Mission report

Introduction to agro-ecological techniques and assessment of their potential for development of sustainable agriculture in East-Kalimantan Indonesia

6-14 February 2002

Olivier Husson
CIRAD GEC

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Schedule of the mission

7 February 2002:
Morning: Arrival in Jakarta and transfer to Bogor
Afternoon: Discussions with B. Lidon and J.M. Lopez

8 February 2002:
Discussions with B. Lidon and J.M. Lopez
Literature review

9 February 2002:
Morning: Transfer Bogor-Jakarta-Balikpapan
Afternoon: Transfer by road from Balikpapan to Samarinda. Stops for observations. Visit of Loa Janan station

10 February 2002:
Morning: Transects study from Samarinda to Separi (north)
Afternoon: Transects study from Samarinda to Kota Bangun (west)

11 February 2002:
Morning: Presentation of Agro-ecology to BPTP staff in Samarinda
Afternoon: Discussion of programme for future activities
Evening: Samarinda- Balikpapan

12 February 2002:
Morning: Balikpapan - Jakarta
Meeting with Cirad representative
Afternoon: Jakarta - Bogor
Meeting with CSAR Vice director

13 February 2002:
Morning: Report writing
Afternoon: Bogor-Jakarta- Singapore

14- February 2002:
Singapore- Paris- Montpellier

1. Introduction

At the end of the P2SUKA project, an important network of meteorological stations all over Indonesia is now operational. The data generated can be used for assessment of risks in agriculture (especially floods and droughts). With its partner, the Centre for Soil and Agroclimatic Research, Cirad now tries to develop new programmes and to extend its partnership in projects proposing agricultural innovations, adapted to the local situations.

Techniques of direct seeding on vegetal cover have, amongst others, the advantage of improving considerably water use efficiency and plants rooting (by regenerating soil structure and thus enhancing soil porosity). Adapting, developing and extending these techniques for Indonesia seems to be a important challenge. East Kalimantan, with its dynamic Regional Centre for Technology Transfer and its original problematic was selected as a first location where research activity could be initiated.

2. Objectives of the mission

The objectives of this mission were to:

i) introduce direct seeding on vegetal cover (also refereed to as agro-ecological techniques) to potential partners,

ii) bring technical assistance on these techniques, especially to identify which of them could have a high potential for the local agriculture in East Kalimantan, and

iii) propose a schedule/programme for simple activities in order to prepare the development of a comprehensive research programme if funds can be raised.

3. Overview of Kalimantan Timur (see map figure 1)

3.1. Climate (from Lidon and Lopez 2002)

This research area proposed is the East coast dry zone of East Kalimantan which extends from Balikpapan north to Tanjung Redeb. It's the only part of Kalimantan having annual rainfall less than 2000 mm. Under normal conditions, the rainy season occurs from October to June with 2 rainfall picks in December and March and the climatic balance is positive even during the less humid period from July to September (see figure 1). El Nino, which occurred roughly every 4 years during the last 20 years period, highly affects these farming systems. This region being protected from the influence of North West monsoon, drought intensifies during November-December in El Nino event, and may continue for several months as illustrated by Figure 2.

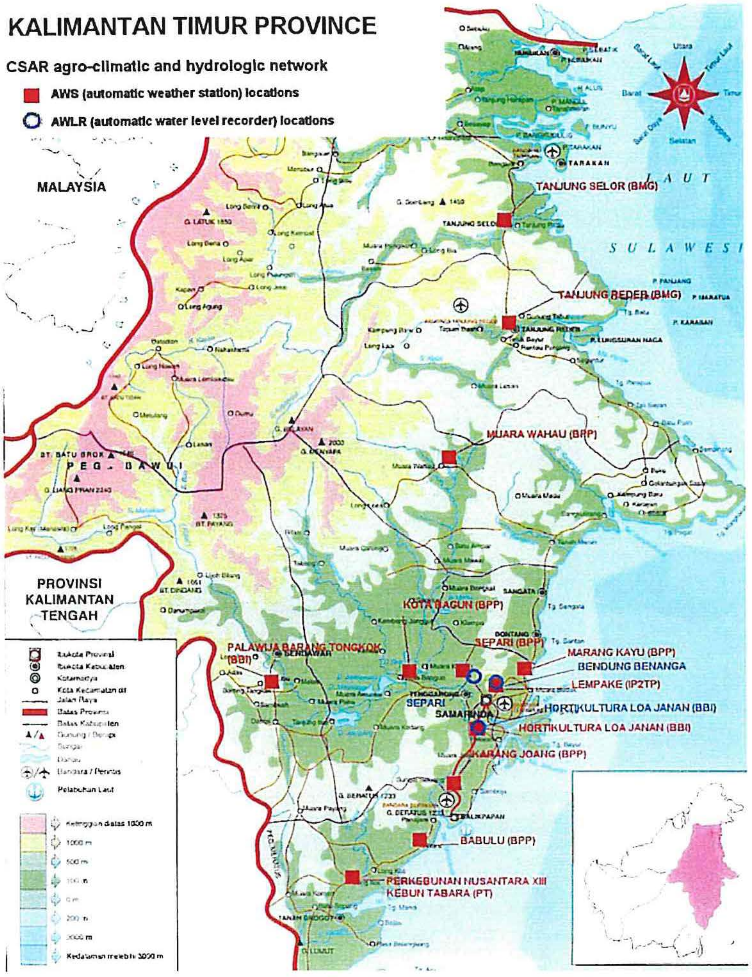
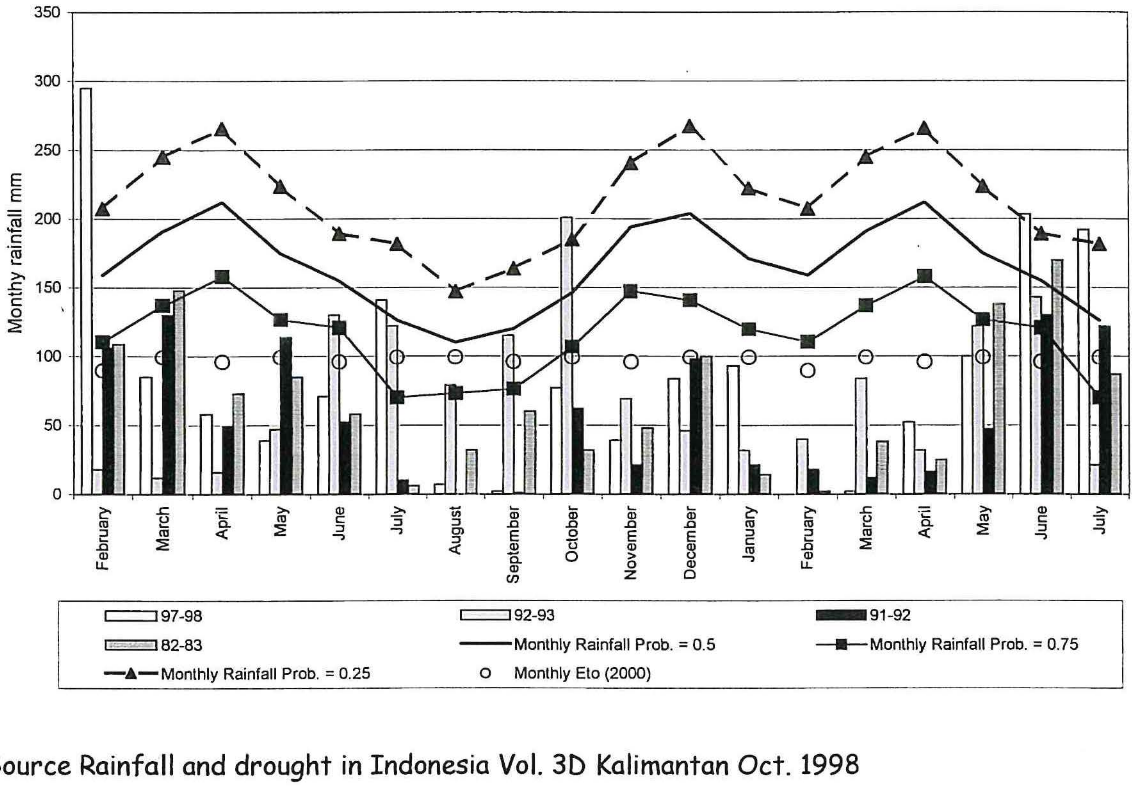


Figure 1: Map of Kalimantan Timor



Source Rainfall and drought in Indonesia Vol. 3D Kalimantan Oct. 1998

Figure 2: Comparison between mean monthly rainfall and data registered during El Nino events.

3.2. Soils and vegetation

Near the sea shore and in the low valleys, acid sulphate soils dominate with a total area of 63 000 km2 according to the 1985 soil map of Kalimantan Timor made by CSAR. The main vegetation consist in reeds or mangrove species. The same map classify most soils on the hills as Tropodults Dystropepts (USDA classification): 113 000 km2.

However, major agronomic differences exist within this same soil unit, especially regarding the kind of substratum (schistes or sand stone) and consequently the texture. Fields observations made during the mission clearly showed that for agronomic purposes, one must distinguished between the clayey soils (developed on schistes, very sensitive to compaction) and the more sandy soils (developed on sand stone). One must also pay attention to the vegetation cover, as soils under fallow (young trees and shrubs) have a much higher porosity than those under Imperata cylindrica.

An amazing characteristic of soils and vegetation in the whole area is their very degraded status, considering the very low population density. Soil and vegetation degradation can be attributed to repetitive fires (cf pictures in appendix).

3.3. Population and economy

With a total population of 2 330 000 inh. for 211 440 km2, Kalimantan Timur has a very low average density of 11 inh./km2 (source: Kalimantan Timor Agricultural services Annual report, 1998). But density is unevenly distributed, with average district density varying from less than 3 to 630 inh./km2.

3.4. Agriculture (from Lidon and Lopez, 2002)

Drought affects both cropping cycles and causes, its impact is especially high on rainfed crops and causes huge drops in yields as well as in harvested surfaces. As example, Table 1 illustrates the effect of 1997-1998 drought on Kutai Kabupaten area and points out its impact on the main rainfed crop which is rice; mean yield losses reached 80% and harvested surface decreased in 40%.

Area harvested		Irrigated Rice	Rainfed Rice	Maize	Soya bean	Ground-nut	Beans	Cassava	Sweet potatoes	Total
Under normal conditions	Ha	32700	45504	6806	2607.25	1970	927.75	5370	1967.5	97850.9
	%	33%	47%	7%	3%	2%	1%	5%	2%	100%
Under El Nino conditions	Ha	30691	30098	4950	1350	1245	610	3965	1230	74139
Loss of harvested area	%	6%	34%	27%	48%	37%	34%	26%	37%	24%

Average yield		Irrigated Rice	Rainfed Rice	Maize	Soya bean	Ground-nut	Beans	Cassava	Sweet potatoes
Under normal conditions	T/Ha	2.53	2.05	0.99	1.06	0.98	0.82	12.66	8.46
Under El Nino conditions	T/Ha	2.24	0.42	0.82	0.80	0.83	0.67	9.85	7.58
Loss of yield	%	11%	79%	17%	24%	15%	19%	22%	10%

Source: Dinas Pertanian 1999 Samarinda

Table 1 : Comparison between mean harvested area and yield during normal conditions and those registered during El Nino event (1997-1998).

Such situation has to be related to the low capacity of the plants to use rainfall water resources. Field surveys, implemented by P2SUKA project, pointed out the weak development of the rooting system (10-20 cm). Such conditions induce a small water buffer capacity of the soil depth used by the rooting system. It increases the dependence of crop water supply upon rainfall distribution and therefore, even low drought events may produce crop water stress.

Such condition is not specific to this region and is a general characteristic of equatorial and sub equatorial areas, which were previously forested (Amazonia region in Brazil for example), main constraint which has to be solve to intensify cropping system in equatorial climatic conditions. Experiments carried out by CIRAD in Brazil show that the development of farming systems through agro-ecological approach is the most likely to improve soil biology and to minimise the effect of the climatic risks while increasing yields.

4. What agro-ecology could bring to Kalimantan Timur

4.1. Lowlands

In the lowlands, with poor (or no) water control, direct seeding techniques could be used to improve water use efficiency (mulching is known for buffering soil temperature and reducing evaporation) and reduce the impact of dry periods on yield (fields observed during the mission, after 20 days without any rain, clearly showed a strong negative impact of drought on plant growth). Simple mulching can be tested rapidly, in fields with no risk of flood occurrence during the cropping period (a flood during the cropping period would move the mulch which would be extremely harmful to young crops).

In the lowlands paddy fields, tests of improved genetic material also can be proposed, with introduction of Brazilian varieties with mixed characteristics (crossing japonica x indica). These varieties are adapted to both irrigated and upland conditions. They seem to have a high potential for these lowland conditions, with poor water control leading to periods of submersion followed by dry periods.

4.2. Uplands

In the uplands, apart from perennial crops plantations (trees for wood and pepper mainly) which cover rather small areas, cultivation is limited to the traditional slash-and-burn system, also at a very small scale. At these low population density (less than 10 inhab. /km2), slash-and-burn systems are sustainable. But they are extremely extensive, with a very low productivity of land (and labour). These uplands, which represents huge areas, are therefore under-exploited. It's where direct seeding techniques have a very high potential (as shown in the Brazilian Cerrados, with similar soil and climate conditions) and can bring a large range of solutions for land reclamation and sustainable cultivation. These techniques could be adapted to the various bio-physical (on clay soils or on sandy soils, on fallow/young forest or on Imperata cylindrica), with various levels of inputs and intensification, and to various target groups (for small farmers or big land owners).

From this very short mission (3 days in Kalimantan Timor only), it is difficult to design a detailed research programme. However, some guidelines and some major research topics and situations can be proposed to target further research.

- Reclamation of land covered by Imperata cylindrica:

Imperata cylindrica covers 35 millions ha in the world, usually on poor soil with rather low organic matter content. It is a grass often linked to human activity: repetitive burning, in particular, favours its development. Chemical control only is difficult, as it will restart from its rhizomes. However, it does not tolerate shadow and is less competitive when organic matter increases. Direct seeding techniques can therefore be adapted to reclamation of land covered by Imperata cylindrica: Basically, Imperata is treated with herbicide (glyphosate, 3l/ha), then a cover crop is installed directly in Imperata mulch: Mucuna sp. or Brachiaria sp. for instance can then control Imperata re-growth, mainly by covering it (shadow effect). In the medium term, direct seeding techniques also help reduction of Imperata by increasing organic matter content in the soil.
The cover crop can then either be used for cultivation, or as forage for animal feeding.

- Reclamation of fallow/bush/young forest: Slash-and-cover and direct seeding as alternative to slash-and-burn

The Brazilian technique of forest reclamation without burning (slash-and-cover) seems to be adaptable to Kalimantan Timor's conditions. It consists in slashing the forest, pruning the main trees, and then directly broadcasting or planting Mucuna sp. seeds. Mucuna will develop and cover branches and leaves on the soil, favouring their decomposition. The following rainy season, crops can be planted directly, in Mucuna mulch, and on a well structured soil, with a high organic matter content. This technique allows to benefit as much as possible from the positive effect the forest had on soil regeneration, without loosing organic matter or nitrogen (which are lost by burning and volatilisation when burning).

- Possible productions:

On soils covered by forest or bushes, with a rather good structure (especially on sandy soils), cultivation of various crops (rice, maize, soybean, etc.) is possible directly. Crops rotations and cultivation of cover crops (to prevent erosion, regenerate soil structure and increase organic matter content) will be needed.

On compacted soil, most of the time under Imperata cover, and especially on clay soils, the first step will be to improve soil structure, by cultivation of a cover crop with strong root system, able to penetrate and improve the soil structure. As most species used as cover crops also can be used as forages (e.g. Brachiaria sp., Panicum maximum, Stylosanthes guyanensis, etc.), this give opportunities for development of animal rearing (cattle especially).
Association with trees (fruit trees, coffee, etc) also is possible, in agro-forestry systems.

These only are some possibilities, which already can be proposed. Other possibilities also can be identified during the diagnostic phase, and during all the research process.
Various research programmes can be planned, according to the priorities, which still have to be set up. Also, information on present cropping systems is lacking and would be necessary to better identify and target such a research programme. A longer mission also is recommended, as it would largely contribute to rapidly propose and prepare an ambitious research and development programme.

5. Questions to be answered when preparing a project for Kalimantan Timur

5.1. What are the existing cropping and farming systems?

Almost no information on present cropping and farming systems is available at the moment. Such information is needed to properly target and design a research programme. A classical diagnosis can be made in 2002, with the technical assistance from Dr. Jean -Marie Lopez.
This study should provide useful information needed for decision making. Basically, the result of this study should provide knowledge on 4 Ws: "Who's doing What, Where and When?", and how they do it. Agronomic performance of these systems also should be assessed.

5.2. Where should we work?

Although direct sowing techniques can be used to improve crop production in the lowlands (especially through better water use efficiency and reduction of drought effects), it is recommended to focus most of the research programme on uplands, where very significant results can be achieved, on large areas. On these rather degraded soils, direct seeding techniques can rapidly regenerate soils and restore fertility, thus allowing sustainable upland cultivation, for food crops and forages. It is on these highlands that direct seeding techniques can provide the most significant results, rapidly. In order to better prepare a research and development programme, it is advisable to conduct rapidly a reconnaissance survey to produce morpho-pedological maps of the concerned region, with identification of main landscape units and their respective areas. These maps will be used to identify sites representative of the major soils and landscape conditions where experimental units can be created in a future programme.

5.3. With and for whom should we work?

The research programme can be targeted either towards small scale farming, with limited inputs and means, and/or towards development of large scale, intensive farming (as developed in Brazil). Of course, yields will be higher and extension to wide areas will be faster when capital and means are available. This particularly holds true in this province with rather low population density, where manpower availability probably will be a limiting factor: in such situation, introduction of mechanisation is an important factor to consider.

Here, a choice has to be made by Indonesia regarding the main priority. The research programme will have to be adapted to the main objective: it will address small scale farming, with limited inputs and investments if the aim is to improve local farmers' life. It will focus on intensive, mechanised agriculture if it is to rapidly reclaim land and develop upland cultivation to increase national production.

6. Programme of activities

In order to answer these questions, to test the feasibility of developing direct seeding techniques in Kalimantan Timor and to prepare an ambitious project, a simple research programme can be propose for 2002:

6.1. Seeds multiplication

Twelve upland rice varieties adapted to both irrigated and rainfed conditions (crossing between japonica and indica, from Brazil) have been introduced (see appendix 1.). They can be multiplicated rapidly, from March 2002 (see appendix 2.).
Cover crop/forages also can be multiplicated rapidly, either by seeds or by cuttings. In addition to Brachiaria ruziziensis and brizantha, to the four Eleusine coracana varieties and to mucuna sp. provided during the mission, seeds of Stylosanthes guyanensis (cv. CIAT 184 imperatively, other cv. being sensitive to fungal disease under such climate), Panicum maximum (TS 58 if possible), Brachiaria decumbens and cuttings of Arachis Pintoi (cv. Amarillo), Bana grass and Elephant grass have to be collected and multiplicated (see appendix 3. for technical advice).

6.2. Analysis of cropping and farming systems

In May and June, site selection can be made from regional secondary data. Land tenure, soil characteristics, climate (especially flooding risks for the lowlands, and drought risks for uplands), farming systems will be rapidly studied. After selection of study sites, agronomic practices and existing cropping systems will be surveyed. Training to survey practices and design of questionnaires will be made by BPTP staff assisted by Dr. Lopez in one village, and then replicated in other villages by BPTP staff alone, in August and September2002. Examples of questionnaires for interviews (from Vietnam) have been provided to Dr. Lopez, for adaptation to local situation.

6.3. Demonstration plots

To sensitise BPTP staff and farmers, and to start rapidly to assess the potential of direct seeding techniques for Kalimantan Timor, a few demonstration plots and simple tests already can be implemented (if funds are available). Choice of the exact location of these tests will be based on the results of the preliminary study. Site selection will be made in order to cover the major agricultural situations (lowlands and uplands with various soil type and preceding vegetation) and farmers types.

6.3.1. Lowland

* Rice: In lowland, a simple test of Brazilian rice varieties can be made. These varieties may have very interesting characteristics for these lowlands, cultivated as irrigated paddy fields, but in which dry periods occur as water control is not insured.
This test can be made in the traditional system, during next cropping season (starting June 2002), with farmers' cropping technique.

* Maize: Mulching

The objective for this first test/demonstration is to show the interest of mulching. Once they are convinced of the interest of this mulch, various techniques for faster and better installation of the mulch can be tested with farmers. For this first tests, having no expertise of direct seeding, it is recommended to keep cropping practices as close as possible from traditional farmers' habit. Land preparation and sowing will be conducted according to farmers' practice. After two to three weeks, when maize plants are tall enough, mulch will be simply cut from surrounding areas and added to the fields (of course, without covering maize plant with mulch!). Ideally, 7 to 10 t/ha of dry matter (equivalent to 35 to 50 t/ha fresh material) have to be applied. To ease mulch installation, maize has to be planted in rows, but sowing density can be decided by farmers.

6.3.2. Upland

- Forages tests. From March, various forage species can be tested. The same species and varieties as indicated in §6.1. (for multiplication) can already be tested with farmers, these fields being used as demonstration and multiplication plots at the same time. Appendix 3.

gives information for installation of forages according to field conditions and species.

- Slash and cover. If available means allow it, the Brazilian technique of slash-and-cover for forested land reclamation (described above) can be tested. Planting density for Mucuna, according to seeds availability, can vary from 40x40cm (1 to 2 grains per pods) to 1m x 1m.

6.3.3. Monitoring

For all these tests and demonstrations, basic data will be monitored:

Field characteristics will be simply assessed: soil type, history of the field, preceding vegetation, etc. If funds are available, soil analysis can be made for a few samples, in order to broadly assess soil fertility.
Of course, weather condition will be monitored (rainfall, flood occurrence, etc.).
All the cropping practices (land preparation if any, sowing method and density, fertilisation, etc.) also will be monitored.

Plants development also can be studied, according to available means:

- Simple monitoring of phenological stages (especially flowering date) should be done
- Simple measurement of crop production: weight of grains, and weight of straw are to be measured. If means are available, yields components (especially tillering and percentage of empty grains) can be measured (methods for yield components measurement and monitoring sheat have been provided as example)
- For forages, aerial biomass should be measured (regularly before cutting if used as forage, or at the end of the rainy season if not exploited). If possible, observation and measurement of root development can be done.

If funds are not sufficient to implement these tests and demonstrations at various location, set up and monitoring of these plots can be done nearby the present research stations, which will reduce the cost and considerably ease the monitoring.

7. Conclusions

Direct seeding technique certainly have a very high potential for development in Kalimantan Timor, especially for the uplands. They can propose sustainable and profitable alternatives to slash-and-burn systems, and give means to reclaim large areas of uncultivated land, either under Imperata grass or young forest. Upland rice, maize, soybean, and cattle raising are amongst the main possible productions.

However, adapting these techniques to local conditions require development of a sound research programme, and clear definition of objectives and priorities.

The objectives of the studies proposed in this report are to assess the potential of these techniques, to sensitise local farmers, extension agents and authorities to these new practices, and to prepare the development of a comprehensive research programme, by studying the present practices and by starting multiplication of the vegetal material which will be needed in the future.
However, the activities proposed for 2002 are very limited (as funds are not available) and will not, in any case, be sufficient to adapt direct seeding techniques to the local situation. This will require human and financial resources which are not, for the moment, available.

A conjunction of various factors make that it would be interesting to speed up the process and rapidly gather the necessary means to conduct a research and development programme:

- the high potential of these techniques for the concern area,
- the expertise of Cirad and its Brazilian partners for similar conditions (Brazilian Cerrados): a simple adaptive research work is needed to propose a large panel of technically and economically efficient, sustainable systems.
- the huge challenge to be faced: largely contributing to increase the national food production and thus reducing importation, reclamation of uncultivated land and participation to population settlement, etc.
- the demand from local and national authorities
- the quality and the motivation of the possible partners (BPTP) in Kalimantan Timur

It is therefore recommended to rapidly perform:

- a mission to produce morpho-pedological maps of the area (absolutely necessary to properly identify the main research situation to be considered)
- a feasibility study to properly identify and design an ambitious research and development programme (priority set up, identification of partners and sites, means , etc.)

APPENDIX

1. PICTURES

Picture 1: Degraded forest, typical vegetation in Kalimantan Timor

Picture 2: Imperata cylindrica and support prepared for pepper plantation

Picture 3: Traditional upland rice field

Picture 4: Maize field in the lowland

Picture 5: Nice lowland rice field, with good irrigation control

Picture 6: Bad lowland rice field, with poor water control

2. LIST OF INTRODUCED GENETIC MATERIAL

Although they already have been treated with insecticide (Pirigrain), please, treat again those seeds with product such as Deltamethrine for instance.

Rice (Brazilian collection, to be renamed):
200 g x 14 varieties

YM 65; YM 94; YM 101; YM 198; YM 200; BSL 47-12; BSL2000; 8FA 67-5; 8FA281-2; 8FA 330-2; 8FA 337-1; GIFA 33; GIFA 36; CIRAD 141.

All these varieties are short or medium cycle varieties (90 to 110 days in northern Vietnam conditions)

Eleusine Coracana (Brazilian collection):
200 g x 4 varieties

PG 5323; PG 5333; PG 5352; PG 5348

Brachiaria ruziziensis: 1.5 kg (be careful, risk of low germination rate)

Brachiaria brizantha (be careful, high risk of low germination on these seeds):

CIAT 16835 (500 g x 2)
CIAT 6780 (1 kg)

3. SEEDS MULTIPLICATION

For seeds multiplication, especially rice, optimum conditions should be sought: paddy field with best possible water control, sufficient mineral (for instance 100 N applied in two or three times, at sowing, tillering and panicle initiation; 60 P2O5 as thermophosphate, applied at sowing; and 50 K2O, in two times, at tillering and panicle initiation) and organic (3 to 5 t/ha farm manure before sowing) fertilisation.

As very limited amount of seeds are available for this first cycle, transplanting (if it is farmers' practice) or sowing in rows should be done with a wide spacing (30 to 40 cm between pods or 50 cm between rows), in order to optimise production per planted grain (and not production per land unit).

Protection against rats and birds (especially at sowing and after flowering), and against insects (pesticide spraying in case of attacks by insects) have to be prepared in advance.

4. INSTALLATION OF FORAGES

4.1. Seeds

- On Imperata cylindrica

To install the various forage species for which seeds are available, on Imperata cylindrica vegetation, apply 3 l/ha glyphosate (warning: apply early in the morning, when temperature is not to high, and make sure water pH used for spraying is at pH around 4 . If need be, add sulfuric acid in the sprayer to reach such pH level, as glyphosate efficiency decreases when pH increases. Also apply on vegetation before flowering, when vegetative development is high). Imperata will die in 7 to 10 days. Make sure the herbicide actually had an effect on Imperata (if need be, spray a second time).
Then directly plant forage seeds in pods, by just opening a hole in the mulch made of Imperata straws. For all the grasses, plant at density varying between 30x30 cm and 50 x 50 cm, according to seeds availability (knowing that the higher the density, the faster the covering of soil by the grass and the better control of Imperata re-growth by shadowing). For legumes (Arachis pintoi and Stylosanthes guyanensis, plant at higher density as they are slow to establish (20 x 20 to 30 x 30 cm).

For Arachis pintoi, use 1 to 2 grains per pod. For Stylosanthes guyanensis, use 4 to 6 grains per pod.
For grasses, as the seeds provided may have a very low germination rate, please proceed to germination test in advance and adjust the density, or plant at very high density: 15 to 25 grains/pod.
In case Imperata mulch is very thick, and weather very humid, it is recommended to treat the seeds against fungi. It also is recommended to treat them against insects to limit the risks of damage. Products such as Thiram, Thiabendazole, Fipronil can be used, according to availability in Indonesia.

- On young forest/bushes

To test forages on young forest, bushes, clearing and land preparation can be made according to usual farmers' practices for this first year of test.
Sowing densities can be the same as indicates above.

4.2. Cuttings

It is possible to multiplicate all these forages species by cuttings.
Most of them produce aerial roots, which ease the use of cutting for multiplication.
In all cases, cut stems including three nodes at least.
After soil preparation, locate two nodes in the soil, and one above the soil. Press slightly with the feet to create contact between soil and the covered nodes.

To increase survival rate, cuttings can be dip in a solution mixing: 1/3 of clay, 1/3 of water and 1/3 of cow manure. Micro-nutrients also can be added to this solution.