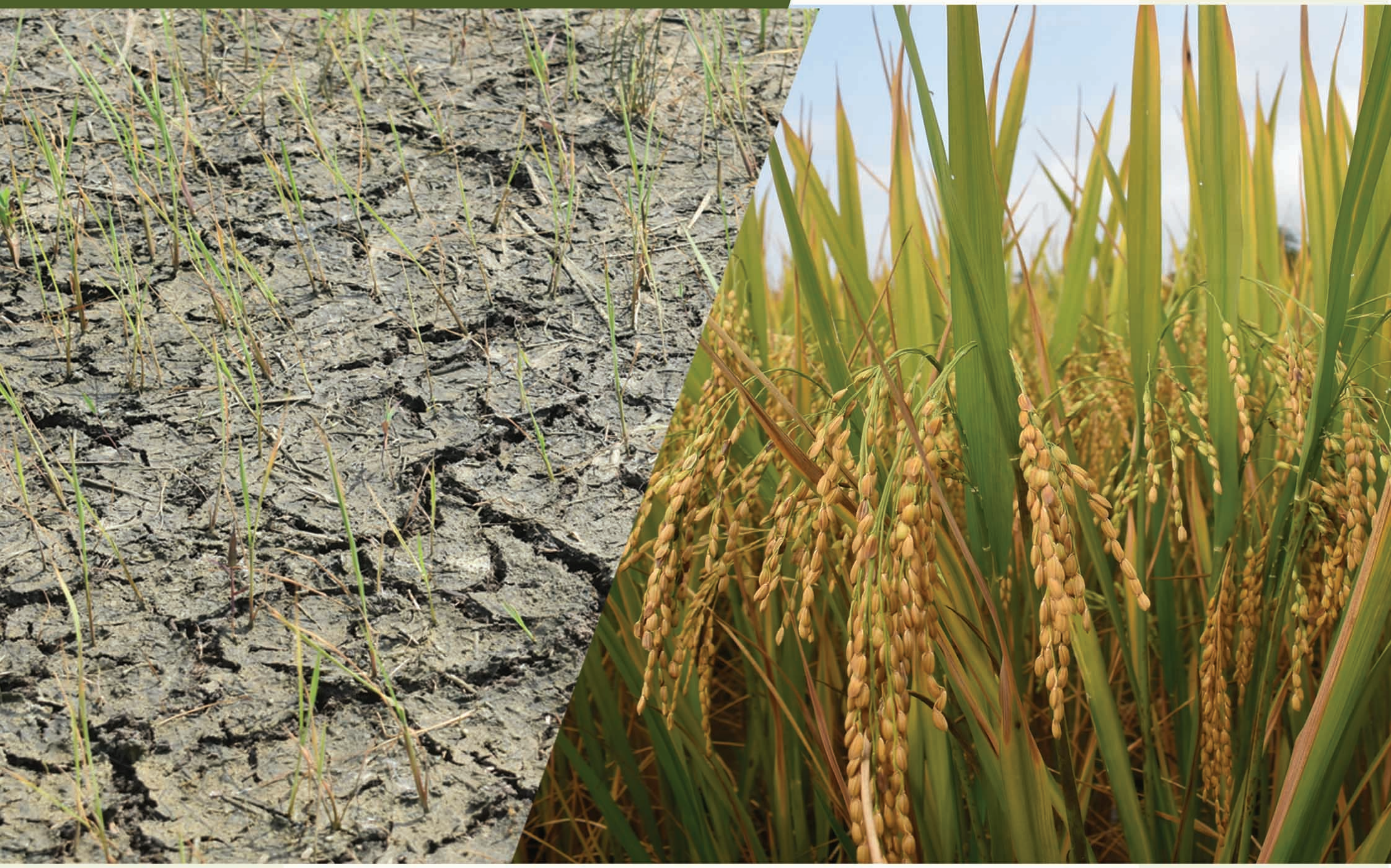
MANUAL FOR RICE CULTIVATION UNDER SOIL SALINITY



Manual for Rice Cultivation Under Soil Salinity

Rice Research & Development Institute,Batalagoda
Department of Agriculture

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Forward

Soil salinity resulting from accumulation of soluble salts in upper layers of paddy soils is a major constraint in improving productivity of paddy lands. Identification of extent and intensity of salinity affected paddy lands, detection of underlining reasons and effects and finally introduction of sustainable and pragmatic reclamation measures are necessary to overcome soil salinity related problems.

In this content Rice Research and Development Institute, Bathalagoda colaborted with the Asian Food and Agricultural Cooperation Initiative (AFACI) Project to identify salt tolerant rice varieties with the purpose of improving productivity in saline paddy fields. Using the information gathered during this project and already available research findings, this booklet is prepared to give guidelines to farmers who are cultivating rice under saline condition aiming at obtaining higher paddy yield under saline condition. Further according to the current government policy on organic farming, this booklet discusses about practicing of organic rice cultivation under saline conditions.

I am very happy to provide a “forward” for this book and also grateful to this team for undertaking this valuable and timely task. I am sure book will be a very useful resource for extension field officers, farmers and students who work with the soil salinity.

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Contents

01. Introduction.

The excess accumulation of soluble salts in the soil surface is referred to as salinization, which has an adverse effect on agricultural production, biodiversity and sustainable development. Saline soils predominantly occur in arid and semi-arid regions, where evapotranspiration exceeds rainfall, as well as in coastal regions as a result of seawater intrusion and coastal tidal inundation.

High levels of salt in the soil adversely affect the rice production in considerable amounts. Effect of salinity on rice plant varies with the stages of the life cycle of the rice plant and it will result the yield reduction. Salinity is one of the major constraints in Sri Lanka like in many other countries in the world. UNDP (2012) indicates that currently about 100,000 hectares of paddy lands in Sri Lanka are affected by high salt conditions or salinity. Therefore, the identification of salt affected rice lands and utilizing them with appropriate agricultural technologies will support to increase the rice production in the country ensuring the food security in Sri Lanka.

1.2. Coursing of Soil salinity

Salts which are more soluble than gypsum are named as soluble salts. This includes sulfate ($SO4^{-2}$), chlorides (CI^{-1}) and bicarbonates (HCO_3^{-1}) of sodium (Na^{+1}), calcium (Ca^{+2}) and magnesium (Mg^{+2}). Accumulation of sulfates ($SO4^{-2}$) and chlorides (Cl^{-1}) in the soil increases the electrical conductivity. When electrical conductivity of soil at 25^0C is higher than 4 dSm^{-1} (decisiemens per meter), that soil is called as saline soil. pH of the saline soil should be less than 8.5 and exchangeable sodium percentage (ESP) should be below 15%. Soils having pH more than 8.5, ESP more than 15% and electrical conductivity at 25^0C and below 4 dSm^{-1} are called alkali soils. Some soils may have both saline and alkaline characters. As a result, both pH and conductivity are high in those soils.

Table1. Characteristics of saline and alkali soil

	pH	Electrical conductivity of saturated extract at 25^0C (dS/m)	Exchangeable Sodium Percentage
Saline soils	< 8.5	> 4	< 15
Alkali soils	> 8.5	< 4	> 15

1.3 Occurrence of salinity

Irregular irrigation practices, low rainfall, high evaporation, high salt contents in ground water and intrusion of sea water are the main reasons for the occurrence of salinity. Two types of salinity prevail in Sri Lanka. ie. Inland salinity and Coastal salinity

1.3.1 Inland salinity

Salt laden irrigation water, low rain fall, high evaporation, and blockage of drain canals, high salt contents in ground water are the main reasons to develop inland salinity. High inland salinity in the dry zone is mainly due to improper usage of irrigation water. Irrigation water was used to irrigate low lands, in the past. As such salinity could not be seen in agricultural lands. At present, irrigation is practiced in the upper lands of the catena causing soil salinity development in the lower lands. Blockage of drainage canals prevents draining off salts, and as a result, accumulation of salts takes place. In the areas where evaporation is greater than rain fall, salinity build up in the soil enhances. Inland salinity exists in Anuradhapura, Puttalam, Jaffna, Galle, Mathara, Ampara and Trincomalee districts.

1.3.2 Coastal salinity

Entering of sea water into the inland areas accounts for coastal salinity. Sea water intrudes into inland areas in many ways. Occurrence of tides and dikes is one reason for intrusion of sea water into Inland areas. Removal of sands from river beds for construction work and reduction in water levels in rivers due to dry weather results sea water entry into rivers. Use of this salt containing water for irrigation purpose increases the salt content in agricultural lands. Predicted rising of sea levels due to climate change would inundate many agricultural lands in Sri Lanka causing a thousands of acres saline in the future. Coastal salinity exist in Mannar, Puttalam, Jaffna, Trincomalee, Ampara, Hambanthota, Galle, Kaluthara and Matara districs.

2. Identification of soil salinity

Both visual observation and chemical analysis help to identify saline lands. Presence of a white salt crust on dry soil surface is a common feature in saline fields. There are some plant species which can withstand high salt conditions. Abundance of these plant species helps to identify salt accumulated lands. Dwarf plants, low tillering and die back of upper leaves are some of the major symptoms of rice plants grown in salt accumulated paddy fields. Chemical analysis of soil for the presence of cations is the easiest way of identifying saline soils. Concentration of sodium, magnesium and calcium ions in the soil can be used to assess salt accumulation. Electrical conductivity of the soil solution increases with the increase in soluble salt content. Therefore, measuring electrical conductivity is the fastest and simplest method to estimate the amount of soluble salt in the saline soil. Measuring electrical conductivity can be done at the laboratory or in the field itself. To measure the electrical conductivity, a weighted soil sample is mixed with water to form a saturated paste and the liquid is taken out by pressure or suction. Electrical conductivity of the extract is then measured in unit of dSm^{-1}. Electrical conductivity of a soil solution changes with the water content in the soil.

Plate 01

Saline field

Plate 02

Salt tolerant plants

2.1. Affected of soil salinity in rice cultivation

Though germination of rice seeds is not affected by salinity, delayed germination or seed death can be observed in some occasions. Uneven plant growth can be observed when salts are accumulated in paddy fields. Most critical stage of the rice plants to salt injury is the 2^{nd}

or 3rd leaf stage. Yellowish spots or death of leaf edges of young leaves appeared in this stage. Later it spreads to the all other leaves as well. Dwarf plants also can be observed. Root developments and tillering can also be affected by salinity in paddy fields. When rice plants are affected by salinity at the reproductive stage, flowering is delayed and pollens become infertile. Therefore, short panicles with more empty seeds are formed. In addition deficiency symptoms of P, Zn, and Fe and toxic symptoms of B can be seen when rice plants are grown under saline conditions.

Plate 03

Leaf tips death in rice seedlings

Plate 04

Effect of iron toxicity

2.2. Effects of soil salinity on soil reaction

When soil becomes saline or alkaline, most of the exchangeable sites are filled with cations, such as calcium (Ca^{+2}), sodium (Na^{+}), and magnesium (Mg^{+2}). As a result, important nutrients are not retained at required quantities. Consequently, soil fertility declines and expected yields are not achived.

Accumulation of Na^{+} ions in the exchangeable sites cause soil particle dispersion which accounts for low porosity. As a result, water percolation through soil profile is declined result in higher run off due to low porosity.

Sodium carbonate (Na_2CO_3) and sodium bicarbonate ($NaHCO_3$) are the major forms of soluble salts in the inland areas. As a result, soil pH is increased while availability of some nutrients are decreased (eg. Zn deficiency). Volatilization of applied nitrogen as NH_3 is also expected from soils having high soil pH. Therefore, considerable amount of nitrogen is lost to atmosphere. A hard layer of $CaCO_3$ and light textured sub soil layers are prominent in saline soils which have high concentration of Ca. Therefore, root growth is retarded in these soils. A rate of nitrogen fixation and organic matter decomposition is also low in these soils.

2.3. Effect of salinity on plant physiology

Though salts are important for plant growth, a high concentration of soluble salts reduces plant growth and finally declines crop yields due to salt accumulation in plant cells. Accumulation of high concentration of sodium (Na) and chloride (Cl) in plant cells causes destruction of plant cells due to Na^+ and Cl^- toxicity. Plant cells damage due to salt accumulation result in low chlorophyll formation and inhibition of food production. A plant subjected to salt affect also has low concentrations of Ca^{+2} in plant cells and plant growth is disturbed due to poor growth of apical buds. Water absorption by plants is difficult in saline soils due to high osmotic pressure; this situation is referred to as "physiological drought". Plant physiological activities are disturbed due to dehydration or water stress and as a result nutrient deficiencies and ion toxicity may occur.

2.4. Effect of salinity on grain yield

Yield reduction of rice plants does not occur at the soil electrical conductivity level of 2 dSm^{-1} or below. When soil electrical conductivity increases to 4 dSm^{-1}, significant yield reductions can be observed. Total yield loss can be observed when salt sensitive rice varieties are grown in salinity level between 8-10 dSm^{-1}.

3. Rice cultivation under salinity

3.1. Land Preparation and crop establishment

Several factors should be considered when rice is cultivated under saline conditions. These include seasonal cultivation, proper land preparation, use of salt tolerant rice varieties and correct crop establishment methods.

3.1.1 Seasonal cultivation

All farmers of the track do seasonal cultivation collectively to get the maximum benefit of rain water and to minimize the pest disease incidences. The cropping calendar suitable for salinity tolerant areas is given in Tables 2 and 3. In *Maha* (Wet) season, cultivation of 4-4 ½ month salinity tolerant rice varieties is possible. However, cultivation of short age salt tolerant rice varieties is preferable in *Yala* (dry) season, due to lack of water. If the season gets late due to delay in rain, the cultivation cannot be initiated as planned. In such occasions, starting the cultivation at the onset of rain, minimizing the time period in between two land preparations and use of short age rice varieties are the suitable alternative options.

Table 2. The cropping calendar for land preparation, nursery establishment, crop establishment and harvesting in *Maha* season.

Age group	Land preparation	Nursery establishment	Transplanting/ seedling broadcasting	Harvesting
4-4 ½ months	Late September	Late September	Mid October	From early February to early March
3 ½ months	Early October	Early October	Late October	
3 months	Mid October	Mid October	Early November	

Table 3. The cropping calendar for land preparation, nursery establishment, crop establishment and harvesting in *Yala* season

Age group	Land preparation	Nursery establishment	Transplanting/ seedling broadcasting	Harvesting
4-4 ½ months	Late March	Late March	Mid April	From early August to early September
3 ½ months	Early April	Early April	Late April	
3 months	Mid April	Mid April	Early May	

3.1.2. Land Preparation

Land preparation in paddy is targeting to develop an edaphic environment conducive for optimum plant growth after seed or seedling establishment. It also facilitates mixing of soil layers to increase the availability of residual fertilizer, incorporation of residues to the soil, increasing soil organic matter content and for efficient water and nutrient management and to minimize weed growth, pest and disease incidences.

The land preparation in salinity affected lands should be started with the onset of rain. Deep ploughing facilitates the moving of salt deposited in lower layers of the soil towards the soil surface. They can be washed off by adding water. Therefore, cleaning and preparation of drainage canals to drain off unnecessary salts is important before ploughing (see 3.4). However, deep ploughing should not be conducted if water is inadequate to prevent the deposition of highly concentrated salt in the soil surface.

Paddy land preparation is basically divided into two as,

1. Wet land preparation - the soil is first flooded with water before tillage
2. Dry land preparation - the soil is not flooded before tillage

3.1.2.1 Wet land preparation

This has 3 steps.

Primary tillage

Primary tillage is done up to a depth of 15-20 cm to turn the soil upside down. Mouldboard plough, disc plough, animal or manual power are used for this operation. In salinity soils, deep ploughing will facilitate replacement of sodium ions remaining in soil surface with calcium ions coming from the deep soil layers. Washing off the soil after deep ploughing minimizes the salinity. It also supports for deep root growth.

After the primary tillage, the bunds should be cleaned and organic manure such as paddy straw and green manure such as *Gliricidia* or *Clotalaria* can be added. Water level should be maintained to cover half of the soil clumps for about 14 days.

Secondary tillage

The objectives of secondary tillage are to break the big clumps of soil remained after secondary tillage into small clumps and to incorporate the weeds germinated late and remaining crop residues to the soil. This is done in perpendicular direction to the primary tillage by using a moldboard plough or rotovator. Water level in the field should be maintained to cover all soil clumps for 7 days. Decomposed straws, cattle manure, decomposed poultry manure or compost can be added to the field. Repairing and replastering of bunds should be also done.

Tertiary tillage

This involves puddling and leveling. A leveling board or rotavator can be used for this operation. Puddling followed by a proper leveling is important for efficient water management, weed control, proper planting /seeding as well as to washing off the salt when required. When field is not leveled, the soil temperature and transpiration can be increased due to the expose of upper parts of the soil clumps to direct sun light. This result in the reaching of salt deposited in deeper layer to the top soil. This can be minimized by using proper leveling.

3.1.2.2 Dry land preparation

Dry land preparation is recommended when rain is delayed or when water is not adequate to perform the wet land preparation. This should be performed at the onset of the first rain. The first ploughing is done using the rotovator. After 1-2 weeks, the dried crop residues/stubbles are removed. The field is ploughed again and sowing is conducted after the fine leveling the field. To compensate poor germination and the losing seed by birds and rodents, 150-250 kg/ha of seed paddy is used either as in dry or wet basis.

3.2. Cultivation of salinity tolerant rice varieties

This improves the productivity of salinity affected rice lands. Some of the salinity tolerant rice varieties have ability to store a higher amount of salts in their tissues without any damage compared to the other varieties. A variety such as Pokkali has ability to absorb sodium ions and can minimize their toxicities. Some varieties have ability to dilute salt by producing high biomass. Salt tolerant varieties include both traditional cultivars such as Pokkali and Nonabokkra and improved varieties such as At 354 (plate 5), Bg 369 (plate 6), Bg 310 (plate 7) and At 401 (plate 8).

Plate 05

At 354

Pericarp colour - White
Grain Shape - Intermediate Long
Avg. Yield - 5 t / ha

Plate 06

Bg 369

Pericarp colour - White
Grain Shape - Intermediate Long
Avg. Yield - 5 t/ha

Plate 07

At 401

Pericarp colour - Red
Grain Shape - Long Medium
Avg. Yield - 5 t / ha

Plate 08

Bg 310

Pericarp colour - White
Grain Shape - Intermediate Bold
Avg. Yield - 4.5 t / ha

3.3. Crop establishment

In salinity affected paddy fields, the sown seedlings can be damaged/ destroyed, if standing water cannot be incorporated into the field regularly. This can be minimized if transplanting of seedling is used for the crop establishment.

3.3.1. Transplanting

The seedlings required for transplanting is obtained from a nursery. A fertile piece of land, which is not affected or minimally affected by salt stress should be selected. The nursery site should receive plenty of sunlight. The land area requirement for the nursery is 1/10 of the cultivated area. Seed paddy requirement is 50 kg/ha. Pre-germinated seeds (soaked in water for 1 day and incubated for 2 days) of a salt tolerant variety should be sown uniformly in the nursery.

The well-developed seedlings with the age of more than 21 days are suitable for transplanting, because they can be more tolerant to the salt stress. Transplanting of 3-4 seedlings per hill maintaining 40-45 seedlings/m^2 can minimize the damages to the seedlings. Transplanting depth should be 2-2.5 cm.

3.3.2. Seedling broadcasting /parachute method

The seedlings required for the parachute method can be obtained using a parachute nursery. The seed paddy and seedling tray requirements are 30kg/ha and 1000 trays/ha, respectively. Seedling trays are kept as 2 rows at the top of the nursery bed, filled with field puddled soil and pregerminated seeds (soaked in water for 1 day and incubated for 1 day) are uniformly sown. The nursery should be covered for 3-4 days to protect from drying and from bird damage. Water should be supplied as required. Broadcast 14-15 days old seedlings uniformly and maintain 35-40 seedlings/m^2 for a better crop establishment under salt stress.

3.4. Management of water

3.4.1. Improvement of drainage

Blocked drainage canals are one of the major reasons for accumulation of salts in paddy fields in the major irrigation schemes of dry and intermediate zones. Therefore cleaning of drainage canals to drain off unnecessary salts should be encouraged to alleviate salt accumulation in irrigated paddy fields of the dry and intermediate zones. Land leveling is very important before establishment of the crop get better water distribution along the paddy field.

3.4.2. Supply of quality irrigation water

Supply of good quality irrigation water is important to reduce salt accumulation. Water having electrical conductivity below 0.5 dSm^{-1} is recommended as good quality irrigation water. Therefore, water having electrical conductivity above 0.5 dSm^{-1} should not be used for irrigation purposes. If good quality irrigation water is not available in adequate quantities, low quality irrigation water can be mixed with high quality water before diverting to paddy fields.

3.4.3. Maintenance of a proper water level in paddy field

Maintenance of standing water level in the paddy fields throughout the growing season reduces the concentration of salts in the soil solution. Maintenance of 2-3 cm water level in paddy fields until milking is necessary when salt accumulated paddy fields are used for cultivation.

3.5. Management of fertilizer

To reduce the salinity and to well manage plant nutrients, it is essential to apply organic fertilizer, which should be added to the soil prior to the tillage. Cow dung, poultry litter, green manure, straw as well as compost could be used as organic matter. For organic cultivation, soil pH should be maintained between 5.5 to 6.5. Addition of dolomite can be practiced to increase pH in the soil. When soil pH is below 5.5 different organic fertilizers can be added in to paddy fields as follows.

- Cow dung – 4 tons per hectare
- Poultry litter - 2 tons per hectare
- Compost – 2.5 tons per hectare
- Application of straw of the same field from previous season

- Straw, green leaf of wild sunflower (*Tithonia*), Gliricidia, Keppetiya (*Croton aromaticus*), could be added to the soil to improve soil nitrogen.

Application of organic fertilizer to the soil could be performed in multiple occasions. Green manure (that is not fully decomposed) could be added to the soil at the time of land preparation, or cow dung/ poultry manure/ compost could be added at the time of crop establishment.

Under organic rice production system almost all P should be applied before planting. Test the soil before application of P enriched organic manure. If soil is having available P above 10 ppm, it is not necessary to apply P enriched compost. If soil P level is below 10 ppm, use P enriched compost. To prepare P enriched compost, 50 kg ERP (Eppawala Rock phosphate) per ton of compost can be used. Application of P solubilizing bacteria to compost will further increase the P solubility. To provide required potassium, test the soil before cultivation to decide the K need. If soil is having exchangeable K level at 160 ppm or above, it is not necessary to apply K enriched organic fertilizer. KCl, wood ash, half burnt paddy husk, fruit waste compost and banana peel compost can be used as potassium sources. Potassium enriched compost can be top dressed after establishment of the cultivation. To provide required level of K, K containing liquid fertilizers can also be added at 4 and 6 weeks after crop establishment. To fulfill the N requirement of rice crop partially, azolla can be grown in rice fields and incorporated later. Nitrogen fixing bio fertilizer, N containing liquid fertilizer and N enriched organic manure can also be applied as top dressings. Nitrogen containing liquid can be mixed with half burnt paddy husk to prepare N enriched compost. It can be top dressed at 2, 4 and 6 weeks after crop establishment.

Organic manure will improve the cation exchange capacity of soil to retain as well as other relevant plant nutrients and assure better nutrient supply to plants. Organic matter improved soil structure and porosity, which support washing out of soil salts, improved water retention in soil and thereby reduction of salt injury. Improved soil aeration and structure will influence on soil microorganism activity, which assists rapid conversion of applied urea into ammonia and reduce wastage of urea fertilizer. Salinity could reduce the root hairs in number and application of organic fertilizer would evade this situation. Therefore, organic fertilizer could bring in an integrated plant nutrient process, which improves fertilizer efficiency and specifically straw make potassium abundantly available, which could reduce salinity and thereby results in improved crop harvest. Application of gypsum is possible to reduce high alkalinity in the soil.

3.6 Management of pests

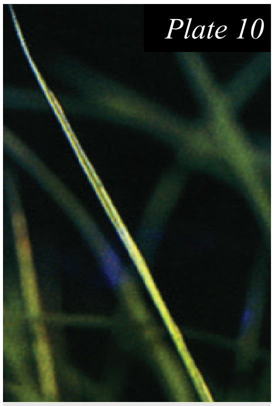
When rice is grown in fields with higher salinity, rice plants cannot absorb potassium from soil due to excessive sodium ions. This results the potassium deficiency. Potassium deficiency may increase the negative effects of pests. Similar to other crops, rice is also subjected to various pest damages from seedling to harvesting stage, and the damage is estimated to be 20%-30%.

Previously thrips, gall midge, brown plant hopper, leaf rolling caterpillar, stem borer and paddy bug are considered as major rice pests and black bug, leaf eating caterpillars, leaf mites, root knot nematodes and field rats are considered as minor pests. However, at present, the damage of leaf sheath mite is recorded from various areas of the country, therefore it should also be considered as a major pest.

In comparison with other cropping systems, pests are present in conjugation with many other organisms such as herbivores, and their predators/ parasitoids (natural enemies) in a rice farming system (or in a field). It is important to ensure the survival of those natural enemies in the eco-system by using pesticides only when absolutely necessary. Integrated pest management mechanisms for each pest are discussed in the next section. This will enable the farmer to get the maximum contribution of the above natural enemies for pest control at no cost.

3.6.1. Thrips *(Stenchaetothrips biformis)*

Adult



Damaged leaf

Damaged field

Rice thrip is a small insect (1 -2 mm in length) with fringed like feathery wings. Adult is black in color and the nymphs are yellowish cream in color. Its life cycle is shorter at high temperatures. It takes about 12 days to complete the life cycle at the temperature of 23°C, while it is 7 days at the temperature of 36°C. Both adults & nymphs suck the sap from tender leaves. As a result, leaf margins are curled upward. At severe infestations, growth retardation and death of plants can happen.

Management

- To prevent or minimize the thrips infestation, late planting should be avoided.

- It is also important to avoid staggered cultivation.
- If field is already infested with thrips, flood the field where water is not scare for 2-3 days and then cutoff water.
- If water is scare, flood the field up to 2-3 inches height and then drag a "Govi poruwa" along the field to enhance the merging of plants in water.

3.6.2. Gall midge *(Orseolia oryzae)*

Plate 12

Adult female

Plate 13

Damage at the tillering stage (silver shoot)

Plate 14

Damaged during reproductive stage (Abnormal structure)

Rice gall midge is a species of small nocturnal dipteran fly. Adult female (with reddish abdomen) laid eggs on the undersides of rice leaf blade or base of the plant. The newly hatched larvae crawls down the leaf sheath and enter into the stem. The larval development and pupation take place inside the stem.

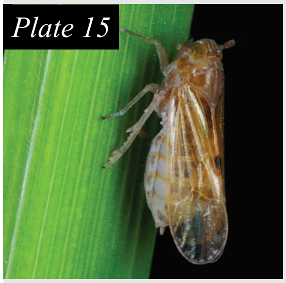
Damage

The damage to the crop is done by the larvae, which forms galls commonly known as "silver shoots" or 'onion leaf'. The damage is done at the tillering stage of the crop. High RH and rainy weather condition is favorable for the pest. It causes severe yield losses as the damaged tillers become unproductive.

Management

- Proper land preparation
- Avoid late planting
- Remove infested plants and plant parts from the field
- Proper weed management
- Avoid excessive use of nitrogen fertilizers
- Establishment of light traps

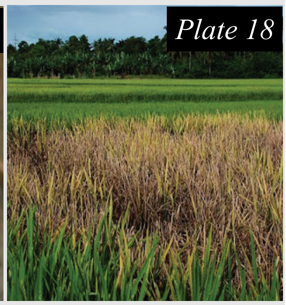
3.6.3. Brown Plant Hopper (BPH)
(Nilaparvata lugens)



Winged adult

Wingless adult

Plant infested with BPH nymphs



Hopper burning paddy field

BPH is considered as the most serious pest of rice. It is a phloem feeder which lives at the base of the plant. BPH acts as the vector that transmits certain viruses such as grassy stunt virus and ragged stunt virus. Development of pest and population density of BPH mainly depends on certain factors such as high RH (>90%) in the micro environment, 28-32°C temperature, high plant density, continuous submerged condition in the field, use of susceptible varieties and succulent plants due to excessive use of nitrogen fertilizer.

Damage symptoms

Uneven burnt patches can be seen in the field which are known as "hopper burn". Apart from that, yellowing and wilting of plants are occurred due to loss of nutrients and obstruction of vessels. Development of sooty mold at the base of rice plants is another symptom which is associated with BPH due to excretion of honeydew.

Management

- Timely planting and avoid staggered cultivation
- Avoid excessive use of nitrogen fertilizers
- Continuous monitoring for early detection
- Enhance naturally occurring biological functions such as predation and parasitism
- Avoid the use of broad spectrum insecticides for the other pests
- Draining of water (if the infestation is low)
- Judicious use of pesticides
- Correct spraying techniques - application to the base of the plants

3.6.4. White - Backed Plant Hopper (WBPH); *(Sogatella furcifera)*

Adult

Damages to the plant and management practices are same with the brown plant hopper.

3.6.5. Rice Leaf Folder (RLF) ; *(Cnaphalocrocis medinalis)*


Plate 20
RLF adult


Plate 21
RLF larvae with the damaged leaf

The RLF larvae cause damages to the rice plant from vegetative to ripening stage. Larvae fold the leaf , lives in it and feed on it. The adult is a 10-12 mm long moth. Damage is severe when fields are under shade conditions. Population density of larvae is increased when temperature is between 25-30 °C and under cloudy and rainy conditions. If temperature is more than 34°C, it is unfavorable for RLF. Sevier yield reductions can happened if the flag leaf is damaged under heavy infestation of RLF.

Management

- Proper land preparation
- Remove the shade around the field
- Weed management
- Remove infested plants and plant parts
- Avoid excessive use of fertilizer
- Maintain proper crop density
- Use of light traps
- Avoid indiscriminate use of pesticides

3.6.6. Yellow Stem Borer (YSB); *(Scirpophagain certulas)*


Plate 22
Adult moth


Plate 23
Larvae stage


Plate 24
White color panicle


Plate 25
Dead heart situation

YSB is a Monophagous pest. Adult females lay eggs on leaves and larvae enters into the leaf sheath after hatching of eggs. Larvae cause damages to the rice plant and live inside the stem and feeds on the growing point (Tillering – Heading). Therefore, emerging new tillers becomes dead, which is known as "dead hearts". When damages occur at booting stage, unfilled panicles are formed, which is known as "white heads". Pupae can survive in stubble for a long time.

Prevention / Management

- Proper land preparation
- Destruction of stubbles as early as possible to kill the remaining larvae/ pupae
- Ploughing/ flooding just after harvesting
- Use of short age rice varieties
- Use of pheromone traps

3.6.7. Paddy bug; *(Leptocorisa oratorius)*

Adult paddy bug

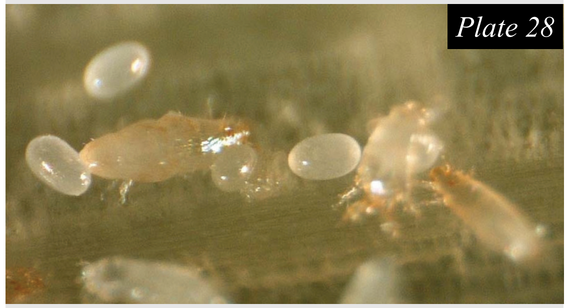
The damaged seeds and the panicle

The pest is found in paddy fields at booting stage to dough stage. Both adult and nymph suck the sap from milky seeds and developing embryo. As a results, the seeds become empty, partially filled or chalky seeds.

Management

- Proper land preparation
- Avoid staggered cultivation
- Proper weed management in and around the field.
- Hand picking of egg masses
- Removing of bugs using catch nets
- Use of sticky traps

3.6.8. Sheath mite;
(Steneotarsonemus spinki)



Eggs of sheath mites

Damaged sheath and panicle

Sheath mites are microscopic in size. They have been reported in Sri Lanka since 2000. Sheath mites live on internal surface of leaf sheaths & feed on it. They act as a vector of sheath rot fungi. Symptoms caused by sheath mites appear as chocolate color lesions on leaf sheaths, seed discoloration and erected panicles.

Management

- Destruction of infested debris
- Destroy stubbles by ploughing
- Drying of seed paddy before incubation
- Proper weed management
- Crop rotation
- Fallowing for 3 months

3.7. Management of disease

Prevention is the most important thing than the direct control of rice diseases under no chemical cultivation. Basic steps to manage diseases in rice,

- Cultivate on season
- Proper land preparation turn over of soil immediately after harvesting using a disc plough to remove infected stubbles and pathogen life cycle
- Proper level land should be maintained
- Apply partially burnt paddy husk
- Use machinery and manual transplanting if possible and maintaining optimum plant density if direct seeding is done
- Use of disease free seed paddy
- Remove infected straw
- Proper weed control
- Proper water and nutrient management
- Give attention to weather pattern
- Remove excess shades if available

3.7.1. Rice blast; *(Magnaporthe oryzae)*

Blast is caused by the fungus *Magnaporthe oryzae*. It can affect all above ground parts of a rice plant: leaf, collar, node, neck, parts of panicle and all growth stages. It occurs in areas with frequent of rain and low night temperature with morning mist. Cultivation of susceptible varieties (Bg 358, Bg 357, Bg 360, Bw 367, At 373 & Bg 94/1) also caused to disease.

Symptoms appear as white to gray - green lesions or spots, with dark green borders in leaves. Older lesions on the leaves are elliptical or spindle-shaped and whitish to gray centers with red to brownish or necrotic borders. Lesions on the node are blackish brown and can cause the culm or the part of the plant that holds the panicle to break. Infection of the neck occurs before milky stage causes no grain formation and white heads.

Lesions on the leaf

Broken neck of the panicle

Rotten neck of the panicle

Disease management

- Other than the basic steps of management, use of botanicals are important to manage rice blast.
- Application of compost tea, Neem seeds, *Pawatta* leaves *(Adhatoda vasica)* in 2 weeks interval (only 30% protection) 100g of Neem seeds + 1L of water keep 12 hrs and filter – 300ml/1L, Compost tea 300ml + 1L of water, 100g of *Pawatta* leaves + 1L of water keep 12 hrs and filter - 300ml/1L

3.7.2. Sheath blight; *(Rhizoctonia solani)*

Sheath blight is a fungal disease caused by *Rhizoctonia solani*. It occurs in areas with high temperature (28-32°C) and relative humidity (85-100%). High levels of nitrogen fertilizer, high seeding rate, close plant spacing, dense canopy and disease in the soil also favor disease development.

Symptoms are usually oval or ellipsoidal greenish gray lesions on the leaf sheath, just above the soil or water level. Lesions on the leaves usually have irregular lesions with gray - white centers. Under favorable conditions, these initial lesions multiply and expand to the upper parts and spread.

Plate 33

Lesions on the leaf sheath

Disease management

- Other than the basic steps of management, removal of shade trees, removal of water just after the observation of symptoms and use of botanicals are important to manage sheath blight.
- Application of compost tea, neem seeds, *Pawatta* leaves *(Adhatoda vasica)* in 2 weeks interval (only 30% protection)
- 100g of neem seeds +1 L of water, keep for 12hrs and filter – 300ml/1L, Compost tea 300ml+ 1L of water, 100g of Pawatta leaves+1 L of water keep 12hrs and filter-300ml/1L

3.7.3. Bacteria Leaf Blight; *(Xanthomonas oryzae pv. oryzae)*

Bacterial blight is caused by *Xanthomonas oryzae* pv. oryzae. It is the most common bacteria diseases in rice. It could be observed in planted crop than seeded crop in generally. The seedling stage damage is called as Kresek.

Symptoms are wilting and yellowing of leaves in seedlings. Kresek on seedlings may sometimes be confused with early rice stem borer damage. On older plants, lesions usually develop as water-soaked to yellow-orange stripes on leaf blades with wavy margins and progress towards the leaf base. Finally leaves become dry and show as straw.

Plate 34

Kresek condition

Plate 35

Lesion on the leaf

Disease management

Follow basic steps of disease management. Allow fallow fields to dry in order to suppress disease agents in the soil and removals of plant residues are important to control the disease. According to research adding of additional 10kg/ha of pottasium after symptoms are observed reduces the spreading of BLB.

3.7.4. Brown spot; *(Cochliobolus miyabeanus/ Bipolaris oryzae)*

Brown spot is a fungal disease caused by *Cochliobolus miyabeanus* (Bipolaris oryzae). The disease is common in un-flooded and nutrient-deficient soil or in soils that accumulate toxic substances. The fungus can survive on the seed for more than four years and can spread from plant to plant through air. Brown spot can occur at all crop stages, but the infection is most critical during maximum tillering up to the ripening stages of the crop.

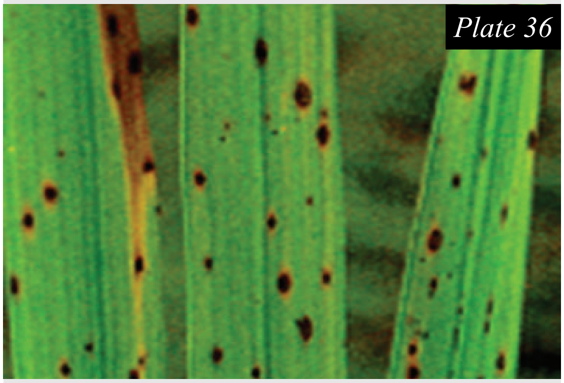


Plate 36

Brown spot disease

Infected leaves have small, circular, and dark brown to purple - brown lesions. Fully developed lesions are circular to oval with a light brown to gray center, surrounded by a reddish brown margin. Infection of florets leads to incomplete or disrupted grain filling and a reduction in grain quality.

Disease management

Other than the basic steps of disease management improving soil fertility is the most important step in managing brown spot by monitoring soil nutrients regularly. Treat seeds with hot water (53−54°C) for 10−12 minutes before planting, to control primary infection at the seedling stage.

3.7.5. Sheath Rot; *(Sarocladium oryzae)*

Sheath rot is caused by fungi *Sarocladium oryzae*. Its incidence increases with in plants that provide entry points for the fungus, in the form of injuries and wounds caused by insects. The typical sheath rot lesion starts at the uppermost leaf sheath enclosing the young panicles. It appears as irregular spot with dark brown or brownish gray. Panicles remain within the sheath or may partially emerge. The disease reduces grain yield by retarding or aborting panicle emergence, and producing unfilled seeds and sterile panicles.

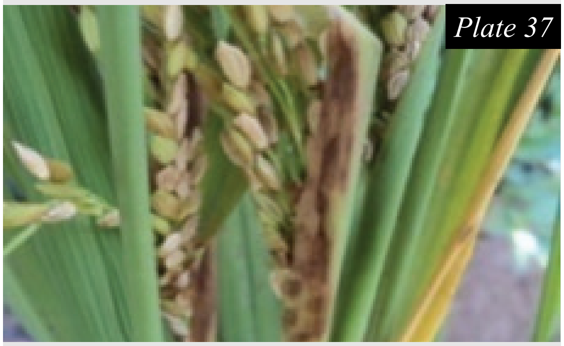


Plate 37

Lesions on the leaf sheath and partially emerge panicle

Disease management

Follow basic steps for disease management

3.7.6. Narrow brown spot

***Sphaerulina oryzina* (syn. *Cercospora janseana, Cercospora oryzae*)**

Narrow brown spot is caused by the fungus *Sphaerulina oryzina* (syn. *Cercospora janseana, Cercospora oryzae*). The disease usually occurs in potassium deficient soils and in areas with temperature ranging from 25−28°C. Plants are most susceptible during panicle initiation stage and onwards. Typical lesions on leaves are linear, light to dark brown and progress parallel to the vein.

Plate 38

Lesions on the leaf

Disease management

Follow basic steps for disease management mension in 3.7.

3.7.7. Leaf scald *(Microdochium oryzae)*

Leaf scald is a fungal disease caused by *Microdochium oryzae*. Disease development usually occurs late in the season on mature leaves and is favored by wet weather, high nitrogen fertilization and close spacing. Zonate lesions of alternating light tan and dark brown starting from leaf tips or edges are the common symptoms.

Plate 39

Zonate lesions on the leaf of scold disease

Disease management

Follow basic steps for disease management mension in 3.7.

3.7.8. False smut *(Ustilaginoidea virens)*

False smut causes by *Ustilaginoidea virens*. Rain, high humidity and soils with high nitrogen content favor for disease development. Disease is visible only after panicle exertion during flowering stage. Velvety smut balls on spikelets could be seen on panicle. Spore balls are initially orange and turn greenish black when mature.

False on the seeds

Management of disease

Reduce humidity levels through alternate wetting and drying (AWD) rather than permanently flooding the fields and follow basic steps for disease management

3.7.9. Grain discoloration
(Alternaria padwickii, Curvularia spp*)*

Grain discoloration of rice is a complex disease due to many causes: Infection by microorganisms (fungi and bacteria), climatic factors, soil problems and insect damages. The fungi that are reported to be associated with discoloration of grains are mostly *Alternaria padwickii*, *Curvularia* spp, *fusarium* spp. and bacteria *Psudomonas* spp.

Discoloured seeds

Management of disease

Follow basic steps for disease management mension in 3.7.

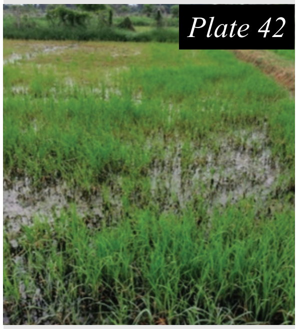
3.8. Management of weeds

Weeds considered as a major biotic constraint in rice production and contributed to approximately 10-40 % yield loss depending on the weed density and type of weed species. Weed diversity and density depend on the crop establishment method, soil moisture availability, herbicides usage and soil type (soil salinity).

Climate change has effects on daily temperature, variation in rainfall pattern and soil moisture depletion. Therefore, change in climate indirectly affects on the weed diversity. Drought conditions are often contributed to the development of sol salinity. Soil salinity is a one factor which determines weed density and diversity.

Soil salinity on rice growth. of the rice plant. However, weed growth is also affected by the salinity. However, some research findins state that, soil salinity affects more on rice than weed in rice. Some research findings show that, *Echinocloa crus-galli* and *Echinichloa colona* can grow under salinity condition than rice.

In addition to that, *Echinichloa colona* and *Cyperus* species are prominent in salinity affected rice fields in Puttlum district. Further, *Cyperus difformis* are the dominant weed species among the sedges. These show that, soil salinity is a major factor, which determines weed diversity in rice system and sedge weed density is a prominent character of salinity affected rice field.



Salinity affected rice field

Salinity affected soil with *Cyperus species*

In addition to that, Hambu (*Typhaangus tifolia*, Family – Typhaceae) is a dominant weed species found in salinity affected soils. *Typhaangus tifoliais* a perennial herb and considered as salinity tolerant plant.

Typha angustifolia* plants in salinity affected *field

when developing weed management strategy for salinity affected rice system, weed species and density factor should consider and integrated weed management approaches should be implemented.

Following integrated approach need to price for effective weed management in saline condition.

1. Surrounding, water channels and bund cleaning is important to avoid weed infestation to field.
2. Proper land preparation practices.
   - 1st land preparation: ploughing practices need to do up to the depth of 5-9''. After 1st plough if water is sufficient added water to cover only the half of the ploughed soil particles and allow for 2 weeks to decay the weeds particles and seeds.
   - 2nd land preparation: Practice 2nd land preparation after two weeks of 1st land preparation. and after 2nd land preparation inundate field with water for one week
   - 3rd land preparation: harrowing and leveling is practice
3. Quality seed paddy usage: paddy seeds should be free from weed seeds
4. Use effective crop establishment method for weed control
   - Transplanting manually/ mechanically: after establishment of 5 days inundate water to field up to 3-5 cm depth. Use weeder to control weeds in transplanted fields.
   - Parachute establishment: at the time of establishment maintain 3-5 cm water layer and maintain thin layer of water up to 21 days.

- Row seeding: row establishment and use of weeder is an effective method to weed control
- Ware seeding rice establishment: effective method of weed control

5. Water management: water is a best tool to manage weeds in rice. Therefore, try to maintain thin layer of water after crop establishment to reduce weed germination and growth.

Above integrated approach is effective to control weeds in saline affected soil.

3.9. Harvesting

Rice is a cereal crop that produces ripened spikelet as a consumable product, which is harvested at maturity of the crop. Harvesting is the final growth stage of the crop. Further, crop maturity duration of rice is almost 30 days and does not change according to the age group. Maturity period starts from flowering of the crop, after milking stage rice plant do not need soil moisture to complete life cycle. Therefore, it is better to drain out water from fields after milking stage.

According to varietal characteristics some varieties maintain their flag leaf colour in green or pale green at physiological maturity. Therefore, colour changes of the leaves are not a sign of maturity. The very important thing is harvesting at physiological maturity. At physiological maturity more than 85% panicles taken a golden brown colour while starting a discoloration of leaves. Late harvesting (after physiological maturity) cause the reduction of head grain yield due to crack formation of grains. High temperature in saline affected areas could further enhanc this condition.

According to the land extent and availability of machinery we can harvest paddy crop manually or mechanically. It is better to air dry the harvest until 13 % moisture level in seeds is obtained. This air drying promotes high amount of head grain yield, good keeping quality and minimum post-harvest pest damages. Under Salinity condition, if soil moisture is available, ploughing field just after harvesting decreased the upward movement of salt during the fallowing period.

NOTES

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