4 Crop management

Key points

- Identify the types of farming systems present before the tsunami, including crops and yields, and management of inputs such as fertilisers.
- Make important resources such as soils or landscape maps available to all organisations and groups working to restore agriculture.
- Establish crops at sites where the tsunami impacts are minimal and the soil is least affected by salinity.
- Test water sources, especially groundwater, for salinity levels before using the water for irrigation.
- Consider using raised beds, which are useful to establish crops in salinity-affected soils and areas prone to waterlogging.
- Where available, use salt-tolerant varieties of crops.
- Assess the local seed supply situation:
  - Distribute viable, certified seed of crops and varieties that farmers are familiar with.
  - Provide training in the production of seed crops, and quality assurance, storage and distribution of seed.
- Monitor changes in weed species. Encourage coordination between farmers to control pests and weeds.
- After planting, monitor growth, yields and any symptoms of nutrient deficiencies or plant stress, to identify trends and develop site histories.
- Test soils for major nutrients before planting and fertilising.
- Use organic fertilisers, such as manure, composts, crop residues and mulches, to improve soil health and fertility.
- Develop trials to demonstrate new production systems and practices, and compare them with existing farmer practices.

Photo: New South Wales Department of Primary Industries

The first rice crops after the tsunami often failed or achieved very low production. The second crops were better, possibly as a result of the leaching of salt by irrigation of the rice paddy for the first crop. As salinity levels declined, vegetative growth improved. However, problems occurred with fruit, grain and nut production, indicating nutrient deficiencies, possibly caused by the tsunami removing organic matter from the soil. Lack of organic matter proved to be a major issue for crop production, particularly in the sandier soils. Some vegetable crops were affected by the quality of groundwater used to irrigate the crops.

To restore cropping quickly, it was useful to know the types of farming systems at the site before the tsunami, including crop types, animal input, fertilisers used and yields. This information, in association with soil assessment and analysis of leaf tissue after the tsunami, helped identify agronomic issues specifically caused by the tsunami (e.g. crop failures, poor growth, low yields, empty pods and husks, change in weeds, waterlogging).

Aceh's experience highlighted the need for good records about district cropping practices, seasons and seed sources. This information could be collated and held by agricultural organisations at local, provincial and national levels, and even at an international level, to enable aid organisations to provide locally appropriate agronomic assistance after seawater inundation.

Site selection

Since cropping on highly saline areas is a waste of resources, it was important to grow crops where tsunami impacts were minimal and soil fertility was relatively unaffected. Avoiding saline areas was relatively easy using EM38 surveys (see Section 3) to identify saline soils. Farmer knowledge and experience of tsunami flooding levels and the duration of inundation, soil and plant indicators of salinity, and soil tests also helped with salinity assessment.

The Aceh experience showed that salinity levels were related to the permeability of the soils, the duration of seawater inundation and the physical location. For instance, crop failures occurred in low-lying areas near tidal creeks after inundation during high-tide events. Crops grown in coastal soils, such as peanut, were more affected by seawater inundation than crops grown on better soils further inland, such as soybean. Sandier soils close to beach dunes appeared to be the most saline following the tsunami. Peanut crops on the dunes showed patchy growth or leaf yellowing. The patchiness was associated with salt that accumulated on the soil surface following evaporation of salty, shallow groundwater. The yellowing appeared to be a related nutritional problem, or possibly a disease problem.

Raised crop beds were useful in saline soils because the beds could be irrigated to leach salt before crops were planted. Raised beds were also useful in areas prone to waterlogging.

Use of salt-tolerant varieties

Aceh's high rainfall meant that salinity was not a long-term problem in most areas, so there was not a great need for salt-tolerant varieties of crops. However, it was useful to have access to seed or planting material of salt-tolerant varieties, particularly in the early months after the tsunami and where salinity problems occurred in rainfed rice fields. Although no rice varieties are truly salt-tolerant, some varieties in Indonesia—Mendawak, Sunggal and Banyuasin—appear to be more salt-tolerant than others. Rice variety AT354 outperformed a variety that was not salt-tolerant (AT362) in trials on tsunami-affected land in Sri Lanka (Reichenauer et al. 2009).

Many salt-tolerant tree crops are recommended for revegetating coastal areas and re-establishing income-producing tree crops. Chaudhary et al. (2006) recommend a range of varieties of salt-tolerant field and tree crops specific to Tamil Nadu, India.

Following the 2011 tsunami in Japan, researchers investigated the use of salt-tolerant varieties of rice. However salt-tolerant cultivars were not adopted by farmers because the taste was not comparable with rice varieties available in the Japanese market. Instead, farmers selected alternative salt-tolerant crops, such as sunflower and rapeseed.

The salt-tolerance thresholds for a large range of different crops are presented in Tanji and Kielen (2002).

Seed supply and quality

Disasters can have a severe impact on the availability of seed for local food crops, and the recovery process may include seed assistance. Obtaining good-quality seed was a major problem after the tsunami in Aceh. Demand was so high that the main seed producers could not supply enough good-quality seed. Not all farmers used certified seed, and so crop establishment was unreliable. Many farmers who were given seed by aid groups found that the seed was not viable or that the varieties were unsuitable for the local market, resulting in loss of income and a waste of farmer time and resources.

The shortage of seed after the tsunami revealed the need to develop and maintain local seed breeding through local farmers' groups. An assessment of the local seed supply situation (Sperling 2008) is an important step in disaster recovery. In Aceh, seedbanks were constructed after the tsunami in rural areas to store locally produced seed. If seed storage facilities are available, farmers can be trained to select plants for mother seed and produce seed crops. Training can also be provided for seed quality assurance, storage and distribution.

The Aceh experience showed the importance of providing agricultural aid appropriate for the area, soil type, season, and local markets and tastes. Access to familiar varieties is important in the initial stages of recovery.

Pests and weeds

After the tsunami, rats and pigs were a problem because there were fewer people to control shrubland where the animals sheltered. Pest control for mice and rats requires coordination between farmers to make a difference (ACIAR 2001). Preventing and controlling pest and disease problems of crops was particularly difficult in Aceh because much knowledge was lost during the 30-year civil conflict in the province, which ended in 2005.

Many farmers commented on the changes in weed species after the tsunami. These changes possibly reflected increased salinity, changed nutrient status and lack of organic matter. Identification of the new weed species was useful because this could provide important information about soil nutrient status.

In one area, farmers did not weed peanuts once they flowered for fear of disturbing the roots, but the weeds competed with the crop for nutrients and moisture, reducing crop yields. Raised beds made it easier to weed between plant rows.

Plant nutrition

Agronomic trials in Aceh after the tsunami found a range of nutritional disorders, particularly lack of grain filling in rice and peanuts. Possible reasons for the nutrient problems included loss of organic matter and trace elements, high inputs of urea in relation to potassium, and lack of phosphorus and calcium in salinity-affected sandy soils.

Two years after the tsunami, most soil fertility problems in tsunami-affected areas were due to nutrient deficiencies and imbalances related to the loss of organic matter, and the effects of salts and sediments. Observations of the variation in crop performance highlighted the importance of monitoring growth, yields and nutrient levels to identify trends and develop site histories. Where there was potential to establish new production systems, such as different crops or rotations, trials were developed to demonstrate these new systems. For instance, the different soil treatments required for rice (compaction) and palawija (non-rice) crops (loose soil) led to trials using permanent beds for palawija crops, rather than alternate puddling and cultivation of one site to the detriment of soil health.

Pre-tsunami fertiliser recommendations were often found to be irrelevant or wrong after the tsunami because of the soil changes. It was therefore important to test tsunami-affected soils for at least the major nutrients before preparing the soil, fertilising or planting (Figure 11). Testing the soil ensured that the correct amount of fertiliser was applied; farmers learned that overfertilising is a waste of money because nutrients not used by the plants leach out of the crop root zone.

Photo: New South Wales Department of Primary Industries

Figure 11 Contents of the paddy soil test kit produced in Indonesia; kits are also available for dryland crops, vegetables and sugarcane

Crops initially grew well in peaty sediments as a result of the high nutrient levels of the sediment. Some coastal rice crops yielded very well within 12 months of the tsunami (Bradbury et al. 2005), probably as a result of a beneficial effect from tsunami-deposited peat sediments. The effects from these sediments were short lived—subsequent crops did not yield as highly without the addition of fertiliser. Inland peat soils offered cropping opportunities for farmers who lost land in the tsunami, but only if they were managed carefully to ameliorate the inherent high acidity. Phosphorus, trace elements and organic matter may be needed on salinity-affected sandy soils to help crops fill.

Case study: Empty peanut pods

Photo: New South Wales Department of Primary Industries

Empty seed pods in peanut crops; this was a common problem for farmers for up to 3 years after the 2004 tsunami destroyed farmland in Aceh

At Bireuen in Aceh, many peanut plants had empty pods in a crop harvested in February 2006. Farmers in the area reported that this was the first time these problems had been encountered. The peanuts were normally grown in deep, sandy soil (sand dunes) without fertilisers, and cropped twice per year, with weed fallows between crops. The plants had good vegetative growth and appeared to have enough nodules, but the root systems were very shallow. Weeds were well established in the crop and in bare areas. Measurements of soil salinity using an EM38 instrument showed low salinity. A possible cause of the empty pods was lack of calcium, which is essential for kernel development; calcium is absorbed directly from the soil through the pod wall. High soil magnesium can also reduce kernel quality and lead to empty pods.

A trial investigating the effects of fertiliser, gypsum, and chicken and cow manures found that the best pod development was obtained by a soil treatment with combined chicken and cow manures, indicating a need for organic matter in the soil. Organic matter helps conserve soil moisture and improves the ability of peanut plants to absorb nutrients.

Organic fertilisers

Lack of organic matter in soils was identified as an important constraint to production in the tsunami-affected soils in Aceh. The tsunami's scouring action removed organic matter, leading to a drop in soil fertility. Organic amendments can substitute 25–100% of the nutrients of chemical fertilisers, depending on the kind, amount and content of the material. In Aceh, manure, composts, crop residues and mulches increased soil nutrient levels and generally improved soil health and long-term soil fertility. As well, they encouraged biological life, and improved soil structure and soil moisture-holding capacity. Farming systems that incorporated crop rotations and stubble management also increased soil organic matter.

A corn trial at the Assessment Institute for Agricultural Technology (BPTP) Banda Aceh grounds found that near-surface salinity was significantly lower when manure was incorporated beneath the corn row. Where organic matter was in limited supply, farmers incorporated compost or rotted manure in the planting row to provide nutrients close to the young plants, and encourage leaching of any salt in the soil.

Demonstration trials were useful for comparing crop production using fermented fertilisers, chemical fertilisers, no fertilisers, and a 50:50 mix of chemical and fermented products. It was important to keep records of fertilisers used and the fertiliser recommendations provided to farmers so that advisers and farmers could link fertiliser applications with crop production.

Compost

Making compost after the tsunami provided a source of organic matter for soil, created a useful product from organic debris and offered productive activity for farmers. Aceh farmer groups made a range of composted fertilisers. One group used rice husks, peanut pods, and cow or chicken manure; another made bokashi fertiliser from cow manure, rice ash, wood ash, rice stubble and micro-organisms; another group made liquid fertiliser from buffalo manure, lime and home-made fish emulsion.

Other soil amendments

Rice husk char (2 t/ha) and gypsum (1.5 t/ha) increased grain yields of rice grown on tsunami-affected soils in Sri Lanka (Reichenauer et al. 2009). Gypsum will ameliorate saline soils with a pH greater than 8.5 and exchangeable sodium percentage greater than 15. The soil pH is likely to increase during the leaching process (Chaudhary et al. 2006).

Rice husk char has shown potential as a soil amendment for wetland rice in Aceh, and for peanut and tree crops on sandy soils in dryland areas of Vietnam (Keen et al. 2013). Char derived from other waste organic materials may also be beneficial to the establishment of crops in tsunami-affected saline soils.

Manure

Approximately 2 million livestock animals (buffalo, cattle and goats) were lost in Aceh as a result of the tsunami. Smaller numbers of large livestock (beef and dairy cattle) were lost in the 2011 Japan tsunami, along with nearly 5 million poultry (Danone 2011). The loss of livestock in Aceh led to a shortage of manure, an important agricultural input in the sandy coastal soils. It is important to reintroduce poultry, goats and cattle as quickly as possible after a tsunami because their manure adds nutrients to the soil, builds organic matter levels and contributes to compost making. One water buffalo can produce about 2 t of manure per year.

The Aceh experience was that farmers would incorporate manures only if they could see a result and only for high-value cash crops, because of the cost of collection and transport of manure. Since it is financially difficult for many farmers to acquire livestock, a useful post-tsunami aid project could be replacing lost livestock, once there is sufficient food available for animals. Reintroduction of poultry where all birds have been killed is particularly useful; the birds' manure is an important nutrient source and organic soil amendment, and the birds also provide eggs and meat.

Grazing is a good use of land that is too waterlogged for cropping or does not have a reliable irrigation source. However, it was not an option for many Aceh farmers because the area of farming blocks is 1 ha or less, and this land is used to grow rice for food and income. A salt-tolerant grass

(*Diplachne fusca*) became more prevalent after the tsunami. Although the mature grass is not palatable to cattle, the grass is grown widely in Pakistan as a forage crop that is eaten when young. Aceh farmers confirmed that cattle will eat the young shoots.

Plant-based mulch

A mulch of dried organic matter such as coconut leaves will lower the soil temperature and hold moisture in the soil, both of which will make the soil more livable for soil organisms. Mulch also protects the soil from drying out and hardening—this is particularly useful for compacted rice paddy soils that are used to grow palawija crops during dry seasons.

The difficulty in Aceh was finding enough suitable organic material to use for mulch, because the local custom is to burn dead leaves to provide ash for use as fertiliser during planting. One option is to grow a green manure crop to act as mulch between crops, but for many farmers this will tie up productive land for too long. Another option is to grow stockfeed or a cash crop that can double as a green manure crop. However, caution needs to be used in growing green manure or stockfeed crops that could become weed pests.

It is important not to use peanut crop residues on soil to be used for peanuts, because of the risk of infecting the new crop with leaf pathogens. Peanut residues are better collected and composted before use.

Farm demonstrations

Demonstration trials comparing existing farmer practices, improved practices and scientifically tested practices provide some of the most useful training for Aceh farmers, especially when new practices or amendments are being introduced. Demonstration trials that actively involve farmers provide evidence of change, but may not be scientifically valid.

Scientifically designed field trials (Figure 12) are set up with a number of replicates to determine statistical differences between treatments. They require the input of trained researchers, and are therefore only possible if resources are available to employ researchers.

Photos: New South Wales Department of Primary Industries

Figure 12 Experimental trials established in Aceh (rice top row, peanuts and vegetables middle and bottom row) to determine the causes of crop problems