MANAGEMENT OF *IMPERATA CYLINDRICA* IN SMALLHOLDER FARMING SYSTEMS. COMPREHENSIVE NOTES OF VISITS TO INDONESIA, JANUARY - FEBRUARY 1993

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ARI Project F0028

John Terry, Helen Fortune-Hopkins, Hugh Bagnall-Oakeley and Richard Morgan

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BACKGROUND

1. This is a comprehensive record of the visit to the Rubber Research Institute (RRI) Sembawa which has been summarized in previously submitted back to office file notes by the staff concerned. It places on record an account of the places and individuals visited and describes the work programme for the Indonesian and UK-based staff of the Project.

2. This project is funded under the NRED Adaptive Research Initiative (ARI) and commenced on 1 November 1992. The Project is based at the Rubber Research Institute Sembawa, near Palembang in South Sumatra, one of five research stations within the newly formed Rubber Research Institute of Indonesia.

3. *Imperata* is a serious perennial grass weed and has been the subject of an ODA/NRI Project (R.3703/X0116) on its biology and management in Indonesia during 1982-91 (Terry, 1992). This ARI Project aims to transfer technology developed for the control of *Imperata* to smallholder farmers in Indonesia.

Objectives of the Project

4. To improve the management of *Imperata* and other weeds by adapting existing control methods to the needs of smallholder farmers in Indonesia. The programme will include on-farm trials to study:

- the efficacy of *Imperata* control methods at the smallholder level;
- the costs and benefits to farmers of adopting recommended practices;
- the social, economic and other factors which affect the adoption of effective control strategies.

5. Outputs of the Project will include a field manual and extension literature on *Imperata* management which offer farmer-tested control strategies. A regional workshop on *Imperata* will be held in 1994-95.

Current status of the Project

6. This Project, in common with some other ARI Projects, was prepared without adequate consultation with the participating institution in the host country before the framework and budget had been approved by NRED. This has presented no serious problems in defining the research objectives and the work programme but essential administrative procedures have been delayed. A request for approval of the Project has been submitted to BAPPENAS by the British Embassy and IPARD on behalf of RRI Sembawa. No problems are anticipated in securing BAPPENAS approval.

7. Mr Bagnall-Oakeley cannot work in Indonesia until approval has been given by the Cabinet Secretariat. This takes about two months after BAPPENAS approves the Project. Therefore, it is likely to be September at the earliest before Mr Bagnall-Oakeley can commence work at Sembawa.

8. Staff inputs to the Project are proceeding as planned, i.e. visits and time spent by the UK experts will meet targets for the current financial year. Short-term visits will go ahead as planned during next financial year but Mr Bagnall-Oakeley will not be in post. Indonesian staff time and travel will be committed as planned.

9. The Project research programme will start in April 1993. This will be done by the Indonesian staff with support from UK staff (a socio-economist and a weed scientist) through short-term visits and backstopping work at NRI and LARS.

10. Capital equipment for the Project, primarily two vehicles, will not be purchased until the Project has been approved by the GoI.

11. Project accounts will be managed so as to permit the delayed purchase of inputs.

Project staff

12. The Indonesian and UK staff on the project are listed below, together with their affiliations, specializations and time inputs per year to the Project:

- Agus Gozali, RRI, Extension Specialist, 6 months;
- Chairil Anwar, RRI, Socio-economist, 6 months;
- Heru Suryaningtyas, RRI, Weed Scientist, none but providing advice;
- L Hugh Bagnall-Oakeley, NRI, Agronomist, 10 operational months (om);

- Helen C Fortune-Hopkins, NRI, Plant Ecologist, 18 days (1993 only);
- Morag E Webb, NRI, Weed Scientist, 1 om;
- Richard J Morgan, NRI, Socio/Agro-economist, 2 om;
- To be identified, NRI, Extension Specialist, 2 om (last two years only);
- P John Terry, LARS, Weed Scientist and Project Coordinator; 1 om.

Objectives of the current visit

13. Visit Indonesia in order to:

- finalise the Project Memorandum prior to its submission to the Bureau of Planning (BAPPENAS) (PJT);
- identify a local organization to provide administrative support (procurement of visas, etc.) (PJT);
- coordinate activities of three NRI experts and Indonesian counterparts (PJT);
- purchase equipment for the Project (PJT, LHBO);
- devise a work programme in consultation with the UK and Indonesian staff (All);
- assess and report on the potential ecological impact of improved control of *Imperata cylindrica* in smallholder systems in South Sumatra, both the direct consequences of the use of glyphosate, and the indirect consequences of weed control in the overall farming system (HCFH);
- plan activities of the Project so that any ecological benefits or costs of *Imperata* control are considered (HCFH);
- make a preliminary assessment of the socio-economic constraints to adoption by farmers of weed control technologies, with particular reference to smallholder rubber cropping systems in South Sumatra, and with emphasis on *Imperata cylindrica*, a major weed of perceived economic importance (RJM);
- identify previous and current research programmes in related fields of study at RIEC (RRI) Sembawa and draw on this experience while establishing and strengthening inter-disciplinary linkages (RJM);
- identify previous and current project initiatives in smallholder rubber development funded by Government and external donors and, where possible, develop links with the ARI *Imperata* Project (RJM);

- supervise PhD student, Heru Suryaningtyas, who is registered for an degree with the University of Bristol (PJT).

ADMINISTRATIVE SUPPORT

14. It has been usual in the past for the British Embassy to provide full administrative support to ODA projects in Indonesia. This is no longer being done, so the possibility of other organizations doing this work was investigated.

15. Two organizations were visited, The British Council and INI ANSREDEF, and considered for their capacity to provide the services required, including the procurement of visas, duty free purchases, customs clearance, vehicle licensing, medical evacuation, language training and diplomatic bag facilities.

16. INI ANSREDEF (Indonesian International Animal Science Research and Development Foundation), a private company based in Bogor, quoted a fee of Rp 1,375,000 (ca. £460) per year to process passport and visa renewals and clearing personal effects through customs, excluding actual costs of visas and agents' fees.

17. The British Council said that it could provide administrative support for the Project under an umbrella agreement with ODA to service their on-stream projects in Indonesia. There could be no cost if work done for ODA by the BC does not exceed an agreed monthly maximum, otherwise unspecified charges would be made. It is unlikely that the cost to the Project would be exorbitant.

18. It is recommended that the BC be formally invited to provide administrative support to the Project in Indonesia.

VISITS

19. The UK experts, as a team or as individuals accompanied by their Indonesian colleagues, visited several field sites and offices to acquire information relevant to planning the Project research.

Plajau Pangkalan Balai

20. The site is located 20 km west of Sembawa. The objective of the visit was to see an Indonesian Government/World Bank smallholder project. The sites visited included the project management unit (PMU) office, a group planting area, a secondary forest clearing and an area of mixed *Imperata* scrub prior to any clearance efforts.

21. The initial call at the office formed an introduction to the smallholder rubber project (SRDP). The basic project components are as follows:

- The PMU was initiated in 1980 and has proceeded in three stages to 1992. To date 3,099 ha have been planted with the involvement of 2,963 farmers grouped together in blocks of 20 ha.

- Loans are made available for the clearance, planting and maintenance of improved planting material. The scheme operates in three steps; (i) establishment during months 0-36, (ii) conversion in months 37-84 and (iii) credit repayment in months 84-240.

- Credit is available in the first 72 months at varying rates of interest depending on the year in which the farmer joined the scheme. Three fixed rates were quoted at 6, 12 and 22%.

- Credit includes cash payment for work force, planting material, cover crops, lining and inputs such as fertiliser and herbicide. Cash and inputs are delivered through farmer groups with a maximum available of Rp 2.5 million (US $ 1,200) over a 20-year period.

22. In South Sumatra as a whole, 27,000 ha of improved rubber has been established in this way. Another programme (TGSTP) has covered an additional 14,000 ha. The latter differs in that a grant is made available for initial costs with subsequent credits covering further costs. The major difference is the lack of a credit-free period on the loan requiring immediate re-payment.

23. Funding for STDP/TGSTP comes from the Government of Indonesia and the World Bank. A very rough estimate of the cost can be put at 42,000 ha x US$ 1000/ha = US$ 42m over the twelve years.

24. The project also provides extension advice to local groups although the ratio of farmers to extension staff is high at 350 to 1.

25. The second site to be visited was a block of clonal rubber planted under the scheme consisting of approximately 20 ha tended by as many farmers. The stand was between 4-5 years old and appeared to be uniform in canopy development and girth width. Some weeds were present, including the occasional patch of *Imperata* but generally the ground was free from weed competition. The land had been cleared from secondary forest and had followed the traditional sequence of cropping post felling. This usually consists of two crops of upland rice intercropped with the rubber in the second year. After this, other intercrops such as bananas, pineapples and groundnuts are grown until the canopy closes or diminished soil fertility prevents further cropping.

25. In this block, weeds had been controlled with a herbicide (glyphosate) obtained via the project. However, precise quantities were not available at this stage so an economic analysis is not possible. Given that the area was cleared from secondary forest, re-emergent weeds would not normally be a serious problem. Provided that weeds are controlled (either by hand or by chemical) in the critical period after the two crops of rice have been taken and before the rubber canopy closes, then competition should not be significant. Due to the availability of credit for the purchase of herbicide, *Imperata* had been successfully controlled.

27. It looked as though the stand would be harvestable in year 6 which would

coincide well with the loan repayment schedule.

28. The SRDP scheme has proved successful for the farmers who have been involved in the programme. Due to the cost, this has been limited to between 10 and 15 % of existing smallholders. Subsequent initiatives have been designed to build on the success of the SRDP projects but in a less capital intensive way. Up to a point this relies on the transmission of techniques and information from informed farmer to farmer. In areas close to SRDP projects this transmission has taken place and there is demand for the necessary inputs to improve production.

29. The third site visited illustrates this approach. This was an isolated area of cleared secondary forest. Unfortunately the farmer was not present so detailed questioning could not be undertaken. However, it provided an example of the more recent PMU approach to farmer assistance, i.e. the "self help" scheme. This was targeted at middle income farmers (Rps 1,000,000 per year). The main difference was that the available credit was much reduced, only providing the farmer with root stock and budwood material with which to bud his own planting material. Thirty six farmers on 58 ha were operating this scheme in the PMU area.

30. The clearing was estimated to be approximately 2 ha, divided into two cropping areas. The perimeter was fenced as protection against vertebrate pests which are a particular problem in more densely populated areas where food crops are also grown. One section was more recently planted and consisted of first planting of upland rice interplanted with rubber and bananas. The second area was in the third year after clearing and consisted of budded rubber interplanted with bananas. The ground was clean weeded and showed signs of runoff erosion. Again weeds would not normally be expected to be a problem here for another year or so until the inter- cropping activities had ceased. The planted material looked in good condition and free from pest and disease damage, the fence obviously doing the required job.

31. The fourth site visited was a 6 ha block containing a mixture of scrub, bush and sheet *Imperata*. The farmer was present and described his wish too clear the land and plant a rubber crop. He hoped to do this with the assistance of the local PMU office who would provide advice and possibly planting material. This farmer was termed "Rich" (estimated income over Rps 2,000,000 per year). He owned the 6 ha of land and also gained an income as a school teacher in the local village. The mixture of vegetation had regrown after the previous secondary forest had been destroyed by fire. This type of regrowth represents one of the most difficult vegetation types from which to establish a tree stand. However, the farmer remained optimistic and intended to employ labourers to slash and burn the area, spray the regrowth with glyphosate, crop two seasons of rice and establish a clonal stand of rubber, i.e. the recommended SRDP practice. This again illustrated the transmission of technology and ideas outside the project participants.

32. The future PMU initiatives will concentrate on this type of farmer, i.e. individuals who have access to credit and are willing to risk this in the necessary investments to improve the productivity of their holdings. This being the case, the

chances of success should be reasonably high. However, it is hard to say what percentage of the total number of farmers this represents and what the implications are for the poorer farmers. Potentially, the rate of holding differentiation will increase and the poorer farmers will have look for occupations elsewhere.

33. The fifth site visited was a rubber smallholders' processing station. With project assistance a farmer group had established processing facilities with two objectives in mind. Firstly, by shortening the marketing chain, farmers were able to increase their percentage of the FOB price from 65-75%. Secondly, by controlling the coagulation and rolling process, the level of contamination is much reduced. This has the benefit of a price premium and in the broader sense improving the quality of Indonesian rubber on the world market which has been questioned recently. The mill (or mini creper) was simple and cheap in it construction, the power coming from a converted truck engine and the rollers from a local factory. Two other points that emerged from the site were that the surrounding rubber trees on the whole looked seriously over exploited with high levels of bark consumption and in some cases premature abandonment of the plantation. It is difficult to say if this was due to the incentives of higher returns from the mill. Another point is that there was pollution of the water course close to the factory. This is inevitable to some extent and will have to be accepted if more such mills are to be encouraged. One of the stated reasons for developing such smaller scale processing units was to dilute and disperse the pollution problem which is getting worse in Palembang.

Sugih Waras

34. This area was started as a transmigration project in 1982 but after ten years it was no longer administered by the government. Our visit was to see a farmer participating in the ARM Project - Phase 1 in which farmers prepare rubber planting material themselves. A budwood nursery of 0.05 ha produces material for the 0.25 ha of rootstock nursery.

35. The collaborating farmer was far from typical. He had increased his original 2 ha land allocation and he was now the owner of 29 cattle which he fattened and sold at a handsome profit. He claimed to be selling 10-15 cows per month at a profit of Rp 25,000 per cow, i.e. an income of Rp 250,000 - 375,000 (£83-124) per month. His wife had an income as a trader in the local market. He actually grazed the cattle on young *Imperata* and did not believe this weed was a problem: he established rubber in two hectares of land in spite of the presence of *Imperata*. *Imperata* is controlled by cutting and grazing with some hoeing. The farmer did not grow food crops because wild pigs are a problem and, presumably, his other enterprise is more profitable.

36. A local extension officer confirmed that farmers prefer growing rubber to food crops but conceded that *Imperata* is the main problem during land preparation. Only 40% of farmers grow rice and complain that the state-controlled price for rice is too low. Many prefer to earn money as rubber tappers when they can earn Rp

5,000 (£1.65) per day.

37. A farmer with an *Imperata* problem said that he would need to sell one of his two cows to purchase Roundup and he was not prepared to do that.

38. We examined a farm with a healthy crop of almost mature rice growing among rubber. When the farmer arrived, he confirmed that he had cleared the *Imperata* with Roundup, waited five months and then planted rice and rubber. It was very successful and good evidence that farmers can use the recommended technology.

Batumarta

39. Batumarta is the site of a Transmigration Project and is situated near Baturaja which can be reached by a drive of about five hours from Sembawa.

40. RRI Sembawa has a sub-station at Batumarta where Mr Kastolani is officer-in-charge. The sub-station has three graduate and four non-graduate staff to support the research activities. The station has 200 ha of land, virtually all of it infested with *Imperata* after removal of the secondary forest. Field work is spread over two areas, 12 ha in Unit 2 near the sub-station, and 14 ha in Unit 12 which is over an hour's drive away. Both of these units were visited.

41. Activities in Unit 2 included a budwood nursery growing clone GT1 and a trial to study weed control in marginal land to study low input systems that are used by farmers.

42. Agus Gozali has a long-term trial to study the establishment of sustainable agriculture in *Imperata*-dominated land. Four farmers were part of the original study but 25 farmers have now copied the system devised by Agus. One participating farmer described the system being evaluated on his land: RRI Sembawa provided all the inputs in the first year (1989). The weeds, mostly *Imperata*, had been slashed down and sprayed with Roundup at 5 l/ha (glyphosate at 1.8 kg ae/ha), followed by spot spraying with a further one litre/ha. Rubber was planted together with maize in the interrow. The maize seed had been dressed with Furadan and the farmer applied farmyard manure, lime and urea. The maize stubble was left as a mulch and cowpea was sown. In the third year rice was grown. It was now the fourth year and the first without an intercrop. Some *Imperata* was present but this was slashed and placed in the tree row as compost. This particular farmer had expanded his land area to 7.5 ha of which 5.5 ha was rubber (3 ha tappable).

43. The farmer above was clearly pleased with the system and and it was evident that *Imperata* can be managed in smallholder farming systems. Roundup is readily available; it can be purchased in the local market for Rp 25,000 per litre (ca. £8.30) or Rp 19,000 per litre (£6.30) in Batumarta.

44. At Unit 12, a visit was made to a farm where demonstrations similar to the

above had been done but without using Roundup. Control of *Imperata* had been by hand cultivations with a cankel. Farmers in this area are obviously poorer than in Unit 2; household incomes of Rp 50,000 per month (ca. £16.70) are achieved in this unit compared with Rp 200,000 per month (ca. £67) in Unit 2. Glyphosate is beginning to be used in Unit 12 but little or no evidence of this was seen.

University of Sriwijaya (UNSRI) Biology Department

45. Mr Agus Purwoko, an environmental biologist at UNSRI, described their research in environmental assessment. There is a legal requirement for industrial companies such as Pertamina (the oil and petrol company) and the electricity generating company, hospitals and plantations, to be assessed from an environmental view point, and recommendations are then made to reduce the pollution they cause. Manpower for monitoring whether recommendations are being implemented is a problem. They do not monitor for pesticides at present.

46. Mr Purwoko has a particluar interest in water quality, and wetlands conservation. He is involved in conservation projects with the Asian Wetlands Bureau for migratory waders and the rare white-headed duck. Other projects are producing 'balance sheets' for South Sumatra, and considering cultural and socio-economic factors, as well as ecological ones.

47. Dr Sulpi Effendi Rahim, a specialist in land resource management and especially soil and water conservation, stressed: (a) the economic constraints likely for smallholder farmers in using pesticides and fertilizers, (b) the role that government pricing of rice plays in farmers' decisions about growing food crops, and (c) farmers' lack of knowledge about pesticides and their toxicity.

Department of Forests, Reforestation (Departemen Kehutanan)

48. The work of the department in reforestation and agroforestry projects in South Sumatra was discussed. These are on marginal land, often infested with *Imperata*. Land clearance is done mechanically and followed by ploughing and harrowing before planting. Agroforestry projects grow principally upland rice and peanuts as the main crops, with chilies, cassava, corn and vegetables. *Albizia*, *Acacia mangium* and *Eucalyptus deglupta* are the main tree species grown.

49. The JICA project in which he is involved has an trial plantation forest where 40 species of native and exotic trees are grown. They are experimenting with nursery techniques, land preparation methods, and planting and tending. Land preparation is again mechanical, and involving either complete or strip clearing. They have looked at soil loss following these methods, and are considering the use of herbicides for land clearance, but apparently these decisions do not rest with local forestry officials.

50. We discussed land use in South Sumatra using a map showing areas demarkated for forest reserves and conservation areas, plantations present and planned, transmigration areas, and concession forest for logging. However they

were unwilling to answer detailed questions about pressures on forest resources and referred me to the Provincial Forestry Office.

Transmigration Office

51. The aim of the visit was to clarify transmigration policy and to identify any areas of collaboration that could be of benefit to the Project. Mr Azis was the transmigration representative present.

52. Although areas of South Sumatra had been designated for future projects, there are no immediate plans to establish more settlements. Current emphasis is on the rehabilitation of abandoned and underutilised land that has become infested with *Imperata*. Estimates put the area infested at about 6,000 ha in South Sumatra alone.

53. These areas of abandoned land have arisen for two reasons. Firstly, when the land was cleared, an allocation of 2-4 ha per family was made. This is more than the farmers' resources will allow to be cultivated. As a result, *Imperata* invades and makes future planting difficult. The second reason is that areas designated for food crops have been abandoned because the returns have been to low to cover costs. Farmers have either moved into cash crops or sought work elsewhere, share tapping for example.

54. Mr Azis pointed out that there was a government policy regarding the areas planted to food and cash crops in order to maintain a degree of food security. This is hard to enforce in non-transmigration areas and will be difficult to maintain while the relative prices favour the substitution of food crops by cash crops. Despite this, there was to be a government-funded programme to clear the *Imperata* areas with glyphosate supplied to farmer groups.

55. While it was not possible to establish any specific links between this and the ODA/NRI Project, there is a possibility that links can be forged in the future, particularly with on-farm trials and data collection.

SRDP office

56. This visit was to clarify the aims and achievements of the Smallholder Rubber Development Project (SRDP). Most of the findings of the meeting have been included in the previous section on SRDP.

57. The opportunity was taken to provisionally establish areas of common interest, with particular reference to future projects and initiatives assisting the intensification of smallholder farming systems.

SOCIO-ECONOMIC PERCEPTIONS

58. The basis for the subsequent discussions will be the visits to Plajau Pankalang Bali, Sughi Waras, Batumarta, the Transmigration Office in Palembang

and the SRDP Office in Palembang. Information will also be drawn from discussions with Sembawa staff and papers in related fields of study.

The SRDP Programme

59. The essential details of the scheme have been outlined above so there is no reason to repeat them in any great detail here. In summary it can be said that the programme has been a success for those farmers that have been involved, i.e. productivity and incomes have increased. It should be borne in mind that 85% of smallholders remain outside the influence of SRDP and similar schemes.

60. The other main form of project assistance to farmers has been the nucleus estate scheme (NES). This has operated in transmigration areas and in close proximity to government estates. It has beeen regarded as less successful than SRDP for two main reasons: (a) it is twice as capital intensive, costing Rp 4m/ha due to higher infrastructure costs and (b) participants worked initially as labourers on areas of land that were eventually distributed randomly in a "ready to tap" state. This meant that the farmers had little connection with the trees that they tapped and, when this was combined with compulsory loan recovery through below market prices for latex, over tapping has lead to a shortened economic life of the plantations.

61. NES also suffered from not being integrated into the local communities. This resulted in poor transmission of improved planting material, technologies and knowledge to non-project farmers, even in close proximity to the plantations. It was against this background the SRDP was initiated. The scheme overcame the above constraints by utilising the farmers' own land and labour and operating at a group/community level. Also, for this reason, transmissions into the local community have been much greater. As a result of farmer to farmer contact, knowledge of and demand for improved technologies (by those that can afford them) is evident. This can be observed by the number of private nurseries that have appeared to meet the demand for improved planting material in the areas around SRDP Projects (Nancy and Gouyon.)

62. A major component of the SRDP programme was the provision of credit. The financing schedule was outlined earlier. This element has been crucial in the success of the scheme in that it has bridged the gap between establishment and maintenance, and the cash flow generated by the improved rubber crop five years later. Clonal planting material is more costly to establish and maintain than seedling types but this is overcome by the availability of credit and the future yield advantage.

63. Exact figures for loan recovery were not available although values of between 15 and 25% were quoted.

64. A second important point is the geographical and hence demographic location of the region. SRDP regions have been located in areas where there is an emergent, if not actual, land constraint on farmers. This concept of a land

constraint has important implications. Under traditional rubber farming systems, forest was cleared, two crops of rice were planted and the rubber established in the second year. The area was then abandoned only to be returned to for tapping twelve or so years later. Under this system, 10 ha of secondary forest per family was required for subsistence. This system continues today in the low population density areas of south Sumatra and Jambi. In fact, 85% of rubber in Southern Sumatra is a product of this system. This system works well provided that land is not a limiting factor. The investment required in establishing the rubber is effectively nil as the rice crop is grown any way. The seedlings are collected from the forest floor or from near the plantation for nothing and there is no maintenance. As a result the subsequent returns to labour are relatively high. In other words, while there is adequate land available and consumption needs can be met, there is little incentive to intensify. As a result, in these areas, there will be limited demand for intensive production technologies such as improved planting material, fertilisers and herbicides.

65. Where population pressure is increasing and holding size is reduced, incomes will fall unless productivity is raised. This is one of the main policy directives behind SRDP and its successors. Individual farmers' abilities to grasp and afford the technologies required for this intensification process will naturally differ, depending on circumstance.

66. From the Project's point of view (and this will be borne out in survey results) it will be important to identify these farmer circumstances and assess the level of technology or assistance that is appropriate with particular reference to weed control technique. A preliminary hypothesis at this stage might be that farmers with access to credit (formal or otherwise), necessary knowledge, improved planting material and those in areas of emerging land constraints would be the most likely to adopt the recommended weed control technologies. The survey and background research need to put these factors in perspective to target specific groups of farmers.

67. It should be re-emphasised that the farmer's perception of the weed problem and his/her preferred methods of control should be taken into account at all stages of the proceedings.

Transmigration Sites

68. The second and third sites visited were in the transmigration areas of Batu Mata and Sughi Waras. The socio-economic conditions and constraints were of a different nature in these regions.

69. The transmigration sites were initiated in this area in the early 80's. The process of establishment has continued up until the present. This has implications in as much as it means that different transmigration sites have reached very different stages of development depending on their date of initiation.

70. This aspect was borne out by the two visits, firstly Sughi Waras (established

in 1981). This site was initiated as a food crop production area. Blocks consisting of 500 families, each with 2-4 ha cropping area were established.

71. The two farmers interviewed showed how the holdings and farming systems had become differentiated. The first farmer, having increased his land holding to 8 ha, diversified into rubber cropping and grazing animals for beef. He was also a trader in cattle from the surrounding area. He was quite clearly by local standards a wealthy man. Via contact from Sembawa, the farmer was also in charge of the village rubber nursery for the production of improved planting material. He was making use of this for his own rubber plantings and for use by neighbourhood. One suspects that this farmer was far from typical but it illustrates how differentiated a once quite homogeneous area has become.

72. The second farmer had diversified into rubber cropping in similar fashion. What was interesting here was that he had established a crop of clonal rubber, inter-crpped with rice from and area of sheet *Imperata* following the recommended weed control techniques without any assistance in the form of extension or credit. This was proof indeed that technology transfer takes place between farmers and that those with the means are willing to make the investment.

73. The second transmigration area at Batu Mata was a rubber production project. Again, initiated in the early 80's, each family was provided with 2-4 ha of land. Typically this consisted of 2 ha of rubber, 0.75 ha of food crops and 0.25 ha of house/plot.

74. In the early stages, the Government PTP estates had established the tree crops. Subsequently, a variety of management and loan recovery schemes have been in operation. There is now a much greater degree of freedom in how farmers manage their plots as the original restrictions have lapsed. This has once again allowed a considerable degree of differentiation to take place in terms of holding size and employment choices (share tapping for example). The farmer interviewed here had also accumulated land (7 ha). He had also received schooling upto secondary level. This farmer had participated in a trial organized from Sembawa and so had also benefitted from extension advice. As a result, the rubber seen was of a very high standard. The area was weed free (maintained by manual means, i.e. employed casual labour) and the trees were vigorous with good canopy development. Once again, the land had been cleared form *Imperata* by spraying with glyphosate, demonstrating that the available technologies can and are used successfully in this type of farming system. In this case, the farmer had provided the materials and the capital and paid labour him self. One suspects that this farmer could be classified as being in the "rich" group and is perhaps in the minority.

75. This highlights the need for clearly defined policy goals in this subject area. Rich farmers with land and capital will use the available technology to improve output. Poor farmers are reliant on the Government and donors for the providing of knowledge and credit to make similar improvements. Schemes like SRDP and Transmigration have been successful for the farmers they have reached, although

this has been at a high cost and to only 10-15 % of the smallholder population. These schemes are now coming to an end with greater reliance being placed on self-help directed at the richer farmers.

76. This will have inevitable consequences for those farmers that do not have access to the basic requirements for intensification. They may well have to look at alternative areas of employment.

77. In summary, some basic divisions can be made:

- The areas visited fall into three main groups:
  - non-assisted smallholders
  - project-assisted small holders
  - Transmigration farmers
- Farmers may be roughly grouped into three income/wealth brackets:
  - poor, i.e. less than Rp 1,000,000/year
  - medium income, i.e. Rp 1-2,000,000/year
  - rich farmers, i.e. more than Rp 2,000,000/year.
- Farmers will be planting rubber on three vegetation types:
  - secondary forest
  - bush/*Imperata* grassland
  - existing rubber plantations

ECOLOGICAL IMPLICATIONS OF IMPROVED CONTROL OF *IMPERATA CYLINDRICA* IN SMALLHOLDER FARMING SYSTEMS IN SOUTH SUMATRA

Introduction

78. The Project will look primarily at the use of the herbicide glyphosate to control *Imperata* in smallholder farming systems, though other methods, including rolling (with a weighted drum) and planting of leguminous cover crops will also be used in on-farm trials.

79. The possible ecological consequences of improved weed control are of two sorts: (a) direct effects, especially those that could be caused by the environmental toxicity of the herbicide and (b) indirect effects, such as those due to changes in vegetation and patterns of land use if *Imperata*-infested land is rehabilitated.

Imperata control using glyphosate

80. The dosage of glyphosate recommended for on-farm trials is 5 l/ha, equivalent to 1.8 kg a.e./ha, since the formulation contains 360 g a.e./l. This is within the normal dosage range for agricultural use as specified in various experiments on toxic effects summarized below. The herbicide will be applied to actively growing plants as a spray of the commercial product 'Roundup'.

81. The information given here is summarized from Grossbard & Atkinson (1985)[1] (*q.v.* for original references), with supplementary information from the ENVIRON pesticide literature database at NRI and from the CABI database.

General properties and mode of action

82. Glyphosate [N-(phosphonomethyl) glycine] has the empirical formula $C_3H_8NO_5P$. The commercial formulation, 'Roundup', is the isopropylamine salt and contains an unspecified surfactant to enhance its penetration (Turner, 1985). It is a broad-spectrum, post-emergence herbicide with no residual soil activity and low toxicity to animals (Franz, 1985). It enters the plant through the leaves and is rapidly translocated in the phloem to roots, rhizomes and apical meristems (Franz, 1985). There is no uptake via roots or bark (Knuuttila & Knuuttila, 1985). Seedlings or plants arising from underground propagules such as rhizomes are more susceptible than mature plants (Caseley & Coupland, 1985) and the effect on woody plants is often small. Drift spray can cause distortion in young leaves, e.g. in rubber, though new leaves produced after spraying are normal. Glyphosate is particularly efficacious against perennial rhizomatous grasses such as *Imperata* since it prevents the germination of rhizome buds as well as killing actively growing aerial shoots (Caseley & Coupland, 1985).

83. The primary site of activity is at apical meristems where as a competitive inhibitor of EPSP synthase, it blocks the shikimic acid pathway, arrests the biosynthesis of aromatic amino acids and hence of proteins, and prevents secondary compound formation (Cole, 1985). It also influences a range of other processes, inhibiting chlorophyll synthesis, reducing IAA levels, and causing the accumulation of ammonia (Cole, 1985).

84. Much of the work on the toxicity of glyphosate has been done in temperate environments and laboratory experiments. Some of its characteristics are temperature sensitive, but there is no indication in the literature that significantly different results would occur under tropical conditions.

Toxicity to terrestrial animals

85. Glyphosate is considered to have low toxicity to animals, largely because they lack the shikimic acid pathway (Cole, 1985).

[1] All references are listed in Appendix 2.

86. Studies of acute and chronic toxicity are summarised by Atkinson (1985). The acute oral LD_{50} in rats is 4.3 g/kg for glyphosate and 4.9 g/kg for the isopropylamine salt, and for mammals and birds in general, is approximately 1% of body weight. However, Roundup is often somewhat more toxic, for instance in levels that cause skin and eye irritation in rabbits, and to fish (see below). In vapour inhalation tests for Roundup on rats, there was no effect after 4 h at 12.2 mg/l air.

87. In long term toxicity tests covering the range of concentrations normally used in agriculture, glyphosate has little or no sub-acute, chronic or neurotoxic effects (Atkinson, 1985). For example, in a two year feeding study with dosages of 300 ppm, rats and dogs showed no adverse effects, and there was no observable teratogenic effect with dosages of 100mg/kg/d in fetotoxicity tests on rats. Tests by the US Environmental Protection Agency (EPA) suggest that glyphosate is at the most only weakly mutagenic and has no carcinogenic potential at the highest dose tested (300 ppm).

88. In the USA, the EPA lays down maximum permissible levels of chemicals in food. For glyphosate in meat, fruit and vegetables these are around 0.2 ppm, and for grain is 0.1 ppm though the actual levels found are usually much lower (Atkinson, 1985).

89. Feeding experiments have shown that glyphosate does not adversely affect the palatability of forage to some animals (Sullivan, 1985, experiments with black-tailed deer), and so grazing is one way that it could enter the food chain. *Imperata* is eaten by cattle when it is young, but it is not a favoured forage except for water buffalo (Agus Purwoko, pers. comm.), though there may be other species of weeds growing with it that are more palatable. However, glyphosate accumulation in food chains is unlikely since Newton *et al.* (1984) found that the visceral and body residues in mammalian herbivores, carnivores and omnivores were at or below those observed in ground cover and litter.

Glyphosate in soil

90. When a herbicide is sprayed on to growing weeds, a large proportion reaches the soil. The activity, mobility, degradation and persistence of glyphosate in soil are therefore important considerations.

91. Glyphosate is rapidly adsorbed onto soil particles where it is practically immobile (Rf value 0.04 - 0.2), and this accounts for its low herbicidal activity through soil. Leaching and run-off are negligible, so it is unlikely to enter water courses, and volatilization does not occur (Torstensson, 1985).

92. The main route of degradation is microbial under both aerobic and anaerobic conditions, and the principal degradation product, AMPA (aminomethyl phosphonic acid), is also biologically degraded. Rates of degradation vary between soils and half-lives range from a few days to months or years according to microbial activity, which is influenced by soil properties (clay and organic matter content, pH), climate

and cultivation (Torstensson, 1985). The half-life in soil is approximately twice that in foliage and litter (Newton *et al.* 1984).

93. A herbicide could potentially affect a range of soil characteristics including litter fragmentation, soil structure, rate of decomposition, nutrient cycling, fertility and nutrient uptake. These may be affected directly through the action of the herbicide on the soil fauna and microflora, or indirectly through the addition of large amounts of dead organic matter to the ecosystem or through changes in the vegetation (see below).

94. According to Grossbard (1985), the impact of biocides on soil fertility cannot be measured precisely, and natural fluctuations are considerable. Inhibitory effects are thus relevant only if they exceeds the level of natural changes.

95. Little is known about the effects of Roundup on the soil fauna (Eijsackers, 1985), which is particularly involved in litter fragmentation and improvement of soil structure. Limited field experiments indicate that side-effects are small or absent, although some laboratory experiments have shown adverse effects.

96. In pure culture, many microbial species are inhibited by glyphosate, but the effect is selective, variable in magnitude, and usually dose related (Grossbard, 1985). Since it is adsorbed and degraded in soil, microorganisms tolerate it much better in the field than in culture, with the possible exception of rhizosphere organisms which could come into contact with herbicide exuded from roots before adsorption has occurred. Chakravarty & Chatarpaul (1990) showed that glyphosate had a significant effect on bacterial and fungal counts in soil two months after application, though not after six months, and effects on ectomycorrhizal fungi were only seen at doses much greater than those recommended for field use.

97. Inhibitory effects, especially on celluloytic fungi, also occur at concentrations above those normally used in agriculture and glyphosate is not regarded as curtailing nitrification in soil (Grossbard, 1985). The toxic threshold at which glyphosate reduces decomposition is >50 times higher than residue levels found after silvicultural use (Fletcher & Freedman, 1986). Little is known about the effect of AMPA on soil microorganisms, and the inhibitory effect of Roundup on some fungi is probably due to the surfactant (Grossbard, 1985). In liquid rooting medium, glyphosate decreases nodulation in Trifolium (Eberbach & Douglas, 1989), though in soil, this effect may be lessened.

98. Although glyphosate has little direct chemical effect on soil fertility (Grossbard, 1985), its use could influence soil structure and the likelihood of erosion. Current methods of *Imperata* control by smallholders in South Sumatra usually involve burning and/or slashing and the mechanical removal of rhizomes. Any removal of ground cover could leave soil exposed to erosion, but the use of a herbicide may minimize this since it does not break up the soil surface. Erosion also depends on the time gap between weed removal and planting, and on the rainfall.

Glyphosate in the aquatic environment

99. Except when used to control water weeds, glyphosate should rarely reach water courses since it is regarded as immobile in soil, AMPA is only slightly mobile, and leaching and run-off values are low (Bronstad & Friestad, 1985). Possible routes of entry are by spillage and from cleaning out bottles and sprayers.

100. The toxicity of glyphosate and Roundup have been investigated in fish, crustacea, molluscs and insect larvae (Atkinson, 1985; Tooby, 1985). Both are considered almost non-toxic or slightly toxic, e.g. in trout the 96h LC_{50} is 86 ppm for glyphosate and 11 ppm for Roundup (Atkinson, 1985). Roundup is more toxic than glyphosate alone because of the surfactant (Mitchell *et al.*, 1987), and toxicity increases with temperature and pH. While little difference is seen in the sensitivities of different fishes and macro-invertebrates, early life stages of fish are the most sensitive (Tooby, 1985).

101. Investigations of sublethal toxicity with Roundup showed that continuous exposure can cause feeding inhibition and avoidance behaviour in fish and possible behavioural abnormalities in crustacea (Tooby, 1985). Bioaccumulation potential is considered low, e.g. a bio-concentration factor of 1.6 occurred in bluegill sunfish exposed to 0.6 mg/l glyphosate for 28 days, and thus residues are unlikely to accumulate in fish tissues (Tooby, 1985).

102. Most of the data evaluating glyphosate as an aquatic hazard were prepared for pesticide registration so they measure effects of concentrations greater than likely to be found in the environment following the application of recommended doses (Tooby, 1985). In addition, effects are not always seen in the field at levels that would be detrimental in the laboratory. In moving water the chemical is rapidly dissipated, and in static water, it is adsorbed onto suspended particles and the hydrosoil, and degraded by microorganisms (Tooby, 1985).

Use and possible misuse of glyphosate

103. In the smallholder farming systems we saw in South Sumatra, glyphosate could be used to control *Imperata* during the initial preparation of land, prior to planting upland rice (or other food crops) and rubber, and again if the weed starts to re-establish, when the cultivation of food crops has ceased but before the rubber has formed a closed canopy. Although more than one treatment may sometimes be necessary, repeated annual applications to a particular area would probably not occur, except perhaps for spot-spraying or weed-wiping.

104. Roundup is currently sold in Palembang in plastic shrink-wrapped bottles of various sizes down to 240 ml, and giving detailed instructions for use including dilutions and warning of its irritant effect, in Bahasa Indonesia. Restorage in other containers and failure to follow the instructions could lead to misuse. Its comparatively high monetary cost to relatively poor farmers reduces the likelihood of overuse.

105. The Roundup for sale in Sumatra is manufactured by Monsanto in Java but their patent has expired and other companies can now also produce it. It is possible that a different formulation could contain contaminants or a different surfactant that would make it more toxic (J Hicks, pers. comm.). This could only be determined by analysis of products on sale in Indonesia.

Possible ecological consequences of other methods to be used in on-farm trials

106. Rolling using a weighted drum is a low technology method with few likely ecological side effects. It might cause some soil compaction, but soils under *Imperata* tend to be hard and compact anyway, and cultivation is necessary before planting crops.

107. Legume cover crops (LCCs) grow vigorously and smother new *Imperata* shoots and many are nitrogen-fixing. However, one reason given at Sembawa for not using LCCs more was that local nodulation levels are apparently low. Some N-fixing trees make a net nitrogen demand during juvenile growth (Wigston, 1985 in Hughes & Styles, 1989), but in general, LCCs are likely to make a positive contribution to soil fertility, by preventing soil erosion, providing mulch, and improving the chemical and physical characteristics of the soil (von Uexkull & Mutert, no date).

Indirect ecological effects of *Imperata* control

108. Herbicides have indirect effects on the demography and populations of animals, and on soil processes, through changes in vegetation. These effects may be important when considering conservation and amenity areas such as forests but in an agricultural context they are less relevant, as a change in vegetation is the desired result, and does not necessarily reflect the technology used.

Diversity and wildlife

109. *Imperata* grassland is very poor in mammal and bird life, though some rodents are grassland specialists (Whitmore, 1975). In South Sumatra dense *Imperata* often contains other weeds and shrubs (e.g. *Melastoma*, *Eupatorium*, Compositae sp., *Grewia*, *Trema*, and see lists in Eussen & Wirjahardja, 1973) which would increase the diversity, for example, of insects. However, the replacement of *Imperata* land by food crops and smallholder rubber would mean changing one low diversity community to another. There are ecological and economic dangers in monoculture.

110. We have no information about agricultural pests and diseases in *Imperata*, except for the mention of rodents which could be pests of grain crops, nor about potentially useful organisms. It is unlikely that farming practices following *Imperata* control would be so intensive as to eradicate any potentially useful organisms or pests. The impact of *Imperata* control on diversity and wildlife is therefore not likely to be great.

111. According to the farmers interviewed, pigs are an important pest of food crops in South Sumatra but they probably prefer the greater cover afforded by secondary forest to *Imperata*.

Fire and soil conservation

112. *Imperata* grassland burns readily, even when green (von Uexkull & Mutert, no date) and besides arresting secondary succession, fire is a danger to the surrounding vegetation (especially logged forest in the dry season) and to crops. It also results in nutrient loss, and repeated burning degrades the soil.

113. By acting as ground cover, *Imperata* can bind soil and reduce erosion, except immediately after fire, and it reduces soil water loss. Thus it is preferable to bare ground, but not to other forms of vegetation. Decaying rhizomes of *Imperata* have an inhibitory effect on crop growth under some circumstances, possibly by causing a reduction in soil nitrogen through increased activity of soil microorganisms. Low soil fertility is a characteristic of *Imperata* land anyway.

Impact on land use

114. *Imperata* grassland is a fire climax community. It occupies land after forest has been cleared, either by commercial logging or for new settlements before cultivation takes place. It also occurs on farmland abandoned because fertility has declined, often as part of a slash-and-burn farming system (Brook, 1989). It usually occurs on nutrient-poor, acidic soils, where the secondary succession to forest is deflected by burning (Whitmore, 1975; and see Eussen & Wirjahardja, 1973).

115. Estimates for the area of *Imperata* grassland in Indonesia vary from 7.5 to 64.5 million hectares (Brook, 1989), though most estimates are between 10 and 25 million ha. The problem is greatest in Sumatra, Kalimantan, Sulawesi and Irian Jaya. One reason for the variation is the scale at which measurements are taken, as *Imperata*-infested areas range from large tracts to small patches, the size of a paddy field. Control of *Imperata* by smallholder farmers is unlikely therefore to reduce the lowest estimates of *Imperata* land. Other projects (funded by Tropenbos, JICA, and ICRAF) are investigating the possible rehabilitation of *Imperata* land through reforestation and agroforestry.

116. The main effects on land use that *Imperata* control in smallholder farming systems might have are the rehabilitation of abandoned farmland and a reduction in pressure to open up new land for cultivation.

117. Current farming systems are extensive rather than intensive and land is often abandoned when fertility is exhausted and weeds invade. Local farmers leave land fallow as part of shifting cultivation but transmigrants may have too small an area to do this. They may either abandon land permanently, preferring to enter paid employment, or under some circumstances clear new land. Controlling *Imperata* should contribute to intensification especially in conjunction with smallholder

rubber, though low soil fertility may still be a problem.

118. To understand whether controlling *Imperata* will reduce the pressure on clearing new land, we need to know about land tenure and ownership, and other land-use options and pressures. This is beyond the scope of this report. There is little primary forest left in South Sumatra and most forest is secondary vegetation, known as 'jungle rubber' (Gouyon, 1991).

Conclusions

119. The direst ecological consequences of using glyphosate to control *Imperata* in smallholder farming systems in South Sumatra are likely to be small. Because of its mode of action, it is especially suitable for controlling this weed, while considered "probably not toxic" to "slightly toxic" to terrestrial animals and "slightly toxic" to fish. It is immobile in soil, biodegradable, unlikely to enter water courses in large quantities, shows no accumulation in food chains, and according to Grossbard (1985), is unlikely to impair soil fertility *per se* when used in agriculture. While there is the possiblity of misuse, this would be localised.

Recommendations

120. In order to minimize the possiblity of incorrect use:

- On-farm trials must ensure that smallholder farmers fully understand:

  (a) safe methods of application, including precautions (e.g. against skin contact), (b) how to calculate dosage levels, (c) the need to dispose of empty containers safely, so they cannot be used for other liquids, and (d) safe storage, away from children.

  While 'farmer-managed' trials are an attractive proposition, no unnecessary risks should be taken with pesticides.

- The Project should pay particular attention to the farmer's understanding of the labelling on Roundup and how to calculate dilutions, and include this in the questionnaires. If present labelling is inadequate (e.g. lettering too small) or too complicated, it should contact the manufacturers and the appropriate government authority.

- The Project should monitor what glyphosate products are available in South Sumatra, and whether they are adequately packaged and labelled.

- Those involved in preparing extension materials should take specialist advice if they do not have previous experience of extension work with herbicides. One possible source of information is The Pesticide Action Network Asia/Pacific, P.O. Box 1170, 10850 Penang, Malaysia (tel. 604 870 271; fax. 604 877 445).

RESEARCH PROGRAMME

Survey methodology and questionnaire

121. The survey questionnaire was constructed in collaboration with Sembawa staff and is based loosely on the assumed availability of time and resources. It was from these constraints that the form of the survey and hence the depth and type of questions that individuals would be asked emerged. An outline of the areas covered by the questionnaire is shown below. It should be emphasised that specific questions and approaches will be finalised by Sembawa staff but the broad topics will remain the same:

- socio-economic and demographic data
- land use
- agronomic practice and farmer activity
- income/OFI
- credit availability
- markets for food and cash crops
- farm budgets
- weed control and farmer perceptions
- extension and other assistance

122. The initial questionnaire will aim to identify possible on-farm trial sites and to make a preliminary assessment of the weed control problem. This will determine whether farmers recognise *Imperata* as a problem, how they control *Imperata* and the basis for their control strategy. This will be set in socio-economic-agro environment as identified by the survey. Adjustments can be made to the specific questions asked if it is necessary to obtain details from other areas.

123. Details of the questionnaire will be presented after the return of HBO form Indonesia.

On-farm trials

124. Previous research by the ODA/NRI *Imperata* Project has focused on the efficacy of different concentrations of glyphosate and imazapyr using different surfactants, delivery mechanisms and cultural practices, in addition to the persistence of imazapyr when applied to wet or dry soils. This research will form the basis of the on-farm trials, but it is evident that some farmers will not be able

to afford the herbicide technology, thus alternative and less expensive technologies will have to be appraised.

125. To-date, several farmers who have gained access to advice, finance and the means of control, have used glyphosate to good effect in bringing land covered by "sheet" *Imperata* back into production. It is thought that access to extension advice and capital to make the initial purchase of the inputs played a crucial role. These are probably rich farmers with land, labour and capital available and the capability to take the risk. Thus it is important to have on-farm trials that reflect different degrees of investment capability which may result in different degrees of control.

126. Following on from the initial questionnaire survey, it may be possible to categorize the farmers questioned according to their perceived access to resources, into three broad wealth classes; rich, average and poor (this assumes that some kind of wealth ranking is possible and there is a reasonable distribution of rich, average and poor farmers). This may be based on land holding size, number of tappable rubber trees and/or the quantity of rubber the farmer sells each month, access to off-farm income sources, labour availability, access to credit and other such indicators. This will be used as a basis for identifying on-farm trial sites, as the aim of the on-farm trials in the short term is to assess the efficacy of the *Imperata* control technology on farm, for farmers with different resource bases. Furthermore, in the medium term, to adapt or change the technology to better suit farmer circumstances and, at the same time, to demonstrate to the farmers and to the extension service the costs associated with adopting or rejecting the various available *Imperata* control technologies, the risks involved and the benefits that may subsequently accrue. It is important to note that as soon as possible these trials should be managed by farmers and not by researchers or extension agents.

127. Concurrent with these on-farm trials must be a comprehensive programme to allow the farmers to evaluate and assess the on-farm trials. The social, economic, agronomic and institutional factors present and how they affect the different categories of farmers will be defined. It is hoped that the questionnaire survey will superficially elucidate this but more detailed and extensive surveys will be required to research this critical background information in more detail. Assessments of the risks which the farmers take when opting for the new technology will obviously vary between different farmer circumstances. It is into this background that the technology must fit and from the farmers' viewpoint, be seen to fit and to be worth investing time, money and effort for a clearly defined benefit.

128. Given that there may be a time constraint between the arrival of Mr Bagnall-Oakeley in Sembawa (September) and the start of the rains (October), it will be necessary to restrict the number of on-farm trials initiated in the first season.

129. Several of the farmers who were briefly interviewed during our reconnaissance emphasized that they were uninterested in planting food crops for sale because they were unprofitable in the light of a perceived weak demand and

controlled prices. For them the priority was planting rubber, which was profitable and the revenue generated was used to purchase provisions. It is thus proposed to test a restricted number of techniques, focusing on those which will bring land infested with *Imperata* back into rubber production. It is realized that cost effective technologies must be explored to bring similar land back into food crop production.

130. The following treatments will be tested:

Treatment 1: Slash, blanket spray glyphosate, burn (?), followed by the farmers' normal tillage and planting practice to plant the trial area with rubber. There is facility to intercrop this treatment, but not other treatments, so food crops will be planted in years 2 and 3.

Treatment 2: Slash, strip spray glyphosate, burn (?) followed by the farmers' normal tillage and planting practice to plant the trial area with rubber.

Treatment 3: Slash, burn (?) and roll followed by a manual tillage operation, using a hand hoe, either in strips or the whole plot, to direct drill with a legume cover crop and rubber seedlings.

Treatment 4: Farmers' own method of eradicating *Imperata* (control).

131. With the Dinas Perkebunan (Government Extension Service) recommended rubber tree spacing at 7 x 3m, each on-farm trial plot should be 25 x 25m (= 625 m^2), excluding a barrier planting around each plot. Using this area there will be 36 rubber trees per plot (3 rows of 9 trees). It is planned that there will be four such plots per farmer, two with the treatment being evaluated and two controls (Treatment 4). Each treatment will be replicated three times using three different farmers, but who are in similar socio-economic circumstances.

132. All herbicide treatments will use a knapsack sprayer (Cooper Pegler CP15 or Solo) depending on the type that is commonly available. The glyphosate application rate will be that recommended by previous research; 5 1/ha for overall treatments and 1 1/ha for spot spraying. For Treatment 2, the band spraying will use the area equivalent of the recommended dose. Burning is not a recommended agricultural practice, but in the light of the evident fire risk and the loss of a previous experiment, it is probably an option the farmer can consider prior to planting the first crop.

133. The total number of on-farm trials in the first season will be 27 (3 treatment/farmer categories) x (3 replicates) x (3 project areas).

134. Concurrent with these trials will be the collection of social and economic data, aimed at quantifying labour required, labour costs, other competing activities, cost of inputs, delivery methods, etc. Partial budgets by farmer wealth class will

be determined as will farmers' perceptions of the treatments. It is proposed that this information be collected every 14 - 21 days using informal or formal questionnaire methods, simple observation or group discussion centred around each wealth class. This will require a technician to be based in the field throughout the growing season, who will be monitored by frequent visits from the researchers.

135. Some modification of the treatments and their allocation to farmer categories may be needed after completion of the preliminary survey.

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136. We thank all who assisted us during this assignment but we are particularly grateful to our Indonesian colleagues Agus Gozali, Chairil Anwar, Heru Suryaningtyas, Gede Wibawa, Anang Gunawang and Dr Amin Tjasadihardja - Director of RRI Sembawa.

APPENDIX 1

ITINERARY OF VISITS TO INDONESIA

25 Jan	PJT	SQ321 Heathrow to Singapore. Dep 2215 Arr 1855 (26th).
26 Jan	PJT	SQ162 Singapore to Jakarta. Dep 2030 Arr 2100.
		Stay at Kartika Plaza Hotel, Jakarta until 30 Jan.
27 Jan	PJT	Visited Dr Tantono Subagyo at IPARD.
	PJT	Visited Dr Alan Wilson and Dr Peter Daniels at INI ANSREDEF in Bogor.
28 Jan	PJT	Visited David Taylor (1st Secretary, Development) at British Embassy.
	PJT	Visited Dr Alan Rogerson and Mrs Siti Suhud at The British Council.
	PJT	Visited Dr Tantono Subagyo at IPARD.
29 Jan	PJT	Report writing.
30 Jan	PJT	MZ134 Jakarta to Palembang. Dep 1315 Arr 1415.
	PJT	Stayed in guest house at Rubber Research Institute, Sembawa until 17 Feb.
31 Jan	PJT	Sunday - free day.
1 Feb	PJT	Met Dr Amin Tjasadihardja, Director of RRI Sembawa, and counterpart staff of the *Imperata* Project: Heru Suryaningtyas (weed scientist), Agus Gozali (extension specialist) and Chairil Anwar (socio-economist).
	PJT	Planned itinerary for next three weeks.
	PJT	Commenced discussion of PhD research programme being done by Heru Suryaningtyas. This activity was continued until 8 February. Subsistence for this period will be paid by The British Council.
2-8 Feb	PJT	Discussion and supervision of PhD research programme at Sembawa.
9 Feb	ALL	NRI experts arrived: Hugh Bagnall-Oakeley (agronomist), Dr Helen

Fortune-Hopkins (ecologist) and Richard Morgan (agricultural economist).

10 Feb	ALL	Meeting of Project team with Dr Amin.
	ALL	Meeting to discuss relevant research being done by scientists at Sembawa.
11 Feb	ALL	Visit Smallholder Rubber Development Project at Pangkalan Balai.
12 Feb	ALL	Visit Sugih Waras Transmigration Project near Prabumulih.
	ALL	Stayed overnight at Harison Hotel, Baturaja.
13 Feb	ALL	Visited Batumarta Transmigration Project.
	ALL	Returned to Sembawa.
14 Feb	ALL	Sunday - free day.
15 Feb	ALL	Project team prepared work plan.
16 Feb	ALL	Meeting with Dr Amin to present work plan and discuss administration of the Project.
	ALL	Attended seminar by Heru Suryaningtyas on his PhD research.
17 Feb	PJT	MZ133 Palembang to Jakarta. Dep 0900 Arr 1000.
	PJT	Stayed at Kartika Plaza Hotel.
	HFH	Meeting with ecologists Agus Purwoko and Dr Suplieffendi Rahim at the University Sriwijaya, Palembang.
	RJM, HBO	Meetings with Dept of Transmigration, Palembang and Socio-economists at RRI Sembawa.
18 Feb	RJM, HFH, HBO	Meetings in Palembang to discuss Smallholder Rubber Development Projectin South Sumatra, and at the Department of Forests to discuss reforestation of *Imperata*-infested land.
	PJT	Visited David Taylor and Tim Fisher (1st and 3rd Secretaries, respectively) at the British Embassy.
	PJT	Visited IPARD office.
	PJT	SQ159 Jakarta to Singapore. Dep 1730 Arr 2000.

PJT SQ322 Singapore to Heathrow. Dep 2330 Arr 0540 (19th)

19 Feb RJM, HBO Meetings with socio-economists at RRI Sembawa.

HFH Report writing.

20 Feb RJM, HFH Leave Palembang.

21 Feb HFH Arrive UK.

22 Feb RJM Arrive UK.

APPENDIX 2

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APPENDIX 3

RESEARCH PROJECTS AT RRI SEMBAWA

PROJECTS IN 1992-93

1. **Rehabilitation scheme of smallholder rubber**

   - Evaluation of smallholder rubber rehabilitation scheme (C Nancy)
   - Study of smallholder rubber farming systems (S Hendratno)
   - Test of smallholder rubber farming systems to increase income (M J Rosyid)
   - To test the adaptability of some selected food crops to shade tolerance under rubber (M J Rosyid)
   - Economic evaluation of minimum cost replanting of smallholder rubber (M Supriadi)
   - Study of social organization to develop smallholder rubber (U Fadjar)

2. **Study of smallholder rubber materials (SRM) and marketing efficiency**

   - Study of thin slab production and CV rolling slab by farmers (M Solichin)
   - To study the influence of the SRM on the quality of SIR (Standard Indonesian Rubber) (R Raswil)
   - The improvement of SMR through the utilization of a mini creper in Musi Rawan, South Sumatra (A G Santosa)

3. **The study of smallholder pre and post-harvest rubber technology of in red-yellow podsolic areas**

   - Assessment of rubber plant propagation techniques (Kuswanhadi)
   - Assessment of several cultivation systems of several recommended clones (U Jinaidi)
   - Assessment of a periodic tapping system on several clones recommended for smallholder use (U Jinaidi)
   - Assessment of sideways tapping on the GT 1 clone (U Jinaidi)

- Assessment of a combination of tapping systems for minimal bark consumption (Kuswanhadi)
- Evaluation of cultivation systems on smallholder rubber farmers land (I Boerhendy)
- Minimal manuring for smallholder farmers in South Sumatra (H Sihombing)
- The critical period of weed control for immature rubber. (H Suryaningtyas)
- Prevention or control of white root disease by fungicide and cultivation (A Sitimorang)
- Assessment of several rubber clones resistance to white root disease (A Sitimorang)
- Mapping the spread of disease in rubber trees (A Budiman)
- Control of tapping panel diseases (A Budiman)
- Assessment of rubber clones adaptability in NES Project, in South Sumatra (M Lasminingsih)
- Evaluation of the level of soil fertility in smallholder rubber in Jambi Province (T Adiwiganda)
- To test of rubber clones suitability for smallholders (M Lasminingsih)
- Test of international exchange clones in West Java and South Sumatra (M Lasminingsih)

4. **Research verification of rubber technology and rubber farming systems at the smallholder level**

   - Test of planting material, clones, level of maintenance and intercrops with smallholders in Jambi Province (M J Rosyid)
   - Economic evaluation of planting material management at farmer level (A G Gozali)

RESEARCH PROJECTS 1993

1. **The study of self-financing rehabilitation schemes of smallholder rubber in South Sumatra and Jambi**

- The pattern of self-financing smallholder replanting schemes (C Nancy)
- Socio-economic evaluation of NES project participants (U Fadjar)
- The study of technology transfer to smallholder rubbers producers in South Sumatra (M Supriadi)

2. **Study of smallholder rubber materials (SRM) in South Sumatra Jambi and West Java**

- Optimization of production of crumb rubber of SIR 20 quality of linear programming (D Suwardin)
- Performance test of a multiple energy source drying tool for processing (ADS - CV) (A M Santosa)
- Study of marketing system development for non-traditional SRM (S Suseno)

3. **Study of appropriate technology for smallholder farmers in South sumatra, West Java and Central Java**

- A multi locational test for 1991 - 93 recommended clones in rubber development area (M Lasminingsih)
- Assessment of several of budded stump clones (I Boerhendhy)
- Economic analysis of manuring immature rubber (H Sihombing)
- A study of rubber's water requirements and the mapping of rubber clones based on climate (I Thomas)
- Integrated control of brown root disease (A Budiman)
- Integrated control of white root disease (*Rigidoporus microporus)* for rubber plants (A Situmorang)
- Assessment of upward tapping from the lower tapping panel (U Junaidi)
- Test of combination tapping system to minimize the consumption of bark (Kuswanhadi)
- Periodicity of integrated weed control on immature rubber (K Amypalupy)
- Land preparation of rubber nurseries using herbicide (H Suryaningtyas)
- Optimization of utilizable farm land for smallholder rubber (M J Rosyid)

- Research dissemination for smallholder rubber (A D Gozali)