TUMPANGSARI METHOD FOR ESTABLISHMENT OF TEAK PLANTATIONS IN JAVA

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Introduction

TUMPANGSARI means co-occupation for a limited period; the co-occupants are agricultural crops in forest area; thus TUMPANGSARI is an agri-silvicultural method, the most popular method for establishment of forest plantations in Java.

The forests in Java and Madura are managed by Perum Perhutani, a State Forest Corporation. The total forest area in Java and Madura is approx. 3 million ha of which 800,000 ha are covered with teak forests. The average rate of establishment of teak plantations in the last 5 years was 40,000 ha, practically all by tumpangsari method.

In the last 4 years the so called "inmas tumpangsari" has been developed. Inmas is an abbreviation for mass intensification and includes use of superior food intercrop plant varieties, mostly dry land rice, application of fertilizers and insecticides so that more output from the food crops may be anticipated. A favorable effect on the teak growth in the first 2—3 years is also noted.

Other minor planting methods are row planting with daily payment ("banjar harian"), planting in holes in the brush ("cemplongan"), shoot regeneration, advance planting etc.

Silvics of teak (*Tectona grandis*, L.F.)

Teak occurs naturally in Java, mostly in the northern part of Central Java and East Java. It is also found on the islands of Kangean.

Zoefri Hamzah reported on the teak plantations in the island of Lombok, in Lampung (South Sumatra) and West Sumatra. Although site conditions in some parts of these areas were found favorable for teak growth, teak reforestation and teak forest management were not yet developed as in Java.

The best conditions for teak growth are, according to Beekman, average yearly temperatures between 22°—27°C, with extremes of 15°—30°C and rainfalls of 1250—3750 mm which correspond with the rainfall types C, D and F of Schmidt & Ferguson. This classification is based on the ratio of average dry and wet months (X 100%), assuming a month is "wet" when a monthly average rainfall of 100 mm and more prevails, while a month is "dry" when the monthly average does not reach 60 mm.

This ratio is represented by the factor Q which moves between 33.3% and 167% for the types C, D and E. This corresponds almost with the boundary lines of the types: 8 wet and 4 dry months on the one hand and 5 wet and 7 dry months on the other hand.

A typical rainfall distribution in a teak area (Bojo negoro, East Java) is shown in the following Table.

(Average of 11 stations : 14 to 83 m above sea level 1961 – 1970)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	One Year
Rainfall (mm)	273	236	310	170	86	67	38	21	31	79	182	274	1769
Rainy days	15.1	13.8	15.1	10.0	6.3	4.4	2.1	1.1	2.0	5.2	10.0	15.2	100.7

Q value : $\frac{3}{6}$ x 100% = 50%; climate type C.

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Regarding soils for teak Beumee and Beekman are of the opinion that teak has no special nor high requirements for soil conditions as far as chemical composition is concerned. Teak can grow on volcanic soils, sedimentary soils as well as alluvial soils of various and mixed origins.

However, teak appears susceptible to physical conditions; it grows well on permeable, well aerated soils and poorly on compact, less permeable, poorly aerated soils; teak is apparently susceptible to air shortage in the soil. This is demonstrated in the test of Coster in which teak seedlings (in pots), put in water with exclusion of air, die after 10 days, whereas seedlings of other tree species in the same conditions die after 30—50 days.

Concerning teak seed, seed production and germination, experiments of Wins, Soetarmo Hardjowarsono, Beekman and others have revealed important data and information which have contributed substantially to the success of the artificial regeneration of teak,

Some important data:

(1) The total germinating power of teak seed is low (30—58%), seldom more than 50%. The germination starts from the 15—20th day and ends on the 41 to 42nd day.

(2) The germinating power and germinating energy deteriorate after storing of teak seed for 200 days.

(3) Big seeds have bigger germinating power and germinating energy than smaller seeds. Recommended are seeds bigger than 14 mm which is 56—57% of the total seed amount.

(4) Seeds collected from September through November germinate faster and have higher germinating power than those selected earlier (June-July).

(5) Best seeds are collected from 20—30 years and older stands but not from too old stands (100 years).

(6) The germination of teak seed is stimulated by high temperatures (35—37.5°C), which occurs only in open field; for germination, teak does not tolerate even light shade.
We may conclude herewith that natural regeneration will be extremely difficult and earlier planted food crops in tumpangsari may be severely damaging to germination of teak seed.

(7) The germinating power appears also to be highest when the seed is covered completed with soil (max. 2 cm); this is also important to avoid washing away by surface water.

(8) Burnt seed (forest fire) germinates poorly.

Successful vegetative regeneration through stumps was reported by Eidmann (90%); sprouting took place very early (2—5 days). He also reported that stem and root—cutting failed to grow.

Successful occulation and grafting of teak is reported by Ferguson, Hardjono, Djojo and Loekito.

Concerning teak tree breeding, Zoefri Hamzah pointed out that not much is done yet in this field.

Coster and Eidmann made experiments on seed from Indo-China, Thailand, Burma and India besides seed from certain areas of Java Muna.

Tentative results on the investigations were reported by Coster and Hardjo Warsono and later by Loekito with the conclusion that good Java varieties have probably the same quality characteristics as good foreign teak. At places exposed to wind and excessive dry periods Siam teak may be preferable.

It is generally accepted that the introduction of *Leucaena glauca* by Jaski as interplanting has substantially contributed to the success of artificial teak regeneration with tumpangsari.

Beekman pointed out various favorable charactristics of this plant.

(1) fast and complete cover of soil,

(2) long life,

(3) no root competition (deep rooter, not climbing, can tolerate cutting/pruning)

(4) control erosion,

(5) enrich soil through bacterium symbiosis (nitrogen) and transportation of nutrients from deep parts of the soil (deep root system) to soil surface.

etc.

The practice of Tumpangsari

It is generally accepted that tumpangsari was for the first time (1883) successfully practised by Buurman V. Vreeden in the forest district of Pemalang, Central Java.

In discussing the tumpangsari as it is practised today I would like you to have a view on Fig. 1 and 2: Time Schedule for Establishment of Teak Plantations and Lay out of Tumpangsari Teak Plantation.

Execution of the tumpangsari includes 4 activity groups, i.e.:

1. Site Preparation
2. Seed Preparation
3. Planting
4. Tending

which is done consecutively within 2 years and 5 months.

1 Site preparation

This includes activities to ensure proper technical as well as administrative performance, covering:

(1) Issuance of Instruction Letter for Planting by the District Forester (January); this is the signal to start activities.

(2) Drawing and marking of plantation boundaries and inspection parts on a map usually of scale 1:10.000 or bigger (January).
This map contains a complete terrain plan which is of substantial importance as a basis for an integrated planting operation.
The plan for erosion control constitutes one of the most important parts of the terrain plan.

(3) Marking of plantation boundaries and inspection paths in the field (February-March) using poles of different colors for different purposes, for example to indicate:
- boundaries of planting area
- boundaries of planting share
- inspection paths
- ditches
- etc.

(4) Conclusion of planting contract (February-March).
This contract is signed by the forest farmers and the district forester witnessed by the village or county chief concerned. In the contract are stipulated:
- the rights and obligation of both parties
- extent of planting share
- kind of food crops allowed as intercrop
- amount and way of payment of planting fee
- period of contract.

(5) Land clearing, soil tillage (3 phases) and construction of rock "cushions", inspection paths, ditches, light structures for erosion control are done in the months of May until September.
Erosion control measures entail:
- Construction of light structures
- Correct lay out of plant rows
- Drainage system in wet or continuously submerged parts: digging of canals, ditches, etc.

(6) Placing of "Acir" stick (wood or bamboo) to indicate the places for planting of teak, leucaena and other tree species (for filling, hedge, fire break, etc.).

(7) At last a plant cabin will be constructed.
This cabin will serve for storage of plant material, tools and equipment, office room, living accommodation for foremen and some laborers.
It is situated in the center of the plant area and may be moved every year to the next planting operation site.

2 Seed preparation

(1) Collection of teak seed

For a continuous planting operation seed is needed every year. Therefore it is of substantial importance to maintain adequate seed stands.

Before harvesting of the seed the soil surface in the teak stands has to be cleared so that old and damaged seed may not be abusively collected. Teak seed is selected on the basis of size color, age and general condition.

The size must be at least 14 mm, (selection is done using an iron sieve), the color must be brown, seed must be reasonably dry without borer holes and harvested in the running year.

(2) Collection of seed for interplanting

Good and mature leucaena seed is dark brown, shiny, without shrinkage, dry, without fungi or borer holes.

Old seed of more than one year is dark brown to black. If peeled the content looks brown while that of fresh seed is green.

It happens sometimes that leucaena seed collectors cook young seed to give the brown color and fullness appearance, however the seed so treated is tough if bitten.

(3) Amount of seed necessary for 1 ha teak plantation.

a. Teak seed: 4—6 petroleum cans (a 18.6 L).
b. Leucaena seed: 4—5 petroleum cans.
c. *Acacia villosa*: half amount of leucaena.
d. Schleichera: 1/2 petroleum can.
(filling species)

3 Planting

Teak seed is planted before the first rains (October) occur; to ensure success 5 seeds are planted for every "acir"

Besides it is also compulsory for every forest farmer to have a nursery where he has to plant at least 1000 teak seeds to secure availability of blankfilling material.

Leucaena seed has to be planted before the first rains (October).

Schleichera seed as filling species is planted in December-January.

If 4 weeks after the first rains the teak seed does not germinate it has to be blankfilled with germinating seed. Blankfilling at later stages is done with pot seedlings (usually grown in perforated vinyl bags).

After February blankfilling is done only with stumps. Leucaena is blankfilled only with seed; it is not justifiable to plant Leucaena seed in the middle of the rainy season, because of its susceptibility to rot and the best time for this purpose is March or November when the soil is sufficiently warm.

Approved agricultural crops in the tumpangsari method are usually dry land rice, corn, pepper, peanut and soybean. Except under certain conditions, cassava, climbing legumes, sweet potato, banana and potato are not allowed to be planted.

4 Tending

If the leucaena interplanting grows too high it will disturb the teak growth, therefore regular cutting is necessary.

Cutting of leucaena is done 4 times in a period of 2 years. One stem is maintained for seed production at 1 m interval. The cutting waste is put along the main plant row as it improves soil conditions.

Further care of the main crop consists of keeping it free from the shade of the agricultural crops by pushing them away from the teak plants with strings.

Also weeding must be done without damaging the roots of the main crop.

By March excess of plants has to be removed, one plant for one "acir" is ultimately selected

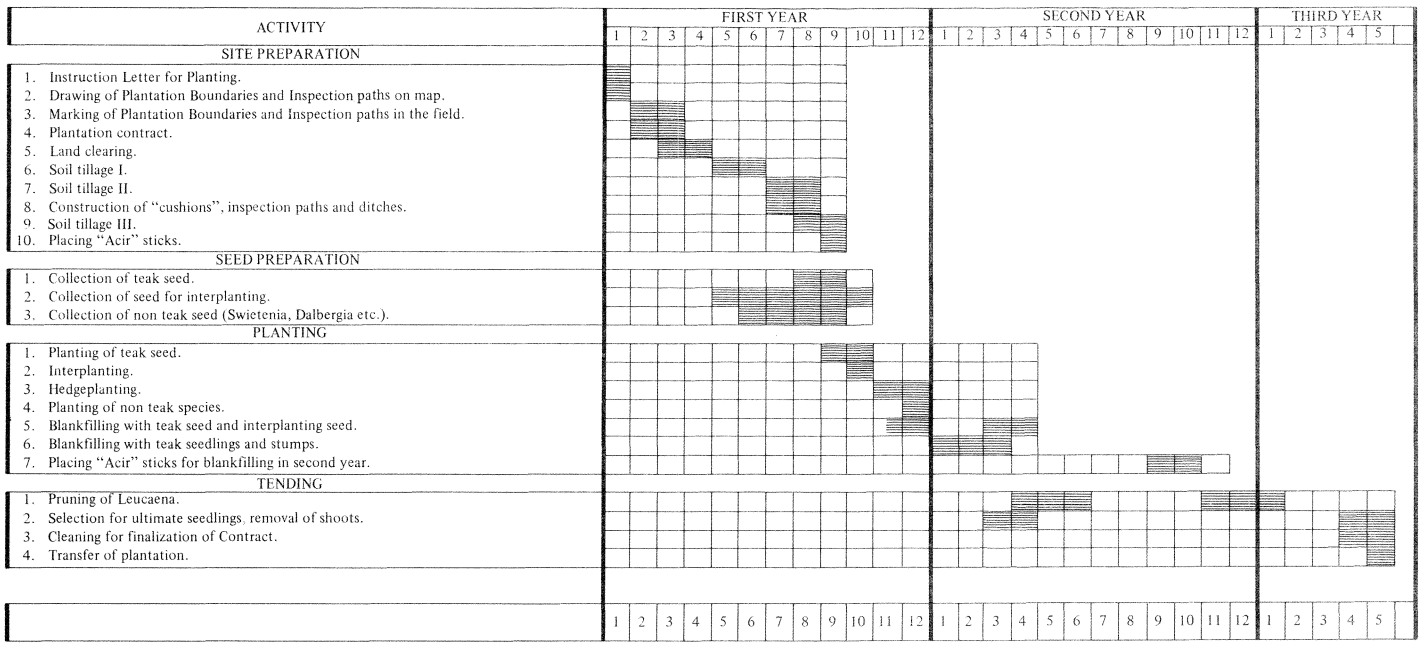

Fig. 1 Time schedule for establishment of teak plantation

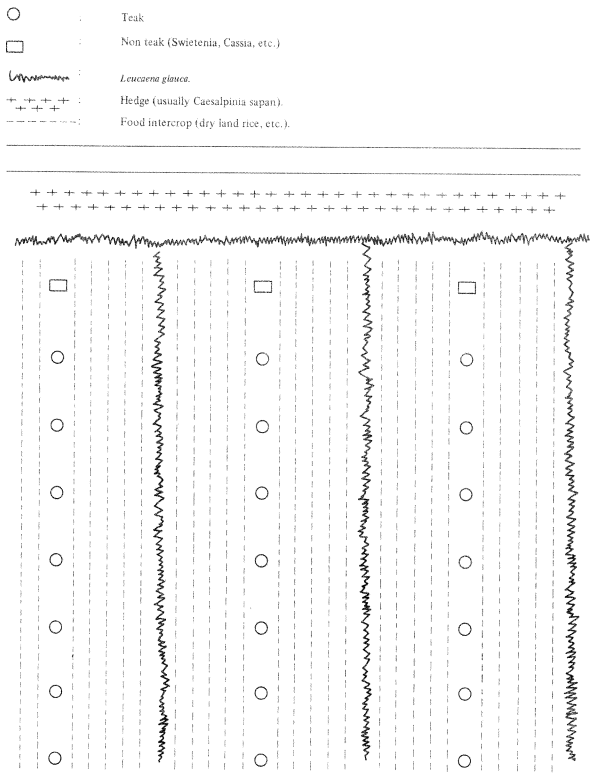

Fig. 2 Lay out of Tumpangsari Teak Plantation

which meets the following requirements:

— the largest, straightest, healthiest
— without defects.

Bottom and branch shoots should be removed with a sharp knife especially made for the purpose.

Damaged trees have to be cut low, one of the shoots being maintained later.

The entire planting operation is finalized at the end of April of the 3rd year. After final checking the plantation is transferred by the farmer to Perhutani; at the same time the contract fee is paid off.

A sign board is placed at the site with a statement that the tumpangsari operation ended as of the first of May.

After the plant contract period has ended care of the plantations has to be extended until the age of 5 years including:

— blankfilling
— pruning of shoots at stem bottom and branches
— cutting of interplanting
— maintenance of hillocks and ditches
— supervision against damage, fire and grazing
— removal of weeds if necessary.

INMAS Tumpangsari

1 Generalities

The rapid increase of the population (2.0% per annum), in the rural areas, creates an ever increasing need for agricultural land and employment. To solve the problem efforts are made to extend the agricultural land (through transmigration) and to intensify the local agricultural methods.

In the tumpangsari reforestation area this led to the introduction of the intensified tumpangsari or inmas tumpangsari (inmas = mass intensification).

The inmas tumpangsari has become one of the prosperity approach programs of Perhutani. These programs call for more activities of Perhutani to assist the local population in acquiring more income, more employment and more social facilities from forestry to create a better understanding among the people and in so doing, to avoid confrontation situations toward the forest.

This assistance entails provision in advance by Perhutani to the farmers of fertilizers, insecticides and superior rice seed whose cost is partly borne by Perhutani and partly by the farmers. In case of harvest failure the farmer's obligation to pay back is abolished.

In order to obtain good results the forest farmers are encouraged to apply the new agriculture technology comprising five steps ("Panca Usaha Tani" = Five endeavors of the Farmer), which for the forest farmer mean:

(1) Use of superior dry land rice varieties
(2) Better soil tillage
(3) Use of fertilizers
(4) Control of pests and diseases
(5) Correct adjustment of planting time to rainfall.

The first trial plots of inmas tumpangsari were established in the Ngawi forest district in the planting years of 1972 and 1973; the results were encouraging: the yield of the inmas plot was 3739 kg/ha of dry rice compared with 700 kg/ha in the non inmas plot.

In order to acquire a solid basis for further development of the inmas tumpangsari Perhutani has sought cooperation with the Gajah Mada University, Jogyakarta, which resulted in the undertaking of field experiments and the drawing of tentative guidelines for execution of the inmas tumpangsari.

2 Experiments and observations

Within this context the inmas tumpangsari research team of the University of Gajah Mada undertook experiments on dry land rice and soybean in 1974 and 1975.

The objective of the dry rice experiments was:

(1) To test the adaptability of IRRI (International Rice Research Institute, Philippines) rice strains.
(2) To seek the right dosage of fertilizers for the rice variety C4-63 on grumusols with teak site quality 3.
(3) Effect of the above mentioned treatment on teak growth.

Results:

(1) With C4-63 as standard the Palawan and C22 varieties gave better results than IR 661-1-170-1-3.
Moreover the three above mentioned varieties were younger than the C4-63 (135 days), i.e. respectively 130 days, 132 days and 129 days; however, the Team admits that it is difficult to draw a conclusion based only on one experiment in one planting season.
(2) The calculated optimum dosage was:
Urea: 72.43 kg/ha
T.S.: 118.48 kg/ha
Z.K.: 377.99 kg/ha
In applying those dosages the expected rice output would be 48.27 quintal/ha.

(3) Two months after rice harvesting the growth of the teak was 2-1/2 to 3 times higher compared with that when harvesting took place.
However in another plot the teak did not show any significant difference in growth.

The conclusions were:
(1) The recommended rice varieties could possibly be replaced by more suitable varieties.
(2) With optimal fertilization a most profitable production may be obtained. In this experiment it was felt that the optimum dosage was not yet found.
(3) Increase of dosage of fertilizer may cause higher increase of teak growth.
In the soybean experiment 3 superior varieties were used, i.e. American TK$_s$, Taichung with one local variety as control.
Applied fertilizers were: Urea and TSP.
Dosage: 100 kg Urea/ha and 150 kg TSP/ha.
From the results of the experiment it was concluded that the TK$_s$ could replace the local variety for tumpangsari purposes.

Practical observations of inmas tumpangsari plantations in 1975/1976 in Bojonegoro forest district have led to the conclusion that topography and site quality have little or no effect on success of inmas tumpangsari; factors exerting a positive influence would be:
(1) intensive soil tillage
(2) the right planting time
(3) the right time for application of fertilizer
(4) intensive crop maintenance.

Soeroso noted that another observation in Gundih (Central Java) revealed that inmas tumpangsari teak trees grew faster in height than non inmas teak trees, while no substantial increase in thickness was observed. This may lead to the following consequences:
(1) Faster crown closure of inmas teak trees may necessitate shortening of tumpangsari period (1 year instead of 2 years) or widening of tree spacing.
(2) The relatively faster height growth leading to growth in thickness may increase the vulnerability of the young trees to wind damage.

However, another report indicated that the impact of fertilizer on tree growth lasted only 1 to 3 years, i.e. only in the period of application of fertilizer to the tumpangsari rice. In the third year when fertilization was stopped the teak trees grew normally again.

In order to protect the young trees against wind damage special efforts were made in the First 2 years. To this effect it is also recommended not to cut the interplanting of leucaena within that period.

3 The technique of Inmas Tumpangsari

Using the data from experiments and experience gained in the practice of Inmas Tumpangsari the research team of the University of Gajah Mada has composed an instruction book entitled:

"Tentative guidelines for planting, fertilization and control of pests and diseases of dry land rice as tumpangsari intercrop in teak forests".

Some highlights:

1) Preparation
   (1) Location for inmas tumpangsari should not be higher than 500 m above sea level, steepness not more than 25%, soil thickness more than 15 cm, land should be well drained and the soil should be of good quality.
   (2) Plant material has to be of superior quality.
   Recommended varieties:
   — C4 63; origin: University of the Philippines.
   — Gama 61; origin: Gajah Mada University, Faculty of Agriculture.

— C22; origin: IRRI Philippines.
— Cartuna; origin: Philippines.

(3) Fertilizers to be used:
— Urea: $CO(NH_2)_2$, N content 40%.
— Triple Superphosphate (T.S.), $Ca(H_2PO_4)_2$ P_2O_5 content 50—60%.
— Zwavelzure Kali (Z.K., Potassium Sulphate, K_2SO_4) K_2O content 50%.
Compound fertilizers (as alternates).

2) Execution
(1) Soil tillage, construction of ditches and inspection paths etc. are the same as in ordinary tumpangsari.
(2) The planting
— Planting time
To find out the right planting time is very important.
The rainy season usually starts with 1—3 shower rains, followed by an interval of dry period lasting 1—2 weeks and afterwards by regular showers. Planting is preferably done after the interval period.
— Planting method
A planting stick is used to make holes in the soil with a planting distance of 30 × 15 cm.
After planting, the hole is to be covered with loose soil (not compacting), preferably with manure if available.
— Weeding and fertilization
Weeding has to be done intensively before fertilization. TS is applied once, i.e. at the time of planting or one day before.
The same is done for the application of ZK.
Urea is usually applied twice: half a dose at the age of 25 days to stimulate emergence of the shoots and the other half at the primordial stage to fill the grains

3) Pests and diseases.
(1) Control of pests and diseases must preferably be done by the forest farmers themselves. Therefore assistance in technical preparation and training must be provided.
(2) Some important pests and diseases mentioned in the guidelines are:
— Rice fly (*Atherigona oxigua* Stein).
— "Waland Sangit" (*Leptocorixa acuta* Tumb).
— "Ganjur" Pest (*Pachydiplosis oryzae* Wood & Mason).
— "Sundep" Pest (*Chilo suppressalis* Walker) and (*Sesamia inferens* Walker).
— Diseases: — *Piricularia oryzae* Cav
— *Helminthosporium oryzae* Breda de Haan.
— etc.

4 Socio-economic aspects

The Directorate of Reforestation and Rehabilitation has calculated the work volume expressed in man-days, necessary for various planting methods for one ha forest plantation; one man-day refers to 7-hour work per day of an adult male.

(1) Row planting: 116.5 man-days.
(2) Cemplongan (hole planting): 86 man-days
(3) Tumpangsari: 62 man-days
(In this calculation are not included work volume for soil tillage, construction of light structures and first stage tending for which the farmer is responsible, the cost being included in the contract fee).

Soendaru & Toemadi reported that the total work volume necessary for tumpangsari, per ha, was:

Soil tillage	29.3 man-days
Planting, weeding, harvesting	99.9 man-days
Total	129.2 man-days

The same authors reported that the work volume for inmas tumpangsari totals 229 man-days per ha.

They further calculated that, taking into consideration wages per man-day, prices of rice, insecticides, fertilizers, etc., an inmas tumpangsari undertaking will be profitable if the rice output is higher than 1,664 kg dry rice grain per ha.

Ahmad Sulthoni (1977) calculated the profit of an average forest farmer from an inmas tumpangsari operation in Cepu forest district.

After subtraction of investments for seed, fertilizers and insecticides the profit amounts to Rp.9,000 ($22) for one inmas crop. Herein is not included the contract fee.

Rachadi reported that within the 2-year and 4-month operation of tumpangsari in Bojonegoro forest district the farmer contractors planted various food crops as follows:

	Months											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
First Year	Corn + Soybean				Japanese Tobacco						Inmas	
Second Year	C.IV/63 + Corn				Corn + Soybean						Local	
Third Year	Dry rice											

Output of food crops per ha in 2 years and 4 months (840 days):

Corn: 1—1.5 ton, dry seed, 2 × harvest
Soybean: 1—2 ton, dry 2 × harvest
Tobacco: 1—1.5 ton, cut dry, 1 × harvest
Dry Rice C.IV/63: 3—3.5 ton, field dry, 1 × harvest
Dry Rice Local: 1—1.5 ton, field dry, 1 × harvest
Corn (filling crop): 8 q.dry seed, 1 × harvest
Cassava (filling crop): 1—2 q.wet (share boundaries), 2 × harvest.
Financial Output per ha.
Minimum: Rp. 1,167,000.- = $2,812.
Maximum: Rp. 1,822,000.- = $4,390.

This is higher than the average income in the area.

In general it can be said that the revenue of the forest farmers increased through the inmas tumpangsari. No wonder that the local authorities and forest population alike enthusiastically participate in this program.

Summary

(1) Tumpangsari is an agri-silvicultural method of establishment of forest plantations, in particular teak, which is widely and successfully practised in Java. The rate of tumpangsari teak reforestation in the island is 40,000 ha per annum.

(2) The requirements for a successful application of the tumpangsari method are:
   a. need for agricultural land by the local farmers
   b. use of selected food crops (dry rice, soybean etc.), not harmful to the main crop
   c. right application of the required silvicultural techniques.

(3) The fast increase of the rural population necessitates an overall intensification (and amplification) of agricultural practices. In forest plantations the inmas tumpangsari (mass intensification of the tumpangsari) is successfully introduced and developed. This includes: use of superior rice variety, seed, better soil tillage, use of fertilizers, better control of pest and diseases and correct adjustment to climatic conditions.
Effect on the forest plantation is being investigated.
The output of agricultural crops is 2—3 times that of the ordinary tumpangsari crop.

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Discussion

Kawana, A. (Japan): 1) How many years can the farmers cultivate the crops? 2) What kinds of fertilizers do you apply? 3)Could the tumpangsari method be applied to other areas in Indonesia?

Answer: 1) Two years and five months. 2) We use urea which supplies nitrogen as well as triple super-phosphates. 3) As the prerequisite for the practice of the tumpangsari method is the need for land, such method may not be applicable to other areas besides Java island.

Lee H.S. (Malaysia): Is there any slope limitation to the practice of the tumpangsari method?

Answer: The limit is 50%.

Choob K. (Thailand): You mentioned that you used urea and triple super-phosphate as fertilizers for the crops interplanted. Have you ever chopped leucaena leaves which can supply nitrogen, as practised in the Philippines in the case of leucaena intercropped with corn?

Answer: We apply both methods. Chemical fertilizers are mostly applied to the food crops while leucaena is chopped 4 times in 2 years and the leaves are placed along the rows of teak to supply nitrogen. The leaves can also be marketed as fodder for the livestock.

Mya Aung (Burma): When do you carry out blankfilling?

Answer: Germination of teak seed takes place from 21 to 40 days after planting. If after 40 days no germination is observed, it is necessary to proceed to blankfilling.

Arihara, M. (Japan): Are there any serious diseases and damage caused by insects?

Answer: There are indeed in sects and diseases but the ffect is not severe. The quality of the wood may be affected by termite and borer attacks. Also stands on volcanic soils are more likely to be attacked by *Xyloborus* beetle (stem borer). Heavy rainfall is an another factor predisposing to attacks by stem borer.

Domingo, I.L. (The Philippines): What variety of leucaena do you intend to use?

Answer: In addition to planting *Leucaena glauca* we intend to try giant leucaena (Ipil-Ipil).