Rice

Rice (*Oryza sativa* L.) is a major food crop of North eastern states. Majority of the rice growing area in hills (under uplands and in jhooms) is under traditional organic cultivation without the use of chemical fertilizers and pesticides. Even in plains where fertilizer is used the utilization level is much below the national average. Therefore, prospects for organic rice production are good.

Organic rice production involves recycling of crop residues, crop rotation, inclusion of legumes in system both in sequence or as intercrop, green manuring, off -farm waste recycling, use of mineral rocks like rock phosphate, mechanical cultivation and biological and organic pest control. Weed control, soil fertility and management of pest and diseases are the principal challenges associated with organic rice production.


Photo – Rice cultivation in hill terraces (left), Rice panicle (right)

Climatic requirements

In India rice is grown under widely varying conditions of altitude and climate. Rice crop generally needs hot and humid climate. The average temperature requirement throughout the life period of the crop ranges between 21 to 37^{o}C. At the time of tillering the crop requires slightly higher temperature. Temperature requirement for blooming is in the range of 26.5 and 29.5^{o}C and ripening time temperature between 20 and 25^{o}C.

Soil

Rice can be grown under any type of soil reaction varying from acidic to alkaline. Soil having good water retention capacity with good amount of clay and organic matter is ideal. Well-drained, loamy and light alluvial soils with pH 5.0 to 6.5 are most suitable for proper growth and productivity.

Varieties Low latitude

IR 64, Naveen, Gomati Dhan, Ranjit, RC-Maniphou-4, RC-Maniphou-5, RC-Maniphou-7, RC Maniphou 10, TRC Borodhan-1, DR 92, Shahsarang 1, Lampnah etc. Aromatic and fine grain rice: Joha, Kalikhasa, Harinarayan

Mid altitude
Upland: Bhalum-1, Bhalum-2, Bhalum-3, Bhalum-4, Iuron and IET 20204

Lowland: Shahsarang-1, IR-64, Lampnah, VD-82, Krishma Hamsa, Mendri, Manipuri Aromatic and fine grain rice : Megha AR-1, Megha AR-2, Kekeki Joha

High altitude
Megha rice1, Megha rice 2, Megha rice 3

Crop Duration
120 – 160 days depending upon varieties and sowing time

Seed rate:
1. **Transplanting:** For medium to fine type rice variety a seed rate of 35-40 kg/ha and for bold type 40-50 kg/ha will be sufficient for transplanting one hectare of land.

2. **Direct seeding**: For direct seeding in upland condition, a seed rate of 60-80 kg/ha is required to get good plant stand.

3. **System of Rice Intensification**: 5 kg/ha

4. **Integrated Crop Management**: 10 kg/ha

Seed treatment

Land preparation:
1. **For transplanting**: Prepare the land thoroughly and keep well leveled with peripheral bunding. Puddling should be done 3-4 times to make it weed free and water retentive. Apply FYM 15 t/ha or FYM 7.5 t/ha + V.C 2.5 t/ha with 150 Kg/ha Rock phosphate 20 days before last ploughing. The quantity can vary if other combinations of organic manure (i.e. chicken manure, deoiled meals etc) are used

2. **For direct seeding:** Two cross ploughing (4 ploughing) is necessary to get good tilth of soil and weed free land. Application of lime @ 2 t/ha at the first or second ploughing is necessary to obtain good yield. Lime should be applied at least 1-2

weeks before sowing. Liming should be repeated every 3-4 years. Quantity of organic manures and rock phosphate shall be the same as above.

Nursery Preparation

a. Wet method

The wet method can be adopted in areas where water is available. Prepare raised beds of 5-10 cm height, 1-1.5 m width and of convenient length with drainage channels between the beds. Total seedbed area should be 1000 m^2 for planting in 1 ha. Apply vermicompost @ 500g / m^2 and rice husk ash @ 100 g /m^2 of the nursery bed and mix well with the soil at the time of preparation of the field. Application of vermicompost reduces the incidence of thrips. If vermicompost is not available, apply compost or cattle manure @ 1 kg /m^2 and 100 g of rice husk ash / m^2 of the nursery bed and mix well with the soil at the time of preparation of the field. Biofertilizers can also mixed with FYM/ compost before application to nursery @ 2kg/1000 m^2

b. Dry method

This method is practiced in areas where sufficient water is not available and the time of planting is uncertain. Prepare raised beds of 1-1.5 m width 15 cm height and of convenient length. Apply vermicompost @ 500 g/ m^2 and rice husk ash @ 100 g/m^2 of the nursery bed. If vermicompost is not available, apply compost or cattle manure @ 1 kg / m^2 and 100 g of rice husk ash /m^2 of the nursery bed and mix well with the soil at the time of preparation of the field. Sow the seeds treated as described under dry seed treatment method, evenly over the bed and cover with fine sand / soil.

Time of transplanting/sowing:

Transplanting: The optimum time of transplanting is first fortnight of July for low and mid altitude. Time of transplanting should be adjusted to avoid low temperature during flowering especially in higher altitudes (above 1300 m). Therefore, under high altitude, transplanting should be completed within 15th June, preferably by first week of June. For mid and low altitude valley land, transplanting can be done as late as 3rd week of July with closer spacing (15 x 10 cm) and aged seedling (40-45 days old). Seedling age of 20 -25 days with 20 x 15cm spacing and 2-3 seedlings/hill is considered best for timely transplanted crop. For SRI, 10-12 days and for ICM 15-20 days old seedlings are transplanted. For SRI and ICM methods of rice cultivation only 1 and 2 seedlings and transplanted/hill, respectively with a spacing of 25 x 25 cm for SRI and 20 x 20 cm for ICM.

Direct sown:

In upland direct sown crops, sowing should be completed within first fortnight of June in mid altitude condition. Timely sowing is necessary to have enough time for the

succeeding *rabi* crops, which are normally sown in the second fortnight of October. Direct seeded crop is sown in line of 25-30 cm apart maintaining a seed rate of 60-80 kg/ha.

Age of seedlings and spacing Methods

Methods	Spacing	Age of seedling	Seedling/hill
Conventional Rice culture (CRC)	20 x15 cm	30 days	3 seedlings
Integrated Crop Management (ICM)	20 x 20 cm	20 days	2 seedlings
System of Rice Intensification (SRI)	25 x 25 cm	12 days	1 seedlings
Late transplanting	20 x10 cm	30-35 days	3-4 seedlings

Lime application

Lime application ameliorates soil acidity and enhances crop nutrient uptake. In general, addition of lime is absolutely necessary when the pH is lower than 5.0 and it is not advisable especially for rice when pH varies between 5.5 and 6.5. For direct seeded crops, apply lime @ 2000 kg/ha at about one month before sowing and if lime was applied in the furrow then dose should be 500 kg/ha applied at the time of sowing. For transplanted crop, apply lime @ 2000 kg/ha about one month before transplanting once in every three years.

Nutrient Management for Main Field:

Rice crop usually require 100 kg N, 40 kg P and 40-60 kg K. As organic management is an integrated approach, efforts should be made to recycle the biomass to keep soil rich in organic carbon. Therefore use of green biomass, green manuring, use of biofertilizers should be the first priority. Gap if any is to be compensated with the use of organic manures. One cycle of green manuring with legume crop such as Sesbania, one cycle of dual Azolla culture and use of *Azospirillum* and PSB biofertilizer can meet 75-80% of nutrient requirements. In such cases only 25-30% nutrients need to be compensated through manures (3-4 tons of FYM or 2 tons of vermicompost/ha).

Nutrient management if entire nutrient is supplemented by manures and organic / mineral fertilizers

(a) Direct sown:

In upland direct seeded crop, 12-15 tonnes well rotten Farm Yard Manure (FYM) along with 150 kg rock phosphate is sufficient for sowing of one hectare area. Alternatively, 5-7.5 tonnes vermicompost along with 150 kg rock phosphate may be used. Integrated application of FYM @ 10 t/ha and vermicompost 2.5 t/ha along with 150 kg rock phosphate is the best option for higher productivity and sustainability of rice production.

Application of neem cake 150 kg/ha provides protection against soil borne diseases and improves nutrition of rice crops.

(b) Transplanted:

All the weed biomass and crop residues of previous crop should be incorporated within the field, which improve the fertility of soil and reduces the requirement for organic manure application. Apply 10-12 tonnes of FYM before 20 days transplanting and 250-300 kg neem cakes during transplanting of rice crop or apply 5-6 tonnes of vermicompost before 20 days transplanting and 250-300 kg neem cakes during transplanting of rice crop. Application of 5 tonnes FYM + 2 tonnes vermicompost + 3 tonnes green manures / weed biomass (*Eupatorium/Ambrosia*) before 20 days transplanting and 250-300 kg neem cakes during transplanting of rice crop is the best nutrient management options. Rockphosphate @ 150 kg/ha may be applied for better phosphorus nutrition.

Please Note

Quantities of manures can be adjusted according to the nutrient contents, therein and the organic carbon status of the soils. During initial conversion years above mention quantities are essential to get optimum productivity. Once soil is adapted to organic management and have adequate organic carbon, then quantities of organic manures can be reduced. One cycle of green manure can add up to 75 kg of N. Similarly Azolla dual culture can also add additional 20-25 Kg N. In such cases reduced quantities of manures will be needed. Rockphosphate and neem cake can still be used. Combined use of Azospirillum and phosphate solubilizing bacterial biofertilizers also help in adding 20-25 kg N and 10-12 kg phosphorus.

Top dressing and foliar feeding

In organic farming as all manures and organic fertilizers including green manures are applied as basal dose, crop may feel hungry at grain formation and filling stage. Therefore it is advisable to undertake topdressing and/ or foliar feeding through any of the following methods:

i. Cow urine mixed with water as soil application @50 lit/ha twice at 60 and 75 days after sowing
ii. Biogas slurry diluted with water @ 200 lit/ ha
iii. Vermiwash (5%) or Panchgavya (3%) or fishmeal extract or on-farm made protein hydrolysate (4-5 ml/ lit of water) as foliar spray. Two sprays can be given at 60 and 70 days after sowing.

Methods of green manuring

Leguminous green manures used in rice based cropping system include *Sesbania aculeata, Sesbania rostrata, Sesbania speciosa* and *Crotalaria juncea*. These are grown during the pre-rice season between April and June and the biomass is incorporated into the soil before rice is transplanted. Wherever limited irrigation facilities are available, grain legumes such as green gram, black gram and cowpea can be grown in summer season.

In-situ green manuring

Farmers can choose the green manure crop according to their local availability and agroclimatic conditions. Dhaincha (*Sesbania aculeata*) is the commonly used and ideal green manure crop for rice fields. Usually after the harvest of *rabi* crop, dhaincha is sown with the onset of summer showers and it is ploughed and incorporated 8-10 weeks after sowing. Among the green manure crops, *Sesbania aculeata* is the one, which can supply highest amount of biomass and nitrogen. It is fairly drought tolerant and resistant to water logging. It is suitable for loamy and clayey soils. One crop of dhaincha can add 10-20 tonnes of biomass per ha. For sowing one ha area, 20-25 kg of seed is required. It can fix about 75-80 kg N per ha depending on the environmental conditions.

Methods of application of biofertilsers

Azospirillum

Seed treatment:

Mix the carrier based inoculum 200 g in 200 ml of rice gruel to make a slurry which is sufficient to treat 10 kg of seed. The seeds are mixed in the slurry so as to have a uniform coating of the inoculum over the seeds and then shade dried for 30 minutes. The shade dried seeds should be sown within 24 hours. Biorganic RF 79 (biofertilizer) developed at ICAR Complex, Umiam @ 40 ml/L for seed treatment has been found to increase rice productivity by about 15 %.

Main field application:

Two kilogram *Azospirillum* is mixed with 50 kg of dried powdered farm yard manure and then broadcast in one ha of main field just before transplanting.

Phosphorus Solubilising Bacteria (PSB)

Carrier based phosphobacteria can be applied as seed treatment and field application as in the case of *Azospirillum.*

Azolla Green Manure

Azolla can be applied as green manure for rice before transplanting. For this, Azolla is grown 15- 20 days before transplanting of rice by applying 1-2 t fresh inoculum per ha in

a well prepared field. Rock phosphate is applied @ 62.5 kg/ha in three equal splits at an interval of seven days. After the formation of thick mat, water is drained out and the field is ploughed for incorporating Azolla.

Azolla Dual culture:

Growing of Azolla along with rice is more easy and feasible. Azolla technology is very efficient in terms of nitrogen fixation and biomass accumulation during *rabi* season due to better environmental conditions for its vegetative multiplication. It can also be used for late *kharif* season. Fresh biomass of Azolla is applied in the main field 7-10 days after transplanting rice. Inoculation of fresh biomass of Azolla @ 200 kg / ha could multiply faster and cover the rice field as a green mat in 2-3 weeks period with 15-20 tonnes biomass accumulation. Azolla is incorporated at the time of first weeding. It can be done with a weeder or leave it for self-decomposition. Azolla decompose in the flooded rice field in 2-3 weeks period. During the incorporation of Azolla, the left over fronds float on water surface which multiply and cover the rice field. Again 2-3 incorporation is possible. The cultivation of Azolla not only supplies biomass and N, but also contributes K, P, Ca, S, Zn, and Fe. The suppression of weed growth is another added advantage of Azolla cultivation along with rice.

The nutrient content of some tree leaves such as *Gliricidia maculcata* grown abundantly in humid tropical areas of NE region contains 2.9% N, 0.5% P and 2.8% K on dry wet basis. Leaves and tender branches of such plants can be a local source of leaf manure producing 12 – 15 kg dry matter / tree. About 400 plants can be grown on the peripheral boundary can yield 5-6 tons green manure/ha. Other tree species like *Crotalaria juncea* and *Tephrosia purpurea* are observed to have 2.4 – 2.7 % N, 0.3 – 0.6 % P and 0.8 – 2.0 % K.

Water Management:

(a) Transplanted rice:

Continuous submergence of 2-5 cm during crop growth (transplanting to maturity) gave higher yield. This practice help to suppress weed growth right from the beginning. Water is drained out during fertilizer application. The depth of water should not exceed 5 cm in the field particularly at the tillering stage of the crop. Higher depth of water during tillering reduces the number of tillers/hill causing reduction in yield. After the completion of tillering, the field should be drained out for a week and reflooded again. This will result in higher number of effective tillers/hill. In any case, there should not be any water stress during panicle initiation to grain filling stage. Irrigation should be stopped 3-4 weeks before harvesting the crop. Under SRI practice no flooding is needed and field is kept saturated. No standing water to be maintained during tillering up to panicle

initiation. Intermittent wetting and drying until panicle initiation stage is desirable. The period of drying and wetting can range from 2-7 days.

(b) Direct seeded rice:

Cultivation of crops in topo-sequence helps in better utilization of water in hill slopes and terraces. While rice is cultivated in terraces or slopes, it should be grown in the lower portion of the hill slope where runoff concentrates. Water harvesting in-*situ* in flat or terrace land can be done by providing peripheral bunding to increase crop yield. Saturation and submergence are equally effective for direct sown rice.

Weed management

Weed control practices includes hand weeding, crop rotation, land leveling, stale seed bed preparation, flooding and use of rotary weeder etc. Longer crop rotation breaks the cycle of weed growth, while proper land preparation, leveling and flooding to uniform depth, suppress weeds directly. In upland rice intercropping with legumes like soybean, groundnut etc. (4:2 row ratio) was found to reduce weed problem besides adding to soil fertility.

Application of fresh makrishal (*Schima walchii*) leaves and twigs @ 10 t/ha was found to improve rice yield besides keeping the weeds at minimal level. Regular incorporation of weeds into the soil during fallow period not only reduces the weed problem but also adds to soil nutrient reserve. The longer rotation allows additional time to break weed life cycles and reduce the number of weed seeds in the soil. Other weed-control options focuses on the use of field flooding to suppress weeds directly and to give the crop a competitive advantage. Flooding will be more effective if fields are precision leveled. Levelling makes the water depth uniform and facilitates rapid flow onto and from the field. Dual cropping of rice with *Azolla* also reduces weed problems and improves productivity through addition of macro and micronutrients. Releasing about 20 ducklings/ha also keeps the weeds at minimal level and increases rice yield.

Pest and disease management

The incidence of pest and diseases in properly managed organic fields are generally low. This is because of resistant varieties, cultural practices like crop rotations, time of planting, balanced nutrition, proper water management, clean field bunds and removal of infested leaves and plants. Selection of healthy and clean seed materials may also keep the problem of disease pest at minimal level.

The pest and diseases in rice can be kept below economic threshold limit (ETL) by using following strategies:

A. Cultural and mechanical strategies

i. Use of disease free and disease resistant/ tolerant varieties
ii. Inoculating seed with *Azotobacter, Azosprillum* and treating with *Trichoderma viride* for protection against seed and soil borne diseases in upland direct seed sown crop
iii. Adopt green manuring and adequate use of organic manures
iv. Grow legumes frequently and incorporate them into the soil at a tender stage
v. Decomposing organic manures suppress the nematode population.
vi. Soil application of neem cake @150 kg/ha or spraying of neem oil @ 2.5 ml/lit water prevent insect pest and disease attacks and enhance plant growth and yield through reduction in nitrogen loss from the system.
vii. Timely planting, variety selection, and cultural practices to suppress weeds and encourage dense stands of rice help control stinkbugs and water weevils.

B. Ecological Strategies

i. Install 4-5 pheromone traps/acre separated by 75 feet distance, Fix the traps on supporting poles at a height of 1 feet above the crop canopy
ii. Install light traps 2-3 traps/ha for mass trapping of insects, light traps with exit option for natural enemies of smaller size should be installed and operate around dusk time (6 pm to 10 pm)
iii. Release of natural enemies such as *Trichogramma japonicum* on 30 and 37 DAT against stem borer and *Trichogramma chilonis* on 37, 44 and 51 DAT (Thrice) against leaf folder,
iv. Release of *Platygaster oryzae* parasitized galls @ 1 per 10 m^2 in the mainfield on, 10 DAT against gall midge.
v. Grow flowering plants as mentioned on border, internal bunds and as intercrops or strip crops in upland situations to attract natural enemies and also repel insect pests harmful to crop. After flowering these plants can be used as green manure/mulch.

Keep on monitoring pest defender ratio and it should not exceed beyond 2:1. If it exceeds then adopt curative control measures. Individual pest-wise integrated management methods are given below:

1. Whorl maggot (*Hydrellia philippina* Ferino)

Symptoms - Visible in early growth states mainly under lowland situations. White or transparent patches on leaves, pinholes damaged leaves easily break from the wind, somewhat distorted leaves, clear or yellow spots on inner margins of emerging leaves, stunting of plants with few tillers.

Management - There is no cultural control for rice whorl maggot. Small beneficial insects such as wasps can parasitize its eggs, Dolicopodid flies prey on the eggs and ephydrid flies and spiders feed on the adults. Therefore manage diversity and conditions for proliferation of such beneficial insects. The rice plant can compensate for the damage caused by the rice whorl maggot with the growth. Usually, the symptoms disappear during the maximum tillering stage of the crop.

2. **Rice hispa [*Dicladispa armigera* (Olivier)]**

Symptoms – Larva scrape upper surface of the leaf blade leaving only the lower epidermis and white streaks parallel to the midrib. Irregular translucent white patches that are parallel to the leaf veins caused by tunnelling of larvae through leaf tissue, causes withering of damaged leaves and leaves become whitish and membranous. Rice field appears burnt when severely infested

Management - Avoid over manuring. Close plant spacing results in greater leaf densities that can harbour higher hispa numbers. To prevent egg laying of the pests, shoot tips can be cut. Clipping and burying shoots in the mud can reduce grub populations by 75−92%. Spary *Bauveria basiana* (1%) having 10^6 viable spores/gm/ml. Eupatorium leaf extract (5%) has also been found to be effective as foliar spray.

Photo – Damage by Rice Hispa (left) Hispa beetle (right)

3. **Yellow stem borer (*Scirpophaga incertulas*)**

Symptoms - Larva feed upon tillers and causes dead hearts or drying of the central tiller during vegetative stage; and causes whiteheads at reproductive stage. Tiny holes on the stems and tillers and frass or fecal matter inside the damaged stems can be seen

Dead hearts and whiteheads symptoms may sometimes be confused with damages caused by rats, neck blast, and black bug diseases. To confirm stem borer damage, visually inspect rice crop for dead hearts in the vegetative stages and whiteheads in

reproductive stages. Stems can be pulled and dissected for larvae and pupae for confirmation of stem borer damage.

Photo – Dead heart in rice

Management - Grow resistant varieties, Clip the tip of seedlings before transplanting to eliminate egg masses. Avoid close planting and continuous water stagnation at early stages. Collect and destroy the egg masses. Pull out and destroy the affected tillers. Set up light traps to attract and kill the moths. Harvest the crop up to the ground level and disturb the stubbles with plough immediately after the harvest. Release the egg parasitoid, *Trichogramma japonicum* on 30 and 37 DAT twice @ 5 ml/ha/release. Apply *Bacillus thuringiensis* var *kurstaki* and neem

seed kernel extract in combination of 2.5 kg and 1% to reduce the oviposition by the stemborer

4. **Rice bug (L*eptocorisa oratorius, L. varicornis* and *L. acuta*)**
   Symptoms - Rice bugs damage rice by sucking out the contents of developing grains from pre-flowering spikelets to soft dough stage (milky stage). Individual grains become chaffy. Black spots on the grains at the site of feeding puncture. Buggy odour in rice field during milky stage

   Management - Keep the field free from weeds and grasses. Drain excess water from the field. Set up light trap during the full moon period to attract large number of bugs and kill. Conserve pest predators *viz.,* spiders, coccinellids and wasps to check the pest. Ducks can be allowed in the field to pick up the bugs. Planting fields, within a village, at the same time (synchronous planting) helps reduce rice bug problems. Foliar spray of Neem seed kernel extract 5% or Notchi leaf powder extract 5% or Ipomoea leaf powder extract 5% or Prosopis leaf powder extract 5% helps in keeping the problem in control. Panchgavya 3% has also been found effective.

5. **Brown plant hopper (*Nilaparvata lugens*),**
   Symptoms - Crescent-shaped white eggs inserted into the midrib or leaf sheath, white to brown nymphs and brown or white adults feed near the base of tillers. Leaves turn to yellow and later brownish "Hopper burn". Presence of honeydew and sooty moulds at the basal parts is characteristic symptom. Infestation is more severe during panicle initiation stage.

   Management - Use resistant varieties. Avoid close planting and provide 30 cm rogue spacing at every 2.5 m to reduce the pest incidence. Control irrigation by intermittent draining. Set up light traps to monitor pest population and to control. Release of natural enemies like *Lycosa pseudoannulata*, *Cyrtorhinus lividipennis*. Spray neem seed kernel extract 5% (25 kg/ha) (or) neem oil 2% (10 l/ha) after draining the water and direct the spray jet towards base of plants. Foliar spray of *Verticillium lecanii* @ 5gm/ lit of water is also effective.


Photo Brown Plant Hopper (left) Damage by gall midge (right)

6. **Gall midge *(Orseolia oryzae)***

   Symptoms - Formation of a hollow cavity or tubular gall at the base of the infested tiller. The gall formed is silvery white hollow tube, 1 cm wide and 10−30 cm long. Affected tiller inhibits growth of leaves and fails to produce panicles. Deformed, wilted, and rolled leaf, elongation of leaf sheaths, also called onion leaf or silver shoot. Plants get stunted. To clearly identify and not getting confused with other pest symptoms check for presence of insect. Particularly, elongate-tubular eggs and maggot-like larva feeding inside developing buds.

   Management - Early planting help crop to escape from infestation. Use resistant varieties. Harvest the crop and plough immediately. Remove the alternate host and adjust the time of planting. Use quick growing varieties. Set up light trap @ 1 /ha as a monitoring device. Infra-red light trap attracts gall midge effectively. Release larval parasitoid: *Platygaster oryzae* through parasitized galls @ 1 per 10 m^2 in the main field at 10 DAS. The carabid beetle, *Ophionia indica* is an effective predator. Conserve the spider predators like *Tetragnatha* and *Argiope catenulata* in rice ecosystem to feed on the adult midge.

7. **Leaf folders [*Cnapha-locrosis medinalis* (Guenée) and *Marasmia* spp.]**

   Symptom - Symptoms include longitudinal and transparent whitish streaks on damaged leaves. Tubular folded leaves, leaf tips sometimes fastened to the basal part of leaf. Heavily infested fields appear scorched with many folded leaves

Management - Use resistant varieties. Clipping of affected leaves reduces the pest population. Keep the bunds clean by trimming them and remove the grassy weeds. Follow rice with a different crop, or fallow period. Flood and plough the field after harvesting if possible. Remove grassy weeds from fields and borders. Reduce density of planting Set up light traps to attract and kill the moth. Release *Trichogramma chilonis* on 37, 44 and 51 DAT thrice. Spray neem seed kernel extract 5% three time.

Photo – Leaf Folder damage

8. **Caseworm (*Nymphula depunctalis*)**

   Symptoms - Symptoms for case worm include: Leaf cases floating on water. Leaves cut at right angles as with a pair of scissors. Leaves with papery upper epidermis as they were fed on to insects. Skeletonized leaf tissues usually appear ladder-like

   Management - Release larval parasitoids viz: *Elasmus* sp., *Apanteles* sp *Bracon* sp., . *Hormiues* sp. Release pupal parasitoids *viz., Pediobius* sp., *Apsilops* sp., *Eupteromalus parnarae*. Drain water from the field. Dislodge the cases by running a rope over the young crop

9. **Sheath blight (*Rhizoctonia solani*)**

   Symptoms - Symptoms of sheath blight appear from tillering stage till milk stage. Oval or ellipsoidal greenish gray lesions, usually 1-3 cm long, on the leaf sheath, initially just above the soil or water level. Under favorable conditions, these initial lesions multiply and expand to the upper part of the sheaths, the leaves, and then spread to neighbouring tillers belonging to different hills (in transplanted rice) or plants (direct-seeded rice). Leaves usually have irregular lesions, often with grey-white centres and brown margins as they grow older.

   Management - Maintain plant density (direct seeding or transplanting). Control of weeds, especially on the levees. Drain rice fields relatively early in the cropping season to reduce sheath blight epidemics. Improve canopy architecture by reducing seeding rate or providing wider plant spacing

Photo- damage by Sheath blight (left) and bacterial leaf blight (right)

10. **Bacterial blight (*Xanthomonas oryzae* pv. *oryza*)**

Symptoms - Water soaked lesions move from tip downwards on the edges of leaves. Gradually turn into yellow and straw coloured stripes with wavy margins. In early morning in humid areas yellowish, opaque, turbid drops of bacterial ooze may be seen. In Kresek (wilt) phase, leaves roll completely, droop and plants die completely

Management - Balanced fertilization. Ensure good drainage of fields and nurseries. Keep fields clean. Remove weed hosts. Allow fallow fields to dry in order to suppress disease agents in the soil and plant residues. Seed and soil application of *Trichoderma viride* and *Bacillus subtilis* has also been found to manage the disease. Use 10 gm each for 1 kg seed treatment and 2.5 kg each/ha mixed with 300-500 kg FYM/ compost for soil treatment.

11. **Rice blast *(Pyricularia grisea* (*P.oryzae*)**

Symptoms - Disease can infect paddy at all stages and all aerial parts of the plant. Leaves and neck infections are more severe. Small specks originate on leaves, subsequently enlarge into spindle shaped spots with ashy centre. Later several spots coalesce to form big irregular patches.

Management - Remove collateral weed hosts from bunds and channels. Use only disease free seedlings. Use resistant varieties. Seed treatment, seedling root dip treatment and foliar spray of *Pseudomonas fluorescens* liquid biopesticide @ 5 ml/lit of water.

Photo – Rice Blast

12. **Sheath Rot (*Sarocladium oryzae*)**

Symptoms - Discoloration in the flag leaf sheath. Rotting occurs on the leaf sheath that encloses the young panicles. Irregular spots or lesions, with dark reddish brown margins and gray center. Discoloration in the sheath. lesions enlarge and often coalesce and may cover the entire leaf sheath. Whitish powdery growth inside the affected sheaths and young panicles, infected panicles and grains are sterile, shriveled, partially or unfilled, and discolored. The disease is important as the crop appears during maturity stage.

Management - Seed treatment with *Pseudomonas fluorescens* @ 10gm/kg seed. Soil application of *Pseudomonas fluorescens* @ 2.5 kg per ha mixed with FYM/ Compost. Foliar spray of *Pseudomonas fluorescens* liquid @ 5 ml/lit of water from 45 days after sowing/ planting for 3 times at an interval of 10 days.

13. **Root knot (*Meloidogyne graminicola*)**

Symptoms - Characteristic hooked-like galls on roots. Newly emerged leaves appear distorted and crinkled along the margins. Stunting, chlorosis

Management - Heavily infected plants flower and mature early. Keep the crop always in submerged conditions. Cultural control includes continuous flooding, raising the rice seedlings in flooded soils and crop rotation These practices will help prevent root invasion by the nematodes. Soil solarization, with 50 – 100µ clear polythene sheets for 3 weeks before preparation of fields. Soil treatment with *Trichoderma harzianum* and *Paeciliomyces lilacinus* @ 2.5 kg each/ha mixed with 300-500 kg FYM/ Compost.

Cropping systems

Since successful *rabi* cropping is very difficult under rainfed upland in NEH region, cropping intensity and total productivity can be increased by intercropping of soybean, arhar and groundnut with rice in upland. It has been found that rice + soybean (4:2 row ratio) and rice + groundnut (4:2 row ratio) are promising in NEH regions. Wherever possible rice should be rotated with leguminous crops for improving soil health and sustaining rice productivity.

Under high altitude conditions monoculture of rice is prevalent but cropping sequence of potato-rice is recommended. Under mid and low altitude, rice-mustard, rice-pea/lentil is recommended. In irrigated condition of Manipur and Tripura, rice-rice-pea/lentil/toria as rainfed is in practice. Rice + tomato, rice - tomato, rice + chillies, rice-chillies, rice-mustard, rice-French bean, rice- carrot etc are recommended on raised and sunken bed systems under wet and marshy valley land of Meghalaya or elsewhere in NEH Region.

Under raised and sunken bed system of cultivation in lowlands and valley lands, rice-rice or rice-pulses on sunken beds and rice-vegetables on raised beds are having very good potential for higher productivity and income.

Harvesting:

Rice attains maturity at around 30 days for early and 40 days for medium to late maturing varieties after 50% heading in low and mid altitude areas. In high altitude areas, it may take some more time to attain maturity. Harvesting is done at the yellow ripening stage to avoid shattering loss in field. SRI rice matures 12-15 days earlier than conventional and 7-10 days than ICM.

Yield

A well-managed direct seeded crop yields about 2.5-3.0 t/ha and transplanted crop gives about 4.5 -5.0 t/ha under organic production.