Information and data on the use of Greenmanure/Covercrops (gmcc) from manual on "Natural Paddy Cultivation" by the Surin Farmers Support (SFS) project, Surin Province, NE Thailand

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1. Background:

In June 2005, the Thailand Alternative Agriculture Network (AAN) organized a workshop on practices and experiences regarding **System of Rice Intensification (SRI)** in Thailand. The workshop was co-hosted by the ***Surin Farmers' Support Project*** (SFS) and was held near the provincial capital of Surin in the southern section of northeast Thailand. The workshop report includes only a few of the details discussed on practices by SFS farmers whose fields the participants visited.
To provide more detailed information, in particular on use of green manure crops in paddy fields, we have arranged for translation of relevant sections of the extension workers' and farmers' manual "Natural Paddy Cultivation." This can be shared with farmers anywhere.

2. Topography & Climate of Northeast Thailand

The northeastern region of Thailand, known as the Khorat Plateau, is a highland area also called Isan. The average elevation is 200 m, and it covers an area of about 1,525,000 sq km. It is an arid region characterized by a rolling surface and undulating hills. Harsh climatic conditions often result in this region being subjected alternatively to floods and droughts.
Rainfall is unpredictable, but is concentrated in the rainy season from June to October. It falls over a period of 125 days between June and October and ranges between l200mm to 2300mm, depending on the year and location. The average temperature ranges from a low of 19.6^{o} C to a high of 30.2^{o} C**.**

3. Planting Green Manures

Natural Paddy Cultivation Manual	
Planting Green Manures (before planting rice)	
Objectives	1. To improve the soil, particularly through using leguminous plants as green manures because they are able to fix nitrogen from the atmosphere. 2. To add organic matter to the soil by incorporating the residue of the green manure plants, which will decompose into humus in the soil.
Techniques: Mungbean	**1.** Broadcast the mungbean seeds, after plowing, at a rate of 25-45 kg/ha. Using a higher rate will yield more residue. **2.** Mungbean should not be planted during a period of frequent rainfall because it will not be able to out-compete the weeds. - Mungbean seeds do not need to be soaked before broadcasting. The seeds will begin to germinate two days after broadcasting. - Mungbean will flower approximately 34-60 days after planting. The best time for incorporation is at 40 days after planting. - Mungbean does not grow well in standing water. If the plants are flooded for more than 3 days, they will rot and die. - It is not possible to collect seed from mungbean grown as a green manure.
Jackbean	**1.** If a lot of planting seed is available, plow before planting, and then broadcast jackbean seeds at a rate of 94-125 kg/ha. **2.** If there is only a little planting seed available, plow first, and then plant seeds in furrows in order to get a good germination rate. **3.** The seeds might be soaked overnight before broadcasting. Jackbean seeds begin to germinate approximately 7 days after planting. **4.** Jackbean flowers approximately 45-50 days after planting. The best time for incorporation is 64 days after planting. Therefore, the seeds should be broadcast in March or April. **5.** Jackbean is drought-tolerant and has a lot of leaves, so it adds a large amount of organic matter (humus) to the soil. **6.** To produce seed, either plant • Some seeds on the dikes or in areas that are not flooded with water, or • Directly after the rice harvest is completed, but observe first whether the soil is still moist. Planting right after the rice is harvested covers the soil, and farmers are able to collect seeds to plant again in the future.
Sesbania rostrata	**1.** Should be planted between April and May. **2.** Green-manure sesbania should be planted at a rate of 30-32 kg/ha. **3.** Sesbania seed does not need to be soaked before broadcasting. Germination will begin 7 days after planting. **4.** Sesbania plants can tolerate moisture and standing water. However, sesbania seedlings cannot tolerate standing water, as their roots may rot and die. **5.** When the sesbania plant is 20 cm tall, water can be let into the rice field. **6.** Sesbania flowers at 45 days after planting (when the plants are around 1 meter tall). The plant material should be incorporated into the soil at around 45 days after planting. **7.** Sesbania has fewer leaves than jackbean, but water buffalo like the taste of it more than jackbean, so they must be kept out of the fields. **8.** After broadcasting sesbania in the first year, allow some plants to grow and set seed. In the second year, the seeds will germinate themselves; there is no need to broadcast them again.
Costs [1]	Mungbean seed sells for 30 baht/kg (at Surin Field Crops Experiment Station 20-25 baht/kg). Jackbean seed sells for 8-12 baht/kg. Sesbania seed sells for 24-25 baht/kg.

[1] Currently, $1 US = approx. 38 baht

4. Research Data on Green Manures

Green manure species	Days to incor-poration	Amount of seed (kg/ha)	Fresh weight (t/ha)	Dry weight (t/ha)	Amount of N fixed (kg/ha)	Amount of nutrients (%)		
						N	P_2O_2	K_2O
Mungbean	40	43.75	25.00	4.30	31.25 - 37.50	**0.39**	0.43	4.16
Cowpea	40	50	25.00	3.07	56.25 – 62.50	**2.92**	0.5	4.00
Jackbean	64	62.50	29.80	6.45	68.75	3.04	0.37	3.12
Sesbania Rostrata	45	31.25	17.00	2.30	87.50 - 118.75	2.05	-	-
Sunnhemp	45 – 50	31.25	31.25	5.75	93.75 - 125	1.98	0.30	2.41

Source: Pracha Nakhaprawet and Prachaya Trainyadee (1992), in Somsak Wangnai (1998), pp. 211-214.

5. Incorporating Green Manures

Objectives	1. To chop up the green manure so that the residue can break down more quickly. 2. To eradicate certain weeds that may have survived the first plowing.		
Techniques	1. Green manure plants should not be allowed to grow too old. 2. The appropriate period for incorporation is when 50% of the plants have flowered, because this is when nitrogen is at its highest levels. 3. If the plants are 1 meter tall (chest height), they should be chopped with a machete before plowing, or else plowed twice so that they will break down quickly. 4. The method of incorporating residue is the same as for an ordinary, rough plow pass. 5. After incorporation, the soil should be kept moist but not wet. Flood the field for 1 night and then drain the water. Leave the field for 10 days, and then flood it for 1 more night. 6. The green manure residue will take approximately 15-20 days to decompose.		
	Mungbean	Jackbean	Sesbania rostrata
	- Plow as normal - After incorporation, flood the field until rice is transplanted (approximately 10-15 days).	- Plow as normal - After incorporation, flood the field until rice is transplanted (approximately 10-15 days).	- Sesbania stems 1 m. tall should be chopped into 3 sections before being incorporated and flooded. - If using a tractor, harrow the plants to lodge them before plowing. If the plants are not very tall, there is no need to harrow first. - Flood to depth of 20 cm for 15-20 days.
Cost	The cost of hiring a plow is around 625-1,250 baht/ha.		

6. Weed Management

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Objectives	1. To prevent and control weeds to a level where they do not compete with the rice.
Techniques	**Principles** • Do not use herbicides in or around the rice field. • Use mechanical methods (plowing, planting, and controlling the water level) or a straw mulch. **Techniques** 1. Pull out large weeds and lay them to dry on the dikes. Pulled weeds should not be piled up because they might regrow. 2. Harvest the weeds with a sickle to use as animal feed. 3. Some weeds can be used for food or herbal medicine, such as *pak bung na* and *pak waen*. 4. Raising fish such as tilapia in the rice field can help control weeds such as *water spinach*

Weeds	Botanical Characteristics	Control method
Water primrose *(Jussiaea linifolia)*	• Grows in open/unshaded areas • Grows in rice fields that were flooded but then have a reduced water level • Once it sprouts, it grows better with water in the field • It has long roots and is a habitat for small worms and black turtles • Rarely seen in transplanted rice fields, but prevalent in broadcast rice.	• Pull • Plow • Transplant rice, regular rainfall
Torpedo grass *(Panicum repens)*	• Found on the dikes, more in the shade than in the sun • Likes high ground, has nodes • Has a panicle and seeds for reproduction • Deep-rooted	• Harvest for cows / buffaloes to eat • Use the straw to cover the soil in the dry season. • Plow (but it will not all die) • Dig it up (clean the soil from the roots and leave it to dry out)
Tadpole grass	• Grows along with the rice, the seedlings are similar • Flood-tolerant, killed by drought • Seeds are ripe before rice • Has no stolons • Tillers like rice but the plant is smaller • Grows in both shade and sun • If it breaks when pulled, it can regenerate • If left, it compacts the soil • Grows more on new dikes than old ones	• Keep the field continually flooded • Use a harrow to rake it out • Hard to cut with a sickle because it grows interspersed with the rice
Water spinach *(Ipomoea aquatic)*	• Likes to grow where there is water, in dry areas it will grow but looks bad • Likes areas with water and sun • Propagates from the nodes • Good aspect is that it can be eaten or sold	• Pull • When destroying it, do not break it or it will come up even more than before • Collect to eat or sell • Raise tilapia, carp or ducks in fields with a lot of water spinach

Ton seng	• Found all over the rice land area, in both dry and moist areas • Seed-propagated • Is a plant with dark red, round leaves arranged opposite each other • Flowers once per year • Tillers quickly • Deep, branching roots • Difficult to uproot • Will float to the top of standing water	• Pull • Plow • Mulch with straw
Primrose willow *(Jussiaea repens)*	• Aquatic plant	• Pull/chop the stem for pigs to eat • Pull up and use for compost • Incorporate, but not when there is water (2-3 plowings will kill it all)

7. Organic Fertilizer Use

Objectives	1. To hasten the growth of the rice during the tillering stage. 2. To increase rice yield.
Techniques	1. Do not use any kind of synthetic chemical fertilizer. 2. Do not use chicken manure from a battery cage farm. However, the use of chicken manure from farms where the chickens are housed together, such as broiler farms or hatcheries, is permitted. 3. Broadcast chicken manure at a rate of 625 kg/ha 5-6 days after transplanting or when the plants begin to establish themselves (when new leaves have emerged), and then broadcast again when tillering begins. 4. Broadcast chicken manure at a rate of 310-315 kg/ha before seed set. 5. Cattle or buffalo manure can be applied every other year before plowing at a rate of 280 kg/ha. If cattle or buffalo manure was applied, then chicken manure should not be applied because the rice will have an excess of vegetative growth. 6. In the case where the soil contains enough nutrients already (observed through good tillering), no more manure need be added because there will be too much vegetative growth and the stem will lodge easily. 7. Rock phosphate might be applied before tillering. This will help with root growth. 8. When broadcasting fertilizer high in nitrogen, the rice should not lack water, or the nitrogen will disappear. At the same time, fertilizer should not be applied before a heavy rain or the rain will wash it all away. 9. Do not apply chicken manure when there is rain or dew on the rice leaves because they might burn.

Specific information on chicken manure:

- To tell whether the chicken manure comes from chickens raised in a common pen, look for rice hulls in the manure. (Some of the rice hulls may have already decomposed but there should still be enough left to observe.)
- Applying pelleted chicken manure should be done according to the following steps:
  1. Pellet the manure using pressure.
  2. Heat the pellets to 400^{o} C for 15-20 seconds in order to reduce moisture.
  3. Cool for 5-10 minutes to further draw moisture out.
- Usually, factories that produce pelleted chicken manure will add chemical fertilizer such as urea (46-0-0) or potassium sulfate (0-0-50) to the chicken manure in order to increase the amount of nutrients in the mix. Fertilizer should only be purchased from factories that do not add chemical fertilizer.
- In general, chicken manure will have the following amounts of nutrients:

		Range (%)	**Average (%)**
Nitrogen	N	1.90 – 3.91	2.7
Phosphorus	$P_2O_{31.25}$	2.98 – 11.14	6.3
Potassium	K_2O	0.51 – 3.52	2.0

Source: Suphamat Prainitchsakpatana (1987), in Wichien Foiphikul (1998), p. 631.254.

8. Producing Rice Seed	
Objectives	1. To have seed of a true variety with minimal contamination by other varieties. 2. To have seed that will have a good germination rate.
Data	♦ Rice is a plant that fertilizes itself; there is less train 1% cross-fertilization. ♦ The rice flower opens from 8 a.m. to 4 p.m., with most of the flowers open at noon. ♦ Rice flowers will open for 4-5 days.
Techniques	1. Select an area that will be the seed selection area. This area should have strong, healthy rice plants with good growth. The area must be large enough to produce enough seed to plant in the following season. 2. Cut out any plants that are of a variety different from the main variety planted as soon as they are seen. Survey the seed field carefully in the period before the rice flowers in order to eliminate any contamination by rice plants of other varieties. 3. Be diligent and consistent in taking care of the seed field in order to prevent damage by rats, birds, or other pests. 4. Harvest the seed portion of the field before the rest of it (separate the planting seed during drying and threshing). 5. The unmilled rice should have moisture content of 12%. This can be observed by grinding some of the grains: • if there is debris/fiber stuck to the grain, the moisture is approximately 16-17%; • if there is only a little debris/fiber stuck to the grain, the moisture is approximately 14-15%; • if there is almost no debris/fiber stuck to the grain, the moisture is approximately 13%. 6. If sun-drying the grain in a courtyard, the grain must be laid on something like a sailcloth or plastic tarp that will block moisture from the ground. Drying rice grains on a cement pad should be avoided because the grains might become too hot (causing them to break). 7. After the rice grains are dry enough, cool them and then store them in sacks of 80 kg. (which is good for ca 2 ha, depending on whether it is broadcast-seeded or transplanted).

Appendix

(compiled by Klaus Prinz)

Crops used for green manure by SFS Project

1. Canavalia ensiformis - Jack bean

Fast-growing, usually erect, sometimes shrubby, twining annual up to l m high, with runners occasionally extending to 10 m. Deep rooted and drought-resistant. Mostly used for green manure, but in some countries, cultivated under irrigation as fodder. The forage is palatable only when dried. Due to toxicity, caution is required in feeding herbage and pods of jack bean, and seed meals must be limited to a maximum of 30% of the total feed for cattle. Heat-treated seeds and pods are harmless.

2. **Sesbania rostrata**

Tall annual species, becoming perennial under favourable conditions, 1-3 m high, erect, leafy, growing during the short rainy season. It forms a symbiotic relationship with *Azorhizobium caulinodans* and is renowned for its stem nodulation. Both stem and root nodules fix nitrogen; however, root nodules form at the curled root hair, while stem nodules occur at the sites of adventitious root primordia via "crack" entry. The stem nodules, unlike the root nodules, contain functioning chloroplasts in the nodule cortex and are therefore capable of carbon fixation. Sesbania rostrata has a very fast growth rate, is able to grow in flooded habitats, and is very nitrogen-rich. Thus it is viewed as a potential crop, which can be used as a green manure for

rice crops. Here it could be grown in the field before the rice crop is sown, then ploughed back into the soil, replenishing the nitrogen levels.

3. Crotalaria juncea L.- Sunnhemp, Indian hemp

Tall herbaceous shrubby annual, 1-3 m tall, vegetative parts covered with short downy hairs; taproot long and strong with many well-developed lateral roots. Sunn hemp is a short-day, erect shrubby annual, generally 1 to 4 m in height. Stems up to 2 cm in diameter, cylindrical and ribbed. Leaves simple, spirally arranged along the stem, oblong-lanceolate, 4-13 cm x 0.30-3 cm, pilose; petiole up to 0.30 cm. Strong taproot, well developed lateral roots.

4. Vigna radiata (L.) Wilezek (Phaseolus aureus Roxb.)- Mungbean, Green Gram

Mungbean is a summer-growing, annual pulse crop which has a short growing season and is relatively drought-tolerant. An upright annual legume ranging in height from 130 cm to 1 m; average height of mature plant, 0.9 m. Branches freely, but not heavily foliaged. Leaves, stems and pods are slightly hairy. Junctions of branches and stems are stipuled. The first flowers appear 7-8 weeks after planting, and the crop reaches maturity in 12-14 weeks. Pods are borne at top of plant. Seeds are green and almost globular (Doherty, 1963a). Pods are clothed in long, spreading, deciduous silky hairs.

5. Vigna unguiculata (L.) Walp. - Cowpea

Herbaceous annual with twining stems varying in erectness and bushiness. Leaves trifoliate, petioles 130 to 1130 cm long. Central leaflet hastate, 130 to 12 cm long, smooth, lateral leaflets irregular. Flowers in axillary racemes on stalks 130 to 30 cm long. Pod pendulous, smooth, 10 to 23 cm long with a thick decurved beak and 10- to 130-seeded. Seeds 4 to 8 mm long, 3 to 4 mm broad, and variable in size and colour (Barnard, 1969).

Cowpea is an important grain legume throughout the tropics and subtropics, covering Asia, Africa, and Central and South America, as well as parts of southern Europe and the United States. Cowpea, a drought-tolerant crop, has the unique ability to fix nitrogen even in very poor soils. It is also shade-tolerant and, therefore, compatible as an intercrop with many cereals and root crops.

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Thai Jasmine Rice

Thai Jasmine rice is commonly known as Fragrant Rice, Scented Rice, or Aromatic Rice. The official name is Thai Hom Mali Rice.

Thai Jasmine rice is a traditional Thai rice variety, found commonly in a small village in central Thailand called 'Bang Klar.' In the old days, Jasmine rice was not popular and was only consumed in local and nearby villages, due taste preferences of traditional Thais who preferred a firm cooking t of rice. Traditional Jasmine Rice was dark in colour and very soft in cooking.

In early '70s, Thailand started to develop rapidly. Both private and government sectors looked for alternative rice varieties for export-oriented markets. Jasmine rice was transferred to other regions for test growth. It was found that Jasmine Rice grown in Northeastern regions of Thailand gives very white and beautiful rice without losing its aroma and soft cooking characteristics, the quality preferred by upper export-oriented markets.

Although Jasmine Rice can be grown in any part of the world, only Jasmine Rice grown in Thailand northeastern region produces best quality rice: long grain, silky smooth, pure white, soft cooking, and strong aroma.

Nutrient Requirements of Jasmine Rice

	Amount	Nitrogen	Phosphorus	Potassium
Grain	2,500 kg/ha	4.0	1.2	1.2
Straw	5,000 kg/ha	4.0	0.8	8.0
Combined	7,500 kg/ha	8.0	2.0	9.2

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<tr><td colspan="3">Model 1 : Seed is broadcast
Field is mulched with straw</td><td colspan="3">Model 2: Rice is transplanted
Field is not mulched with straw</td></tr>
<tr><td colspan="3">Formula 1 (4.3 – 2.9 – 0.8)</td><td colspan="3">Formula 1 (8.2 – 2.9 – 0.8)</td></tr>
<tr><td colspan="3">Chicken manure 625 kg/ha</td><td colspan="3">Chicken manure 625 kg/ha</td></tr>
<tr><td>Mung bean *
31.25 kg/ha</td><td>Jackbean *
15.62 kg/ha</td><td>Cowpea *
31.25 kg/ha</td><td>Sesbania *
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31.25 kg/ha</td><td>Cowpea *
62.5 kg/ha</td></tr>
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<tr><td colspan="3">Formula 2 (5.9 – 1.5 – 0.4)</td><td colspan="3">Formula 2 (7.7 – 3.1 - 3)</td></tr>
<tr><td colspan="3">Chicken manure 312 kg/ha</td><td colspan="3">Chicken manure 312.5 kg/ha</td></tr>
<tr><td>Mung bean,
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62.5 kg/ha</td><td colspan="3">Compost 625 kg/ha</td></tr>
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<tr><td colspan="3">Sesbania 15.62 kg/ha</td><td colspan="3">Sesbania 15.62 kg/ha</td></tr>
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