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NERAD PROJECT TECHNOLOGY DOCUMENTATION SERIES

WORKING PAPER NO. T4*

PRE-RICE-CROP GREEN MANURING: A TECHNOLOGY FOR SOIL IMPROVEMENT UNDER RAINFED CONDITIONS IN NORTHEAST THAILAND

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PRE-RICE CROP GREEN-MANURING: A TECHNOLOGY FOR SOIL IMPROVEMENT UNDER RAINFED CONDITIONS IN NORTHEAST THAILAND

BACKGROUND AND JUSTIFICATION:

Both of the major annual crops grown in Northeast Thailand are traditionally cultivated year after year with little or no fertilizer application. Both are extremely efficient at removing nutrients from the soil: submerged rice due to its ability to grow under reduced, water-logged conditions whereby nutrient availability is increased, and cassava by virtue of its physiological response to nutrient stress whereby it maintains leaf nitrogen levels and thus photosynthetic activity at the expense of leaf area index (Cock, 1983). Very little crop residues from either crop are returned to the soil, cassava due to its high harvest index (Cock, 1983) and rice because most of the straw is removed as cattle feed. The result is that traditional annual crop production in the Northeast has been eroding soil nutrient status. This is clearly illustrated at a cross section in time by the current soil fertility levels of the NERAD project sites in order of their longevity in continuous annual cropping since they were opened from primary forest (Figure 1). This continued mining of soil nutrients has led to the situation where Northeastern soils are generally the poorest in S.E. Asia (Table 1).

Figure 1. Soil fertility levels in the NERAD sites.

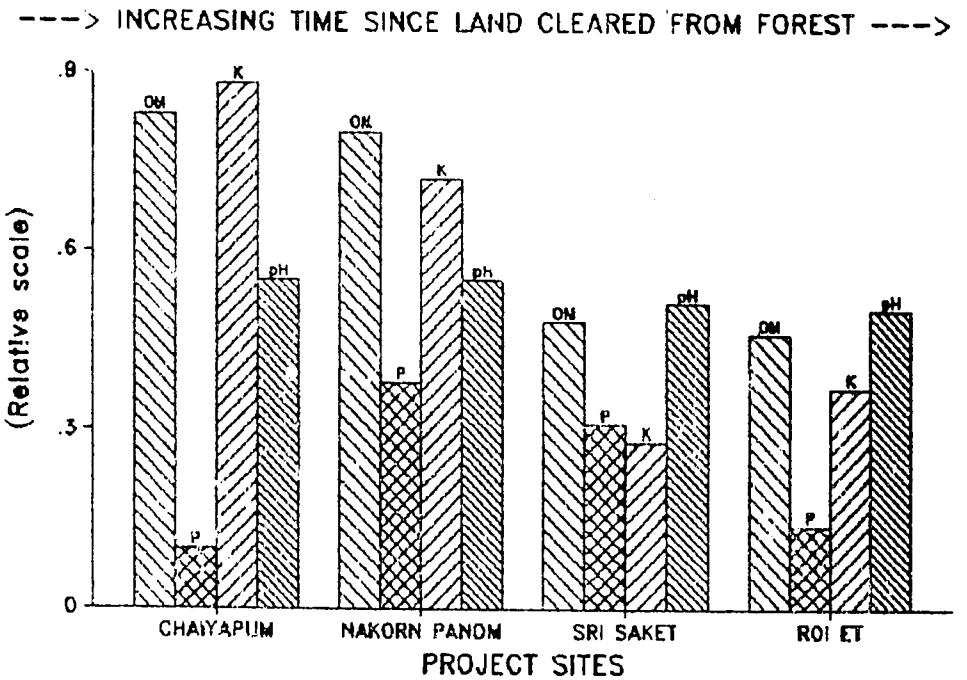


Table 1. Soil fertility scores for the soils of South East Asia (after Ragland, 1984).

AREA	RELATIVE SCORE
1. India, Godavari-Krishna	+1.76
2. West Malaysia, Kedah-Perlis	+1.48
3. Bangledesh, Ganges	+1.27
4. Bangledesh, marginal zone	+0.57
5. Bangledean	+0.54
6. Bangledesh, Bramaputra	+0.43
7. Thailand, Bangkok plain	+0.26
8. Thailand, southern region	-0.11
9. Thailand, upper central	-0.30
10. Sri Lanka, wet and intermediate zone	-0.33
11. Thailand, intermontane area	-0.93
12. West Malasia, east coast	-0.99
13. Sri Lanka, dry zone	-1.58
14. NORTHEAST THAILAND	-3.26

Because of the limited availability of animal manure, the limited production potential for compost due to lack of raw materials and water and the high cost of chemical fertilizer, attention within NERAD turned to green manuring as the only feasible, low-cost means of increasing soil-nutrient levels and improving soil condition to give significant improvements on a large scale.

Rainfall patterns in the Northeast are dominated by both the southwest monsoon and tropical cyclones originating over the Indian Ocean. There is a distinct rainy season from May to October exhibiting a bimodal pattern with peaks in June and September (Anon., 1982). The first rainfall peak is insufficient for rice transplanting but can in some years support short-duration upland cash crops although results are highly variable and farmers' risk attitudes generally preclude the production of pre-rice crops on a large scale (Craig et al. 1985). The NERAD project has been exploring ways of utilizing the early rains to produce a green manure crop that is plowed under before rice transplanting with the objective of increasing rice yields and improving, or at least maintaining soil condition and nutrient status in a low-cost, low-risk manner acceptable to local farmers.

RESULTS TO DATE:

Green manure trials using various crop materials have been conducted in a number of project sites for four years with varying results (Table 2).

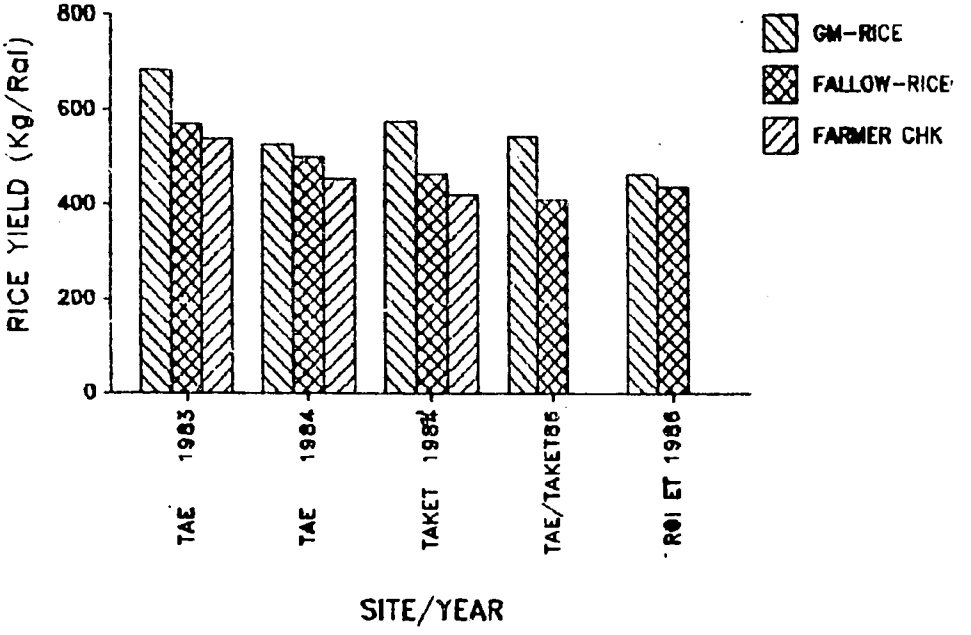
Table 2. The effect of green manure on rice yields, NERAD cropping system trials, 1983-86.

SITE	YEAR	G.M. MATERIAL	REPS	TRIAL TYPE	GM - RICE	FALLOW -RICE	FARMER CHECK
					Rice yield (Kg/rai)		
TAE	83	COWPEA	5	ON-FARM	684	569	539
TAE	84	COWPEA	10	ON-FARM	526	499	455
TAKET	84	COWPEA	5	ON-FARM	575	464	421
SRISAKET	86	VARIOUS	18	MULTI-LOC	543	408	N/A
ROI ET	86	VARIOUS	10	ON-FARM	464	435	N/A

Results of the trials presented in Figure 2 show consistent rice yield increases due to green manure in the range of 5 to 20 percent. Farmer interest in some areas is very high, with significant adoption already occurring in Sri Saket and Roi Et where soil fertility levels have declined the furthest. In Nakorn Phanom and Chaiyaphum, however, where the land has been opened for a shorter period and natural fertility levels are higher, farmer interest is low and adoption rates are zero or negligible.

Early trials used cowpea (Vigna sp.) because it was known to the farmers and seed was available in local markets. Results and experience have shown, however, that it does have a number of draw-backs as a pre-rice, green-manure material. First, although more tolerant to water-logging than mungbean (Phaseolus aureus) and some other legume species, it is still affected by water-logging after heavy rainfall. Second, bean fly (Melanagromyza phaseoli) is endemic in the region and prophylactic insecticide application, which adds significantly to production costs, is virtually essential. Finally, in the 45-60 days available for crop growth, cowpea cannot rival some of the other legumes in terms of dry-matter production.

Figure 2. Effect of green manure on rice.
NERAD CROPPING SYSTEM TRIALS, 1983–86.



The testing and screening of a variety of green manure materials was initiated within NERAD in 1986. The results obtained (Table 3) indicate that cowpea and blackbean are the most appropriate materials. In addition, other NERAD trials have identified a variety of Sesbania (rostrata) obtained from the International Rice Research Institute as having considerable promise as a pre-rice, green-manure crop for the Northeast due to its ability to grow well and nodulate under acid, saline and water-logged conditions and because of its apparent lack of serious pests in the vegetative stage. Trials to date would indicate that sesbania is a better green manure crop under wet conditions but that cowpea and black bean tend to perform better under dry conditions.

Table 3. Results of NERAD green manure screening trials. Nong Kaew, Roi Et, 1986.

CROP MATERIAL	YIELD (Kg/rai)	
	G.M. CROP	RICE
COWPEA	4352	479
RED COWPEA	1836	446
BLACK BEAN	3728	482
SWORD BEAN	2208	449
NO FIRST CROP	-	435

CURRENTLY RECOMMENDED PRACTICES:

TECHNOLOGY: Pre-rice green manuring under rainfed conditions.

OBJECTIVES:

1. Increase rice yields and reverse the trend of declining soil fertility.
2. Reduce the cost and associated risk involved with the relatively high cost of chemical fertilizer.

APPROPRIATE CONDITIONS:

1. Most acceptable to farmers in conditions of very low soil fertility (low O.M. 1.0%).
2. Soil pH > 5.0.
3. Middle or upper paddy land.
4. Absence of early season flooding or prolonged water-logging if possible.
5. Good water control is an advantage.

RECOMMENDED PRACTICES:

1. Any cowpea variety can be used (and other legume species can be considered).
2. 1 plowing followed by 1 harrowing.
3. Broadcast at 5 kg/rai (cowpea).
4. Lime at 100 kg/rai if pH is less than 5.0 at planting.
5. No fertilizer if possible, but for extremely poor soils use manure.
6. Spray dimethoate prophylactically at about 2 weeks P.P. for beanfly control.
7. Plow cowpea under at flowering (45 days) preferably in water-inundated conditions.
8. If possible, allow 1 month for decomposition of green manure residues under water-logged conditions before rice transplanting.

FUTURE RESEARCH AND DEVELOPMENT REQUIREMENTS:

1. Green manuring is appropriate for extremely infertile soils but unfortunately, this gives rise to the problem that it is often impossible to establish a satisfactory stand of a green manure crop without the use of fertilizer. However, to be successful green manuring should be a low-cost technology and this rules out the use of fertilizer. It may be possible to obtain a satisfactory green manure crop by planting it in the same fields that receive cattle manure under the farmer practice of applying animal-manure to some of his fields each year on a rotational basis. Further testing is therefore required on the fertilization of green manure crops with small amounts of animal manure.

2. The residual effect of fertilizer applied to a first crop on the following rice crop can be quite pronounced on the poorly-buffered, infertile paddy soils of the Northeast (Craig, 1987). In some areas, farmers already apply chemical fertilizer to their rice crops and in these situations it might be valuable to test split applications of the fertilizer between the green manure and the rice crop according to the design suggested in Figure 3.

Figure 3. Possible trial design for split application of available fertilizer between the green manure and the following rice crop.

Treatment 1. All available fertilizer applied to green manure crop.	Treatment 2. All available fertilizer applied to post-green-manure rice crop.
Treatment 3. Available fertilizer split equally between green manure and following rice crop.	Treatment 4. Zero fertilizer control.

3. It may be possible to establish satisfactory stands of green manure without any form of soil ammendment if appropriate crop species can be identified that are both drought-resistant and can tolerate water-logged conditions and are capable of vigorous growth on infertile, and often acidic and saline soils. Sesbania rostrata is one such candidate that has already been identified but further screening and development is still required.

4. It may not be possible to identify any one species that meets all the necessary requirements for a successful green manure crop as defined in '3' above. It is rare for any plant species to combine both drought resistance and water-logging tolerance, however, a species mixture may exhibit such properties. It is not possible to predict rainfall before planting green manure, but by sowing a seed-mixture containing both drought resistant and flood tolerant species, intra-specific competition may produce a satisfactory crop. In an attempt to address this hypothesis, trials this year will include a comparison of sesbania, cowpea and black bean and also a species mixture of all three to test its ability to offset the effect of risk due to the uncertainty of climatic factors (see proposed trial design in Figure 4).

Figure 4. Proposed experimental design to test the appropriateness of a species mixture as a green-manure, mixed-intercrop under conditions of rainfall uncertainty.

Treatment 1. Sesbania roatrata as a water-logging-tolerant, sole-crop green-manure followed by rice.	Treatment 2. Cowpea as a drought-tolerant sole-crop, green manure followed by rice.
Treatment 3. Black bean as a neutral, sole-crop, green-manure followed by rice.	Treatment 4. Sesbania/cowpea/blackbean mixed-intercrop, green-manure followed by rice.
Treatment 5. Fallow-rice control plot.	

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Craig, I.A. 1987. Framing Systems Based Annual Crop Development, Proceedings of the 4th National Farming Systems Conference, Prince of Songkhla University, Thailand.

Craig, I.A., and Pisone U., 1985. Overview of rainfed agriculture in Northeast Thailand. Proceedings of an International Workshop on Dryland Soil/Water Management. Khon Kaen University, Thailand.

Ragland, J.L. 1984. Soil fertility evaluation of soils in North East Thailand. p. 13-27, NERAD Project, University of Kentucky Technical Assistance Team, Quarterly Report No. 8.

APPENDIX 1

The following NERAD Working Papers are available on request from the Project Director:

NERAD Methodology Documentation Series

M1 A cropping systems technology development process: the NERAD model. Craig, I.A. et al., 1986. (Thai or English)

M2 Triage: a methodology for screening agricultural technologies and prioritizing research and extension activities. Craig, I.A. and Sukapong, C., 1987. (Thai or English)

M3 North East Rainfed Agricultural Development Information and Coordination System (NERADICS). Hopkins, J., 1987. (English)

NERAD Technology Documentation Series

T0 Executive Summary: NERAD Promising Technologies. Thamabood, S. (Editor), 1986. (Thai)

T1 Direct sown rice technology documentation. Craig, I.A. et al., 1986. (Thai or English)

T2 Cooperative buying groups in Thailand: results of a social experiment. Meyer, A.L. and Infanger, C.L., 1987. (English)

T3 Modified shallow well technology documentation. Ragland, J.L. and Thamabood, S., 1986. (English)

T4 Pre-rice green manuring: a technology for soil improvement under rainfed conditions in Northeast Thailand. Craig, I.A., 1987. (English)