field
4-6	End wet	Thin Gliricidia branches
12	Start wet	Poison or ring bark 2 out of 3 temporary shade trees between cocoa
15	Mid wet	Poison or ring bark all temporary shade in every second row of cocoa
24	Start wet	Poison or ring bark 1 out of 2 temporary shade trees
36	Start wet	Poison or ring bark all remaining temporary shade trees, leaving only coconut as shade

J) Drainage

Areas with heavy rainfall and heavy soils (high clay content), water logging or a high water table can be a problem

Can be solved by digging drains so water table is lowered

1. Easier to dug drains before felling trees
2. Placement of drains needs to accommodate the likely lay out of the trees, roads and paths on the block so drains do not interfere with management operations
3. Open drains works if they have a slope- a fall of 0.25 to 1 percent, or 2.5 to 10.0 cm for every 10 m of horizontal distance is sufficient
4. For drain with such a full use an 'A frame' with a plumb line that is calibrated for defining a slight slope
5. It is best to commence surveying the drainage line at the planned outlet point of water and work back up to highest point on the block that needs drainage
6. Use interim peg to mark the 'foot falls' of the 'A frame, mark out course with large pegs that will remain until the drain is dug every 10 meters or so
7. Maintenance of drains must be regular to avoid flooding and water logging problems

Teaching Strategies

a. ***Introduction***

Outline block preparation method

K) ***Body***

1. Methods of lining
2. Relevant shade
3. Use notes and field trip/visit/exposure, describe and explain

L) ***Closure***

a. Orally ask students to:
   i. Give block preparation
   ii. Show lining
b. Short test on plant density

Student Activities

1. List how Site survey is conducted

2. Draw/Sketch a Map

3. Carry out Site clearing

4. Carry out Lining

5. Practice Shade establishment

6. Carry out Cocoa establishment

7. Carry out Intercropping

8. Carry out the recommended Planting patterns

9. Establishment Drainage

Block preparation

Tall growing weeds cut and laid neatly	
Cocoa trees ringed to a 1 meter diameter	
All chupons removed other than those for regeneration	
Sanitary pruning up to date	
A ½ meter diameter ring of soil earthed up around the base	
Suitable cover crop planted or allowed	
Mulch applied at based of trees	
Farm yard manure (FYM) applied at base of trees	
Any dead missing or poor quality cocoa plants replaced	
Glyricidia shade planted and controlled correctly	
Evidence of pest and disease control	
Weeds removed by roots	
Whole block mulched	
NPK application	

UNIT 6: BLOCK MANAGEMENT (WEED CONTROL)

Introduction

Weeds, when not controlled affect badly the productivity and profitability of the block. Weeds complete against cultivated plants for soil moisture, nutrients and sunlight. Often better than cultivated plant at getting these resources as they are well adapted to the environment in which they grow. Can suppress the growth of cocoa trees and eventually kill them

Weeds harbour insects and disease organisms. Where weeds are present, pests like Longicorns, which damage stems of cocoa trees. Grey weevils eat young leaf flushes

Impede the access through the block and prevent efficient management. In covering this unit student should have learn the following out comes.

Learning Outcomes

At the completion of the unit, the student can:

A) List and describe types of weed control
B) List and describe types of herbicides
C) Describe and demonstrate spray recommendations for various stages of block development
D) Explain and carry out calibration of knapsack sprayer
E) State and demonstrate types of field techniques

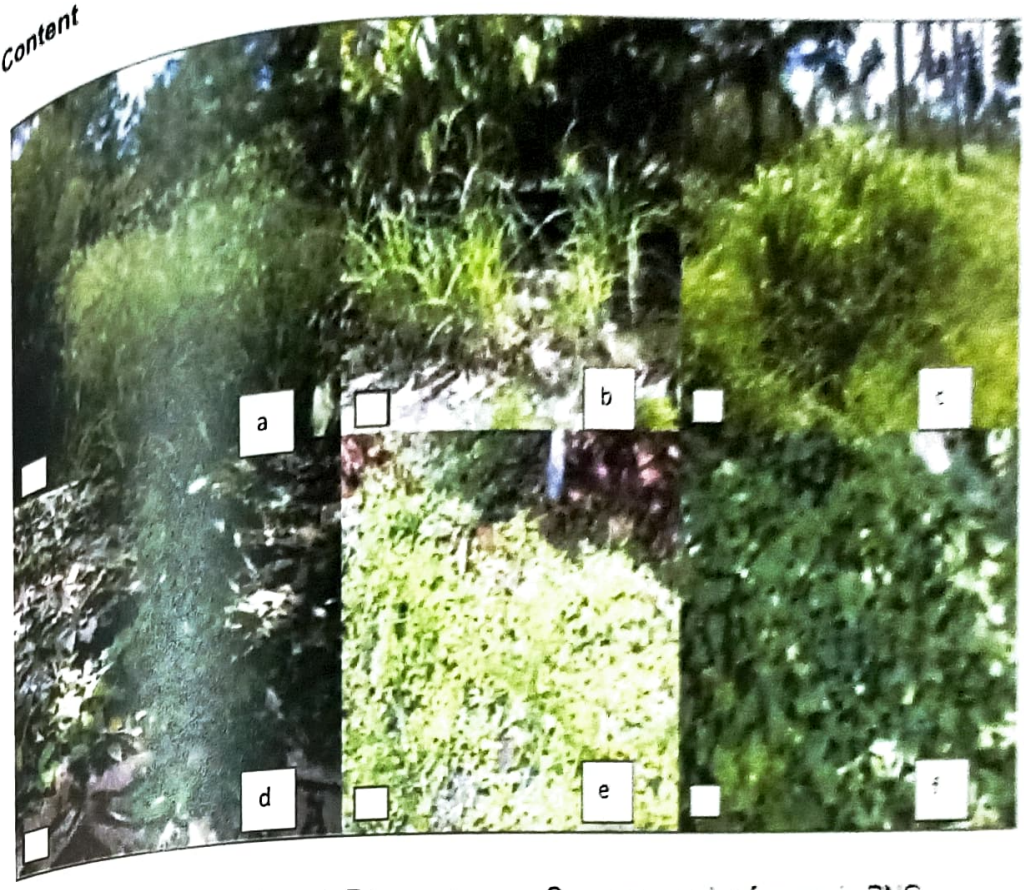


Figure 6.1: Reading from L-R across we see Common weeds of cocoa in PNG

(a) a newly introduced grass weed, *Rottboellia exultata* growing strongly in a patch of full sunlight; (b) the same grass at the edge of a block; (c) Johnson grass (*Sorghum verticilliflorum*) at the edge of a block; (d) one of the Aroid creepers, known as Monsteria; (e) and (f) *Mikania micrantha*, "mile-a-minute", in full sun (e) and shade (f)

Types of weeds control measures

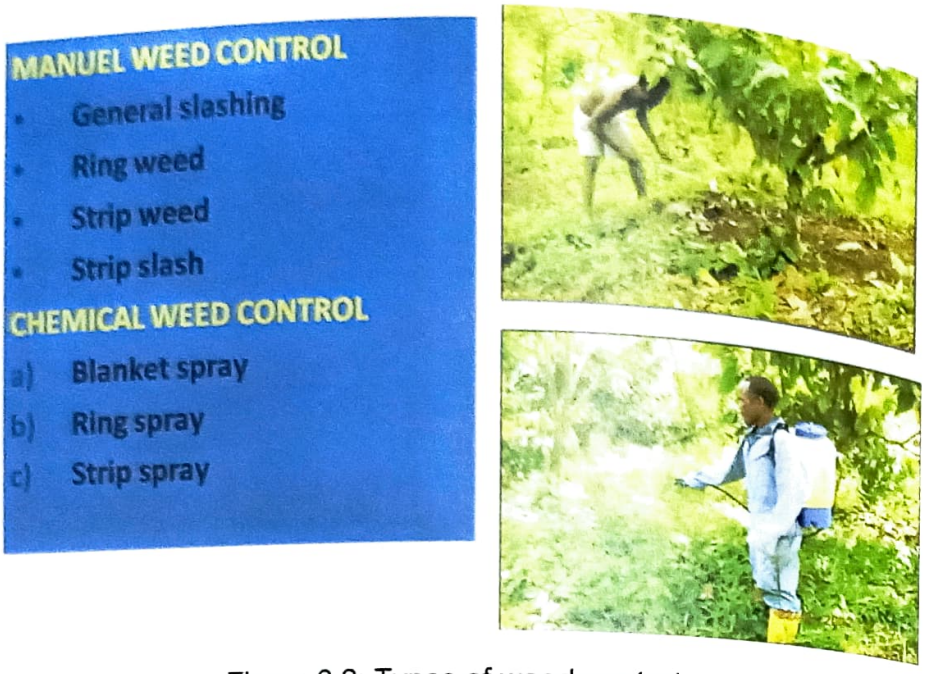


Figure 6.2: Types of weed control

The two types of weeds control

1. Manual/ Mechanical
2. Chemical

1. Manual weed control

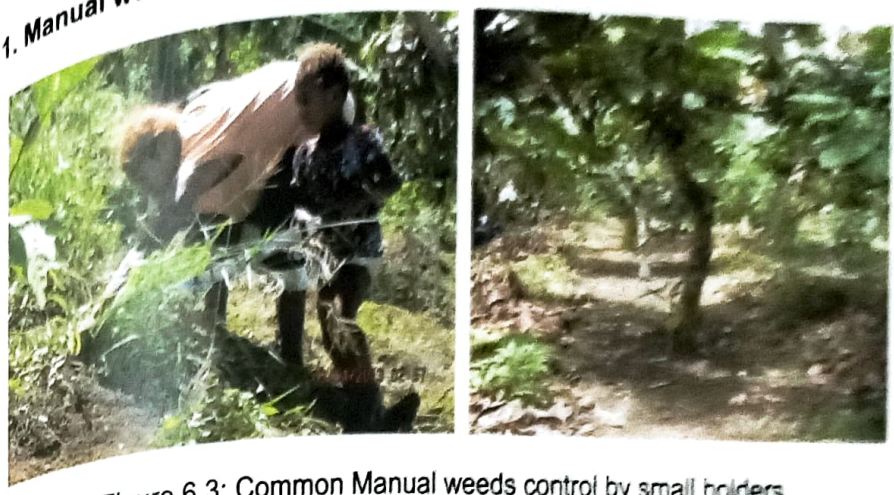


Figure 6.3: Common Manual weeds control by small holders

Figure 6.4: An example of strip weeding along cocoa rows

1. Carried out by pulling as in ring weeding
2. Using knives and grass knives
3. Environment friendly
4. Cost benefits

2. Mechanical weed control

1. Use machines
2. Cost disadvantage

3. Chemical weed control

1. Use herbicides provides longer term weed control (about three months) as it kills weeds
2. Faster for larger area
3. Extended period
4. Reduction in labour costs justify cost of chemical and capital investment in spray equipment

Figure 6.5: Chemical weed control equipment

Using herbicides demands knowledge and skills to minimize damage to cocoa trees, wastage of herbicides and ensure health and safety of people doing spraying

How well herbicides kill weeds without damaging cocoa or shade trees depends on:

1. Use the right herbicide of the right concentration
2. How the herbicide is applied
3. The stage of growth of weeds
4. The stage of growth of cocoa and shade tree
5. Weather during and after application

Types of herbicides

Classified by their mode of action and weather are selective or not. Two modes of action are 'contact' and 'systemic'.

Contact herbicides

1. Only damage the plant parts the hit (cover as much of the plant as possible)
2. Act rapidly and usually achieve full effect within one to three days
3. Useful in controlling annual weeds and perennial seedlings where most of plants' resources are invested above ground tissue
4. Not effective on established perennial like kunai (Centrosema spp and 'Monstera')

Some examples: Paraquat (Gramoxone ICI) and Glufosinate (Basta)

Table 6.1: Some common herbicides, their type of action, selectivity and spraying precautions for cocoa

...on name	Trade name	Type of action	Annual grasses	Perennial grasses	Annual broad leaves	Perennial broad leaves	Spraying precautions cocoa
...etryne	Gesapax, Ametrex	Systemic (roots, bark & leaves)	**	-	**	-	Avoid contact with foliage and bark
...-D amine	2-4D	Systemic (roots, bark & leaves)	-	-	***	***	Avoid contact with foliage and bark
...:2DPA	Dalapon	Systemic (leaves)	***	***	-	-	Relative safe, unless foliage thoroughly wetter
Diuron	Diuron	Systemic (leaves)	***	-	***	-	Avoid contact with foliage and bark
...azifopbutyl	Flusilade	Systemic (leaves)	***	***	-	-	Relative safe, unless foliage thoroughly wetter
...fosinate	Basta	Contact & mildly systemic	***	**	***	**	Avoid contact with foliage and bark
...araquat	Gramoxone	Contact (leaves)	***	*	***	*	Avoid contact with foliage and bark
...mazine t ...metryne	Gesatop Z	Systemic (roots, & leaves)	**	-	**	-	Avoid contact with foliage and bark
...lyphosate	Roundup	Systemic (roots, bark & leaves)	***	***	***	**	Avoid contact with foliage and bark

Systemic herbicides

1. Absorb by the leaves and green stems they hit and translocate into the roots and underground storage organs through the phloem
2. Slow but completely kill weeds
   Examples: Glyphosate (Roundup) and Fluazifop-butyl (Fusilade)

Residual herbicides (Pre-emergnce herbicides)

1. Systemic herbicides that are absorbed from the soil into the roots of germinating seedlings
2. Gives good long-term control of germinating and existing weeds
3. Most belong to the sulfonylurea family of herbicides

Examples: Simazine (Gesatop Z) and Diuron (Karmex).
Some translocated herbicide such as Ametryne (Ametrex) work when applied to either soil or leaves of weeds
Atrazine should not be used because it damages cocoa plants
Adding wetting agents ('surfactants') helps herbicides work better by reducing surface tension of mixture
Means it takes less mixture to cover a weed

Spray recommendations for various stages of block development

It is important that appropriate weed control is carried out in young cocoa.

Weed control after shade planting
Better to miss weeds close to stakes and go back and ring weed afterwards

Weed control during cocoa establishment
Strip spray with Glyphosate just before planting
Herbicide should not be used until eight months after field planting
Ring weed or mulch during this time

Weed control in mature (1 year t) cocoa
Intervals between weed controls in mature cocoa depend on the types of weeds present, the level of shade and the control method used

Herbicide application technology

Rope wick application

- Work by applying herbicide onto weeds from a thick nylon rope wick that runs back up in to the herbicide reservoir attached to the handle of the applicator

Spray equipment

Electrostatic sprayers are expensive to buy and complex to maintain so unsuitable for small holders

Knapsack sprayers

Knapsack sprayer consist of a 10 to 20 litre tank that is worn like a backpack on the back of the person doing the spraying
It is a simple and inexpensive machine suitable for spot spraying large areas or strip and blanket spraying small areas (1 to10 hectares).
There are several types of knapsack sprayer available in PNG,

These include:

1. Cooper Pegler CP3/CP15
2. Cooper Pegler Prima
3. Solo 425/475 and
4. Allman Kestrel 16/20

Nozzles

Design and pressure at which the system operates determines the

1. swathe width,
2. spray droplet size
3. spray output rate
4. manufacturers make a variety of nozzle for a range of applications
5. use standard colour- coded system to denote the different types of nozzles

Table 6.2: Nozzle equipment from different manufactures

Allman/Lurmark (Kemetal)	Cooper Pegler (Kemetal)	Cooper Pegler VLV (Brass)
AN 0.5 Pink	50/pink	VLV50
AN 0.75 Light Brown	–	–
AN 1.0 Orange	100/Orange	VLV100
AN 1.5 Red	–	–
AN 2.0 Cambridge Blue	200/Blue	VLV200

Table 6.3: Nozzle types with recommended swath width, approximate number of 20 litres tanks to spray one hectare and time (min) to spray a 20 litre spray tank

Nozzles	Recommended swath width (m)	Recommended flow rate (litres/min)	Number of 20 litre tanks to spray one hectare	Time (min) to spray one 20 litre tank
Red Polijet	2	2.5	20	8
Blue Polijet	1.5	1.6	18	12
Green Polijet	1.0	0.9	15	22
Yellow Polijet	0.5	0.5	22	29
AN 2.0	1.2	0.9	12	22
AN 1.0	1.2	0.5	6	40
AN 0.5	1.2	0.2	3	100

Table 6.4: Flow rate (mist/min) from different nozzles when sprayers are set at different pressures

nozzles	Pressures (psi)			
	15	20	30	40
Yellow Polijet	600	850	980	1100
Green Polijet	920	1130	1310	1460
Blue Polijet	1850	2260	2610	2920
Red Polijet	2350	2830	3270	3650
AN 0.5 Pink	230	280	330	370
AN 1.0 Orange	460	570	650	730
AN 2.0 Red	920	1130	1310	1460

Calibration of knapsack sprayers

In using knapsack sprayer the following variables have to be measured and calibrated (adjusted and controlled to ensure that the herbicide is being applied at the correct rate:

1. Flow rate of mixture from the nozzle. Flow rate is itself dependent on the two variables of nozzle type and the pressure at which the spray is being pumped
2. The width of the swath, which will vary depending on how high the spray lance is held
3. The walking speed of the operator
4. The concentration of the herbicide concentrate in the spray mixture

Most commonly used method of calibration knapsack sprayers is called the speed-width- output method. This uses walking speed, swath width and nozzle flow rate to calculate how much water (spray volume) is needed to cover the area to be sprayed

How to measure the variables

Flow rate- amount of liquid that flows out of the nozzle in one minute

Steps:

1. Fill spray tank with water
2. Pump the sprayer normally
3. Place a bucket under the nozzle
4. Collect water for one minute (use a watch)

5. Measure water collected by tipping water from bucket into a ml measuring jug
6. Do this for three or four times
7. Work out the average

Note: flow rate obtained must be very similar to specified flow rates for the different nozzles in table 8.3

Swath width:

Is the path marked out by the spry as the operator walks along. Its width is measured in meters. Depends on how high the nozzle is held. Recommended swath widths for various nozzles used in herbicide spraying are set out in Table 8.

Figure 6.6: Calibrating for spraying with a knapsack sprayer: at left, measuring flow rate; centre, swath width; right, walking speed

Walking speed:

It is the distance walked, measured in meters per minute. Recommended speed is 45m/minute

Steps

1. Have the operate walk 100 meter while spraying with a full tank
2. Time him over the last 20 meters
3. Do this for three or four times
4. Work out average

Transform the average time taken into speed by using the following formula

60 (no. of seconds in a minute) x 20 (no. of metres walked) = walking speed

Average time over 20 m

If the time from the example given above is applied to this formula the result is a walking speed of approximately 44.5 meter per minute

60 x 20 = 2.22 x 20 = 45 meters per minute (44.44)

27 m

Total volume application rate:

It is the amount of mixture that is needed to cover a hectare. Must be calculated to find out how many tanks full is needed for a hectare and how much chemical should be put into each tank

Now that the flow rate, swath width and walking speed have been determined, this can be calculated by following this formula:

TVAR (litres/ha) = Flow rate (litres/min) x 10, 000 (i.e. no. of meter2 in a hectare)

Swath width (m) x walking speed (m/min)

Maintaining knapsack sprayers

Knapsack sprayers are robust and will last for many years if care for

At the end of each day of spraying:

1. Flush the tank and spray system out with clean water, as herbicides can be very corrosive
2. Check for material clogging the filters
3. Check to see if there is anything clogging the nozzle
4. Check the tank and spray system for leaks
5. Clean the sprayer and put it in a clean, dry store room
6. Before using it again recalibrated and all moving parts should be boiled or greased

Field techniques

To use herbicides really need training on how to use agricultural chemicals

Right conditions for spraying are:

1. Favourable weather- little or no wind and no rain
2. Weeds in a vulnerable condition
3. Cocoa and shade trees in a low risk condition

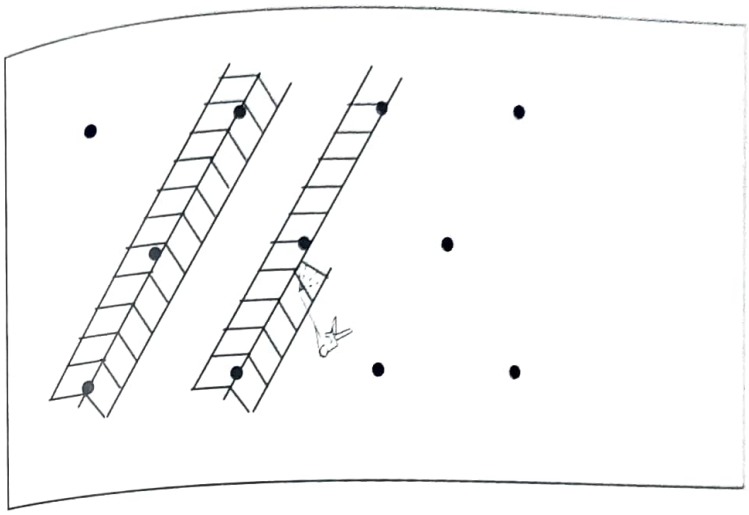


Figure 6.7: Plan of double swath strip spraying

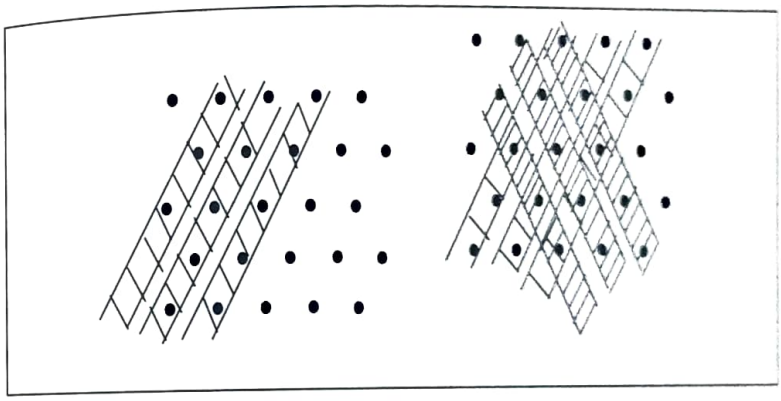


Figure 6.8: Plan of single swath strip spraying in one and two directions

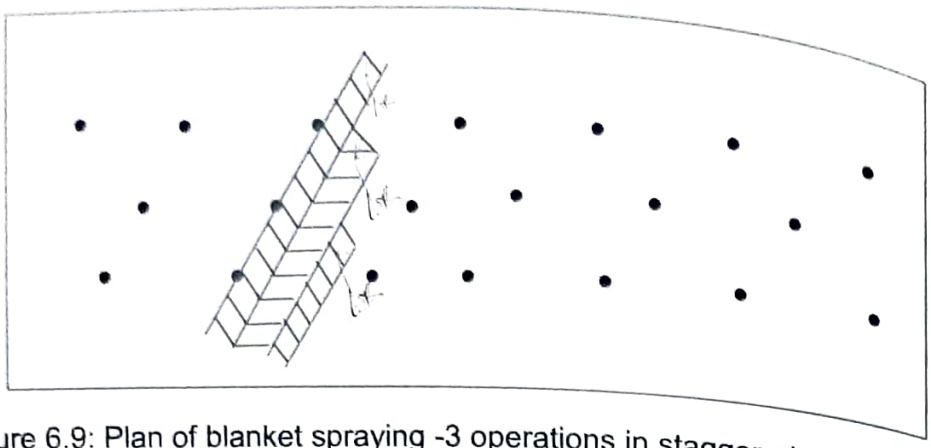


Figure 6.9: Plan of blanket spraying -3 operations in staggered formation

Safe spraying

1. **Before using herbicides (and any pesticide)**

Steps:

1. Use right chemical for the job. **READ LABELS. ALSO SEEK EXPLAIN AND A WRITTEN TRANSLATION IF NOT IN LANGUAGE YOU UNDERSTAND**
2. Use protective clothing
3. Wear rubber gloves, rubber boots and an eye shield for mixing, and rubber boots and boots and a hat for spraying
4. Check for leakages and that it is working properly
5. Check that right nozzles are being used and machines have been calibrated so to know exactly how much spray you are applying

2. **Mixing**

Steps:

1. Plenty of water available for mixing and washing. Soap at mixing site
2. Children or other people not allowed near the mixing
3. Avoid splashing liquids. If concentrated chemical gets on your skin, wash immediately
4. Pour or measure powders carefully and accurately and avoid breathing in any powder. Wash immediately with soap if chemical gets on your skin
5. Pour or measure power carefully and Avoid breathing in any powder
6. Use proper tools to open containers. Avoid risk of material spurting into the face or eyes
7. In windy situations, make sure it blows spilled chemicals away from you and not towards you
8. Never eat, drink or smoke whilst mixing chemicals

3. Spraying

Steps:

1. Machines used for spraying herbicides are not used for spraying any other chemicals
2. Avoid walking through sprayed areas
3. Never blow out blocked nozzles or hoses with your mouth
4. Any leakages, stop spraying immediately and wash skin with soap and water
5. In strong winds, do not spray
6. Never eat, drink or smoke whilst spraying
7. Continue spraying until the tank is empty

4. After spraying

Steps:

1. Return unused chemicals to the store
2. Never store chemicals near/with food and drink
3. Return empty containers to store and disposed of properly
4. Clean equipment and return to the storage shed. Never leave unused spray solutions in a machine overnight
5. Remove and clean protective clothing
6. Wash well with soap and water
7. Keep records of the use of chemicals
8. Never eat, drink or smoke until you have washed with soap and water

5. Storage of chemicals

Steps:

1. Avoid misuse, herbicide must be stored in original labelled and in identified areas. Herbicides should be kept separately from Insecticides and Fungicides to avoid mistakes
2. Never put Herbicides into soft drink, beverage or food containers
3. Empty containers should be broken to prevent their other purpose and either buried away from rivers and streams or destroyed by burning. Do not stand in the smoke

Exercise-Appendix 8.1

How to calculate total Volume Application Rate without a watch

Calculate Total Volume Application Rate with a known volume of water

Here you measure what area of ground is covered by known volume of water

1. Known volume of water put in tank
2. Sprayed out while maintaining a consistent swathe width, walking speed and pumping rate
3. Spraying is continued until the tank is empty
4. Area that has been covered by the spray is then measured
5. Repeat this process 3 to 4 times an average is taken from all the results
6. This area and amount of water used are applied to the following formula to calculate the total volume application rate (litres/ha):

Total application = Volume used in calibration (litres) X 10000 (m2/ha)

Volume (litres/ha) Mean area sprayed

Example:

If the volume of water put into the tank for calibration is 10 litres
The average of three areas sprayed is 364 metres squared

Total application volume (litres/ha) = 10 litres x 10,000 (m2/ha)
364 = 275 litres/ha

Calculate Total Volume Application Rate with a known area

This method, measure what volume of water is needed to cover a known area of ground.

1. Known volume of water is added to tank
2. Sprayed out over a measured and marked area at maintained consistent swathe width, walking speed and pumping rate
3. After marked out area been sprayed, the amount of water remaining in the spray unit is measured
4. That amount is deducted from total amount that was in the sprayer when started with
5. Exercise is repeated three or four times for an averaged result. Result should fairly similar
6. Figures for the average of amount of water used and known area over which it was sprayed are applied to the following formula to calculate the total volume application rate (litres/ha):

Application volume (litres/ha) = Mean volume sprayed x 10 000 Area sprayed (m2)

= 275 litres/ha

Teaching Strategies

A) Introduction

1. What is a weed?
2. What are the common weeds in the garden?
3. Name some common weed found in the cocoa plot at your home or in the school cocoa plot

B) Body

To do this project successfully, the teacher has to prepare well and provide a demonstration of how to do a proper weed collection and sample.

1. Give an assignment to your students to take a collection of five important cocoa weeds in the school cocoa plot or from the community
2. Get students to press them using newspapers over a week
3. Provide reference text for students from the library to complete the assignment
4. Get them to identify and label the weed and its parts
5. Students should provide a sample of five important economic weeds with village names, common names and scientific names for assessment
6. Provide due date

C) Closure/Conclusion

1. Teacher to collect and assess the weed collection
2. Teacher to display good collections
3. Provide feedback students

Student Activities

1. List and describe types of weed control

2. List and describe types of herbicides

3. Describe and demonstrate spray recommendations for various stages of block development

4. Explain and carry out calibration of knapsack sprayers

5. State and demonstrate types of field techniques

Study the figure and state if safety regulations are being followed? If not, then list what safety requirements are not being followed

Weeds collection assignment

Common weeds and control

Weeds	Control	Marks

UNIT 7: COCOA PRUNNING

Introduction

Pruning is the removal of unwanted branches from a cocoa tree. Pruning affects yield for many months or years and it gives shape and structure of the tree for the rest of its life. Therefore, pruning is one of the most important operations in a cocoa plot is to promote high yield and of good quality.

Learning Outcomes

At the end of the unit, the students can:

A. List reasons prune cocoa

B. Explain in a page a block of cocoa that needs pruning.

C. Identify or state all pruning types and their impact on the cocoa tree

CONTENT

Pruning is removal of plant parts either as a single part or a combination of parts that are not needed

We prune the cocoa tree to control pests, reduce diseases, increase access sunlight and encourage the cocoa tree to enable maximum yield

Types of Pruning:

There are four main types of pruning. Each type will be discussed and illustrations will be shown on each type of pruning and their impact on the cocoa tree.

1. **Formative Pruning**

Formative pruning is also known as tip pruning or canopy shape pruning. To do formative pruning, we need the following tools and equipment: secuters, knives, etc.

A hybrid clone

Figure 7.1: Before formation pruning

Figure 7.2: After formation pruning

The steps in formative pruning in the most logical order is listed and described as follows:

Phase One: Tip Pruning Timing: 3-6 months after planting

Steps	Main Points	Safety Points
a)	Identify 3-6 month old cocoa tree for formative pruning	Not older trees
b)	Using your sacruteers cut off the dominant growing tip to promote upright growth of more side branches	
c)	Prune back droopy branches to promote union of branches	At early age

Phase two: Canopy shaped pruning

Time: 6-9 months after planting and after phase one which is tip pruning.

Steps	Main Points	Safety Points
a)	Cut back lateral branches 40-60cm above ground level Leave good strong looking branches	
b)	Cut branches below kneel height to promote well spaced main braches	
c)	Prune droopy & low hanging branches to for circular canopy	
d)	Leave 4-5 evenly spaces main branches from jorquette (the point at which the stem fans out to branch) to promote canopy coverage	

Prune to develop a good primary tree structure and promote the development of secondary branches

Precaution: Avoid pruning resulting in poor tree structure and canopy formation, and access vegetative growth

2. **Chupon or water shoot pruning**

Chupon pruning is applied to young cocoa trees to get structural strength and to avoid excess branch formation. It is also applied to mature trees to reserve nutrients for good pod development and to promote sunlight penetration and aeration

Figure 7.3: Before chupon pruning

Figure 7.4: After chupon pruning

A hybrid seedling tree

A hybrid clonal tree

Figure 7.5: Before chupon pruning

Figure 7.6: After chupon pruning

Timing: Chupon pruning is applied every 3 months after tip pruning

Steps	Main Points	Safety Points
	a) Prune all shoots below knee height where they meet the trunk (lower than 40-60cm from the ground) b) Prune most of the regrowth shoots within the primary formed structure c) Encourage chupon at the base of fallen and leaning trees to grow up to replace the old trees. Remove or prune chupons that do not grow straight up	

Precaution: When pruning chupons and shoots, make sure that the whole chupon is removed back to the main stem and that no stumps or end remains

3. Sanitary Pruning

Figure 7.7: Pruning technique using correct tools

Sanitation is cleanliness which helps increase sunlight for photosynthetic activity and aeration, and to prevent and reduce pest, disease and weed infestation. This improves the tree health and promotes pod development. Sanitary pruning is carried out at the same time as structural pruning, and when diseased or death branches are seen in the cocoa block.

Figure 7.8: Removal of Cherelles

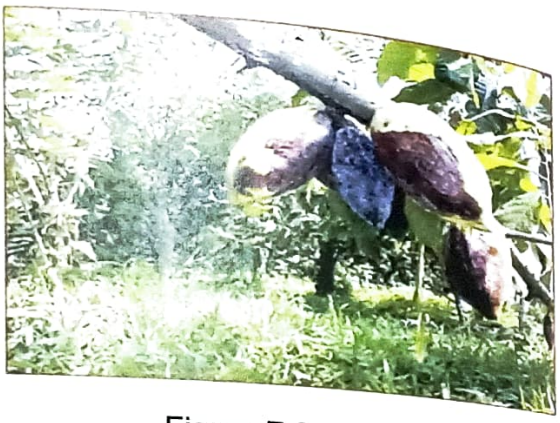
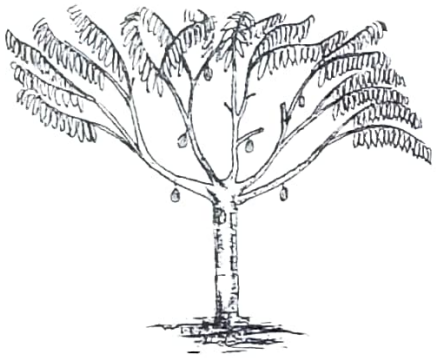


Figure 7.9: Removal of Pods

Figure 7.10: Before sanitary pruning



A hybrid seedling tree

Figure 7.11: After sanitary pruning

A hybrid clonal tree

Figure 7.12: Before sanitary pruning

Figure 7.13: After sanitary pruning

Timing: Sanitary pruning is done every 5-6 months

Steps	Main Points	Safety Points

a) Remove low hanging and drooping branches at height of 1.2m

b) Chupons and small unproductive twigs removed

c) Cut and remove all infected and damaged branches

d) Remove interlocking branches and leave 20-40cm gap between branches

e) Remove leading branches to maintain tree height at 3.5m

f) Cut a central incision: prune lightly at the centre of the canopy

g) Cut side incision: prune a few small branches on the side of the tree to create a gap

h) Cut and Remove any pod mummies

Caution: Correct pruning increase ventilation and helps reduce humidity, thereby making less suitable for pests and diseases.

4. Structural Pruning

Timing; Applied 5-6 months

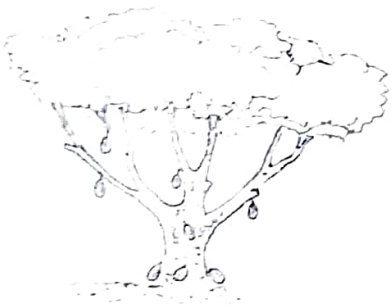
Structural pruning aims to promote the continued development of 4-5 main branches as the primary structure. This pruning stimulates the replacement of old and infected branches on mature trees with a new growth. This maintains the productive area,

while opening the canopy and allowing ventilation within and between cocoa trees. The aim of structural pruning is to maintain a well-rounded tree canopy.

A hybrid seedling tree

Figure 7.14: Before structural pruning

Figure 7.15: After structural pruning



A hybrid clonal tree

Figure 7.16: Before structural pruning

Figure 7.17: After structural pruning

Steps **Main Points** **Safety Points**

a) Height control: Prune leading branches at 3.5m to maintain reach for ease of harvest. This pruning applied to cocoa tree above 3.5m or two people tall

b) Ground Clearance: Prune low-lying and drooping branches to achieve a clearance of 1.2m from the ground

c) Develop the mid-canopy: Prune a small v-shape in the middle of the canopy in the east-west and then north-south direction for sunlight penetration

Caution: Do not prune tree that do not have active leading branches. Avoid pruning productive branches, particularly in the centre of the tree. Height control pruning is

applied to tree that grow beyond 3.5m. Pruning should not leave a gap in the side of the tree that is greater than your outstretched arms (1.5m)

PRUNING OF SHADE TREES

Shade trees (and especially legume trees) are generally used to promote healthy growth cocoa tree to about high yield. The two main reasons and they are:

1. Reduce light intensity on the crop
2. Provide nutrition and enable nitrogen fixation (if shade tree is a legume tree)

Too little shade can result in poor health to the tree due to high light intensity and high weed growth while high shade may lead to high humidity, and pest and disease infestation. These conditions may result in low cocoa production.

It is recommended that the cocoa block must have 75% shade. About 50% of the shade should be absorbed by the cocoa tree while the other 25% should hit the soil.

Shade tree recommended for cocoa blocks in PNG are:

1. Coconut (for shade only). If coconut is used the farmer must remove fallen leaves regularly
2. Gliricidia sepium. This shade tree is managed as follows:

   Timing: In July and December (5-6 months after structural pruning) and during sanitation pruning rounds.

3. Steps	Main Points	Safety Points

a) Canopy reduction: Prune heavy canopy branches to reduce the weight of the shade tree Gliricidia canopy.

b) Debarking: Remove bark from around the trunk at shoulder level and cut out conducting tissues of the surface from which the bark have been removed.

c) Regrowth removal

   i) Prune 3 months after debarking groom 2-3 regrowth and remove the rest.

   ii) Six months after debarking, leave one of the first regrowth and debark the rest.

   iii) Leave two of the new regrowth from the main branch (selected after 6 months) and remove the rest. Repeat the cycle when necessary.

TEACHING STRATEGIES

A) Introduction

1. Ask students to define pruning
2. Show a tool and ask what these tools used for in Agriculture
3. Show a picture of a garden/ block being pruned
4. Describe the cocoa tree that needs pruning

B) Body

1. Provide correct definition
2. Describe pruning types, reasons and describe a pruned cocoa block
3. Show photos of pruning and explain features of each
4. Write a page about pruning cocoa

C) Closure

1. Orally ask students to define, explain effects of pruning or show photo of pruned garden of a type of pruning
2. Short test to define, explain or provide reasons to prune
3. Mark (1 or 2) and evaluate student performance

STUDENT ACTIVITIES

1. Define pruning in your own words

2. List the four types of pruning of cocoa

3. Describe each pruning type and provide reasons for each type

a)

b)

c)

d)

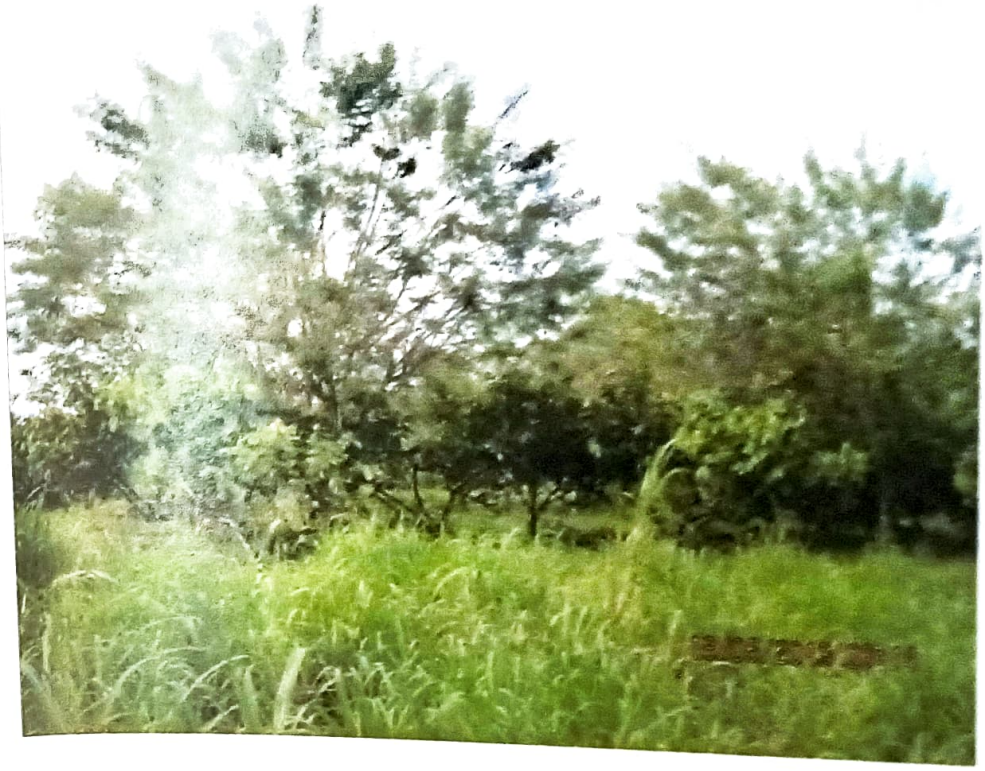
4. Write a paragraph or two about cocoa pruning and its benefit

5. Get students to the school cocoa block that needs pruning and demonstrate the four types of pruning. Where not possible show pictures, photos and illustration of each pruning type.

NB: This is a practice activity and must be done in the field. Teacher to prepare this activity carefully. Provide a demonstration and have student practice them

6. Teacher to have student field practice pruning in the village own cocoa block. Student to prepare a report on their field experience (five pages and include pictures and photos as means of verification)

UNIT 8: COCOA SHADE



Introduction

Shade has a big effect on the growth and productively of cocoa throughout its development into a mature tree. Some degree of shade control is needed through pruning and thinning to achieve desired level of shade to maximize growth and production. The appropriate percentage of shade for a mature cocoa tree will vary depending on level of management applied to the block and the amount of fertilizer applied to its soil

The timing and extent of shade control is highly variable between different blocks. This is because may be altered according to the:

1. Growth stage of cocoa trees
2. Weather patterns
3. Local environment
4. The nutrient status of the soil/ fertilizer application program and seasonal soil moisture levels of the area

At the completion of this unit, students should realized the importance of shade in cocoa production

Learning Outcomes

At the completion of the unit, the students can:

A) State Reasons as to why there shade control
B) Explain why we prune shade in a cocoa block
C) Describe how shade is thinned in a cocoa block
D) State and describe factors required in shade management

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easons for shading

he effect of shade on cocoa is very complex. It influences the micro- climate of the ocoa block through its effect on the

1. Amount of solar radiation received by cocoa trees
2. Air turbulence (wind)
3. The relative humidity
4. Metabolic rate of the cocoa trees as it indirectly influences the nutrient status of the soil

Micro- climate in turn, influences the incidence of pests and diseases

All these factors combined have a big effect on the cocoa yield

1. The rate of photosynthesis increases with an increase in the solar radiation/ light intensity
2. Most plants only need certain level of light intensity to attain maximum photosynthesis rates
3. Beyond that the level of photosynthesis stays the same or goes down when 1- the heat 2- lack of moisture
4. Intensity of solar radiation combine to cause stomates to close or leaf cell turgidity to be reduced
5. Typical under Papua New Guinea conditions to cocoa with very little or no shade
6. Increase photosynthesis increases the 1- uptake and use of water 2- mineral nutrients to sustain the higher rate of metabolism
7. Thus regular watering and fertilizer application are needed to support the high rate of photosynthesis that occurs under low shade and high light intensity conditions
8. If water is limited, cocoa trees will suffer from water stress
9. If soil nutrients levels are low, the tree will suffer nutrient deficiencies

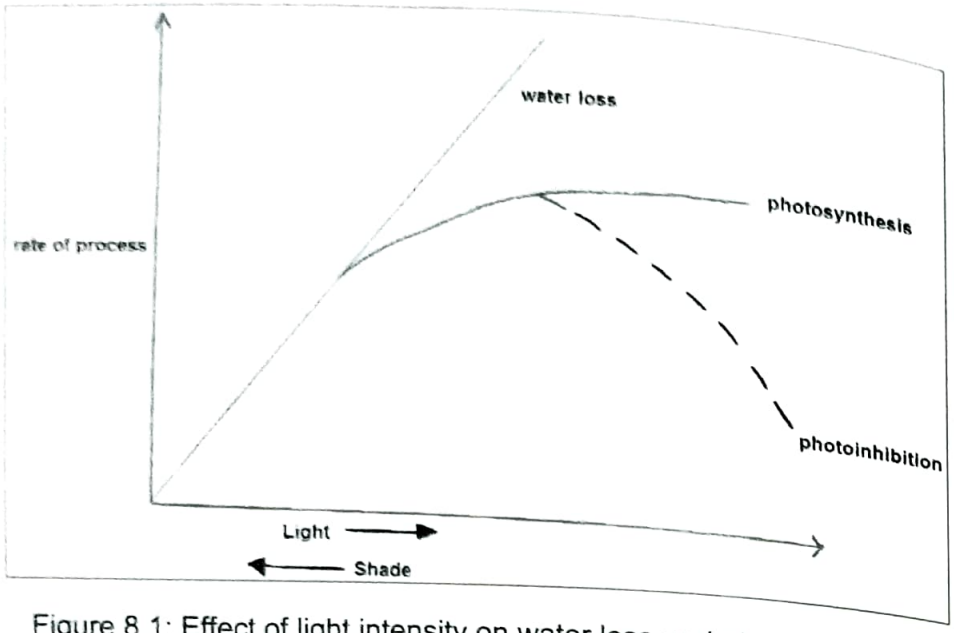


Figure 8.1: Effect of light intensity on water loss and photosynthesis

This figure demonstrates that beyond a certain point further increases in solar radiation will not increase photosynthesis because 1- once maximum photosynthetic rate that a tree is genetically capable of operating at has been reached1- no amount of extra sunlight 2- soil moisture 3- nutrients will increase the rate of photosynthesis

1. The maximum rate of photosynthesis a tree is capable of will vary between different plant species depending on the environments in which those species have evolved
2. There can be differences between different varieties of the same species
3. Non- genetic variations in actual maximum photosynthetic rates can exist even between clones- individual vegetative reproduced with material from the same parent if individual raised under and adapted to different light intensities
4. Cocoa trees grown in heavy shade would reach their maximum rate of photosynthesis at a much lower light intensities than trees adapted trees were "hardened off" gradually their maximum rate of photosynthesis would rise

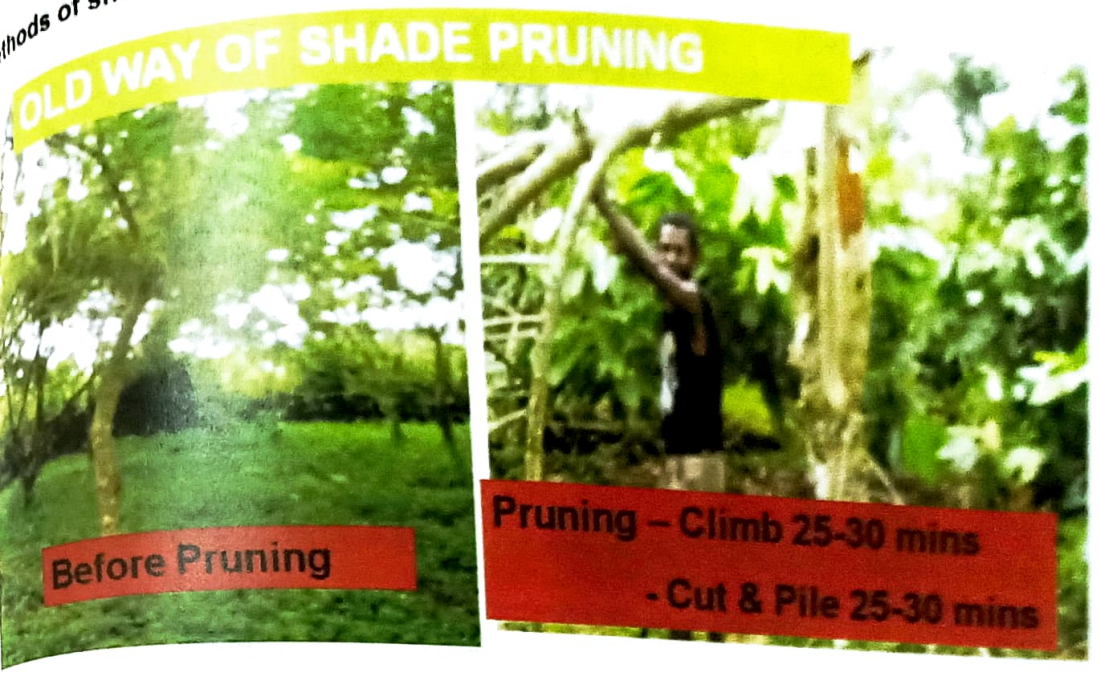


Figure 8.2: Normal way of shade pruning used by most farmers

Figure 8.3: improve way of shade control

Effect on young cocoa

1. If shade levels are too heavy for young cocoa, the growth is reduced
2. Trees develop longer and fewer leaves and fewer shoots
3. Stems and branches are tinnier and longer as they grow in search of light
4. Commence of flowering and bearing later than if had adequate light
5. Under medium light shade levels, young cocoa will quickly establish provided the environment, weather patterns, the nutrients status of the soil and weed control are adequate
6. There will be a lot of new growth giving many leaves- small and thicker than under heavy shade
7. Stems and branches be shorter and thicker

Effect on mature cocoa

1. Cocoa grown under heavy shade will produce large and few leaves. eaves usually thinner than those grown under lighter shade
2. Under heavy shade, yields are lower and disease incidence are higher, particularly "black pod"
3. High levels of "black pods" associated with heavy shade due to lack of free air circulation and light to dry out tree surfaces after the rain. It is much higher in high and frequent rainfall areas
4. Experiments from cocoa growing countries show that cocoa yield increased after shade removed
5. However, is not sustain after 10 years of complete shade removal when. Fertilizer additions are not made

Most probably the reasons are 1- nutrient stress (as the soils run out of the nutrients needed to support increased metabolic rate of trees in full light) 2- water stress 3- wind damaged to leaves 4- shoot and tree die back (leaves getting smaller and smaller until shoots die off) because of continuous exposure to direct sunlight 5- insect damage also probably contributes to die back

1. It is advisable to carry out shade thinning or shade removal gradually so cocoa trees can gradually adapt to higher light intensities
2. Sudden removal of shade will greatly affect the trees' health as will probably be damaged by 1- sun scorching 2- bark cracking 3- wind 4- insect pest damage
3. Shade removal has to be accompanied with high levels of management in put, especially in regard to 1- fertilizing 2- weed control 3- management of soil moisture levels

Pruning

1. Pruning is done in the first year after planting and continuous until the shade trees are removed in the thinning process
2. It is necessary every 3 months where soils are fertile and where rainfall is well distributed throughout the year. May be done more frequently

when need to as the aim is to ensure that shade does not become too heavy and so limit maximum photosynthetic activity and hence growth of cocoa

3. Where regular cloud cover reducing the intensity and duration of sunlight, slightly lighter shade will be required and pruning done more extensively
4. The main objective of pruning is to encourage vertical growth so light can be evenly distributed
5. Where no branches are growing vertically, new developing shoots with upward growth will be allowed to remain. Unnecessary branches should be pruned off to reduce the number of developing new shoots
6. Pruning involves risk, therefore runner should be careful where to place the feet and hand when cutting especially in slippery rainy conditions

Thinning

It involves ring barking and poisoning them commencing when the cocoa are well established and already producing

1. If the soil is fertile, the soil moisture adequate and block well managed 2 to 3 years after planting hybrid varieties and sooner hybrid clones
2. It is best done at the start of the wet season to minimize water stress in cocoa trees. It is important in areas where soils is shallow or sandy
3. Lack of soil moisture in such soils during the dry season may harm cocoa tree if sudden exposed to higher levels of solar radiation due to increased rate of photosynthesis results from sudden removal of shade
4. In-addition, the more soil water during wet season and cloud cover reduces the level of photosynthesis and tree need for moisture

Poisoning trees

1. The following mixtures can be used.
2. A 1.5 percentage mixture of Garlon with diesel. I.e mix in 15 mls of Garlon for every liter of diesel
3. A 5 percent mixture Glyphosate with diesel. I.e mix in 50 mls of Garlon for every liter or diesel

Thinning temporary shade trees may be done in stages over 4 years so cocoa trees can gradually adapt to high light intensities. Commence thinning by poisoning alternate (every second) trees

X c x o2 x o3 x c x o2 x o3 x c x o2 x o3 x

X o2 x o4 x o2 x o4 x o2 x o4 x o2 x o4 x o2 x

X o3 x o2 x o3 x o2 x o3 x o2 x o3 x o2 x o3 x

X c x o2 x o4 x c x o2 x o4 x c x o2 x o4 x

X o2 x o3 x o2 x o3 x o2 x o3 x o2 x o3 x o2 x

X o4 x o2 x o4 x o2 x o4 x o2 x o4 x o2 x o4 x

X c x o3 x o2 x c x o3 x o2 x c x o3 x o2 x

Figure 8.4: Showing planting arrangement

Key: x= Cocoa tree, c= coconut shade, o2= Gliricidia removed at 2 years, o3= Gliricidia removed at 3 years, o4= Gliricidia removed at 4 years

ble 8.1: Gradual thinning of gliricidia shade, where cocoa is planted on a 4.0
me sequence can be followed for gliricidia as a permanent shade species
ade management after required and individual approached largely dependent on:

ths)	Season	Operation
-18	End wet	Plant coconut polybag nursery
5	Mid dry	Mark out block for individual planting sites of coconuts and cocoa
2	Start wet	Plant out coconuts with Gliricidia
	Mid dry	Plant cocoa nursery
	Start wet	Plant out cocoa seedlings in the field
	End wet	Thin Gliricidia branches
	Start wet	Poison or ring bark 2 out of 3 temporary shade trees between cocoa
	Mid wet	Poison or ring bark all temporary shade trees in every second row of cocoa
	Start wet	Poison or ring bark 1 out of 2 temporary shade trees
	Start wet	Poison or ring bark all remaining temporary shade trees, leaving only coconuts as shade

1. Local environment
2. Soils
3. Weather patterns
4. Types of shade trees

Research has shown that generally, 60-70% shade is required by tree crops to have sufficient sunshine for photosynthetic activity and to have adequate air circulation. Heavy shade can lead to pest and diseases build up while too light a shade may contribute to high light intensity which is not suitable for tree crops.

Teaching Strategies

A) Introduction

1. Group discussion on the effect of shade on cocoa production
2. Show a photo of a shaded cocoa plot and discuss what needs to be done
3. Get students into groups to discuss what kinds of shade trees are seen on the cocoa plantations or plots in the local area
4. Tell student the fact that the cocoa and coconut shade tree was pioneered in Papua New Guinea

B) Body

1. Use notes and field trip/visit/exposure to cocoa plots and records number of shade trees observed
2. Use notes and field trip/visit/exposure to describe and explain the advantages of each shade tree
3. Discuss based on:
   i) Coconut –cocoa interaction
   ii) Coconut – Glarcidia interaction
   iii) Coconut –Cocoa and Glaricida Interaction

C) Closure

Orally ask students to:

1. Report to class on groups activities
2. Give reasons for shade control
3. Discuss the cocoa, coconut & Glaricidia interaction

Student Activities

1. State Reasons as to why there shade control

2. Explain why we prune shade in a cocoa block

3. Describe how shade is thinned in a cocoa block

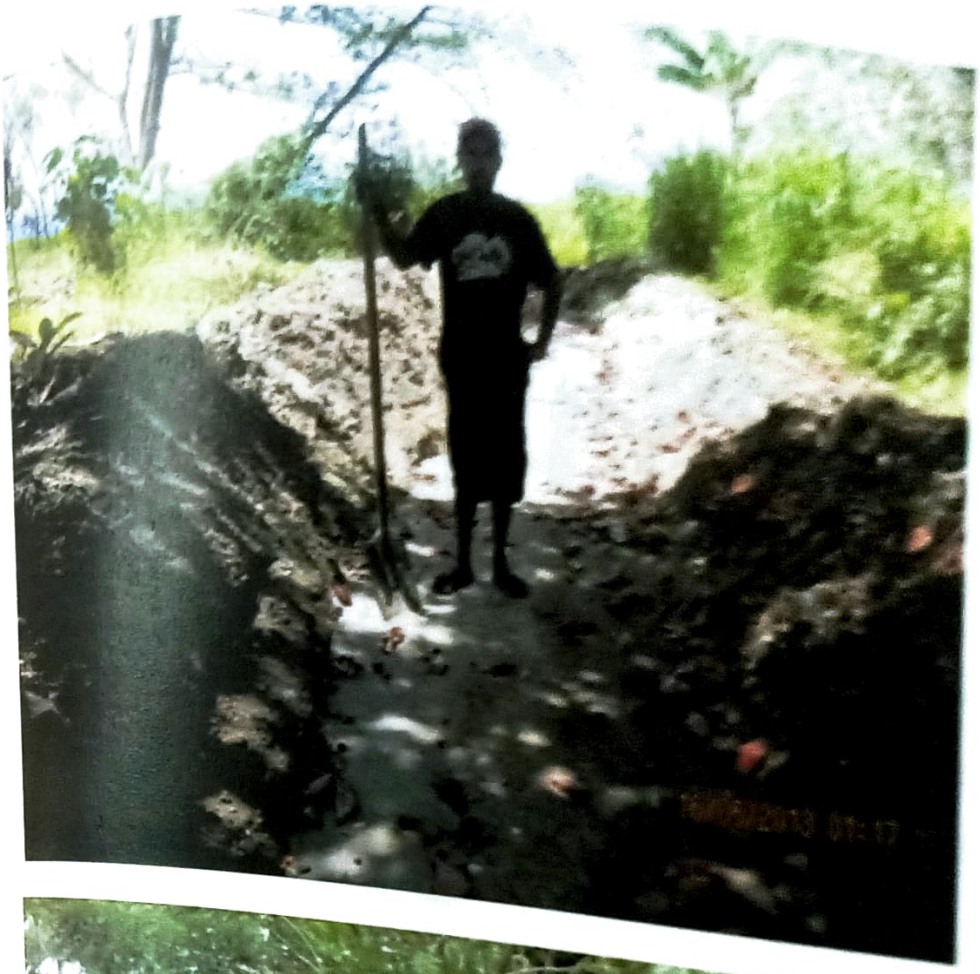
4. State and describe factors required in shade management

Types of shade control

Shade control	Criteria
Ring weeding base of tree	
Grass cutting between rows of plants	
Pruning – remove chupons	
4-5 fan branches left	
No branches within 60cm of jorquette	

Mulch base of tree	
Structural pruning – remove disease parts	
Cutting off any low lying branches	
Less lateral branches interlocking	
Shade trees removed	
Enough sunlight into the block	
All black pods removed	
Diseased pods removed	
Cocoa branches not touching each other	
Infilling or replacement	
Pruning shade trees	
Introduction of cover crops	
Pruning done at base of plant	
Pruning with correct tools	
Harvesting done thoroughly	
Read scale correctly	
Wet beans clean and free from dirt	
Use correct tool for harvesting	

UNIT 9: DRAINAGE



Introduction

Drainage is needed either because:

1. There is a high water table as in low lying areas
2. The physical condition of the soil impedes the drainage of surface water to a depth below the roots of crops.
3. These two causes are the main effects of improving the drainage. Thus it improves soil aeration. This allows crops to develop a deeper root system.

This unit should be taught as a practical session for student to appreciate the importance of drainage

Learning Outcomes

At the end of unit, the students can:

A) Explain the reason for the constructions of drains

B) Explain why hilly land has natural drainage

C) Importance of rain drainage in the movement of water in the soil

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rains to lower a high water table

1. Soils that have water table that is permanent or seasonally high enough to affect crop growth need drains to lower the water table
2. Depths of drains depends on the nature of soil, rainfall and evapo-transpiration, and crops to be grown
3. Tree crops, such as cocoa, need to be developed on a deep root system will require a lower water table than annual or surface- rooting perennial crops
4. It is not necessary to keep water table below rooting depth at all times of the year as in short periods of water- logging during heavy rainfall may not be harmful
5. Areas where rain fall is seasonal, water conservation for dry seasons is important

rosion occurs on bare soils without proper and well-constructed drainage. Erosion the washing away of soils and if not maintained may lead to loss of crops such as coa. In high rainfall areas such as the ENBP, erosion is a major problem. In the it, students will study

1. What is erosion?
2. What are the types of erosion?
3. How erosion can be controlled.

pes of Drains

4. Open surface drains are cheaper and easier to construct

Figure 9.1: An open cut drain

These drains are common on cocoa plots and gardens. They are easy and cheaper to prepare and establish.

However, the disadvantages of open drains are:

a) Taking up land
b) Harboring noxious weeds and rodents
c) Require constant maintenance

5. Sub-surface drains made of plastic or concrete pipe

Figure 9.2: A sub-surface drain mainly with re-enforcements such as plastic or concrete material

Surface drains are made with bulldozers, excavators or suitable ploughs or can be dug manually. Most of these type of drains are dug in well managed areas or property and are not suitable for cocoa plots and gardens. These are also very expensive to establish and if they are blocked, they are hard to repair.

Draining on flat or gently sloping land

Flat and gentle sloppy land is a natural drain. Such slopes only require simple construction and the costs are slow.

Steps

a) Find and construct an efficient outlet
b) Cut the main drain starting at outlet and digging away from it, keeping it in straight as possible
c) Cut the field drains at intervals depending on soil texture

Some major considerations:

1. Drains closer on heavy soils (higher in clay content) then on light soils (higher sand content)

2. Gradient of a drain must be sufficient to prevent from rapidly silting up but not as great that the scouring or erosion quickly occurs
3. Provided drains are well maintained, a fall of between 1 in 5 000 and 1 in 3 000 depending on the size of drain where is normally adequate

illy land has a natural drainage

n some areas, artificial drainage system for soil conservation work with field drains unning across the

rains to improve the down ward movement of water in the soil

1. Drains needed in soil which physical condition of one or more of the horizons impedes the downward movement of excess water
2. Problems may occur on soil surface as the result of breakdown of soil aggregates by
   a. Rainfall impact
   b. Excessive tillage or cultivation when the soil is too wet

Some major considerations

1. The remedy for this lies in protecting soil with a cover crop or mulch or avoiding inappropriate tillage
2. Drains cannot help once the structure of soil has been destroyed but may help reduce the risk of this sort of damage occurring by keeping surface large ther
3. Impeded drainage may be due to impermeable layers below the soil surface. sometimes called hard pans, can occur quite close to the surface or at greater depths

Drainage as a way to control erosion

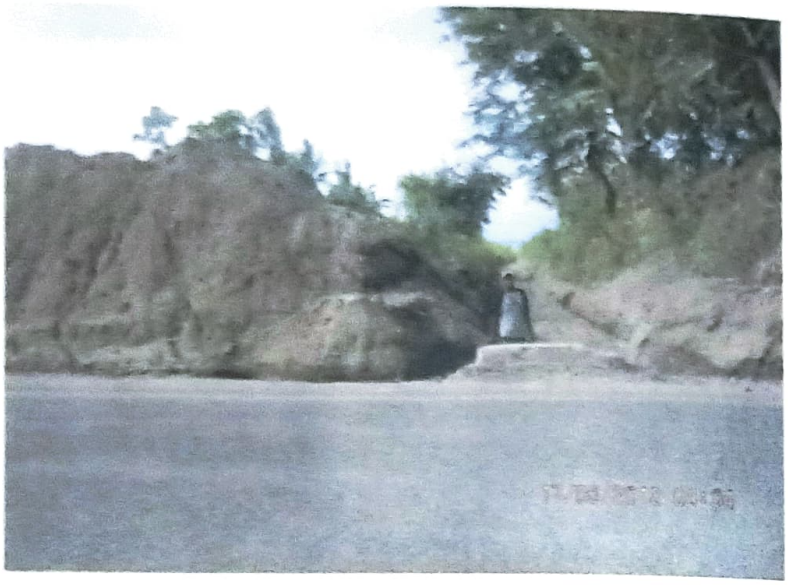


Figure 9.3: Drainage system

Erosion is the loss of soil as a result of heavy rains causing the soil to be saturated and therefore being run-off down the slope and on to the river system. This loss of soil can be severe in sand, and silky soils. It is important to note that lack of proper drainage in sandy and silky soils can result in sever wash away or erosion of soils.

Good management and drainage can help control erosion, therefore this can be controlled

1. Good drainage
2. Contour drainage
3. Growing grass on the land or soils
4. Not leaving land bare
5. Reduce heavy deforestation
6. Using cover-crops thus reducing speed
7. Avoid using heavy machinery

All the above listed methods used independently or in a combined manner can reduce the effect or impact of soil erosion.

Teaching Strategies

A) Introduction

1. Show picture or get a field trip to a cocoa plot and have them identify and describe the types of drainage and erosion in the area
2. Get students to read and explain what they found
3. Make summary notes for students

B) **Body**

1. Explain reasons for drainage
2. Describe types of drains
3. Discuss how to control water
4. State definition of erosion and name the types
5. Discuss erosion control methods

C) **Closure**

Orally ask students to:

i. Give reasons for drainage
ii. Describe how drainage is constructed
iii. Describe control measures to prevent erosion

Student Activities

1. Explain the reason for the Constructions of drains

2. Explain why Hilly land has a natural drainage satisfactory

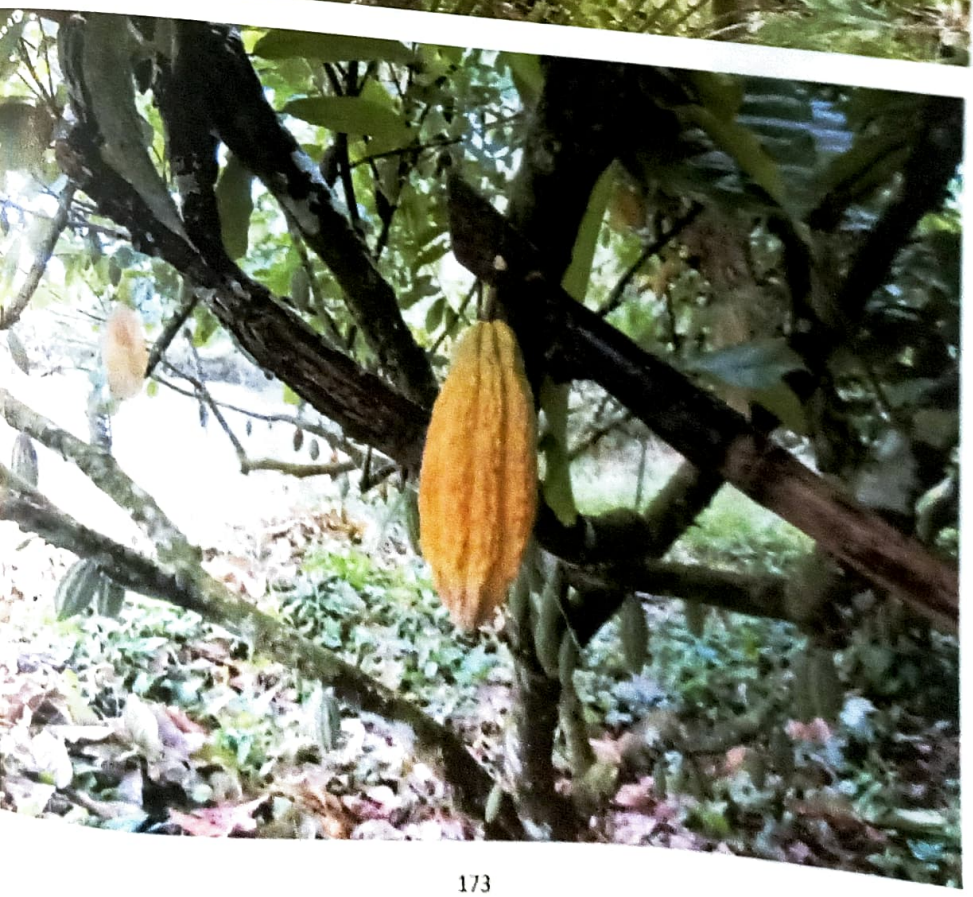
3. How does Drains improve the down ward movement of water in the soil

4. Discuss the methods to prevent erosion

5. Types of Drains

Drainage	Criteria

UNIT 10: HARVESTING THE COCOA PODS



Introduction

After all the management aspects of cocoa production, harvesting is the beginning towards achieving quality cocoa beans. It must be done as required so it directly affects fermentation and quality of the end product. Student must learn and realized the ultimate aim towards quality cocoa production for export is when harvesting is done correctly and processes as recommended as these have a big *bearing* in the world cocoa pricing

Learning Outcomes

At the end of the unit, the students can:

A) Frequency/ timing of harvesting

B) Identify ripe pods

C) Harvesting techniques and tools

D) Outline the Sanitation issues of harvesting

Content

A. Frequency/ timing

1. Ripe pods are to be harvested straight away
2. Harvesting every two weeks if there are not too many ripe pods appearing on the cocoa trees
3. Every week during cocoa flush
4. Do separate round of the block every week to remove sick pods and cherelles with a cocoa hook used only for removing diseased material
5. Essential pods do not become over ripe
6. Over-ripe pods are more likely to become infected with black pod disease
7. Beans inside over- ripe pods will germinate causing deterioration of cocoa product
8. Likely to be eaten by cockatoos and flying foxes
9. Important not to harvest unripe pods
10. Unripe pods beans will not be ready for fermenting as
    a) They are hard
    b) They are without mucilage
    c) They will not separate easily
    d) They will not ferment properly
    e) The beans from unripe pods must not be included in the wet beans for fermentation

A) Identify ripe pods

1. Most cocoa in Papua New Guinea produces either a green pod that goes yellow coloration when ripe (Forastero) or a purple pod that goes orange or red/orange when ripe (Criollo)

Figure 10.1: Ripe Forasterio Pod

Figure 10.2: Ripe Criollo Pod

2. Do not harvest black pods at the same time as good ripe pods. Black pods will reduce the quality of cocoa

Harvesting techniques and tools

1. Use a sharp cocoa hook on a stick to harvest cocoa pods
2. Secateurs can be used where farmer can easily reach
3. Tools should be kept clean
4. Disinfected the tools & equipment every day with ridomil or "red copper"
5. Sharpened harvesting hook regularly with a file
6. Hook should not to be used for removing diseased pods or cherelles as will spread fungus to previously healthy trees
7. Do not use a bush knife as it is
    a) very easily damages the flower cushions
    b) damages flower cushions can be likely to be infected by canker
8. This then kills flower cushion
9. It then weakens and eventually kills the whole tree
10. Be careful not to cut the tree with the cocoa hook as will provide a site for inspections to enter the tree
11. Means of carrying harvested pods to fermentary or bagging stand include wheelbarrow, manual, vehicles, tractor

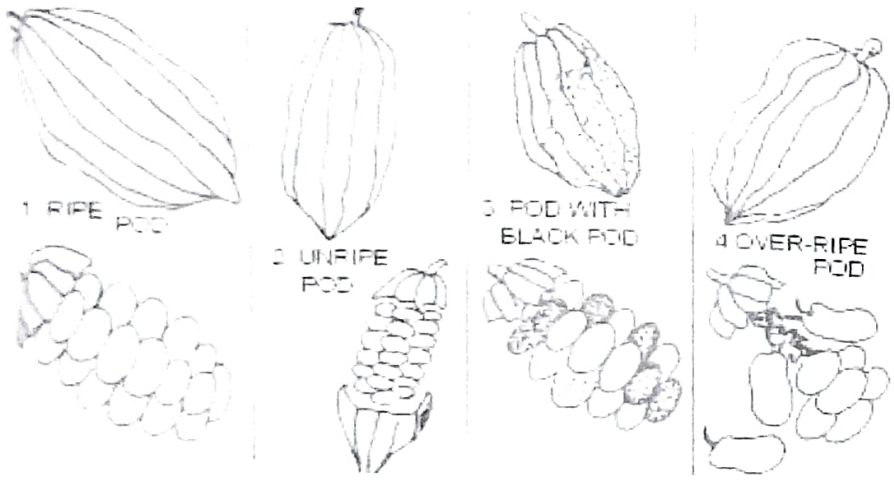


Figure 10.3: L-R, Ripe, Unripe, Diseased and over ripe pods

Reading from Left to Right, the above photos show the difference between ripe, unripe, diseased and overripe seeds. These features when the farmer is familair will help in the determinations for good cocoa. Ensure that only ripe cocoa pods are harvested to maintain good quality cocoa rfom your plots

Figure 10.4: Good Harvesting Techniques

Take care when harvesting cocoa pods. Use clean and sharp tools to prevent damage to the tree and other unripe pods, Make a clean harvest and avoid disturbance ofd the tree. Ensure that the harvesting tools and equipment are cleaned and washed before storage.

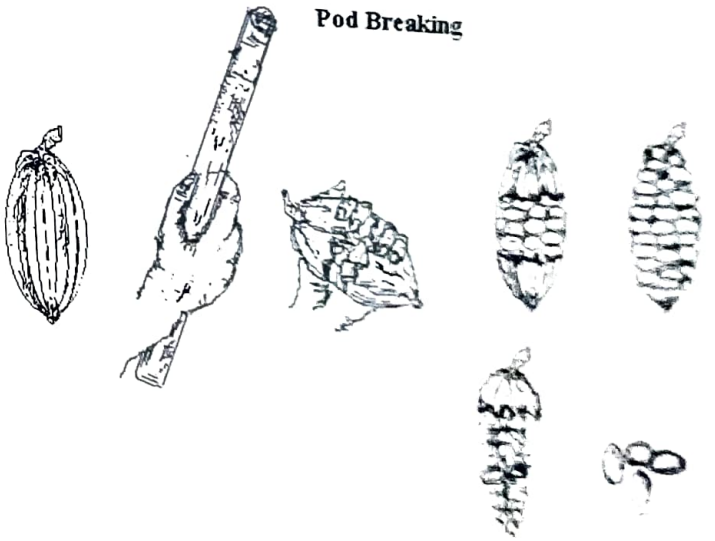


Figure 10.5: Correct method of pod breaking

Use the correct equipment to break open the pod to access the cocoa beans to avoid damage to the beans. Bean damage and foreign objects can reduce cocoa quality.

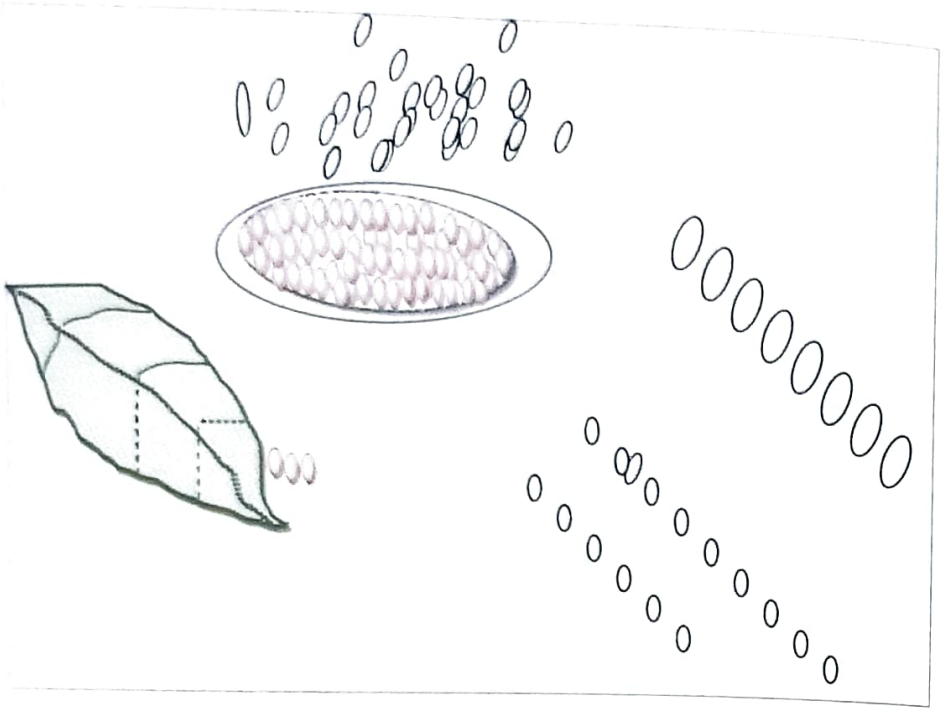


Figure 10.6: Taking out the beans

Figure10.7: Take cocoa beans out of the pods cleanly and with care. Place the beans in a clean bag to be taken to the fermentry for processing.

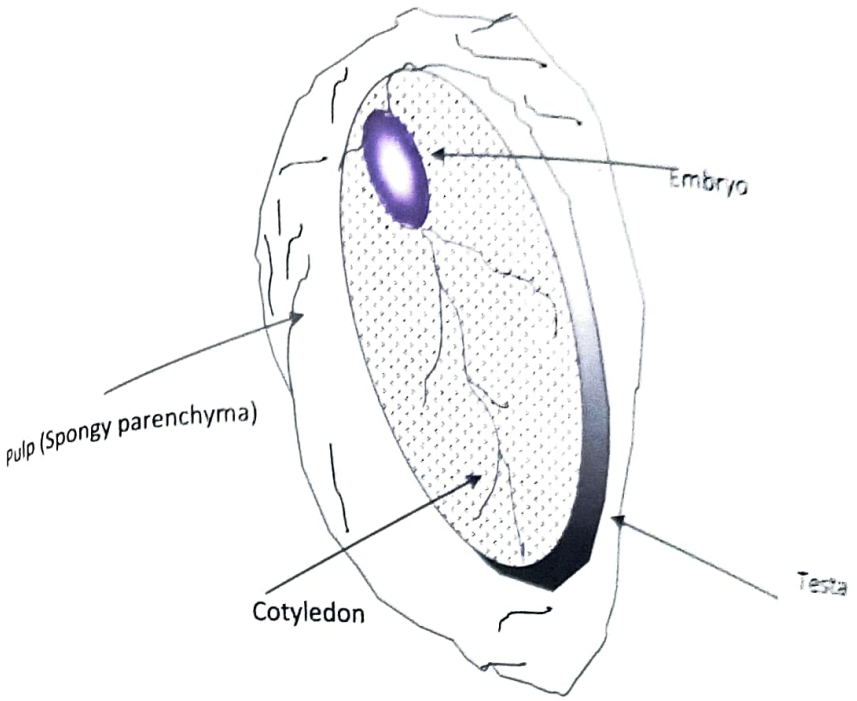


Figure 10.8: Composition of the fresh bean

Sanitation issues of harvesting

Consider the following as important

1. It is important to remove all ripe pods
2. All diseased or damaged pods and cherelles be hooked down during a separate round but NOT during harvest
3. Do not leave sick pods near base of cocoa trees as fungal spores can easily spread from infected pod husks to young pods on the truck
4. Sick pods must be moved to the middle rows or taken right away from the block
5. Use separate cocoa hooks for harvesting healthy pods
6. Separate for the removal of diseased pods
7. Damaged, diseased or discoloured beans should be kept separate from good beans to be fermented
8. Diseased and damaged beans are spread out and dried without fermenting and sold as reject coca. Sells at half the price of fermented dry beans

Some important rules

1. Cocoa hook must be sharp. This is so that the pod stem is cut off clearly without damage to the flower cushion
2. Take care not to cut the tree with the cocoa hook. Cuts may help canker disease to enter the tree
3. Use different hooks for hooking good pods separate from disease pods. Use of the same hook can spread the disease

Teaching Strategies

A) **Introduce unit/Motivational tool**

Ask student questions like:

1. What is the colour of the cocoa pods that is ready for harvest?
2. When (time) is the correct time to harvest
3. What is the interval to harvest?
4. What tools do use to harvest cocoa pods
5. How does harvesting help maintain good quality cocoa

Present two ripe pods of cocoa (one each from Criolo and Trinadario and get students to describe the features

B) **Body**

1. Explain proper and important issues of harvesting techniques
2. What is the pod colour when harvesting cocoa breeds?
3. Demonstrate correct process of harvesting
4. Discuss recommended tools and equipment for harvesting

- Demonstrate harvesting techniques, breaking steps and show good quality practices for harvesting

C) **Closure/Conclusion**

Orally ask students to:

1. Identify a pod ready for harvest
2. Give steps of harvesting
3. Show correct method of harvesting

Student Activities

a. Work out the Frequency/ timing/ calendar for cocoa harvesting

b. Describe to Identify ripe pods

c. Describe the Harvesting techniques and tools used

d. Outline the Sanitation issues of harvesting

Harvesting	Marks

UNIT 11: PROCESSING FACILITIES

Introduction

In this unit students must realized that, there are regulation on the cocoa industry. This guides facilities used into the cocoa processing for sound quality. Thus, the processing facilities should meet certain standards as basically set up in the outcomes

Learning Outcomes

At the completion of the unit, the students can:

A. Describe a Weather proof building
B. Explain Importance of Fermentry boxes
C. Describe types of dryers
D. Explain Drying process

Content

Types of processing facilities

A. Weather proof building

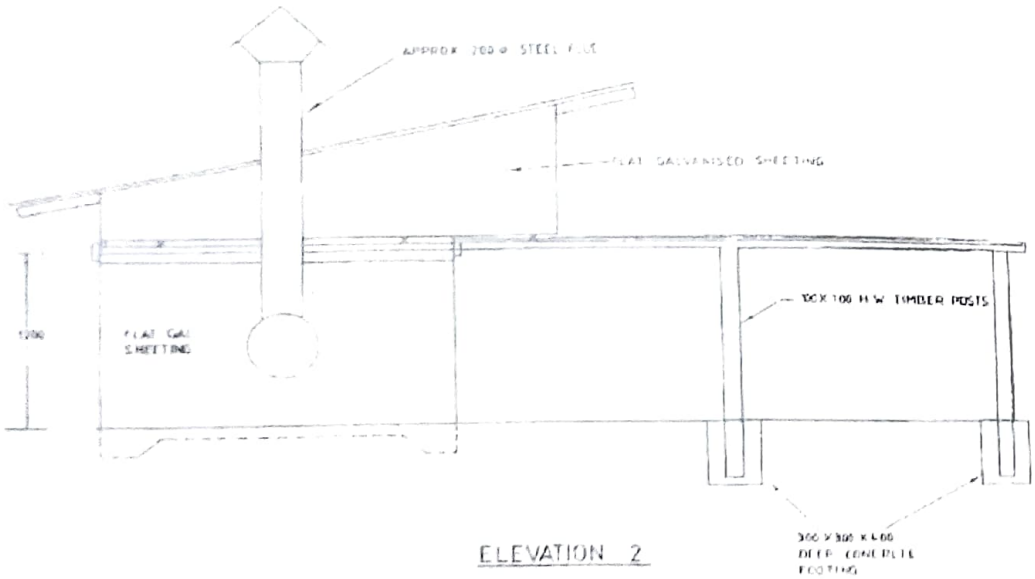


Figure 11.1: A weather proof building plan

B. Fermentry boxes

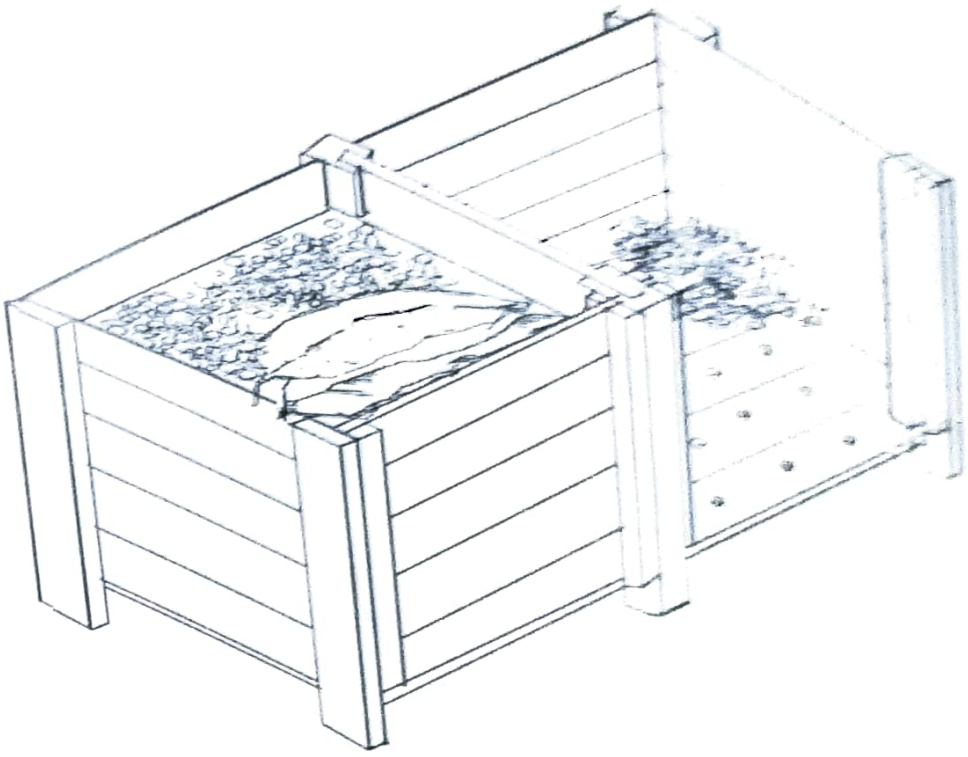


Figure 11.2: Fermentry boxes

Dryers

Types of drier- four kinds

1. **Oil- fired (Fuel) hot air dryer**

Figure 11.3: Fuel based cocoa drier at CCI PNG (L-R Diesel power drier & workmen sorting dry cocoa beans

The fuel based drier is used in plantations by major cocoa bean producers since they have the money to establish big fermentries. They have a lot of beans to dry and if left to wait, the bean will deteriorate in quality. Besides, bigger cocoa producers can afford the cost of fuel to dry cocoa beans and they have a lot of cocoa to off-set the cost of fuel.

2. **Solid fuel (firewood) hot air drier**

Usually take 2 to 3 days

Figure 11.4: The most commonly used fire wood based energy drier

Figure 11.5: Putting Wet beans into fermenting box

The firewood based energy drier is most commonly used to dry cocoa beans in PNG. This drier type is easier and often used because firewood is easily available, it is cheaper to build and that whether it rains or shine, the cocoa bean will be dried when required in preparations for market. Such a type is

preferred by cocoa farmers because the beans will not be left to wait and loss quality while awaiting sun light energy to dry the beans.

This type of drying spoils the cocoa based products as the smoke on the beans contributes to bad smell and poor quality cocoa. Therefore this method will be phased out in due course and in favour of the sun drying method as market requires demand a better drying method.

3. Sun (Solar) drier

Depends on number of sunshine hours, usually 10 days

Figure 11.6: Solar Drier at CCI PNG

This figure shows the solar drier used to dry cocoa beans. The sun light energy is used to drier cocoa beans but when in prolonged wet season, the heat from firewood is used to dry cocoa. The main disadvantage of a solar drier is that it cannot be relied upon in wet and rainy areas. Cocoa dried by sun light energy is increasingly preferred in the world market because it is clean and does not have the smoke smell on the cocoa based products. This type of drier is the future for the cocoa industry in Papua New Guinea

4. Combined hot air and sun drier

Usually take 3 to 4 days

Used by most small-holders using solid fuel

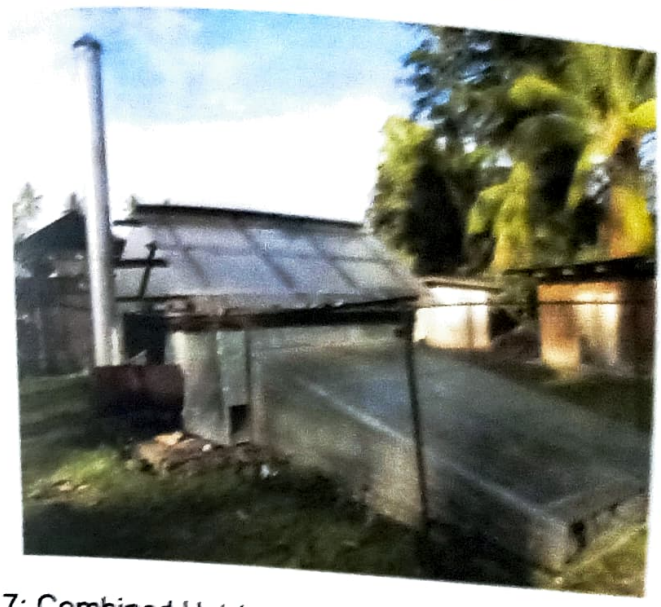


Figure 11.7: Combined Hot (smoke) and Sun (Solar) Drier at CCI PNG

The advantage of a combined drier is that when the weather is favourable (or unfavourable) for either of the drier heat source is used. For example if it rains a lot the firewood heat used to drier the cocoa. But when the sun shining the sun light energy is used to drier the cocoa beans. It is ideal in the PNG conditions to use both drier like the one shown in figure 17.6 but as the markets demand for the sun drier to be used the firewood based drier will be phased out.

Options

Sun Drying -passive i.e. open sun-active solar (i.e. solar drier)

1. Artificial/ kiln dying either solid fuel(e.g. wood, copra husks) or liquid fuel (e.g. diesel or fuel oil)

Natural draught fires relies on convection currents that naturally occur with fires to convey the hot air to the drying bed - forced draught fires the heat is fed through to the drying bed by means of s fan

Beans depth on different dryers

1. For sun drying, beans should not be more than 50 mm deep
2. Kiln drying (and active solar dryers) using natural convection, depth of beans should not exceed 100mm
3. Solid or liquid fuel force draught dryers can be loaded up to 30 cm depending on the design

Cost of smallholder fermenteries (Collect information plans, quotations from relevant people)

Table 11.1: Quotation Sample

MATERIALS	LENGTH	NUMBER
Posts 12.5 x 12.5 cm	400 cm	6
Posts 12.5 x 12.5 cm	250 cm	12
Bearers 12.5 x 12.5 cm	500 cm	4
Beamers 12.5 x 12.5 cm	400 cm	8
Bearers 12.5 x 7.5 cm	500 cm	3
Rafters 10 x 5 cm	500 cm	6
Battens 7.5 x 5 cm	400 cm	12
Cater board timber 15 x 2.5 cm	300 cm	4
Pessa board timber 10 x 2.5 cm	400 cm	4
Construction timber for wall 7.5 x 5 cm	400 cm	36
Construction timber for sliding bed	500 cm	27
Construction timber 10 x 5 cm	500 cm	4
Roof brace timber 7.5 x 2.5 cm	400 cm	12
Fermentary box timber 7.5 x 2.5 cm	500 cm	
Fermentary box timber 15 x 2.5 cm (kwila)	500 cm	6
Fermentary box timber 15 x 2.5 cm (kwila)	400 cm	24
Fermentary box floor 9.5 x 2.2 cm	400 cm	50
Fermentary box timber posts 10 x 10 cm		5
Fermentary bearer timber 12.5 x 7.5 cm	500cm	2
Fermentary box brace laterals 2.5 x 2.5 cm	500 cm	15
Corrugated Iron	305 cm	16
Ridge capping	200 cm	3
Iron brace		1
Flat iron 180 x 120 cm		36
Sliding bed rail	400 cm	8
Flue pipe		1
Arc mesh wire		
Cocoa mesh wire		
Kiln pipe	650 cm	1
Wheels for sliding roof		8
Cement 40 kg bags		17
Roofing nails		10 kg
Nails joll head 2 inch		30 kg
Nails joll head 3 inch		30 kg
Nails joll head 4 inch		30 kg
Nails joll head 5 inch		25 kg

Teaching Strategies

A) Introduction

1. Get student into groups to discuss and present the features of cocoa drier in the local area.
2. Discuss the features and identify the drier used in the local area
3. Present its advantages
4. Present its disadvantages (consider smoke on the skin and its smell)
5. Discuss what the cocoa market would think of our cocoa that is dried under fire

B) Body

1. Show pictures and discuss the features of each drier and discuss their functions
2. Use notes and field trip/visit/exposure to describe and explain the features and functions of each drier
3. Discuss each driers advantages
4. Present its disadvantages (consider smoke on the skin and its smell)
5. Discuss what the cocoa market would think of our cocoa that is dried under fire

C) Closure/Conclusion

1. Group summary on the board
2. Teacher to ask key questions like:
   a) Which drier is preferred
   b) Why it is preferred
   c) As a cocoa farmer trying to make money to sustain you livelihood, which would you use?

Student Activities

1. Describe a Weather proof building

2. Why are Fermentry boxes important

3. List and describe types of dryers

4. How is sun Drying carried out and why is it favoured by the market

5. What is the most commonly used drier and why?

Practical assessment

Processing component	Marks

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Cocoa as an Entrepreneurial Activity

Cocoa is an important cash crop for the coastal many rural, remote and isolated villages and communities in the country. Cocoa like coffee these crops provide cash income for about 85% of the people in the country. Cocoa is an important economic lifeline for rural people.

Cocoa has been and will be a major source of income for many communities. However in the last five years, the invasion of the cocoa pod borer (CPB) has devastated the cocoa industry in Papua New Guinea (PNG). The East New Britain Province (ENBP) was producing about 23, 000 tons of cocoa in 2005 for export until after the CPB invasion which has reduced cocoa production to a mere 7, 000 tons in 2012. Reduced production means a low cash income for many farmers have departed cocoa for other cash income earning opportunities.

Other Provinces where the CPB incursion has been low, cocoa production has gone up. Bougainville, East Sepik Province, Madang and Morobe Provinces have increased production dramatically and they are now the leading producers. Efforts are being made by the CCI and the Cocoa Board along with other stakeholders to contain the spread and impact of the devastating pests. Admittedly though, cocoa remains a major player in the social, economic and the political fibre of the communities in Papua New Guinea.

It is therefore important to teach and prepare the youth to consider cocoa as an entrepreneurial crop in the communities and each household can potentially benefit enormously if they are to take up cocoa as an entrepreneurial crop. When all things are considered, the cocoa curriculum at grades 6-8, offers great potential to prepare our youth for life after school. Cocoa as a cash crop when school leavers are well prepared to return to the communities with cocoa skills, it can help the youth become purposeful and productive citizens of our country.




Cocoa Nursery Seedlings, Harvesting Cocoa Beans (By A C. PARAPI & S. VUARI)

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