INOVASI MODEL PEMBELAJARAN

LEARNING MODULE AGROFORESTRY

Team Teaching Agroforestry

PROGRAM STUDI AGROTEKNOLOGI
FAKULTAS PERTANIAN
UNIVERSITAS PEMBANGUNAN NASIONAL "VETERAN" JAWA TIMUR
AGUSTUS
2021

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1. Expected Learning Outcome (Programme Learning Outcome)

ELO-A1	*be defending country character, namely the love of the motherland, national and state awareness, believes in Pancasila as the ideology of the state, willing to sacrifice for the nation and the state, and has the initial ability to defend the country.*
ELO-A2	*Responsible, expert in the field of science independently*
ELO-A3	*able to maintain and develop collaborative networking within and outside the institution;*
ELO-4	*Applying the knowledge of Plant Science , the basic concepts of Plant Production, land resources and soil science , and integrated concept of plant protection against of pests and diseases.*
ELO-5	*Mastering and applying the principles of agricultural technology to solve agricultural problems*
ELO-6	*Capable in analyzing, planning, and implementing the principles of sustainable agriculture on lowland farming systems based on local wisdom*
ELO-7	*able to study the implementation of sustainable agriculture systems Base on scientific rules aplication, procedures and ethics in order to produce solutions, ideas, and designs based on the results of information and data analysis*
ELO-8	*The ability to master plant propagation technology, and crop management in accordance with the agro-climate zone*
ELO - 9	*Capable in identifying, formulating, analyzing and solve land resources problems*
ELO – 10	*Ability to diagnose, analyze and solve plant pest problems*
ELO – 11	*Capable in understanding and managing the main issues of lowland agriculture and its environmental problems*
ELO – 12	*Mastery of technology and be able to communicate with the community in solving agricultural problems both oral and written*

2. COURSE IDENTITY

Course	:			AGROFORESTRY
Course Code	:			
Credit unit per semester	:			3
Course model	:			Lecture Discusion Group learning Discussion Individual learning Practise Problem base learning/project base learning evaluations
Learning Outcome		ELO-A 2	:	Responsible, expert in the field of science independently
		ELO- A 4	:	Applying the knowledge of Plant Science, the basic concepts of Plant Production, land resources and soil science, and integrated concept of plant protection against of pests and diseases.
		ELO-6	:	Capable in analyzing, planning, and implementing the principles of sustainable agriculture on lowland farming systems based on local wisdom
		ELO – 9	:	Capable in identifying, formulating, analyzing and solve land resources problems
		ELO–11	:	Capable in understanding and managing the main issues of lowland agriculture and its environmental problems
Indicator fo performace				
ELO-A 2		CLO-1		LLO A2-1 : Capable in understanding the agroforestry concept : definistion, classification, and component of agroforestry
				LLO A2-2 : Capable in understanding the kind of agroforestry systems in Indonesia
ELO- A 4		CLO 2		LLO A4-1 : Capable of applying the knowledge of the interaction of the agroforestry component in designing the agroforestry system
				LLO A4-2 : Capable of applying the nutrient cyle, carbon cyle, and water cycle concept under agroforestry systems in designing the agroforestry system
ELO-6		CLO 3		LLO 6.1. : Understanding the tree domestication concept, and apply it in designing the agroforestry system on lowland agriculture by using the local tree
				LLO 6.2 : Understanding the function of agroforestsry in enhancing the soil productivity and ecosystem protection
				LLO 6.3 : Applying the local wisdom in developing agroforestry under lowland agriculture in order to enhance the soil productivity and ecosystem protection

ELO – 9		CL0 4		LLO 9-1 : Capable in managing, developing, and formulating the design of agroforestry systems to solve the land resources problems
				LLO 9-2 : Enhancing the development of agroforestry system by planning and implementation of institutional and government policy
ELO–11		CLO 5		LLO 11-1 : To Understand the main factor that influence the agroforestry development
				LLO 11-2 : To Study how is the socio-economic and cultural aspects affect the agroforestry development

2. MATRIX OF LEARNING OUTCOME – SUBJECT COURSE

LEARNING OUTCOME FOR EACH SUBJECT COURSE

No	SUBJECT COURSE	CODE	CREDIT UNITS	Semester	LO 1	LO 2	LO 3	CPL 4	LO 5	LO 6	LO 7	LO 8	LO 9	LO 10	LO 11	LO 12
1	Geo & Klasifikasi Tnh (P)	PG141216	3	V												
2	Agrohidrologi	PG141217	2	V					V	V	V				V	
3	Teknologi Benih	PG141119	3	VI												
4	Survai Dan Evaluasi Lahan	PG141120	3	VI			V	V		V			V			
5	Pengelolaan Tanah dan Air	PG141121	3	VI												
6	Agroforesty	PG141118	2	VI		V		V		V			V		V	
7	Manajemen Pembibitan (P)	PG141204	2	VI												
8	Konservasi Tanah dan Air (P)	PG141218	3	VI					V		V		V			V
9	Kesehatan Tanah (P)	PG141220	2	VI												

4. LESSON PLANNING

3.1 Determination the Weight of Learning Outcome on This Course

No	Semester	Course Code	Course Subject	Credit unit	LO-1	LO-2	LOP-3	LO-4	LO-5	LO-6	LO-7	LO-8	LO-9	LO-10	LO-11	LO-12
6	5-6		Agroforestry	3		X		X		x			X		X	

LESSON PLAN : COURSE SUBJECT: AGROFORESTRY

	UNIVERSITY OF PEMBANGUNAN NASIONAL "VETERAN" JAWA TIMUR **AGRICULTURE FACULTY** **AGROTECHNOLOGY** **PRODI: S1**						
SUBJECT COURSE	**Code**	**Classes of Courses**	**Weight (credit unit)**		**SEMESTER**	**Tgl Penyusunan**	
AGROFORESTRY		**HAMA PENYAKIT TANAMAN**	**2**	**1**	**II (DUA)**		
AUTHORIZATION	**Lesson Plan Maker**		**COORDINATOR of COURSE**		**Head of The Study Programme**		
			Dr. Ir. Bakti Wisnu Widjajani, MP		Dr.Ir. Bakti Wisnu Widjayani, MP		

Learning Outcome (LO)	**Determination the Weight of Learning Output on This Course** ELO-A 2 : Responsible, expert in the field of science independently ELO- A 4 : Applying the knowledge of Plant Science, the basic concepts of Plant Production, land resources and soil science, and integrated concept of plant protection against of pests and diseases.; ELO-6 : Capable in analyzing, planning, and implementing the principles of sustainable agriculture on lowland farming systems based on local wisdom ELO – 9 : Capable in identifying, formulating, analyzing and solve land resources problems ELO–11 : Capable in understanding and managing the main issues of lowland agriculture and its environmental problems
	Learning outcome : Capable of applying the concept of agroforestry for developing marginal land become productive land
	Course Learning Outcome CLO 1 : Able to explain the concept and principle of agroforestry which refers to sustainable agriculture principles, and is based on the local wisdom CLO 2 : Capable in managing and developing marginal land through implementing appropriate agroforestry concepts to get the healthy and productive land

	CLO 3 : Capable to plan, design the agroforestry concept on each type of land use to maintain and increase the productive land CLO -4 : capable to describe the role and function of agroforestry on nutrient and water cycle; carbon cycle, as well as their role in controlling pest and disea se CLO-5 : capable in understanding the interaction of agroforestry component; the processes affected, and use this knowledge to plan, design, and manage the unsustainable land unproductive land
Short Description of the Course	Agroforestry is a branch of science in agriculture and forestry and has been practiced by farmers for a long time. In simple terms, Agroforestry means planting trees on agricultural land, with farmers or the community as the main element (subjects). Agroforestry studies do not only focus on technical and biophysical issues but also social, economic, and cultural issues that are always changing from time to time, so that agroforestry is a dynamic branch of science in the context of sustainable agricultural development.
Main subject	This course consist of : classification and component of agroforestry; Tree-soil-crop interaction; the function of agroforestry; nutrient and water cycle, carbon cycle on Agroforestry systems, tree domestication, socio-economic cultural on agroforestry, institutional policy on developing agroforestry, and managemen of agroforestry; and agroforestry systems in Indonesia.
Literature	**Mandatory:** No. Judul Penulis 1. Toward Integrated Natural Resouece Management in Forest margins of the Humid Tropics : local action an global concerns ICRAF, 2001, 2003 2. An Introduction to Agroforestry P.K. R. Nair, 1993 3. Agroforest khas Indonesia H.D. Foresta, A. Kusworo, G. Michon dan W.A. Djatmiko, 2000 4. Tree-Crop Interactions : A Physiological Approach Chin K. Ong and Peter Huxley 5. Agroforestry for Soil Conservation A. Young, 1990 6. Agroforestry for Soil Fertility A. Young, 1990 7. WaNuLCAS, Model Simulasi untuk Sistem Agroforestri K. Hairiah, Widianto, S.R. Utami dan B. Lusiana, 2002 8. Dll. **Optional :** 1. Article/journal related with the topics of agroforestry 2. Other source of agroforestry such as: ICRAF website, INAFE website, agroforestry webinar etc
Media Pembelajaran	**Software :** / **Hardware :** LCD Projector & PC
Team Teaching	

The requirement lesson	

Weeks-	**Final abilities at each stage of lesson learning (Sub-CP-MK)**	**Evaluation**		**Learning Model, Learning method, and student assignment [Estimated time]**		**Learning material [Literature]**	**Weight evaluation (%)**
		Indicator of Evaluation	**Criteria & assessment form**	**Daring (online)**	**Daring(online)**		
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
1	**The students able to :** Describes : a. Definition of agroforestry b. The phylosopy of agroforestry, history of agroforestry and their development c. Processes under agroforestry system d. The advantage, constraint, potency, and challange on agroforestry system	**The ablity to describe correctly, accurately, and precisely** The definition of agroforestry, the phylosopy , history, and development of agroforestry; included the processes, advantage, contstraint, potency and challenge in developing agroforestry	**Test** Asses the students ability in describing accurately and correctly related with: a. the agroforestry concept; the criteria of agroforestry b. how is agroforestry has been formed and developed c. The advantage of agroforestry implementation, as well as the constraint and challenge of agroforestry development	Show the film and video: **TM = 2 X 2 X 50 menit** **BT = 2 X2 X 60 menit** **BM =2 X 2 X 60 menit**	The lesson explain: a. The Lesson plan b. Learning contract semester c. Describing the agroforestry concept, definition, and characteristics d. Agroforestry history, how is the agroforestry formed and developed e. The advantage, constraint, challenging in applying and developing agroforestry **Workhome discussion on 1 semester** **Journal review / journal summary**	**An Introduction of Agroforestry**	5%

2.	The students were able to determine the classification of agroforestry based on their component in the ecosystem as well as the pattern of the combination of the component on the agroforestry system	The ability to determine the component of agroforestry, and their relationship with the classification and component combinantion on agroforestry The practices report contains (a) result of field observation (b) discussion of the observation results (c) book diagram of component agroforestry systems The report must be arranged properly, coherent, and clearly according to the practical guidelines	**Non test** **1. Assigment collection** The students ability to deliver the results of their discussion related with the classification of agroforestry in a official report **2. Practical report (Group)** Practises report and diagram book of component agroforestry systems	**1. Internet (browsing, ..descriiption**	1. Presentation/video/ learning material about the component agroforestry, agroforestry classification, ang the combination of agroforestry component 2. Forming a group discussion for all students 3. Making a summary of the learning materials and the article	**1. An Introduction of Agroforestry**	**5%**
				Courses **Practices** **TM = 2x 50** **2 X 1 X 100** **BT =2 X 60.** **3 X 2 X 1 X 70** **BM = 2 X60**			
3	The students were able to analyze and explain about agroforestry system (complex agroforestry and simple agroforestry and their management practises	The ability to differentiate the differentiation between complex agroforestry and simple agroforestry, analyze the agroforestry systems component as well as their management practices The practices report contains (a) result of field observation (b) discussion of the observation results (c) book collection of agroforestry systems The report must be arranged properly, coherent, and clearly	**Non test** **Practises Report (Group)** **1.** Students ability in delivering their observation, analyze the types of agroforestry based on their component, literature study 2. Practises report and collection book of agroforestry systems		1.Presentation/video/ learning material about the types of agroforestry systems 4. Forming a group discussion for all students 5. Making a summary of the learning materials and the article	1. **An Introduction of Agroforestry**	**10 %**

		according to the practical guidelines		**Couse Practices** **TM = 2 x2x 50 3 X 2 X 1 X 100** **BT =2 X 60. 3 X 2 X 1 X 70** **BM = 2 X60**			
4.	The students were able to explain and analyze the tree-soil-crop interaction; especially from the light uses, water, and nutrient (roots)	The students ability to explain and analyze : (a) how is interaction of tree-soil-crop in using light, water, and nutrients. (b) How is the tree-crop competition to get light, water, and nutrients (c) How to design tree-crop position to avoid or minimize the competition	**Non test** **Individual Assignment (Literature review)** The students take one sample of agroforestry systems from the literature, then they analyze and describe the light uses, as well as water and nutrient on this systems	**Internet** **E learning :** **Reading the module, literature, and the lecture learning materials**	1.Presentation/video/ learning material about the tree-soil-crop interaction and their effect on light, water, and nutrient 2. Forming a group discussion for all students 3. Making a summary of the learning materials and the article	Tree-Crop Interactions : A Physiological Approach	**10 %**
				Course Practices **TM = 2 x2x 50 3 X 2 X 1 X 100** **BT =2 X 60. 3 X 2 X 1 X 70** **BM = 2 X60**			
5.	The students were able to explain the advantage of implementing the local wisdom on agroforestry in maintain and developing sustainable agriculture, especially on lowland agriculture	The students ability to explain, summarize, and review how to implement agroforestry based on local wisdom in lowland area This activity conducted by reviewing some journal with related issue	**Non test** **Individual Assignment** The assignment (summary, review journal) must be related with this topics: a. The advantage of using agroforestry based on local wisdom in improving lowland agriculture b. How is agroforestry could enhance the sustainable agriculture c. How to use local wisdom in agroforestry systems	**Internet** **E learning :** **Reading the module, literature, and the lecture learning materials**	1. Presentation/video/ learning material about the implementation the local wisdom on agroforestry to maintain and develop sustainable agriculture, especially on lowland agriculture 2. Forming a group discussion for all students 3. Making a summary	1.Agroforestry for Soil Conservation 2. Agroforestry for Soil Fertility	**5%**

					of the learning materials and the article		
				Course **TM = 2 x 50** **BT = 60** **BM =60**			
6.	The students were able to analyze all of the processes under the agroforestry system, and how is this process affect the soil organic matter and nutrient availability due to tree planting on the agroforestry system	The students ability to explain, analyze, and review all of the process under the agroforestry system. The students make a mindmap to describe and summarize: (a) How is the process affect the soil organic matter (b) How is the process affect the nutrient availability (c) How is the process affect the micro –climate and influence the process (a) and (b) through their affect on soil microorganisms This activity conducted by reviewing some journal with related issue	**Non test** **Individual Assignment** The assignment (summary, review journal) must be related with this topics: (a) How is the process affect the soil organic matter (b) How is the process affect the nutrient availability (c) How is the process affect the micro –climate and influence the process (a) and (b) through their affect on soil microorganisms	**Internet** **E learning :** **Reading the module, literature, and the lecture learning materials**	Presentation/video/ learning material, (a) 1 How is the process affect the soil organic matter (b) How is the process affect the nutrient availability (c) How is the process affect the micro –climate and influence the process (a) and (b) through their affect on soil microorganisms	1. Agroforestry for Soil Fertility 2. Toward Integrated Natural Resouece Management in Forest margins of the Humid Tropics : local action an global concerns	5%
				TM = 2 X 50 menit **BT = 60 menit** **BM = 60 menit**			

7	The students were able to explain how is agroforesty affect the water balance	The student's ability to explain and analyze how is the agroforestry affect the water balance; the student's were also must be able to review an article related with topic. The student's join in a group, discussed the topic, then reported and presented fluently	Oral presentation Presentation and group discussion. The presentation must be present clearly, fluently, and comprehensive in understanding the learning materials (water balance in agroforestry systems)	**Internet** **E learning :** **Reading the module, literature, and the lecture learning materials**	Presentation/video/ learning material, (a) How is the water balance under agroforestry systems	1. Tree-Crop Interactions : A Physiological Approach 2. Agroforestry for Soil Conservation	20%
8	MIDDLE EVALUATION SEMESTER						
9	The students were able to characterize and analyze the agroforestry function, either their role in enhancing land productivity or their function in land protection	• The ability to summarize and write the agroforestry function : 1. The role of agroforestry in enhancing soil productivity 2. The role of agroforestry in protecting pest and diseae 3. Agroforestry and sustainable agriculture	**Non test** **Individual assignment: Characterizing and Analyzing the function of agroforestry :** 1. The role of agroforestry in enhancing soil productivity 2. The role of agroforestry in protecting pest and diseae 3. Agroforestry and sustainable agriculture	**Internet** **E learning :** **Reading the module, literature, and the lecture learning materials**	Presentation/video/ learning material, (a) What is the function of agroforestry systems (b) The role of agroforestry in enhancing soil productivity (c) The role of agroforestry in protecting pest and diseae (d) Agroforestry and sustainable agriculture	1. Tree-Crop Interactions : A Physiological Approach 2. Agroforestry for Soil Conservation 3. Agroforestry for Soil Fertility	
				TM = 2 X 50 menit… **BT = 60 menit** **BM = 60 menit**		•	
10	The students were able to explain the nutrient cycle model under the tree component (close nutrient cycle) and under the crop component (open nutrient cycle)	The student's ability to (a) explain the nutrient cycle model under the tree component (close nutrient cycle) and under the crop component (open nutrient cycle) ; and	**Non test** **Group assignment:** Presentation and group discussion. The presentation must be present clearly, fluently, and comprehensive in	**Internet** **E learning :** **Reading the module, literature, and the lecture**	Presentation/video/ learning material, (a) the nutrient cycle model under the tree component (close nutrient cycle) and under	1. Tree-Crop Interactions : A Physiological Approach 2. Agroforestry for Soil	

		(b) determine the proper tree-crop combination to conserve the nutrient	understanding the learning materials (closed and opened nutrient cycle)	**learning materials**	the crop component (open nutrient cycle) ; and (b) the proper tree-crop combination to conserve the nutrient	Conservation 3. Agroforestry for Soil Fertility	
				Course **Practices** **TM = 2 x2x 50** **1 X 100** **BT =2 X 60.** **1 X 70** **BM = 2 X60**			
11	The students were able to understand related with the role of tree domestication in developing agroforestry, especially on tree productivity (CPMK 3,4) (PBL)	The students ability to explain how is tree domestication can develop tree productivity through agroforestry	**Non test** **Group assignment** (a) Presentation and group discussion. The presentation must be present clearly, fluently, and comprehensive in understanding the learning materials (tree domestication) (b) Journal resume	**Internet** **E learning :** **Reading the module, literature, and the lecture learning materials**	Presentation/video/ learning material, Tree domestication	1. Tree-Crop Interactions : A Physiological Approach 2. Agroforestry for Soil Conservation 3. Agroforestry for Soil Fertility	
				Course **Practices** **TM = 2 x2x 50** **2 X 2 X 1 X 100** **BT =2 X 60.** **2 X 2 X 1 X 70** **BM = 2 X 60**			
12	The students were able to understand the role and function of agroforestry globally as well as landscape scale	The student's ability to describe the role and function of agroforestry globally and ladscape scale	**Non test** **Group assignment** 1. Presentation and group discussion. The presentation must be present clearly, fluently, and comprehensive in understanding the learning materials (the role and function of	**Internet** **E learning :** **Reading the module, literature, and the lecture learning materials**	Presentation/video/ learning material, Agroforestry function at global and landscape scale	.1.Tree-Crop Interactions : A Physiological Approach 2. Agroforestry for Soil Conservation 3. Agroforestry for Soil Fertility	15

			agroforestry at global scale) 2. Journal resume	**Course** **Practices** **TM = 2 x2x 50** **1 X 100** **BT =2 X 60.** **1 X 70** **BM = 2 X60**			
13	The students were able to apply the principal of management and development of agroforestry	The student's ability to design the appropriate agroforestry system by applying the proper tree and management of agroforestry The student's must be read some journal related with the topics and resume the article	**Non test** **Group assignment** 1. Presentation and group discussion. The presentation must be present clearly, fluently, and comprehensive in understanding the learning materials (the principal of management and development of agroforestry) 2. Journal resume	**Internet** **E learning :** **Reading the module, literature, and the lecture learning materials**	Presentation/video/ learning material, the principal of management and development of agroforestry Project Base Learning : Designing the appropriate agroforestry to improve the soil productivity	1.Tree-crop Interactions : A Physiological Approach 2. Agroforestry for Soil Conservation 3. Agroforestry for Soil Fertility	
				Course **Practices** **TM = 2 x2x 50** **1 X 100** **BT =2 X 60.** **1 X 70** **BM = 2 X60**			
14	The students are aware and understand the concept of institutional and policy in developing agroforestry as well as the impact on the agroforestry development	The student's ability to explain how is the importance of institutional policy in developing agroforestry The student's must be read some journal related with the topics and resume the article	**Non test** **Group assignment** 1. Presentation and group discussion. The presentation must be present clearly, fluently, and comprehensive in understanding the learning materials (the concept of institutional and policy in developing agroforestry) 2. Journal resume	**Internet** **E learning :** **Reading the module, literature, and the lecture learning materials**	Presentation/video/ learning material, the concept of institutional and policy in developing agroforestry	1.Tree-crop Interactions : A Physiological Approach 2. Agroforestry for Soil Conservation 3. Agroforestry for Soil Fertility	
				Course **Practices** **TM = 2 x2x 50** **1 X 100** **BT =2 X 60.** **1 X 70** **BM = 2 X60**			

15	The students can apply the agroforestry model in planning and designing the agroforestry system	The student's ability to demonstrate how to design and plan the agroforestry model	**Non test** **Group assignment** 1. Presentation and group discussion. The presentation must be present clearly, fluently, and comprehensive in understanding the learning materials (the WaNuLCAS model)	**Internet** **E learning :** **Reading the module, literature, and the lecture learning materials** **Course** **Practices** **TM = 2 x2x 50** **1 X 100** **BT =2 X 60.** **1 X 70** **BM = 2 X60**	Presentation/video/ learning material, the principal of management and development of agroforestry Project Base Learning : Designing the appropriate agroforestry using WaNuLCAS model	WaNuLCAS, Model Simulasi untuk Sistem Agroforestri	
16	**FINALSEMESTER EVALUATION - WRITING TEST** **Evaluation of the learning outcome achievement**						15%
Total							

Notes :

1. **The learning outcome of the graduates of the study programme (CPL-Prodi)** are the abilities of each study programme graduate through the learning processes which are the internalization of attitudes, knowledge, and skills that got through the learning processes
2. **The learning outcomes that are charged on the course** are several learning outcomes of the study programme (LO-STUDY PROGRAMME) which is taken for course development, and consisting of several aspects, i.e. attitude, general skill, special skills, and knowledge.
3. **The learning outcomes of the course (LO-C)** are the abilities that are specifically described from the learning outcomes that are charged into the course, and are specific to the learning material for the course**.**
4. **Sub learning outcomes (Sub-CPMK) of the course** are abilities that are specifically spelt out from the learning outcomes of the course (LO-C), it could be measured or observed, specific for the learning materials of the course, and it becomes the final abilities that are planned to achieve at the end of the learning session
5. **Indicator of ability assessment** of learning processes or learning outcomes of the students is a specific and measurable criterion that identifies the student's ability or student activity.
6. **Evaluation criteria** are measurements or benchmarks of the learning outcomes achievement based on the determined indicator. The criteria of the indicator were the manual for the reviewer in evaluating the learning outcomes achievement. Therefore, the evaluation will be consistent and unbias. The criteria could be a quantitative or qualitative question
7. **Evaluation method :** Test and Non-test.

8. **Learning method :** Lecture, Discussion, Tutorial , Field Practices, Review and Literature Analysis , Class practices, study case presentation (group or individual)
9. **Learning method :** Small Group Discussion, Role-Play & Simulation, Discovery Learning, Self-Directed Learning, Cooperative Learning, Collaborative Learning, Contextual Learning, Project Based Learning, and other similar methods.
10. **Learning material are the** details or descriptions of the study material that can be presented in several main and sub-topics.
11. **The weight of assessment of learning outcome** of the course achievement is determined from the difficulty level of the sub-learning outcomes (sub-LO), and total of the weight is 100%.
12. **TM**=Face to face, **PT**=Structured assigment, BM=self study

The Weight of Learning Outcomes

No.	Semester	Code	Course	Credit Unit	LO-1	L0-2	L0-3	LO-4	L0-5	L0-6	L0-7	L0-8	LO-9	LO-10	L0-11	LO-12	Total
	6		Agroforestry			X		X		X			X		X		
	Weight																

1. ASSESSMENT AND EVALUATION

	ASSESSMENT AND EVALUATION UNDERGRADUATE PROGRAMME, AGROTECHNOLOGY, AGRICULTURE FACULTY		**AP&E**
	AGROFORESTRY		Edition :
Code :	Credit Unit (Course/Practises : (2/1)	Class of Course : soil Science	Semester :
Authorization	Author of AP&E	Coordinator of CCS	Coordinator of Study Program
	Dr. Irl Rossyda Priyadarshini, MP		Dr. Ir. Bakti W.W

Task/ Weeks	**Sub CP-MK (2)**	**Bentuk Asesmen (Penilain) (3)**	**Bobot(%) (4)**
1	Capable in explaining the concept and principle of agroforestry which refers to sustainable agriculture principles, and is based on the local wisdom (CPL - S1)	**Assignment 1:** **Test** describing accurately and correctly related with: a. the agroforestry concept; the criteria of agroforestry b. how is agroforestry has been formed and developed c. The advantage of agroforestry implementation, as well as the constraint and challenge of agroforestry development	**5%**
2	capable in managing and developing marginal land through implementing appropriate agroforestry concepts to get the healthy and productive land	**Assignment 2** **Non test** Presentation and group discussion. (closed and opened nutrient cycle)	**5%**
3	Capable to plan, design the agroforestry concept on each type of land use to maintain and increase the productive land,(CPL-S2, CPL-KK4 ,)	**Assignment 3** The students take one sample of agroforestry systems from the literature, then they analyze and describe the light uses, as well as water and nutrient on this systems	**20%**
4	capable to describe the role and function of agroforestry on nutrient and water cycle; carbon cycle, as well as their role in controlling pest and disease	**Assignment 3** Project Base Learning : Presentation and group discussion The principal of management and development of agroforestry	**20%**
5	capable in understanding the interaction of agroforestry component; the processes affected, and use this knowledge to plan, design, and manage the unsustainable land unproductive land	**Assignment 4** The assignment (summary, review journal) must be related with this topics: (a) How is the process affect the soil organic matter (b) How is the process affect the nutrient availability (c) How is the process affect the micro –climate and influence the process (a) and (b) through their affect on soil microorganisms	**20%**

RUBRIC OF ORAL ANSWERED – ASSIGNMENT PRESENTATION

RUBRIC ARGUMEN

GRADE	SCORE	PERFORMANCE INDICATOR
More Less	<41	*The argument*
		• *does not make sense and*
		• *there is no logical relationship*
Less	41–55	*The argument is*
		• *quite logical, but*
		• *it doesn't make sense*
Enough	56– 70	*The argument:*
		• *Logical argument,*
		• *Logical argument,*
		• *reasonable, but*
		• *less innovative*
Good	71- 85	*The argument:*
		• *Logical argument,*
		• *reasonable, a*nd
		• *innovative*
Very Good (Excellent)		*The argument:*
		• *Logical argument,*
		• *innovative and*
		• *can be easily implemented in the real world*

8. RUBRIC – ASSESSMENT LEARNING OUTCOME -7 – THE ABILITY TO COOPERATE WITH THE TEAM

ASSESSMENT OF THE TEAMWORK

Peer name be assessed								
NPM – peer be assessed								

No	*Aspect to be assessed*	1	2	3	4	5	6	Score in Numbers (50-100)
1	Teamwork towards Learning Outcome (LO) achievement							
2	Showing the interpersonal skill effectively							
3	Very active in participating on group discussion							
4	Sharing of learning material and resources to all members on group							
5	Willing to find new information for their group							
6	Providing constructive feedback and solutions for any problems and difficulties							
7	Working hard for the group interest							
8	Willingness to get the feedback patiently							
9	Willingnes to think positively on critical feedback							
10	Managing emotional well							
11	Stick to his/her point of view							
12	Improving his/her behavior and cooperation in doing teamwork							
13	Open minded for the new information							
14	Actively participate and present on time in all team activities							
15	Responsible and committed							
16	Honest							

1 = *very bad / very non-constructive*

6 = *very good / very constructive*

1.1 6.3 ANSWER RUBRIC WRITING AN ARTICLE 7

Current Event Article Summary Grading Rubric

CATEGORY	4 - Above Standards	3 - Meets Standards	2 - Approaching Standards	1 - Below Standards
Introduction	The introduction has a strong hook or attention. This could be a strong concept sentence, a relevant quotation, statistic, or question addressed to the reader.	The introduction has a hook or attention grabber. Includes a good concept sentence and/or interesting quote.	The author has a weak introductory paragraph, the connection to the topic is not clear. Paragraph includes a weak concept sentence or quote.	The introductory paragraph is not interesting AND is not relevant to the topic. No concept sentence or quote.
Quotes and Concept Words	All of the examples are specific, relevant and full explanations are given.	Most of the evidence and examples are specific, relevant and explanations are given.	Some of the pieces of evidence and examples are relevant and include an explanation.	Evidence and examples are NOT relevant AND/OR most are not explained.
5 W's	All supportive facts and statistics are reported accurately. Article is fully explained and summarized in own words.	Almost all supportive facts and statistics are reported accurately. Article is mostly explained and summarized in own words.	Some supportive facts and statistics are reported accurately. Weak explanation and summary that is partially plagiarized.	Most supportive facts and statistics were inaccurately reported. Article is poorly explained and summary is mostly plagiarized.
Grammar & Spelling	Author makes no errors in grammar, sentence structure, or spelling that distract the reader from the content.	Author makes 1-3 errors in grammar, sentence structure, or spelling that distract the reader from the content.	Author makes 4-6 errors in grammar, sentence structure, or spelling that distract the reader from the content.	Author makes more than 6 errors in grammar, sentence structure, or spelling that distract the reader from the content.
Conclusion	The conclusion is strong and leaves the reader solidly understanding the writer's response and personal reaction to the article.	The conclusion is good. Includes the author's response and personal reaction to the article.	Conclusion is weak or incomplete. Limited response and personal reaction to the article.	There is no conclusion - the paper just ends.
Proper Format and Organization	Article summary is typed, has a heading, title, and is submitted on time. Summary is organized into 4 or more paragraphs. A challenging newspaper article of sufficient length is attached.	Article summary is typed, has a heading, title, and is submitted on time. Summary is organized into 4 paragraphs. Acceptable newspaper article of sufficient length is attached.	Article summary is typed but submitted late. Incomplete heading and title. Summary has 3 or less paragraphs. Attached item is not a current event newspaper article and/or it is not a sufficient length.	Article summary is not typed. No heading. No article is attached. No title.

LEARNING MATERIALS

WATER BALANCE UNDER AGROFORESTRY SYSTEMS

The Aimed of This Lesson :

- Understand the water cycle and water competition in agroforestry systems.
- Knowing the water requirements for trees and annual crops in agroforestry systems.
- Understand how trees and annuals share water in agroforestry systems.
- Studying the effect of water shortages on crop production in agroforestry systems

1. Water Balance under Agroforestry Systems

Water is one of the important components needed by plants, both trees, and annuals to grow, develop and produce. Water that can be absorbed by plants is water that is in the pores of the soil in the root layer. The plant roots of all agroforestry components absorb water from the same water reservoirs and at a limited capacity. When the amount of water in the reservoir decreases, there is a struggle between the roots of various types of plants that exist to take water. In this case, there is competition for water to maintain the growth of each type of plant.

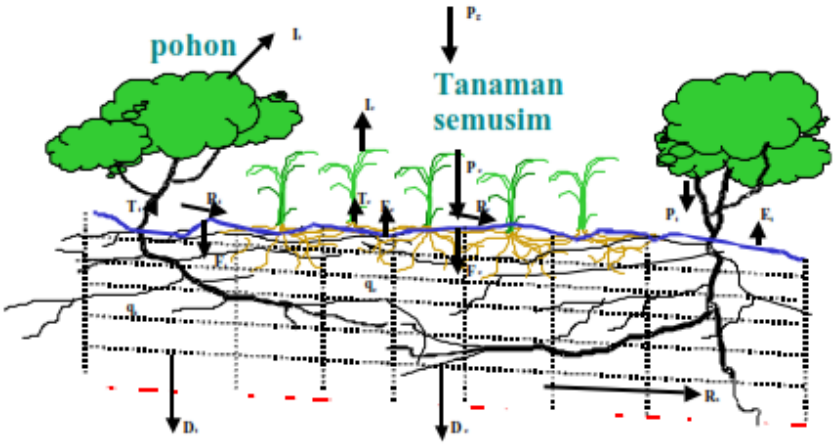
The soil layer in the root area as a reservoir that stores water can be replenished through the entry of water from other places, such as rain, irrigation, lateral flow or upward flow (capillary). The entry of rainwater and irrigation into the root layer through an event called infiltration. Air flows in and out of the root layer at the start of the water cycle. The magnitude of each component of the cycle can be measured and combined with one another to produce an air or air balance.

Some soil properties which are components of the water balance, such as the capacity to store water (amount of pore space), infiltration, pore stability are strongly influenced by the type of land use or the type and arrangement of plants growing on the soil. So the types of trees or annual crops planted on a plot of land can affect the cycle and water balance in the system. On the other hand, the cycle and water balance in this system in turn also affects the competition between the existing plant components. In Figure 1 is presented a schematic illustration of the water cycle in an agroforestry system and some of the important components involved in the water cycle and equilibrium.

Rainfall that falls on an area (Pg), some will be retained by the tree canopy (It), and partly by the canopy of annual crops (Ic), and others pass to the soil surface under trees (Pt) and under annual crops (PC). Most of the water held by tree crowns and annuals evaporates so that it has no effect on water reserves in the soil. The different crowns of trees and annuals resulted in differences in the amount of water held by the crowns of the two types of plants. As a result, the amount of water that escapes and reaches the soil surface under trees and under annual crops is also different.

Rainwater that escapes from the plant canopy will reach the soil surface (Pt and Pc) and some enter the soil through the infiltration process (Ft and Fc), partly flows on the soil surface as surface runoff (Rt and Rc). The properties of the soil under trees and annuals and

the amount of water that falls under the two different plants cause infiltration rates (Ft and Fc) and surface runoff under annuals (Rc) and trees (Rt) to also differ. Under certain conditions the infiltration under trees can be high enough so that it is not only sufficient to reduce Rt to zero (no surface runoff), but is able to accommodate surface runoff from the area under annual crops (Rc).



Gambar 1. Skema siklus air dalam sistem agroforestri sederhana pada tanah miring.

Keterangan Gambar 1:

P_g	= Curah Hujan Total	R_s	= Aliran Air Lateral
I_t,	= Intersepsi Pohon	I_c	= Intersepsi Tanaman Semusim
P_t,	= Hujan Lolos Tajuk Pohon	P_c	= Hujan Lolos Tajuk Tanaman Semusim
F_t,	= Kecepatan Infiltrasi di bawah Pohon	F_c,	= Kecepatan Infiltrasi di bawah Tanaman Semusim
R_t	= Limpasan Permukaan di bawah Pohon	R_c	= Limpasan Permukaan di bawah Tanaman Semusim
E_t	= Evaporasi Tanah (dari bawah pohon)	E_c	= Evaporasi Tanah (dari bawah tanaman semusim)
q_t,	= Kadar Air Tanah (dibawah pohon)	q_c	= Kadar Air Tanah (dibawah tanaman semusim)
T_t	= Transpirasi Pohon	T_c	= Transpirasi Tanaman Semusim
D_t	= Drainasi dibawah Pohon	D_c	= Drainasi dibawah Tanaman Semusim

The water balance in a simple agroforestry system consisting of a combination of tree rows and annual crop rows can be summarized in the following equation:

$$\P(q_t+q_c) = P_g - (I_t+I_c) - (D_t+D_c) - (R_t+R_c) - (E_t+E_c) - (T_t+T_c)$$

The water balance of an agroforestry system can be understood from the following questions:

- Do trees use more water than annual crops?
- How trees share water with annuals in the soil profile and over time. Are they mutually beneficial? • How do seasonal differences affect this system?
- How do water availability constraints affect crop production?
- Land use conversion from forest to agroforestry system affects river water flow in downstream areas. What is the mechanism?

Case 1: Simulation of water absorption in hedge system versus tree monoculture.

The following is an example of using the WaNuLCAS model to simulate water absorption by trees (Peltophorum dasyrrhachis) and annual crops (maize) in a hedge system in Pakuan Ratu, Lampung. The normal average annual rainfall in Lampung is 3100 mm. This simulation illustrates the second growing season (March – May) in conditions at the end of the rainy season where rainfall is only 20% of normal conditions. Soil is assumed to have sufficient nutrient content (N and P) so that the system does not have a nutrient deficiency problem.

In this simulation, it will be seen how changes in the total density of the root length of trees or annual plants affect the distribution of water absorption by trees and annual plants. The simulation results on this hedgerow system are also compared with the conditions of peltophorum and corn monocultures, as can be seen in Figure 3. In the peltophorum monoculture system, the reduced total density of root length indicated less influence on water uptake by peltophorum. On the other hand, if the same thing happens to the hedgerow system, then water uptake by Peltophotrum will decrease and water uptake by corn will increase (Figure 3a). This shows that in the peltophorum monoculture system, the decrease in rhizopher potential is not strong enough to reduce water uptake by peltophorum. Changes in the density of corn root length resulted in a greater change in water uptake in the system (Figure 3b). Water that cannot be absorbed by corn due to a decrease in the density of its root length cannot be fully absorbed by the roots of Peltophorum, so that the utilization of water from the system is reduced.

Exercise :

To deepen the understanding of water balance in agroforestry systems, WaNuLCAS can be used to simulate various scenarios of cropping pattern systems and layout arrangements. between trees and plants. Examples of simple scenarios that can be tried to understand the interaction of trees and annuals on water use in agroforestry systems are presented in the Box below. Furthermore, other scenarios can be and are developed according to individual needs for understanding the water balance. Good luck with simulating with WaNuLCAS, the more we do simulations, the deeper our understanding will be of the benefits of the model for understanding natural phenomena and water resource management problems in agricultural systems in general.

Answer the following questions:

1. Do trees use more water than annual crops?
2. How trees share water with annuals in the soil profile and over time. Is this water sharing mutually beneficial?
3. Do seasonal differences affect this system?
4. What are the barriers to water availability for plants and how do they affect crop production?
5. How will the change in the nature of the river flow that will fill a reservoir downstream if there is a change in land use from a “forest” system to an “agroforestry” system in the upstream catchment area?

Literature

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LEARNING MATERIALS

INTERACTION BETWEEN TREE - SOIL - CROP: KEY SUCCESS OR FAILURE IN AGROFORESTRIC SYSTEMS

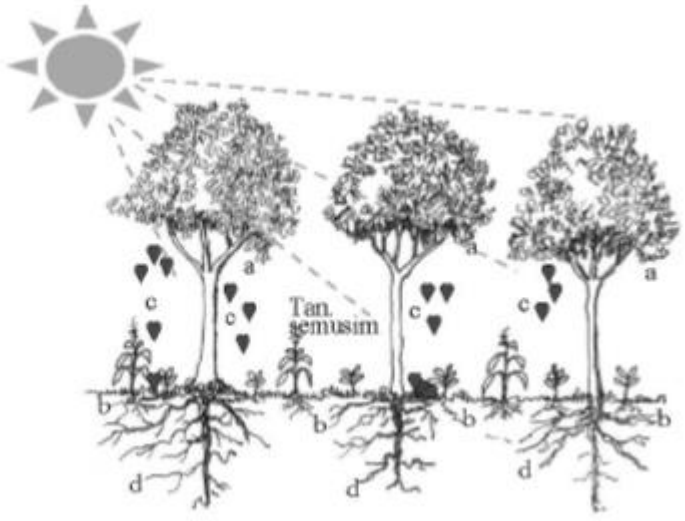
THE AIM OF THIS LESSON

- Understanding the interaction (both positive and negative) between annual plants (trees) and annual crops (seasons) planted at the same place and time in terms of the use of light (for the top of the plant), water and nutrients (roots).
- Get an overview of how to test and improve agroforestry systems in the field

In monoculture farming systems, spacing that is too close will result in competition for water and nutrients. If the spacing is widened, the level of competition will decrease. In practice in the field, farmers manage their crops by adjusting the cropping pattern, setting the spacing, pruning branches and twigs and so on.

In a mixed cropping system, each type of plant can change its environment in its own way. For example, a type of plant that has many branches will shade other plants. Some plants that are not too close will benefit, the process is often referred to as 'facilitation'. For example, the tall Dadap tree and its wide canopy provide favorable shade for coffee plants. Another example, the type of plant that has deeper roots than others so it is more likely to absorb water and nutrients from deeper layers. In a short time the environmental conditions around the plant will change (the availability of nutrients is decreasing), so that it will eventually lead to competition between plants.

The process of mutual influence, both beneficial and detrimental, between the components that make up this mixed system (including agroforestry systems) is often referred to as 'interaction'. It is briefly described schematically in Figure 1.



Gambar 1. Interaksi antara tanaman tahunan dengan tanaman semusim pada sistem agroforestri (a = naungan; b = kompetisi akan air dan hara; c = daun gugur (seresah). Pohon berguna dalam menambah C tanah dan hara lainnya serta sebagai "*jaring penyelamat*" hara yang tercuci ke lapisan bawah (d = pohon berperakaran dalam).

Discussion

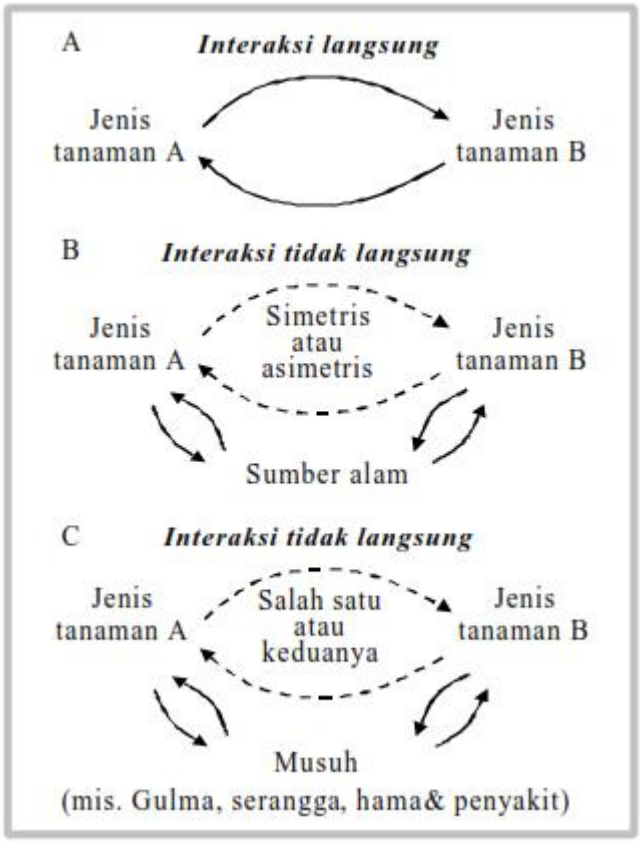
If two plants of the same species or of two different species are planted side by side with a fairly close distance, what will happen?

2. Tree-Soil-Crop Interaction

One of the keys to the success of agroforestry efforts lies in increasing understanding of the interactions between plants (short-term goal) and their impact on changes in soil fertility (long-term goal). In order to avoid agroforestry failures, there are three main things that need to be considered, namely: (a) the process of interaction, (b) the factors causing the interaction, and (c) the types of interactions.

2.1.Process of Interaction: direct or indirect

In mixed farming systems, competition between crops grown side by side on the same land often occurs, when the availability of plant life resources is limited. This competition is usually manifested in the form of growth inhibition against other plants. Barriers can occur directly or indirectly. Barriers directly, for example through the effect of allelopathy, but these direct barriers are rarely encountered in the field. Indirect barriers can be through reduced light intensity due to tree shade, or depletion of nutrient and water availability due to the close proximity of roots of two types of plants that are side by side. Plants sometimes affect other crops through a 'third party' i.e. when that plant can become a host for pests or diseases of other plants (Figure 2). Despite the fact that in the field there are also many plants that are planted separately, their growth is not good when compared to those planted together in the same plot (for example, planting Dadap trees in coffee plantations, Dadap here not only functions as an N enhancer but also as a shade). A deep understanding of the process of interaction between plants (both in the same species and different species) in agroforestry systems is needed in order to determine the right management.



Gambar 2. Bentuk–bentuk kompetisi antar tanaman: (A) spesies A secara langsung menghambat pertumbuhan spesies B atau sebaliknya, (B) interaksi tidak langsung yaitu dengan merubah lingkungan pertumbuhan, (C) interaksi tidak langsung yaitu dengan menstimulir pertumbuhan musuh (hama+penyakit) bagi tanaman

2.2. Factors Causing Interaction

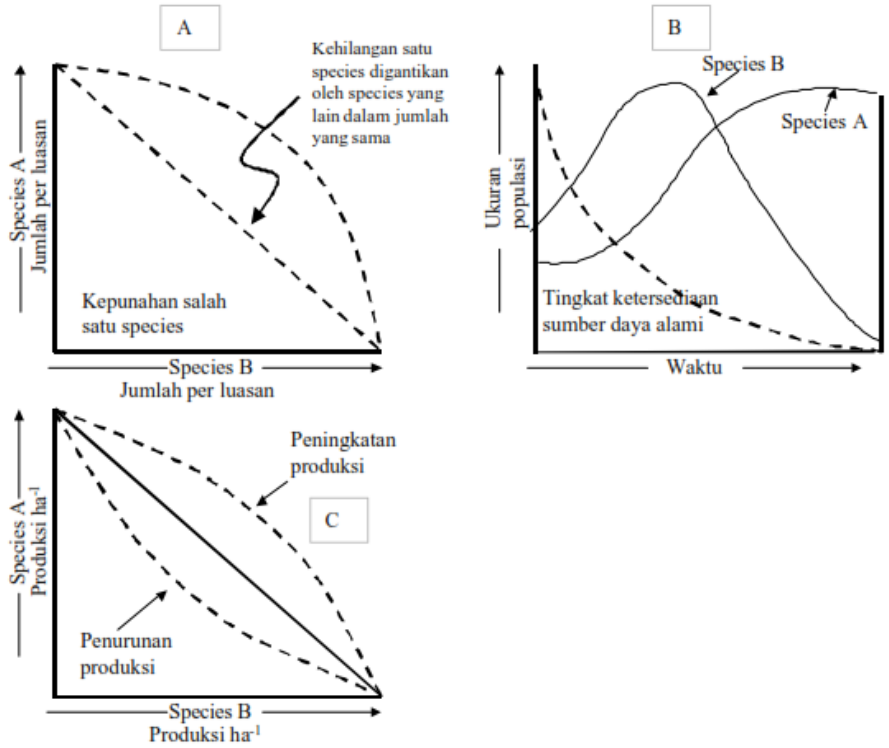
In general, negative interactions can occur due to (1) the limited carrying capacity of the land which determines the maximum number of population that can grow on a land; and (2) limited growth factors in a field

2.2.1. Maximum Population

The concept of carrying capacity of nature is a concept that is also important for ecologists to know. This concept describes the maximum number of a species in an area, either as a monoculture system, or a mixture. A species may be able to grow in abundance in a field. If two species grow together on the land, then one species is more competitive than the other. This is likely to cause the second species to become extinct (Figure 3). In agriculture, especially staple crops, which are expected to grow better.

2.2.2 Limitations of Growth Factors

One of the conditions for competition is the limitation of growth factors (water, nutrients and light). Plant growth declines if there is a decrease in the availability of one or more factors. Lack of nutrients in a land may occur due to low natural fertility, or because of the large process of nutrient loss in the land, for example due to evaporation and leaching. Water shortages can occur due to low water holding capacity, uneven distribution of rainfall, or large amounts of water loss (surface runoff). Knowledge of the availability of growth factors (water and nutrients) and knowledge of the needs of these plants are indispensable in the implementation of agroforestry.



Gambar 3. (A) kemungkinan adanya 2 species tumbuh bersamaan atau salah satu mengalami kepunahan bila ada keterbatasan daya dukung lahan; (B) Salah satu species (sp B) yang mengalami kepunahan, di lain pihak species A masih mampu menimba sumber alam yang telah semakin menipis. Pada sistem agroforestri tentunya diharapkan semua komponen penyusunnya 'menang', walaupun dalam praktek di lapangan ada spesies yang agak dikalahkan (C). Contoh untuk menunjukkan adanya penurunan (terjadi kompetisi) atau peningkatan produksi (terjadi komplementari) dari dua jenis tanaman dalam sistem campuran (Huxley, 1999).

2.3. Types of Tree-Soil-Plants

Planting various types of plants on the same land in an agroforestry system will lead to various forms of interaction between plants. The types of interactions are presented in Table 1.

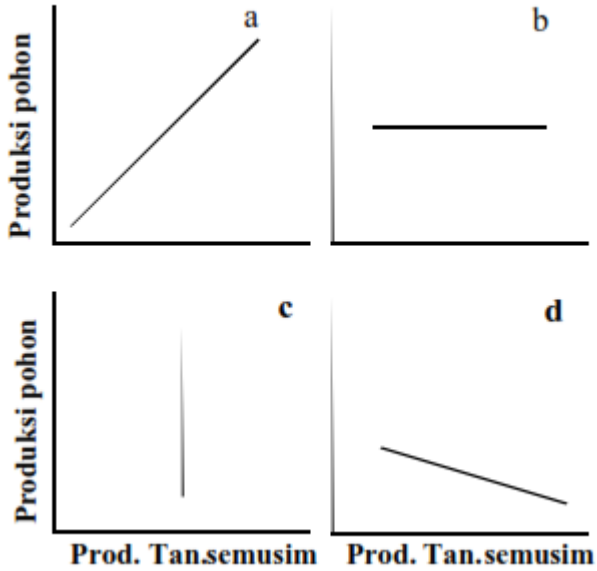
Tabel 1. Analisis interaksi antara 2 jenis tanaman A dan B (dimodifikasi dari Torquebiau, 1994). (0 = Tidak ada interaksi yang nyata; + = Menguntungkan bagi tanaman utama (pertumbuhannya, ketahanan terhadap "stress", reproduksi dsb.); - = Merugikan bagi tanaman utama)

Macam interaksi	Pengaruh interaksi terhadap tanaman:		Penjelasan	Contoh dalam Agroforestri
	A	B		
Mutualisme (*Mutualism*)	+	+	Interaksi yang saling menguntungkan	Mycorrhizae, rhizobium dengan legume
Fasilitasi (*Facilitation)*	+	0	Satu tanaman (B) membantu jenis tanaman lainnya (A) walaupun tidak mutlak diperlukan; B tidak dipengaruhi	Penghalang angin (*Windbreaks*), pohon penaung (*shade trees*), Budi daya pagar (*hedgerow inter cropping*)
Komensalisme (*Commensalism*)	+	0	Satu jenis tanaman (A) harus mendapatkan dukungan tanaman lain (B)(*Interaction obligatory)* ; tetapi B tidak dirugikan	Sebagai tempat rambatan; Bero (*Improved fallows*)
Netralisme *Neutralism*	0	0	Tidak ada saling pengaruh	Pohon tumbuh berpencar
Parasit / pemangsa *Parasitism/ predation*	+	-	Satu jenis tanaman (A) ***harus menghambat*** (*Interaction obligatory)* yang lain untuk hidupnya; B dihambat	Hama dan penyakit
Amensalisme	-	0	A terhambat; B tidak	Allelophathy
Kompetisi dan penghambatan (*Competition and interference*)	-	-	Satu jenis tanaman dihambat oleh tanaman lainnya melalui persaingan terhadap cahaya, air dan hara .	Alley cropping (yang tidak dikelola dengan baik)

In agroforestry systems, positive and negative interactions in the short term are mainly emphasized on their effect on annual crop production. The forms of these interactions include:

In principle, there are three kinds of interactions within the agroforestry system (Figure 4), namely:

- Positive interaction (complementarity = mutual benefit): when an increase in the production of one type of crop is followed by an increase in the production of another crop (Figure 4a).
- Neutral interaction: if the two crops do not affect each other, an increase in annual crop production does not affect tree production (Figure 4b) or an increase in tree production does not affect annual crop production (Figure 4c).
- Negative interaction (competition/competition = mutual harm): if an increase in the production of one type of crop is followed by a decrease in the production of another crop (Figure 4d), there is a possibility of a decrease in the production of both.



Gambar 4. Interaksi positif (a), netral (b dan c), atau negatif (d) antara komponen penyusun agroforestri (Torquebiau, 1994).

2.3.1. Positive Interaction (Facilitation)

Leaves from trees that fall to the ground as litter are useful as ground cover (mulch), increasing the supply of N and other nutrients that are useful for annual crops. The level of N supply from the mineralized tree litter is strongly influenced by its quality (see Chapter 6: Nutrient Balance). Low quality litter (low N concentration, high lignin and polyphenol concentration) is actually detrimental in the short term due to N immobilization, but beneficial in the long term.

Tree roots help in the recycling of nutrients (recycled nutrients) in several ways, namely:

a. Tree roots absorb nutrients in the upper layers by competing with annual crops, thereby reducing nutrient leaching to deeper layers. However, to a certain extent this competition will harm seasonal crops.
b. Tree roots act as a "nutrient rescue net" i.e. absorbing nutrients that are leached to the lower layers during the growing season. Case example 1 (Rowe et al, 1999; Suprayogo et al, 2000) can be used as a guide to prove the theory.
c. Tree roots act as "nutrient pumps" especially in fertile soils, i.e. absorbing nutrients from weathering minerals/rocks in the lower layers. However, this is still a hypothesis, and still needs further research.
d. These rotting roots will neutralize Al poisoning at a deeper layer, so that other plant roots can grow following the former root hole. See example case 2.

- Nitrogen supply is available to the roots of annual crops, either through weathering of dead roots during growth or through air-free N-fixation (for legumes). Provision of N through this fixation can be utilized directly by the roots of annual plants that grow close together.

- Suppress weed populations through shading, and in the dry season reduces the risk of fire due to better humidity preservation. • Often reduces pest and disease populations. • Maintaining a stable microclimate (reducing wind speed, increasing soil moisture and providing partial shade (eg Erythrina in coffee plantations). • Maintain soil organic matter content and improve soil structure, thereby reducing erosion hazard (in the long term).

2.3.2 Negative Interference:

- Shade by trees will reduce the intensity of light that can be used by annual plants.
- Competition between tree roots and annual crops to absorb water and nutrients in the topsoil,
- Trees and annual crops can be hosts for pests and diseases.
- Rotten tree roots can create waterways, thereby accelerating nutrient loss through vertical and lateral flows.

Case 1. Tree roots as a nutrient safety net

Proof of tree roots as a nutrient rescue net was carried out by measuring the amount of N washed at a depth of 0.8 m and > 0.8 m in the fence cultivation system in Pakuan Ratu, Lampung. The hedgerows, namely petaian (Peltophorum) and gamal (Gliricidia) were planted in 1985. The hedges were planted in rows with a spacing of 4 x 0.5 m or as a mixture of alternating rows of petai with gamal. The annual crops planted between the hedgerow rows are maize (planting season I) and followed by beans soil (planting season II). Corn fertilized with N as much as 90 kg ha. The amount of mineral N (NH and NO3-) obtained was compared with monoculture corn plots, without hedges (as a control). The measured high and low concentrations of N-minerals indicate the effectiveness of tree roots in absorbing leached N. The lower the concentration of leached mineral N, the more effective the tree roots in absorbing the leached N. The measurement results can be seen in Figure 4. There was no difference in the amount of drainage water in all plots. However, when viewed from the concentration of N-minerals (NH4+ and NO) both at a depth of 0.8 m and > 0.8 m, the highest concentration was found in the control plot. The lowest concentrations were found in the map plots. The concentration of N-mineral in the gamal plot, a mixture of petaian/gamal is in between.

Case 2 Benefits of dead tree root burrows for annual crops

On acid soils, the burrows of dead tree roots are useful for the growth of other plant roots. The level of Al toxicity in the burrow was lower than the soil outside the burrow. Decomposition and mineralization of tree roots will release some organic acids such as citric, malic and fulfat which can chelate Al into a form that is not toxic to plants. In Table 2, an example of the results of soil pH measurements at various depths of soil profiles is presented in a fence cultivation plot in Ultisol, Onne, Nigeria. For comparison, the last two columns show the pH inside and outside the root canal in the subsoil.

Tabel 2. pH tanah pada berbagai kedalaman dalam profil tanah yang dibuat pada petak budidaya pagar dan di dalam liang akar pada lapisan tanah bawah pada Ultisol, Onne, Nigeria (Hairiah & van Noordwijk, 1986).

	Kedalaman (cm)			Di luar liang	Di dalam liang
	0-20	20-30	30-60		
$pH\text{-}_{H2O}$	3.6	3.6	3.6	3.7	3.4
$pH\text{-}_{KCl}$	4.7	4.5	4.4	4.4	4.2

From the data above, it can be seen that the pH in the tree root hole is relatively lower than the surrounding soil or soil in the soil profile. Why do cassava roots still prefer to grow in the tree's root burrows? (see Figure 5.). There are 3 possibilities that cause cassava roots to grow in tree root burrows: (a) low Al toxicity, (b) richer in nutrients (c) soil structure is more crumbly.

Assignment : Group Discussion ; Reporting
Project Based Learning

Literature

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