Agronomic Management and Production Technology of Unpuddled Mechanical Transplanted Rice

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Preface

In the first green revolution the intensive agriculture through conventional method has been successful in enhancing production level of cereals, but simultaneously led to degration of natural resources. For ever growing population and requirements for other sectors land and water resources for agriculture purpose are getting scare day by day, a serious t

hreat to food security. The new challenges demand efficient resource use by adopting resource conserving technologies to fulfill the country's requirements. Conservation agriculture has emerged as a way for sustainable intensive crop production system and can save huge manpower involvement, water and energy requirements in agriculture.

In South-east Asia, rice is grown by transplanting of seedlings in the puddle fields and for this a huge amount of water, man-power and energy is required. In recent years, water and labour scarcity in agriculture has emerged as a serious problem and for transplanting of rice it requires about one-third of total man-power and water requirement in rice. Secondarily, Direct seeded rice is unable to compete with the transplanted rice in respect of yield and economics due to heavy weed infestation in kharif season. The need has been realized throughout the country to explore possibility of rice cultivation by eliminating pudding, huge labour and water requirement. Unpuddled Mechanical Rice Transplanting has emerged as a solution over these burning problems and now a day it is coming up in a big

way throughout the country especially in Punjab, Uttar Pradesh, Bihar, Odisha, West Bengal and Tamil Nadu.

The present bulletin mainly consists upon production technology of Unpuddled mechanical transplanted rice and their agronomic management. Raising of seedling through "Rice Mat Nursery" method and operating of rice transplanter need some technical specifications therefore, discussed in details. I am sure that this technical bulletin will benefit technocrafts, planners, scientists, students and farmers in understanding the technology and promoting such a noble technology in right time throughout the rice producing states of the country.

(Arvind Kumar)
Deputy Director General (Education)

Contents

In south east Asia, rice is grown by transplanting of rice seedlings (21-30 days age) in puddled fields and for this about 30 percent of water (1400-1800 mm) is required and due to puddling activity, physical changes in soil takes place which are detrimental for non-rice crops due to sub-soil compaction. Now a day, labour scarcity is a big problem and rice transplanting activity requires about 1/3 of total labour requirement for rice. Secondarily, Direct sown zero tilled rice (ZTDSR) is not competing with transplanted rice in respect of yield and economics due to heavy weed infestation in the rice fields and yet not a single herbicide is available which can be used to control multiple weed species. The need has been realized throughout the region including India to explore rice production technologies that eliminate puddling, critical labour requirement, energy and facilitate timeliness in crop establishment. Unpuddled mechanical rice transplanting is one of the solution of these problems and it is coming up in a big way throughout the region. Many state governments are facilitating upto 1.5 lakhs subsidy (50% of total cost of the transplanter) to the farmers.

Mechanical Transplanting of Rice

Mechanical transplanting of rice is the process of transplanting specifically raised seedling of rice as a mat (mat type nursery) using a self propelled mechanical rice transplanter at pre-determined and desired spacing. The mechanical rice transplanter is fitted with a tin based tray like a roof top on which mat type nurseries are placed during the operation. One labour transplants approximately 400-500 m^2 manually in one day whereas with self propelled rice transplanter one can transplant upto 3-4 acres in a day.

Advantages of unpuddled mechanical rice transplanting

- Efficient use of resources by saving labour (20 person-days ha^{-1}), cost saving (₹ 1500 ha^{-1}), water saving upto 10%.
- Timely transplanting of seedlings of optimal age (15-18 days).
- Ensures uniform spacing and optimum plant density (30-35 hill/m^2 with 2-3 seedlings/ hills).
- Productivity level ($\pm$ 0.5 to 0.7 t ha^{-1}) as compared to traditional methods.

A view of unpuddled mechanical transplanted rice field

- Less transplanting shock, early vigour of seedling, better tillering and uniform maturity of crop that facilitate timely harvest and reduce harvest losses.
- Improving soil health through eliminating puddling.
- Reduces stress, drudgery and health risks of farm labourers.
- Generates employment and alternate sources of income for rural people through custom services on nursery raising and mechanical transplanting.

Rice Mat Nursery

Seedlings raised by this technique are ready for transplanting within 15-18 days after seeding (DAS). The seedlings are raised in a layer of soil mix (soil: FYM/ Vermicompost: 4:1) on a firm soil surface. At the time of transplanting seedlings are uprooted like a mat. It can be easily rolled and transported to distant places. The mat nursery uses less land, can be installed closer to the house than traditional field nurseries.

Rice mat nursery (8 days old)

Advantages of rice mat nursery

- Production of robust seedlings of 18-20 cm. in 15-18 days.
- Mat nursery reduces the cost of fertilizer by 90%, labour by 34% and water use by 55% in nursery raising over traditional transplanted rice.
- It reduces the cost of seedling production by about ₹ 1500-2000 over traditional rice seedlings per hectare.

Establishment of rice mat nursery

Sowing of mat type nursery should be done 15-20 days prior to transplanting. Method of raising nursery for manual transplanting of rice is glaringly different from technique of nursery raising for machine transplanted rice. When it comes

to machine transplanting, the nursery that forms a mat of its root system is needed. The success of paddy transplanter depends on the quality of nursery. For successful raising of rice mat nursery following points should be taken into consideration:

Seed: To plant one ha (with 2-3 seedling/hill at 20 x 20 cm spacing), use 20-25 kg/ha good quality treated seeds. If treated seeds are not used, give a treatment of streptocycline @ 1g plus 10g gemisan per 10kg seed.

Germinated seeds ready for nursery sowing

Soaking of Seed: Dip the seeds in 10 litre of water and leave it for 8-12 hrs. After soaking, drain and cover the soaked seeds with gunny bags. Sprinkle water over seed after regular intervals and turn with hands about 2-3 times for proper aeration and avoiding damage by heat. After about 20 hrs, the seed sprouts and is ready for sowing. Even if the sprouting takes 24 hours or more it does not matter.

Preparation of nursery bed

A nursery bed of 20 m long, 1.2 m wide are prepared on a well-leveled field and smoothened uniformly by hand tools. 20 x 1.2 m bed is sufficient for one acre nursery i.e. 60 m^2 nursery area is sufficient to transplant 1 ha of land. Between two beds there should be a furrow which should be kept flooded after 3-4 days of putting pre-germinated seeds on the beds.

Preparation of nursery beds

If area is not sufficiently compacted, then spread a plastic sheet on the marked area to prevent roots growing into soil. Shallow raised beds to a height of 5 cm and width of 1.2 m can be raised having water facility and free from animal. 60-80 m^2 mat nursery is required to produce seedling that is sufficient for planting 1 ha.

Spreading of plastic sheet

Spread an opaque 80-100 micron polythene sheet of required size on each bed. For convenience to use, two pieces; each 10m long may be used on one bed. Before spreading the sheet on bed, small holes of same size are made after making folds of the plastic sheet. Such holes are made with the help of a locally made ice-cutter. Holes should be small enough to keep the plastic sheet sealed on the soil surface without letting the roots of rice passing through holes. These holes also helps in oxygen supply as well as moisture supply from the soil.

Laying of plastic sheet on the bed

Application of soil mixture on plastic sheet

Soil mixture provides nutrients to the nursery that is spread on the plastic sheet. The uniformity of soil mixture helps uniform transplanting by the machine. For preparation of soil mixture, take soil from a weed seed free field and pass it through a 2 mesh sieve. Prepare a mixture of sieved soil and farm yard manure or vermicompost or decomposed press mud in 4:1 ratio. After thorough mixing, spread the mixture on the plastic sheet with a layer of 1.5 to 2.0 cm. A soil mixture volume of $4m^3$ is needed for each $80m^2$ of nursery. Now place a wooden frame/iron frame of 0.5 m long, 1 m wide and 2cm deep divided into 4 equal segments on the plastic sheet. Fill the frame almost to the top with the soil mixture and level it.

Application of soil mixture on the plastic sheet

Spreading of seeds on soil mixture

The seed rate per bed for 1.2 x 20 m, which covers one acre area should be 12.0 kg of open pollinated varieties and 9.0 kg for hybrids. Broadcast the pre-germinated seeds on the 1.5-2.0 cm layer of soil mixture over the polythene sheet as described above. Please ensure that there are 2-3 seed per square inch. Broadcast it uniformly on the soil layer. After broadcasting, cover the seed with a thin layer (0.5 cm) of already prepared soil mixture. It should be very light even seed may be visible.

Spreading of seeds on soil mixture

Irrigation of nursery beds

Irrigate the beds by sprinkling water in fine droplets probably by using a fountain type of small containers or micro-sprinklers. Regular supply of water will help rice seedling to produce roots and shoots to hold the soil together. It is better to have regular supply of water upto 7-8 times a day upto 3-4 days in order to establish the mat type nursery.

After 3-4 days when roots hold the soil enough, allow flooding, keep the peripheral channels/furrows between two beds flooded. Flooding should be such that it crosses the top of the beds. Keep the corners bit elevated to facilitate water retention on the bed. Repeat this till the nursery is ready. As growth stage advances each day, roots keep intermingling with each other. Stop watering 12 hrs before actual transplanting by machine. 15-18 days old seedling can be transplanted successfully.

Nutrient supplement

The nutritional requirement of the nursery is usually met through the mixture of soil + FYM/ vermin-compost/decomposed press mud but, application of 1.5 kg powdered DAP or 2.0 kg 15-15-15 powdered NPK fertilizer for every 80m^2 of nursery area will help in faster growth that facilitate in transplanting of 15 days old seedling. In case where nutrient deficiency symptoms (yellowing) appear, foliar application of mixed solution of 0.5% zinc sulphate (21%) + 2.5 % urea in 1.2 litre water is advisable and if required, it should be repeated after 5-7 days. In case symptoms of iron deficiency, foliar application of 0.5% solution of iron sulphate should be done.

Cutting of nursery mat for transplanting

Seedlings cakes have to be made of the nursery for fitting to transplanter. Make the cakes of 60 cm x 20 cm size (as per the standard size of nursery platform of the transplanter) using a sharp knife/ sickle for ready to use in mechanical transplanter. Approximately 200 mats are required for one acre transplanting. Where the nursery cakes are to be transported to distant places, put them in plastic trays/ baskets and keep the nursery cakes moist by sprinkling water intermittently to avoid wilting.

Rolling and Cutting of mat nursery

Mass production/custom hiring

The mass production of mat type nursery (service providers) can be done through advance planning and using the dame bed or same plastic sheet three times in a season. Half acre field can be used to plant nursery of 150 acres if advance planning is made. The mass production of nurseries by this technique and custom hiring of rice transplanting can be good business for some entrepreneurial farmers. The tray on the rice transplanter where mat type nursery is set, can accommodate 0.6 m length mat. The width of nursery bed is kept 1.2 m so that 2 pieces can be cut from each slice/cake.

Self Propelled Mechanical Rice Transplanter

- The self-propelled mechanical rice transplanter has two detachable parts i.e. front and rear portions. The front portion has diesel engine ranging from 6-14 Horsepower (HP) depending on the make, gear box, lever for adjusting hill spacing, power tiller operated shaft (PTOS), toothed iron wheel for field operation, steering, driver's sheet and two sheet for helpers while feeding nursery. The rear portion has floating board, nursery platform, transplanting fingers with screws for adjusting plants/hill, depth setting lever, chains for height adjustment of float board and pedal for float-lifting.
- For movement from one field/ location to another, toothed iron wheel should be replaced with motor bike wheel, and two small wheels should also be fitted below the floating board.

- The floating board of the transplanter serves as a base and also helps in movement of the machine over excess water in the field. It also serves as a platform for placement of nursery during transplanting operation.

Mechanical rice transplanter (Manually operated)

- On the lower side of the floating board, moulded rectangular plates with round and smooth edges are attached (front to back) 23.5 cm apart for corrugation and smooth movement of machine. Corrugation helps in firm establishment of the transplanted seedlings and also in the faster movement of irrigation water. It also serves the purpose of light planking/ smearing which reduces percolation losses.
- In general, the self propelled mechanical rice transplanters have a provision of transplanting 4-8 rows in single pass with 2 spacing arrangements i.e. 23.5 cm x 12 cm and 23.5 cm x 14 cm that maintains 35 and 30 hills/m^2, respectively. The plant to plant spacing can be adjusted using a lever. Similarly, number of plants per hill can be varied (2-4 seedlings/hill) by adjusting the position of fingers through screws vis-à-vis nursery platform.
- To and fro movement of nursery platform is guided by the sliding mechanism provided below it. Now, 6 row transplanters are also available having row spacing of 30 cm.
- The field efficiency of transplanter is 2.0-2.5 hours per acre. The efficiency under zero till is higher than unpuddled fields and lowest efficiency is under puddle conditions.
- The labour requirement for transplanting using mechanical transplanter is 1 person-days per acre and 1 transplanter can cover 4 acres per day.


Mat nursery tray of self propelled Mechanical rice transplanter

Some Experiences in Eastern India

Demonstration conducted at on-farm and on-station by ICAR Research Complex, Patna (2010-12) revealed that unpuddled mechanical transplanting of rice is being preferred by farmers of Bihar in a big way over zero tilled direct

sown rice. The performance of rice transplanter were evaluated and presented in Table 1.

Table 1 : Performance evaluation of mechanical transplanter (manually operated) in Patna.

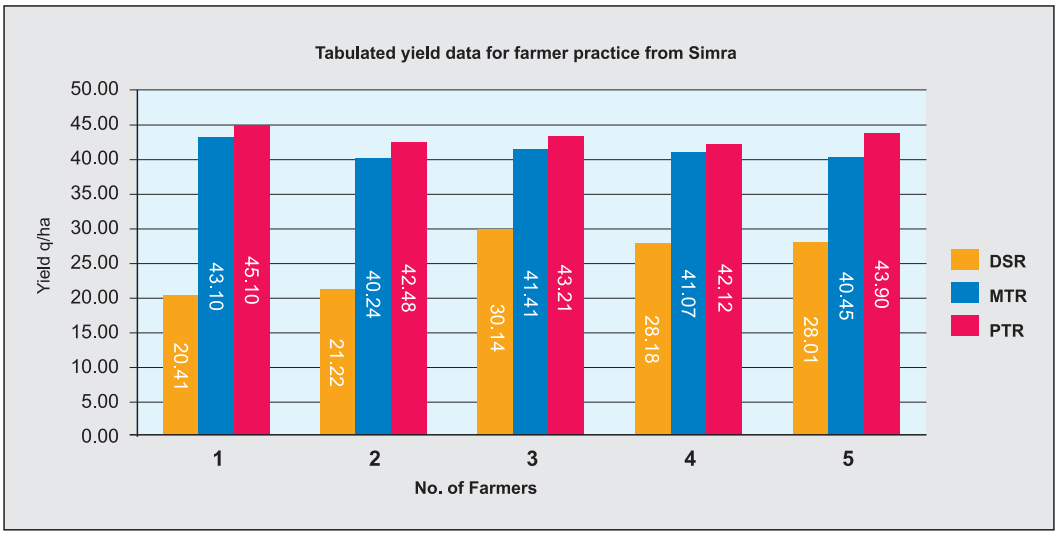
Average Planting Speed (kmph)	1.10
No of rows	4
Row spacing (cm)	30
Distance between Hill (cm)	14
Width of seedling mat (cm)	30
Age of seedling (days)	15
Total study area (ha)	4.66
Speed of operation (kmph)	1.10
Width of transplanter (m)	1.20
Actual field capacity (ha/hr)	0.132
Theoretical field capacity (ha/hr)	0.16
Field efficiency (per cent)	81.00
Labour requirement (man days /day)	2
Fuel consumption (l/hr)	1.60
Fuel consumption (l/ha)	9.81
Time taken to cover 1 ha (hrs)	7.57

The comparative economics of zero tilled direct sown rice, unpuddled mechanical transplanted rice and puddle transplanted rice has been worked out and presented in Table 2 on the basis of finding from on-station as well as on-farm trials:

Table 2 : Comparative economics of transplanting methods in rice

Sl. No.	Practice	Cost (₹/ha)		
		Direct Sown Rice	Puddled Transplanted	Mechanical Tansplanted
1	Seed Cost @ ₹ 25/kg	625	1000	750
2	Nursery raising/Mat nursery	00	1000	1600
3	Nursery uprooting	00	2000	140
4	Dry field preparation (ploughing and planking)	1600	4600	3200
5	Pumping irrigation cost to wet field for DSR/ PT/MT @ ₹ 80/hr. (rainfall from July-Sept., 11:883.3 mm)	1600	3200	2000
6	Puddling operation	00	2000	00
7	Sowing DSR/transplanting charges	1600	3200	1000
8	Weed management	4300	3200	3200
	Total	**9725**	**20,200**	**11,890**

Based on the table, mechanical transplanted rice has curtailed a sum of ₹ 8,310/ ha over conventional puddle transplanted rice but more than direct sown rice in



respect of cost of cultivation while in respect of yield mechanical transplanted rice (43.4 q/ha) supersedes direct sown rice (28.7 q/ha) and at par with conventional transplanted rice (41.2 q/ha).

Pre-requisites for unpuddled mechanical transplanter

- The fields for zero-till or unpuddled mechanical transplanting should preferably be laser leveled for uniform crop establishment.
- Under no-till conditions, pre-plant application of non-selective systemic herbicide (Glyphosate 41 SL, 1.0 % solution + 0.1 % surfactant) 7-10 days before transplanting is a must to knock down the pre-emerged weeds, if any. Irrigation water should be applied 12 hours before transplanting to soften the soil for ease in transplanting.
- Under unpuddled transplanting, 1 dry and shallow tillage using harrow/ cultivator followed by planking should be done. Prior to transplanting, apply a light irrigation and drain-out the excess water, if any and allow the soil to settle for 12-24 hours. Again, apply a very light irrigation to maintain a uniform depth of 1 cm standing water before transplanting. Transplanting can be done even without any standing water.

Steps for using mechanical transplanter

Load the mat type nursery cakes on the slanting nursery platform using one cake per tray.

- Leave space equal to one machine pass on all four sides of the field before
starting transplanting so that while turning of transplanter in the field no seedling is damaged.

- Run the machine straightway in the field, take U-turn at end of the field and each return pass should be along the last row of the previous pass like in the figure.

Loading of nursery mat on the trays

- Forks of transplanter pick the seedlings from mat type nursery on the seedling platform and put the seedlings into the soil just like a labour takes seedlings in fingers. The density which is assessed by the amount of seeds in the soil layer should be uniform in the whole block that is placed on the tray of transplanter.
- Keep on feeding nursery cakes as per need during the transplanting operation.
- The vacant space left on sides of the field will ease transplanting at corners and enable to take the machine out of the field once transplanting is completed.
- Keep a close watch over the transplanted area and if there are some gaps due to floating of nursery, fill the gaps, if any, manually.
- For proper establishment of seedlings, depending on the soil conditions, light irrigations should be ensured daily or on alternate days (depending on soil type) for initial five days.

A view of field being transplanted by self propelled rice transplanter

- After seedling establishment, the other management practices for weed, nutrients and pest will remain same as recommended for conventional puddle transplanted rice.
- Continuous flooding is not required and water can be applied on alternate wetting and drying (AWD) basis or IW/CPE ratio.

Some useful tips /care for successful unpuddled mechanical transplanted rice cultivation:

- Rice seed should be of good quality and germination upto 90 %.
- Polythene sheet should be handled carefully so that it can be reused for 2-3 seasons.
- At each end, especially along the length of nursery beds, the problem of overflow of water that carries seeds along must be avoided. This can be achieved by watering the nursery bed with the help of sprinkling of water for 3-4 days. This will help ensuring uniform display of nursery beds and therefore more accurate transfer/transplant of nursery in the field.
- Some time Zinc (Zn) deficiency appears. Apply 0.5% zinc sulphate + 1.5 % urea (100 litre water + 1.5 kg urea) and 0.5 kg zinc sulphate (21%). Apply this if yellowing appears. Generally it appears 13-15 days after sowing (DAS).
- Irrigate the field 12-24 hr before transplanting.
- Avoid use of transplanters in low land ecologies where water remains stagnant for more than 15 days.
- Field should not be flooded with water for a week.
- The soil needs to be leveled and have sufficient bearing strength to carry the machine and support the planted seedlings.
- Fields need to be drained one or two days in advance compared to those for puddled manual transplanting if water is stagnant in the field.

Note: Machine transplanting works better in no-till/unpuddled conditions as compared to puddled conditions as it requires distinct soil characteristic that prevent the sedimentation of soil. Under puddled conditions, soil cannot make a strong grip on the seedlings. In sodic soils where unpuddle transplanting is desirable, this method is very useful.

Other Agronomic Managements

A) **Suitable varieties:** Select the suitable varieties according to your preferences and land situation. Always use certified seeds of reputed brand. If farmers want to reuse their own seeds then collect the seeds from disease and weed free plots or seeds have no any mixture with other varieties but it is advisable to change the seed or use new certified seeds after every 2-3 years. Hybrid seeds can't be reused. Some of the promising varieties for Bihar, eastern U.P. and West Bengal are listed in Table 3.

Table 3 : Promising varieties

Variety	Duration (days)	Productivity (q/ha)	Remarks
(i) Short duration varieties			
Sahbhagi	100-110	35-40	Irrigated and unirrigated
Prabhat	110-120	40-45	Irrigated and unirrigated
Dhanlaxhmi	100-115	45-50	Irrigated and unirrigated
Richaria	110-115	45-50	Bacterial leaf blight resistant
Saket-4	105-110	40-45	Irrigated and unirrigated, Eastern region
Pusa 2-21	105-115	30-35	Irrigated and unirrigated
Satyam	95-100	35-40	Irrigated
Govind	115-120	45-50	Bacterial leaf blight resistant
Ashwini	99-110	40-45	Irrigated and unirrigated
Narendra-2	110-115	40-45	Blast resistant
Narendra-118	85-90	45-50	Unirrigated
Narendra-80	110-120	50-60	Eastern region
Manhar	119-122	47.5-50	Bacterial leaf blight resistant
Pantdhan-12	115-122	50-60	Bacterial leaf blight resistant
Narendra-97	85-90	45-50	Unirrigated
I R-50	105-110	45-50	Unirrigated
Hybrid			
PRH-10	100-110	60-70	Irrigated
Arise-6129	115-120	60-70	Irrigated
(ii) Medium and long duration varieties			
Rajendra Bhagwati	130-135	45-50	Mid and lowland
Sita	120-130	40-45	Mid and lowland
Saroj	125-130	40-45	Mid and lowland
Rajshree	125-135	45-50	Mid and lowland
Prabhat	125-135	45-50	Mid and lowland
Sahbhagi	110-120	37.5-45	Mid and lowland
Rajendra Sweta1	30-140	50-55	Mid and lowland
Rajendra mahsuri1	30-140	45-50	Mid and lowland
BPT- 5204	140-150	55-60	Mid and lowland
Swarna	140-145	50-55	lowland
Swarna sub-1	140-145	50-55	lowland
Ratna	120-12	40-45	Bacterial leaf blight resistant
Pant Dhan-4	120-130	50-60	Eastern U.P. and Bihar
Pant Dhan-10	125-130	55-60	Eastern U.P. and Bihar
Suraj-52	130-135	50-60	Bacterial leaf blight resistant
Jaya	130-135	50-60	Bacterial leaf blight resistant
I R-8	135-140	55-65	Bacterial leaf blight resistant
Pusa-169	130-135	60-65	Bacterial leaf blight resistant
P R 106	145	55-60	Bacterial leaf blight resistant

Variety	Duration (days)	Productivity (q/ha)	Remarks
P N R -381	120-140	50-60	Bacterial leaf blight resistant
Malavia Dhan-36	130-135	45-55	Bacterial leaf blight resistant
Hybrid			
Arise-6444	130-145	65-75	Mid and lowland
P.R.H.-10	125-130	60-65	Mid and lowland
P.H.B.-71	130-145	65-75	Mid and lowland
(iii) Scented varieties			
Rajendra Subhasini	130-140	35-40	Mid and lowland
Rajendra Kastoori	130-140	35-40	Mid and lowland
Type 3	130-145	30-35	Dwarf
Kasturi	115-125	30-40	Medium dwarf
Pusa Basmati-1	135-140	40-50	Dwarf
Haryana Basmati-1	140	35-45	Tolerant to grass hopper
Basmati-370	135	22.5-27.5	Eastern region
Pusa-1121(Sugandha-4)	140-145	40-45	Eastern region
Pusa-2511(Sugandha-5)	125-130	40-45	Eastern region
Taravadi Basmati	145-155	25	Eastern region
(iv) Variety suitable for salt affected soils			
C.S.R 10	115-120	50-60	It can be grown upto 8.8-9.5 pH soil (8.0-10.0 q/ha)
C.S.R 30	130-140	25-45	pH 8.8-9.5
C.S.R 36	130-140	50-60	pH 8.8-9.5
Usar Dhan-1	140-145	40-50	pH 8.8-9.5
C.S.R 13	110-115	50-60	pH 8.8-9.5
Usar Dhan-293	125-130	45-50	Dwarf
(v) Flooded soil/stagnant water lowland varieties			
Swarna-Sub 1	140-145	45-50	Lowland
M.T.U. 7029	165	65-70	Dwarf
Jal Laheri	145	40-50	Dwarf
Jalmagn	150-200	35-40	Deep water
Madhukar	145-150	30-40	Deep water and flooded soils

B) Spacing

Proper spacing between plant to plant and row to row should be maintained for higher tillering and productivity

Field condition	Row – Row X Pl - Pl.
Normal condition	30 X 20 cm
Upland	20X 20cm
Late sown condition	20 X 15 cm

C) Nutrient management

Nutrient management in form of fertilizers or organic amendments should be done according to the soil test and targeted yield from the crop. In irrigated condition, nutrient management should be done like:

Variety	Nutrient (Kg/acre)				
	Nitrogen	Phos-phorus	Potash	Zinc Sulphate	Sulphur
Short duration varieties	50	25	25	10	12
Medium and long duration varieties	50-60	25-30	25-30	10	12
Scented varieties	30-40	25	25	10	12

Method and time of application

One third of Nitrogen and full Phosphorus (P), Potash (K) and Sulphur (S) should be applied in the field at the time of transplanting. Rest nitrogenous fertilizer should be applied in two equal splits. First at the time of active tillering (25-30 days after transplanting) and the rest at the time of primordial initiation (40-50 DAT) or the second split of nitrogen could be also applied on the basis of Leaf Colour Chart (LCC). Apply whole Zinc at the time of transplanting or 5-7 days after transplating. If Zinc could not be applied at these stages then first foliar application of 0.5 % Zn + 2 % Urea solution should be done at 30 DAT and repeat it thrice at 15 days interval. Apply Urea in the moist field but not in standing water during evening.

Method of Using Leaf Colour Chart (LCC)

Choose some healthy plants from the representative area of field after 15-20 days after transplanting (DAT). Put the leaf on the stripes of LCC and match top portion of leaf colour with the LCC stripe colours. Also match the middle portion of the leaf with stripes edges of the LCC.

Some of the important points to be considered while taking the observations or matching the colour with LCC:

Matching of paddy leaves with Leaf Colour Chart (LCC)

- Don't pluck the leaves for this purpose
- Take reading with LCC between 8.00 to 10.00 am in the morning.
- Direct sunlight should not fall on the leaves or LCC while taking the reading.
- The same person should record or match the colour from beginning to end of reading.
- If observes value falls below 4, then apply 25 kg urea/acre in case of coarse rice and hybrid rice and if value falls below 3 in case of fine and scented rice then apply 20 kg of urea/acre.
- Repeat the same procedure at interval of 8-10 days till flowering stage.

Method of taking reading/observations :

Let we have taken observations from 10 plants then value should be calculated like this:

3 + 4 + 2 + 3 + 3 + 3 +3 + 2 + 3 +4 = 30/10 = 3

Irrigation Management

With Unpuddled mechanical transplanted rice, we could be able to save about 30 % of irrigation water over conventional puddle transplanted rice. Apply one irrigation 12-24 hours before transplanting by machine to soften the soil. Maintain 1 cm. of irrigation water in the field at the time of transplanting by rice transplanter and keep the field moist upto 7 DAT but not standing water. If excess water is present in field due to rain etc. it should be drained out for better establishment of mat nursery seedlings. If there is shortage of moisture in the soil at 7 DAT then apply one irrigation.

After 15 DAT, one can maintain 3-4 cm of irrigation water in the field or alternating wetting and drawing (AWD) should be preferred. This will help in better growth and development of the seedlings and will also help in weed control. There should be proper moisture at the time of active tillering, primordial initiation, flowering, milking and grain filling stages otherwise there will be loss in the yield due to moisture stress. There is no need for any standing water between active tillering to panicle initiation but proper moisture should be maintained by offering light irrigation after every 15 days interval. Stop irrigating the rice field before 20-25 days of maturity.

Weed Control

Since, rice is grown mainly in *kharif* season therefore, rice crop suffers from heavy weed infestation which can lead to 40-70 % of yield losses if proper weed management practices has been not applied to the crops. The weeds may have broad leaves, narrow leaves or sedges or all depending upon soil, climate, temperature, tillage operation and water availability etc. Hand weeding is the best tool to control weeds but due to labour drudgery and standing water in the field this operation

becomes difficult. Chemical weed control is an effective way of weed control in rice and several chemicals are available in the market. The most effective way of weed control is integrated weed management i.e. chemicals + 1-2 hand weeding after 30-35 DAT and at 60-65 DAT. Type of weedicide, time of application, weed flora, doses and method of application is very important which is shown in the Table 4.

Table 4 : Weedicides, doses and method of application in the mechanical transplanted rice.

S. No.	Weedicide	Doses/acre	Method and time of application
For control of narrow leaf weeds and sedges			
1.	Butachlor (machete 50 E.C., Delchlor 50 E.C., Milchlor 50 E.C., Narvadachlor 50 E.C., Capchlor 50 E.C., Tir 50 E.C., Hiltachlor 50 E.C.	1.0-1.2 lit. (500-600 ml. a.i)	2-3 days after transplanting by mixing the chemical in 90-120 lit. of water.
2.	Anilophos (Arozin 30 E.C., aniloguard 30 E.C.)	533 ml. (160g a.i.)	As above
3.	Pretichlor (Refit 50 E.C.)	600 ml. (300g a.i.)	As above
4.	Oxadiorzil (Top Star 80 W.P.)	50g (40g a.i.)	As above
5.	Pendimethalin (Stomp 30 E.C.)	1.3 lit.(400g a.i.)	As above
For broad leaf and bushy type weeds and shrubs			
6.	Metsulfuron + Chlorimuron (Almix 20 W.P.)	8g (0.8 + 0.8 g a.i.)	20-25 DAT in 120-150 lit of water
7.	2.4-D Sodium salt 80 %	520 ml. 9200g a.i.)	As above
8.	2,4- D Ester 38 E.C.	526 ml.(200g a.i.)	As above
9.	Ethoxysulfuron (Sunrise 15 W.D.G.)	53g (8g a.i.)	As above
10.	Bensulphuron (landax 60 D. F.)	40g (24g a.i.)	As above
For control of sanwa, bartha, broad leaf weeds and some shrubs			
11.	Bispyribac Sodium (Nomineegold 10 % E.C.)	80-100 ml. (98-10g a.i.)	18-25 DAT in 120-150 lit. of water
12.	Fenoxaprop (Whipsuper 9.3 E.C.)	250 ml. (24g a.i.)	As above

Weed control in direct seeded rice (DSR)

Under direct sown rice weed is the major problem as in case of DSR seeds are sown in dry moist soil and it favours the weeds to grow due to moist condition of the soil. There is not a single herbicide formulation available which could control all kind of weeds under DSR condition. Under such conditions yield may be reduced from 20- 40 percent or even more if proper weed management practices are not taken into care. The most commonly found weeds in rice are given below:

Grassy weeds	Broadleaf weeds	Sedges
Echinochloa colonum	*Setaria glauca*	*Cyperus rotandus*
Echinocloa crusgalli	*Parthenium hysterphorus*	*Fimbristylis miliacea*
Echinochloa glabrescens	*Monocharia spp*	*Fimbristylis litoralis*
Ischaemum rugosum	*Ipomea aquatica*	*Cyperus difformis*
Dactyloctaneum	*Celosia argentine*	*Cyprus iria*
Eleusine indica	*Eclipta alba*	*Scirpus* spp.
Cynodon dactylon		

Weed management in direct seeded rice is done through chemical herbicides. Many researches on weed control aspect have been carried out as station and on farm research. On the basis of the experimental findings effective weed management in direct seeded rice may be done by following the schedule given in the Table 5.

Table 5. Herbicide use schedule in DSR

Sl. No.	Name of herbicides	Quantity/ acre	Time of application	Method of application	Weeds affected
1.	Pendimethalin 30 E.C. (Stomp)	1.3 lit. (400 g a.i.)	1-2 days after sowing (DAS)	Chemical should be mixed with 150-200L of water and sprayed in the field.	All kinds of weeds
2.	Bispyribac 10% S.P. (Nominee Gold, Adora)	80-100 ml. (8-10 g a.i.)	15-20 DAS	Chemical should be mixed with 120-150L of water and sprayed in the field.	*Sedges, annuals, broad leaf weeds except grassy weeds.*
3.	Oxadiarzil 80 W.P. (Top Star)	50 g (40 g a.i.)	1-2 DAS	Chemical should be mixed with 150-200L of water and sprayed in the field.	All kinds of weeds
4.	Azim Sulfuron 50W D.G.	24-28 g (912-14g a.i.)	15-20 DAS	Chemical should be mixed with 120-150L of water and sprayed in the field	*Sedges, annuals, broad leaf weeds except grassy weeds.*
5.	Propanil 35 E.C. (Stam)	45671 ml. (1.6 kg a.i.)	2-15 DAS	Chemical should be mixed with 120-150L of water and sprayed in the field	*Sedges, annuals, broad leaf weeds except grassy weeds.*
6.	Propanil 35 E.C. (Stam)+ Pendimethalin 30 E.C. (Stomp)	45671 ml. (1.6 kg a.i.)	10-12 DAS	Chemical should be mixed with 120-150L of water and sprayed in the field	*Sedges, annuals, broad leaf weeds except grassy weeds.*

Sl. No.	Name of herbicides	Quantity/ acre	Time of application	Method of application	Weeds affected
7.	Metsulfuron + Chlorimuron 20 W.P. (Almix)	8g (0.8 + 0.8 g a.i.)	15-20 DAS	Chemical should be mixed with 120-150L of water and sprayed in the field.	*Broad leaf weeds, sedges, annuals*
8.	Pyrazosulfuron 10 W.P. (Sathi)	60 g (6 g a.i.)	15-20 DAS	Chemical should be mixed with 150-200L of water and sprayed in the field.	*Broad leaf weeds, sedges, annuals*
9.	Carphentrazone 40 D.F. (Afinity)	20g (98 g a.i.)	15-20 DAS	Chemical should be mixed with 120-150L of water and sprayed in the field.	*Sedges, broadleaf weeds except grassy weeds*
10.	2, 4 D Sodium salt 80 %	250 ml. (200 g a.i.)	20 DAS	Chemical should be mixed with 120-150 ltr of water and sprayed in the field.	*Broad leaf weeds and Dhaincha*
11.	2,4 D Ester salt 38 E.C	.526 ml. (200g a.i.)	20 DAS	Chemical should be mixed with 120-150L of water and sprayed in the field	*Broad leaf weeds and Dhaincha*
12.	Cyahalophop (Kilanchar)	400 ml. (40g a.i.)	10-12 DAS	Chemical should be mixed with 120-150L of water and sprayed in the field.	*Annuals, Broadleaf weeds.*
13.	Ethoxysulfuron 15 W. D. G. (Sunrise)	53 g (8 g a.i.)	15-20 DAS	Chemical should be mixed with 120-150L of water and sprayed in the field.	*Sedges, annuals, broadleaf weeds except grassy weeds*
14.	Phenoxaprop + safner 6.7 E.C. (Rice Star)	447 ml. (30 g a.i.)	20 DAS	Chemical should be mixed with 150L of water and sprayed in the field	*Sedges, annuals, broadleaf weeds except grassy weeds.*
15.	Bensulfuron 60 D.F. (Lindex)	40 g (24 g a.i.)	15-20 DAS	Chemical should be mixed with 120-150L of water and sprayed in the field.	*Sedges, annuals, broadleaf weeds*
16.	Halosulfuron 75 w. G.P. (Permit)	36 g 1 (27 g a.i.)	5-20 DAS	Chemical should be mixed with 120-150L of water and sprayed in the field	*Sedges, annuals, broadleaf weeds except grassy weeds.*
17.	Pinocasulam (8 g a.i.)	33 g	15-20 DAS	Chemical should be mixed with 120-150L of water and sprayed in the field.	*Annuals, broad leaf weeds*

PLANT PROTECTION

A. Management of Insect-Pest in Transplanted Rice Crop

Plant protection plays an important role in successful cultivation of any crop. If proper control measures are taken into consideration, better and quality yield is expected. It is very important to identify the insects harmful for the crops, nature of damage and their timely control with insecticides, integrated pest management or effective ITKs. If these insect-pests are not controlled at right stages, crop may be affected adversely and reduction in yield may be upto 70 percent. Some insect-pest control practices for major insects are described below.

1. Paddy Stemborer: *Scirpophaga incertulas*

Symptom of damage

- Presence of brown coloured egg mass near leaf tip.
- Caterpillar bore into central shoot of paddy seedling and tiller.
- Causes drying of the central shoot known as **'dead heart'**.
- In grown up plant whole panicle becomes dried **'white ear'**.

Management

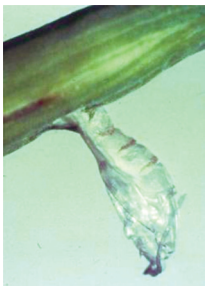
- Resistant varieties: Ratna, Jaya, TKM 6.
- Avoid close planting and continuous water stagnation.
- Pull out and destroy the affected tillers.
- Set up light traps to attract and kill the moths.
- Harvest the crop upto the ground level and disturb the stubbles.
- Release the egg parasitoid, *Trichogramma japonicum* on twice @ 5 cc/ha (followed by monocrotophos 36 SL spray thrice @ 1000 ml/ha on 58, 65 and 72 DAT).
- Apply *Bacillus thuringiensis* var *kurstaki* and neem seed kernel extract.

Spray any one of the following insecticides

- Monocrotophos 36 SL 1000 ml/ha
- Endosulfan 35 EC 1000 ml/ha

- Quinalphos 25 EC 1000 ml/ha
- Phosphamidon 40 SL 600 ml/ha
- Profenophos 50 EC 1000 ml/ha

2. Gall midge, *Orseolia oryzae*



Symptom of damage

- Maggot feeds at the base of the growing shoot.
- Causing formation of a tube like gall that is similar to **'onion leaf'** or **'Silver-shoot'**.
- Infested tillers produce no panicles.

Management

- Early ploughing.
- Resistant varieties: MDU 3, Shakthi, Vikram and Sureka.
- Remove the alternate hosts and adjust the time of planting (early).
- Use early maturing varieties.
- Optimum recommendation of potash fertilizer.
- Setup light trap and monitor the adult flies.

3. Swarming caterpillar, *Spodoptera mauritia*

Symptom of damage

- Larvae cut the seedlings in large scale.
- Severe infestation - cattle grazing appearance to the field.
- They feed gregariously and march from field to field.


Management

- Kerosenate the water while irrigation - suffocation.
- Allow ducks into the field.

Nursery

- Drain the water.
- Spray chlorpyriphos 20 EC 80ml or endosulfan 35 EC 80 ml+20 lit of water

4. Rice skipper, *Pelopidas mathias*

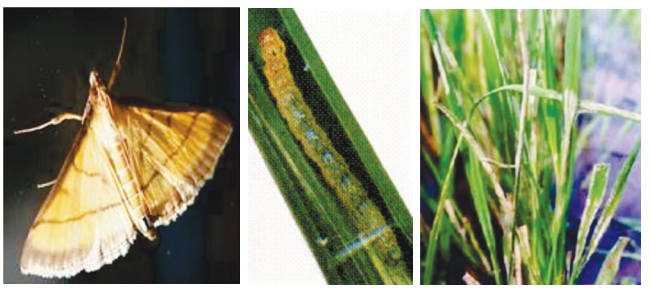
Symptom of damage

- Edges of the leaves are fastened with webbing.
- Backward rolling of leaves,
- Caterpillar feeds from margin to inwards.

Management

Spray endosulfan 35 EC 1000 ml/ha or monocrotophos 36 WSC 500 ml/ha.

5. Leaf folder (or) leaf roller, *Cnaphalocrocis mainsails / Marasmia patnalis*



Symptom of damage

- Leaves fold longitudinally and larvae remain inside.
- Larvae scrape the green tissues of the leaves and becomes white and dry.
- During severe infestation the whole field exhibits scorched appearance.

Management

- Clipping of the affected leaves and keep the bunds clean.
- Avoid excessive nitrogenous fertilizers.
- Light traps to attract and kill moths.
- Release *Trichogramma chilonis* @ 1, 25,000/ha thrice.
- Spray NSKE 5 % or carbaryl 50 WP 1 kg or chlorpyriphos 20 EC 1250 ml/ha.
- Apply Cholorpyriphos 5 ml in 1 lit of water.

6. Rice horned caterpillar, *Melanitis ismene*

Symptoms of damage

- Larva feeds on leaf blades of rice.
- Leaves are defoliated from the margin or tip irregularly.

Management

- Spray endosulfan 35 EC 1000 ml/ha or monocrotophos 36 WSC 500 ml/ha.

7. Yellow hairy caterpillar, *Psalis pennatula*

Symptoms of damage

Caterpillar causes defoliation.

Identification of insect pest Larva

- Caterpillar is yellowish brown with red stripes.
- Orange head and tufts of hairs all over the body.
- **Pupa -** pale white cocoon of silk and frass attached to the leaf.
- **Adult** - Moth is stout with straw coloured forewings.

Management

- Spray endosulfan 35 EC 1000 ml/ha or monocrotophos 36 WSC 500 ml/ha.

8. Grasshopper, *Hieroglyphus banian*
Short horned grasshopper, *Oxya nitidula*

Symptom of damage

- Irregular feeding on seedlings and leaf blade.
- Cutting of stem at panicle stage.
- Completely defoliate the plants leaving only the mid ribs.

Identification of insect pest

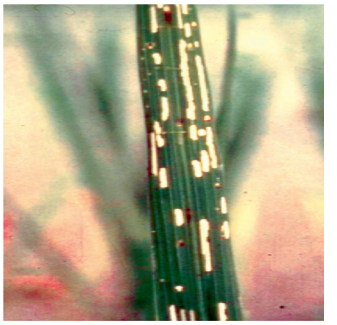
- **Adults -** Green, larger with transverse black lines on pronotum

Management

- Expose the eggs to be picked up by birds after ploughing and trim the bunds.
- Dusting the crop with 5-10% BHC or methyl parathion 2% @ 25-30 kg/ha.
- Dusting malathion 5% @ 20 kg/ha.

9. Spiny beetle / Rice hispa, *Dicladispa armigera*





Symptoms of damage

- Adults feed on chlorophyll by scraping and causing **white parallel streaks**.
- White patches along with long axis of leaf.
- Grubs mine into the leaves and make **blister near leaf tips**.

Management

- Leaf tip containing blotch mines should be destroyed .
- Manual collection and killing of beetles - hand nets.
- Spray endosulfan 35 EC @1000 ml/ha.

10. Whorl maggot, *Hydrellia sasakii*

Symptom of damage

- Maggot feeds on the tender tissue inside the whorl.
- Yellowish white longitudinal marginal blotching with hole.
- Leaves shriveled plant stunted and maturity delayed.
- Drooping of young leaves near the tip.



Identification of the pest

- **Maggot** - Yellowish white in colour.
- **Adult** - Small dull grey fly.

Management

- Remove the alternate hosts and adjust the time of planting (early).
- Use early maturing varieties.
- Optimum recommendation of potash fertilizer.
- Spray endosulfan 35 EC @1000 ml/ha.

11. Green leafhopper, *Nephotettix virescens*



Symptomof damage

- Yellowing of leaves from tip to downwards.
- Vector for the diseases *viz.,* Rice tungro virus, rice yellow & transitory yellowing.

Management

- Use resistant varieties like **IR 50, CR 1009, Co 46**.
- Apply neem cake @ 12.5 kg/20 cent nursery as basal dose.
- The vegetation on the bunds should also be sprayed with the insecticides.
- Set up light traps.
- Spray insecticides twice, 15 and 30 days after transplanting like :
  Phosphamidon 40 SL@ 1000 ml/ha
  Profenophos 50 EC @1000 ml/ha

12. Brown plant leafhopper, *Nilaparvata lugens*

Symptom of damage

- Nymphs and adults congregate at the base of the plant above the water level.
- Affected plant dries up and gives a scorched appearance called '**hopper burn**'.



- Circular patches of drying and lodging of matured plant.
- It is vector of **grassy stunt, ragged stunt and wilted stunt diseases**.

Identification of insect pest

- **Adult**: Brown body and chestnut brown eyes. It has two forms *viz.*, (Macropterous (long winged) and brachypterous (short winged).

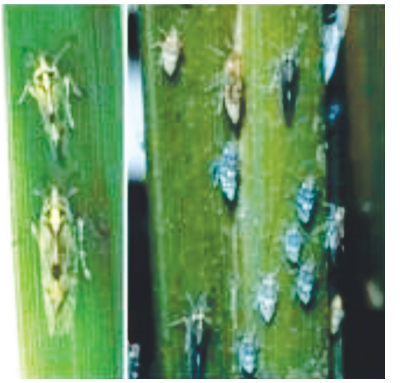
Management

- Use resistant/tolerant varieties like **Aruna, ADT 36, Co 42, Co 46 IR 36, IR 72**.
- Avoid close planting.
- To provide 30 cm rogue spacing at every 2.5 m to reduce the pest incidence.
- Avoid use of excessive nitrogenous fertilizers.
- Control irrigation by intermittent draining.
- Set up light traps during night.
- Yellow pan traps during day time.
- Conserve natural enemies like *Lycosa pseudoannulata, Cyrtorhinus lividipennis.*
- Avoid synthetic pyrethroids, methyl parathion, fenthion and quinalphos causing resurgence.
- Drain the water before the use of insecticides.

Apply any one of the following :

- Phosphamidon 40 SL@ 1000 ml/ha,
- Monocrotophos 36 SL @ 1250 ml/ha
- Carbofuran 3 G @ 17.5 kg/ha
- Imidacloprid 18.5 @ 100 ml/ha
- Thiomethoxam 20 WDG@ 100 ml/ha
- Dichlorvos 76 WSC @ 350 ml/ ha
- Neem oil 3% @ 15 lit/ha
- Iluppai oil 6% @ 30 lit/ha
- Neem seed kernel extract 5% @ 25 kg/ha

13. White backed plant hopper, *Sogatella furcifera*



Symptoms of damage

- Suck the sap and cause stunted growth.
- "Hopper burn" is caused in irregular patches.

Management

- Avoid use of excessive nitrogenous fertilizers.
- Control irrigation by intermittent draining.

Apply any one of the following chemicals for control:

- Phosphamidon 40 SL@ 1000 ml/ha.
- Monocrotophos 36 SL @ 1250 ml/ha.
- Carbofuran 3 G @ 17.5 kg/ha.
- Dichlorvos 76 WSC @ 350 ml/ ha.
- Neem oil 3% @ 15 lit/ha.
- Iluppai oil 6% @ 30 lit/ha.
- Neem seed kernel extract 5% @ 25 kg/ha.

14. Mealybug, *Brevennia rehi*

Symptoms of damage

- Large number of insects remains in leaf sheath and suck the sap.
- Plants become week, yellowish and very much stunted in circular patches.
- Presence of white waxy fluff in leaf sheaths.

Identification of insect pest

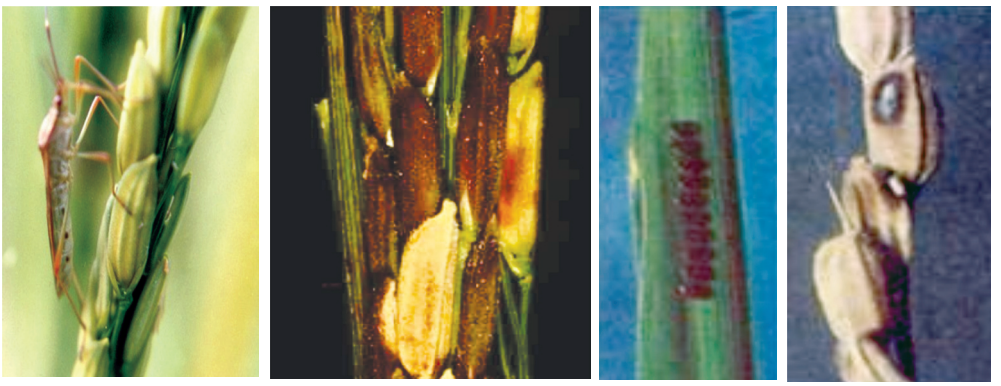
- **Adult** - Small reddish white, soft-bodied wingless insect covered with filamentous materials.

Management

- During field preparation - remove the grasses from the bunds and trim the bunds.
- Remove and destroy the affected plants.
- Spray any one of the following insecticides in the initial stage of infestation.

- Dimethoate 30 EC 500 ml/ha.
- Methyl demeton 25 EC@ 500 ml/ha.
- Conserve the natural enemies like *Scymnus* sp.,*Anatrichus pygmaeus, and Mepachymerus ensife.*

15. Rice earhead bug: *Leptocorisa acuta*



Symptoms of damage

Both the adults and nymphs feed on grains at the milking stage which can reduce yield by as much as 30%. Adults are slender and light brown measuring 19 mm long with distinct ventrolateral spots on the abdomen.

Nature of damage

- Sucking the sap from individual grains, which are in milky stage.
- Feeding causes empty or small grains during the milking stage.
- Individual grains become chaffy.
- At the soft or hard dough stage, feeding causes deformed or spotty grains.
- The grains become dark as a result of spilling of endosperm.
- The spillage becomes a medium for fungal infection.
- Buggy odour in rice field during milky stage.

Management

Dust any one of the following at 25 kg/ha twice, the first during flowering and second a week later.

- Quinalphos 1.5 D
- Carbaryl 10 D
- Malathion 5 D
- KKM 10 D
- KKM dust formulation consists of 10% of *Acorus calamus* rhizome powder and 90% of fly ash.

- This dust formulation repels the rice earhead bug.

Spray any one of the following twice as above

- Fenthion 100 EC @ 500 ml/ha or Malathion 50 EC @ 500 ml/ha
- Neem seed kernel extract 5% @ 25 kg/ha or Notchi or *Prosopis* leaf extract 10% .

16. Thrips: *Stenchaetothrips biformis*

Symptoms of damage

- Laceration of the tender leaves and suck the plant sap.
- Yellow (or) silvery streaks on the leaves of young seedlings.
- Terminal rolling and drying of leaves from tip to base.

Identification of insect pest :
Adults - are dark brown in colour.

Management

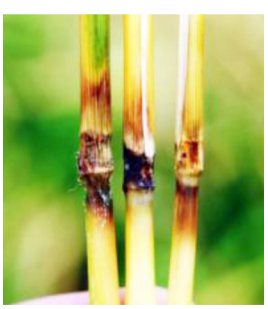
Spray any one of the following in nursery stage

Phosphamidon	40 SL	50 ml
Monocrotophos	36 SL	40 ml
Endosulfan	35 EC	80 ml

Spray any one of the following in main field stage

Phosphamidon	40 SL	300 ml
Monocrotophos	36 SL	30 ml

B. Management of Diseases in Transplanted Crop



1. Blast *(Pyricularia oryzae)*

Symptoms

- The fungus attacks rice at all stages from seedlings in nursery to heading in main field.
- The typical symptoms appear on leaves, leaf sheath, rachis, nodes and even the glumes are also attacked.
- On the leaves, the lesions start as small water soaked bluish green flecks, soon enlarge and form characteristic spindle shaped spots with grey.The spots join together as the disease progresses and large areas of the leaves dry up and wither. Similar spots are also formed on the sheath.
- Severely infected nursery and field show a burnt appearance.
- In infected nodes, irregular black areas encircle the nodes can be noticed.
- The affected nodes may break up and all the plant parts above the infected nodes may die.
- At the flower emergence, stage the fungus attacks the peduncle which is engirdled and the lesion turns to brownish-black.
- This stage of infection is commonly referred to as rotten neck/neck rot/ neck blast/panicle blast.
- In early neck infection, grain filling does not occur and the panicle remains erect like a dead heart caused by a stem borer. In the late infection, partial grain filling occurs. Small brown to black spots also may be observed on glumes of the heavily infected panicles. Generally, the yield losses caused by the pathogen ranges from 30-61 per cent depending upon the stages of infection.

Favourable Conditions

Application of excessive doses of nitrogenous fertilizers, intermittent drizzles, cloudy weather, high relative humidity (93-99 per cent), low night temperature (between 15-20°C), more number of rainy days, longer duration of dew, cloudy weather, slow wind movement and availability of collateral hosts.

Management

- Grow resistant varieties like IR20.
- Avoid cultivation of highly susceptible varieties IR50.
- Remove and destroy the weed hosts in the field bunds and channels.
- Treat the seeds with Captan or Thiram or Carbendazim or Carboxin or Tricyclazole at 2 g/kg.
- Seed treatment with biocontrol agent Trichoderma viride @ 4g/kg or Pseudomonas fluorescens @ 10 g/kg of seed.

- Avoid close spacing of seedlings in the main field. Spray the nursery with Carbendazim 25 g or Edifenphos 25 ml.
- Spray the main field with Edifenphos 250 ml or Iprobenphos 500 ml or Carbendazim 250 g or Tricyclazole 400 g or Thiophanate Methyl 500 g or Pyroquilon 500 g/ha.

2. Brown spot or sesame leaf spot (*Helminthosporium oryzae*)

Symptoms

- The fungus attacks the crop from seedling in nursery to milk stage in main field.
- Symptoms appear as lesions (spots) on the coleoptile, leaf blade, leaf sheath, and glume, being most prominent on the leaf blade and glumes.
- The disease appears first as minute brown dots, later becoming cylindrical or oval to circular.
- The several spots coalesce and the leaf dries up.
- The seedlings die and affected nurseries can be often recognized from a distance by their brownish scorched appearance.
- Dark brown or black spots also appear on glumes which contain large number of conidiophores and conidia of the fungus.
- It causes failure of seed germination, seedling mortality and reduces the grain quality and weight.

Favourable Conditions

Temperature of 25-30°C with relative humidity above 80 per cent is highly favourable. Excess of nitrogen aggravates the disease incidence.

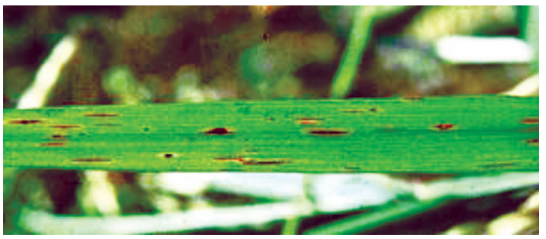
Management

- Field sanitation-removal of collateral hosts and infected debris in the field.
- Crop rotation, adjustment of planting time and proper fertilization are suggested. Use of slow release nitrogenous fertilizers is advisable.
- Use disease free seeds. Treat the seeds with Thiram or Captan at 4 g/kg.
- Spray the nursery with Edifenphos 40 ml or Mancozeb 80 g or Captafol 40 g.

- Spray the crop in the main field with Edifenphos 500 ml or Mancozeb 1 kg or Captafol 625 g/ha.

3. Narrow brown leaf spot (*Cercospora janseana*)

(Sexual stage : *Sphaerulina oryzina*)



Symptoms

- The spots appear in large numbers during later stages of crop growth.
- The fungus produces short, linear brown spots mostly on leaves and also on sheaths, pedicels and glumes.

Management

Spray Carbendazim 250 g or Mancozeb 1 kg/ha.

4. Sheath rot (*Sarocladium oryzae*)

Symptoms

- Initial symptoms are noticed only on the upper most leaf sheath enclosing young panicles.
- The flag leaf sheath show oblong or irregular greyish brown spots.
- They enlarge and develop grey centre and brown margins covering major portions of the leaf sheath.
- The young panicles may remain within the sheath or emerge partially.
- The panicles rot and abundant whitish powdery fungal growth is formed inside the leaf sheath.

Favourable conditions

Closer planting, high doses of nitrogen, high humidity and temperature around 25-30ºC. Injuries made by leaf folder, brown plant hopper and mites increase infection.

Management

- Apply recommended doses of fertilizers.
- Adopt optimum spacing.

- Spray Carbendazim 250g or Edifenphos 1 lit or mancozeb 1 kg or Chlorothalonil 1 kg/ha at boot leaf stage and 15 days later.
- Soil application of gypsum in 2 equal splits (500 kg/ha) reduce the sheath rot incidence.

5. Sheath blight (*Rhizoctonia solani*)



Symptoms

- The fungus affects the crop from tillering to heading stage.
- Initial symptoms are noticed on leaf sheaths near water level.
- On the leaf sheath oval or elliptical or irregular greenish grey spots are formed. As the spots enlarge, the centre becomes greyish white with an irregular blackish brown or purple brown border.
- Lesions on the upper parts of plants extend rapidly coalescing with each other to cover entire tillers from the water line to the flag leaf.
- The presence of several large lesions on a leaf sheath usually causes death of the whole leaf, and in severe cases all the leaves of a plant may be blighted in this way.
- The infection extends to the inner sheaths resulting in death of the entire plant. Older plants are highly susceptible. Five to six week old leaf sheaths are highly susceptible.
- Plants heavily infected in the early heading and grain filling growth stages produce poorly filled grain, especially in the lower part of the panicle.

Favourable conditions

High relative humidity (96-97 per cent), high temperature (30-32^{o}C), closer planting and heavy doses of nitrogenous fertilizers.

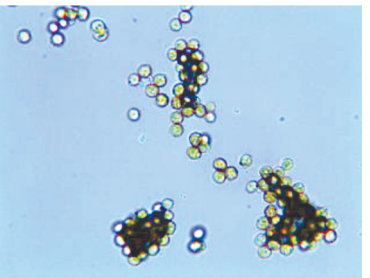
Management

- Avoid excess doses of fertilizers.
- Adopt optimum spacing.

- Eliminate weed hosts.
- Apply organic amendments.
- Avoid flow of irrigation water from infected fields to healthy fields.
- Deep ploughing in summer and burning of stubbles.
- Spray Carbendazim 250 g or Chlorothalonil 1 kg or Edifenphos 1 lit/ha. Seed treatment with Pseudomonas fluorescens @ of 10g/kg of seed followed by seedling dip @ of 2.5 kg or products/ha dissolved in 100 litres and dipping for 30 minutes.
- Soil application of P.fluorescens @ of 2.5 kg/ha after 30 days of transplanting (This product should be mixed with 50 kg of FYM/Sand and then applied).

6. False smut (*Ustilaginoidea virens*)





Symptoms

- The fungus transforms individual grains into greenish spore balls of velvety appearance.
- Due to the development of the fructification of the pathogen, the ovaries are transformed into large velvety green masses. Usually only a few spikelets in a panicle are affected.
- Pathogen Chlamydospores are formed on the spore balls, they are spherical to elliptical, waxy and olivaceous.

Favourable conditions

Rainfall and cloudy weather during the flowering and maturity periods are favourable.

7. Stackburn disease *(Trichoconis padwickii)*

Symptoms

- Leaves and ripening grains are affected. In the leaves, circular to oval spots with dark brown margins are formed.
- The central portion of the spot turns to light brown or almost white and has numerous minute dots.

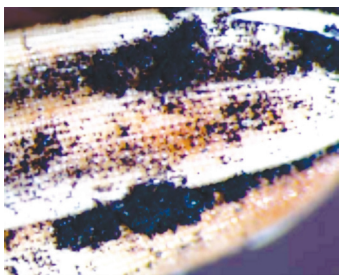
- On the glumes reddish brown or pale brown spots appear.
- The kernels may shrivel and become brittle when severe spotting occurs.

Management

Treat the seeds with Thiram or Captan or Mancozeb at 2g/kg. Hot water treatment at 54ºC for 15 minutes is also effective. Burn the stubbles and straw in the field.

8. Kernel smut or black smut (*Tilletia barclayana*)





Symptoms and signs

Kernel smut appears as a black mass of chlamydospores that replace all or part of individual kernels near or at maturity. Usually only a small number of kernels on each panicle are infected. Completely smutted kernels may be slightly swollen while others may break open exposing the dark spores. Minute black pustules or streaks are produced in the grains which burst open at the time of ripening. The grains may be partially or entirely replaced by the fungal spores. The sorus pushes the glumes apart exposing the black mass of spores. Only a few flowers are infected in an inflorescence. The fungus survives as chlamydospores for one or more years under normal condition and 3 years in stored grains.

Comments on the disease

Chlamydospores liberated during harvest fall to the soil where they overwinter. The fungus can also overwinter in or on seeds. In spring as the fields are flooded, chlamydospores float, germinate, and produce other spore and mycelial stages. At flowering (heading), secondary airborne spores (sporidia) infect individual florets or kernels.

Kernel smut is generally considered a minor disease of rice. In rice growing areas, it is more prevalent during rainy years and in areas of fields receiving high rates of nitrogen fertilizer. Disease surveys have shown short and medium grain varieties to have lower incidence rates for kernel smut than long grain varieties. Long grain rice varieties may be more susceptible to kernel smut because their florets are open wider and longer during flowering.

Management

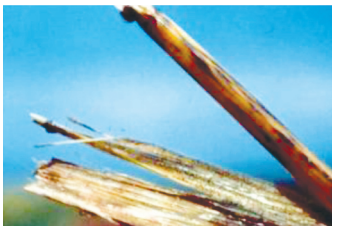
Cultural practices are the primary means of managing kernel smut. Chemicals for controlling this disease are not registered for use on rice in California at this time.

Cultural Control

Avoid excessive rates of nitrogen fertilizer. Plant short or medium grain varieties in fields with kernel smut history. Plant certified rice seed.

9. Stem rot (*Sclerotium oryzae*)

Symptoms



- Small black lesions are formed on the outer leaf sheath and they enlarge and reach the inner leaf sheath also.
- The affected tissues rot and abundant sclerotia are seen in the rotting tissues.
- The culm collapses and plants lodge. If the diseased tiller is opened, profuse mycelial growth and large number of sclerotia can be seen.
- The sclerotia may be seen in the stubbles after harvest.

Favourable Conditions

Infestation of leaf hoppers, stem borer and high doses of nitrogenous fertilizers.

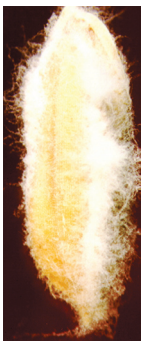
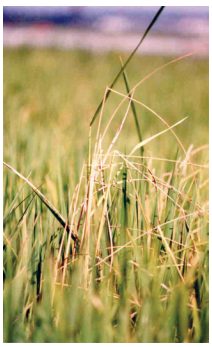
Management

Use of recommended doses of fertilizer. Deep ploughing in summer and burning of stubbles. Avoid flow of irrigation water from infected fields to healthy fields.

10. Foot rot or bakanae disease (*Fusarium moniliforme*)

The most visible symptom is the bakanae tillers, which are highly elongated and can be seen from the distance in fields and seedbed. Diseased plants appear abnormally elongated, thin, and yellow green compared with the other plants. Diseased plants may be distributed irregularly in an infected field. In the seedbed, heavily infected seedlings with necrotic lesions on roots die before or after transplanting. White powdery growths of conidiophores can be seen over the lower regions of the diseased plants. Diseased plants bear few tillers and their leaves dry up quickly. The diseased plants survive but bear empty panicles.

Symptoms

- The infected seedlings in nursery are lean and lanky, much taller than healthy seedlings and die after some time.
- In the main field, the affected plants have tall lanky tillers and have longer internodes and aerial adventitious roots from the nodes above ground level.
- The root system is fibrous and bushy.
- The plants are killed before earhead formation or they produce only sterile spikelets. When the culm is split open white mycelial growth can be seen.

Pathogen

Fungus produces both macro and micro conidia.

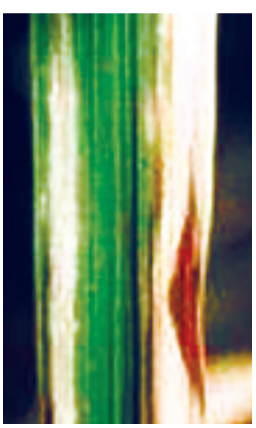
- Micro conidia are hyaline, single celled and oval in shape.
- Macro conidia are slightly sickle shaped, narrow at both ends and two to five celled.
- The fungus produces phytotoxin called fusaric acid, which is non-host specific.

Mode of Spread and Survival : The fungus is externally seed-borne.

Management

Treat the seeds with Thiram or Captan or Carbendazim at 2 g/kg.

11. Bacterial leaf blight (*Xanthomonas oryzae p.v. oryzae*)




Symptoms

- The disease is usually noticed at the time of heading but in severe cases occur earlier also.
- Seedlings in the nursery show circular, yellow spots in the margin, later enlarge, coalesce and cause drying of foliage.
- "Kresek" symptom is seen in seedlings, 1-2 weeks after transplanting. The bacterium enters through the cut wounds in the leaf tips, becomes systemic and cause death of entire seedling.
- In grown up plants water soaked, translucent lesions appear usually near the leaf margin. The lesions enlarge both in length and width with a wavy margin and turn straw yellow within a few days, covering the entire leaf.
- As the disease progresses, the lesions cover the entire leaf blade which may turn white or straw coloured.
- Lesions may also be seen on leaf sheaths in susceptible varieties. Milky or opaque dew drops containing bacterial masses are formed on young lesions in the early morning.
- They dry up on the surface leaving a white encrustation.
- The affected grains have discoloured spots surrounded by water soaked areas.
- If the cut end of leaf is dipped in water, bacterial ooze makes the water turbid.

Favourable Conditions

Clipping of tip of the seedling at the time of transplanting, heavy rain, heavy dew, flooding, deep irrigation water, severe wind, temperature of 25-30ºC and application of excessive nitrogen, especially late top dressing.

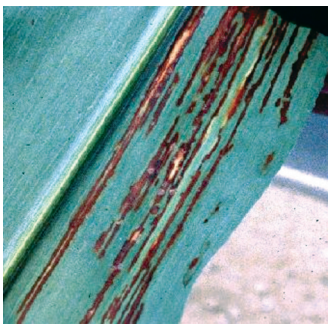
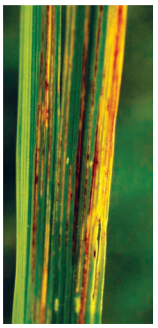
Management

- Burn the stubbles. Use optimum dose of fertilizers.
- Avoid clipping of tip of seedling at the time of transplanting.
- Avoid flooded conditions. Remove weed hosts.
- Spray Streptomycin sulphate and tetracycline combination 300 g + Copper oxychloride 1.25 g/ha.

12. Bacterial leaf streak (*Xanthomonas campestris p.v. oryzicola*)

Symptoms and mechanisms of damages of the two bacterial diseases are almost similar. Hence, it is very important for the rice growers to gain skills and expertise in distinguishing what particular causal organisms are attacking their fields, and what types of symptoms are manifested by the crops. BLS infection usually comes in earlier than BLB, wherein disease symptoms become noticeable 40 to 45 days after seeding (DAS). The disease may occur in both lowland and upland rice.

Symptoms


Initial symptoms of BLS include the formation of narrow, dark green, water-soaked, interveinal streaks of various lengths on the leaf blades. The lesions enlarge and streaks eventually turn yellow to orange or yellowish-gray and translucent with numerous milky to yellow beads of bacterial exudates. Individual plants may develop a pronounced yellowing of the tips of new leaves if infection occurs early in the season. As the disease progresses, streaks become more diffuse and coalesce, then eventually turn brown to grayish-white, causing leaves to die. High temperatures, high humidity, and rainy weather favour the development of the disease.

- Fine translucent streaks are formed on the veins and the lesions enlarge lengthwise and infect larger veins and turn brown.
- On the surface of the lesions, bacteria ooze out and form small yellow band-like exudates under humid conditions. In severe cases the leaves may dry up.

Factors favouring disease development

a. Strong winds, heavy rains, and deep water
b. High temperature and humidity
c. Presence of the bacteria on leaves and in water
d. Sources of inoculums (volunteer plants, infected straws, weeds, etc.)
e. Over fertilization (excessive use of N)
f. Poor handling during transplanting (wounded leaves)
g. Closer plant spacing (high frequency of tissue contacts among plants)

Management

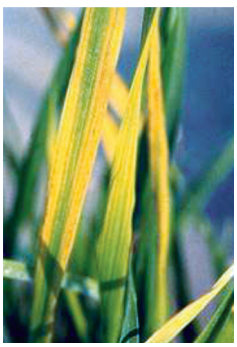
(a) Reducing the amount of inoculum by practicing field sanitation. Destroying rice ratoons, volunteer seedlings, crop stubbles, infected straws, and weeds can minimize the inoculum at the beginning of the cropping season. Fallowing the field and allowing drying thoroughly can kill the bacterial pathogens that may have survived in the soil and plant residues.
Maintaining proper drainage which will also prevent water stagnation and will provide good aeration which is one of the best preventive options to minimize disease occurrence.

(b) Reducing the spread of the disease by avoiding seedling damages. This is done by proper handling of the crops during transplanting and various fertilizer and chemical application activities.
These injuries will provide point of entries for the causal pathogens. Hence, these will allow rapid occurrence of the disease. Infection spreads through direct plant-to-plant contact and through water (strong winds and heavy rain).
Use of copper fungicides may help prevent disease occurrence and stop further disease spread. The Dupont product Kocide® (containing copper hydroxide) is effective against bacterial leaf diseases of rice such as leaf blight and streak. Fungicide application must be done not later than 40 DAS. Beyond this, the bacteria must have taken their place inside the leaf.

(c) Reducing the susceptibility of the plants to infection. This is done by planting resistant varieties, application of balanced levels of plant nutrients, proper plant spacing, and seeding rate.
Excessive amount of N can worsen disease infection. Likewise, a variety resistant to BLB is also probably resistant to BLS. Dry season is the best time to grow hybrid rice as rice crops are highly susceptible to BLS and other diseases during wet season.

13. Rice tungro disease or Rice tungro virus

Symptoms



Tungro affects the plant at any growth stage, most severely during the vegetative stage where symptoms are more pronounced. Leaf discoloration begins from the tip and spreads down the blade to the lower leaf portion. Leaves may also exhibit mottled or striped appearance. Stunting is also evident as well as reduced tillering. Flowering is delayed and consequently, maturity. Panicles are small, not well exerted, and are partially sterile. Grains are covered with dark brown blotches, and grain quality is poor. Other indications are the presence of GLH adults, nymphs, and eggs.

- Infection occurs both in the nursery and in the main field.
- Plants are markedly stunted. Leaves show yellow to orange discoloration and interveinal chlorosis.
- Yellow discoloration is commonly seen in "Japonica" varieties, while "Indica" varieties show orange discoloration.

- Young leaves are often mottled with pale green to whitish interveinal stripes.
- The plants may be killed if infected early.
- Tillering is reduced with poor root system.
- The infected plants have few spikelets and panicles are small with discoloured grains.
- Tungro infected plants can be chemically identified by:
  Iodine Test: Ten cm long leaf tip is cut in the early morning before 6 A.M. and dipped in a solution containing 2 g Iodine and 6 g Potassium Iodide in 100 ml of water for 30 minutes. Tungro infected leaves show dark blue streaks.

Management practices in minimizing injection

Effective management of tungro disease in hybrid rice, however, is limited by lack of resistant hybrid rice varieties, lack of symptoms during early development of the disease, and vector adaptation to insect resistant varieties. Farmers start noticing the disease when the symptoms appear, and usually at this point, the disease has already spread and the GLH has already reproduced. Currently, there are no hybrid varieties resistant to tungro. Existing resistant inbred lines such as the Matatag series are provided only as stop-gap varieties and may not yield as high as what farmers usually plant. However, these Matatag lines usually yield more that the farmers' varieties under tungro disease pressure. So it is important to detect the disease as early as possible. Some of the signs to look for are non-uniform growth or patches of irregular growth in the field, presence of GLH, and presence of the disease in neighboring fields. Observe the field diligently and ratoon or cut off infected plants. Stubbles and plant debris should be removed after harvesting by plowing and harrowing to eliminate the inoculum. Farming communities should be organized so that planting would be synchronous to at most, the within one month of the general planting schedule of the locality.

There are no chemicals available that can be used to directly control the virus. However, the insect vector can be controlled. Lannate, a DuPont product, is an effective chemical control for GLH and other hoppers.

- Summer deep ploughing and burning of stubbles.
- Destroy weed hosts of the virus and vectors.
- Control the vectors in the nursery by application of carbofuran 170 g 10 days after sowing.
- Spray Phosphamidan 500 ml or Fenthion 500 ml or Monocrotophos 1 lit/ha or Neem oil 3 per cent in the main field 15 and 30 days after transplanting to control.
- **Mode of Spread and Survival.**
  Transmitted by leaf hopper.
  Leaf hoppers.

14. Grassy stunt virus

The infected plants are markedly stunted and have excessive tillering and have an erect growth habit. The leaves become short, narrow, pale green or pale yellow and have numerous small dark brown spots. On older leaves these spots spreading give a bronze colour to the plants. The plants may produce a few small panicles which bear dark brown and unfilled grains.

Mode of spread and survival

The virus is transmitted in a persistent manner by the brown plant hopper, Nilaparvata lugens. It has a latent period of 5 to 28 days in the vector.

15. Rice dwarf virus

Symptoms

- The virus infected plants show marked stunted growth with chlorotic or whitish specks on the leaves.
- The size of specks varies often and form interrupted streaks along the veins and distal part of infected leaves show diffuse yellowing.
- The number of tillers may be reduced with retarded growth.
- The diseased plants may survive until harvest time, remaining more or less green.
- Plants which are infected at early stage produce no earheads, if produced, may have small unfilled grains.

Favourable conditions

High population of *Nephotettix cincticeps, Recllia dorsalis and N. nigropictus*. The presence of gramineous weeds like *Echinochloa crusgalli, Glyceria acutifolia* and *Panicum miliaceaaum.*

Mode of spread and survival

The virus is found to survive in the gramineous weeds. The virus is transmitted through the egg masses of leafhoppers from one generation to another (Trans ovarial transmission).

Management

Destroy the weed host which harbors the virus and the vectors. Spray Phosphamidon or Fenthinon 500 ml or Monocrotophos 1 lit/ha.

16. Rice yellow dwarf mycoplasma like organism (MLO)

Symptoms

- The infected plants are stunted and have yellowish green to whitish green leaves.
- There is excessive tillering and leaves became soft and droop slightly. Plants are usually sterile but some may produce small panicles with unfilled grains.
- If plants are infected early they usually die before maturity, and even if they do survive no panicles are produced or only a small number with no grains.

Mode of spread and survival

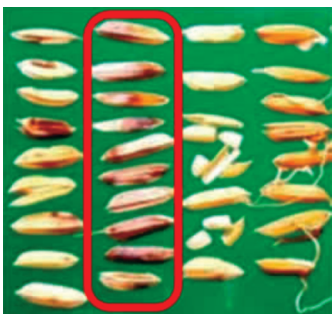
The MLO is transmitted by *Nephotettix virescens* and *N. nigropictus* with a latent period of 25-30 days. It survives on several grass weeds.

Management

Deep ploughing during summer and burning of stubbles. The management practices followed for Rice Tungro disease need to be adopted for this disease also.

17. Grain discolouration

Symptoms



- The grains may be infected by various organisms before or after harvesting causing discolouration. The infection may be external or internal causing discoloration of the glumes or kernels or both.
- Dark brown or black spots appear on the grains.
- The discolouration may be red, yellow, orange, pink or black, depending upon the organism involved and the degree of infection.
- This disease is responsible for quantitative and qualitative losses of grains.

Favourable conditions

High humidity and cloudy weather during heading stage.

Management

- Pre and post-harvest measures should be taken into account for prevention of grain discolouration.

- Spray the crop at bootleaf stage with Mancozeb 1 kg or Iprobenphos 500 ml or Carbendazim 250 g/ha.
- Store the grains with 13.5-14% moisture content.

Indigenous (ITKs) Insect Pest Management in Rice

1. Clipping off the tip of rice seedlings before transplanting is practiced all over the state of Assam, to ease transplantation; to facilitate uniform growth and to remove insect egg masses and other major insect pests present on the leaf tips is an alternative for chemical pesticides application.
2. Pieces of tree branches are randomly fixed in the rice field to control some major insect pests through biological means. Generally Chara (*lata mahudi*) plants are preferred. The practice is followed since long by almost all the paddy growers of Assam. The idea is to attract birds to perch on the branches fixed in the rice field and eat up the insects.
3. Chopped pieces of colocatia and sometimes chopped peels of *Citurs grandis* are spread in rice field to drive away the insect pests. In some places *Calotrophis gigntea* is grown on bunds of paddy fields to check the insect pests.
4. Fixing of dead crabs, frogs or even pieces of jackfruit (*Artocarpus heterophyllas*) to bamboo sticks in rice fields.
5. Rope dipped in kerosene oil is drawn over the standing rice crop.

   These practices have been in use since long time without any modification by all the rice farmers all over Assam.
6. The farmers of Disoi khash village under Dhekargoya Development Block in Jorhat district of Assam have adopted different methods for the management of rice caseworm, *Nymphalla depunctalis* in paddy field. When infestation of caseworm occurs, one of the following practices is adopted:
   - Water is drained out from the rice field and it is kept dry for 3 or 4 days. If it is not possible to drain out the water, wild colocasia plants are chopped and applied to the field on standing water and raw cow dung is applied to the standing water in the rice field. The purpose of the practice is to kill the larvae of the caseworm, which float on the standing water in rice field and feed on the leaf epidermis of rice plants during morning and afternoon. The case worm larva respires with the help of rectal gills and oxygen is taken from the water like fish. Therefore, if water is drained out from rice fields, they cannot thrive.
   - On the other hand, if the raw cow dung is applied to standing water, it becomes turbid and respiratory function is disturbed. Application of colocasia plants make the water toxic to case worm larvae. Draining out water from rice fields has excellent effect, killing about 100% case

worm larvae, whereas, application of chopped colocassia plant and raw cow dung to standing water in the field controls 75-80% of case worm larvae.

7. Farmers of Boutepoabari village under Jalah block in Barpeta district of Assam use pulp of *pumelo (Citrus grandis)* locally called robaltenga, or *siam weed* (*Eupatorium rugosum*) locally called Germany ban, for control of *hispa infestation* in paddy. This practice has been in use since for many years . The plant materials and fruits used are locally and cheaply available. Alternatively bark of kedamba tree or cow dung or ash is used by the farmers for the same purpose.
9. Farmers in Buribara village of west Singhbhum district in Jharkhand use custard apple (*Annona squamosa*) for pest control in paddy crop. Leaves and seeds of custard apple contain chemicals having insecticidal properties. Insect/ pests of paddy crop are controlled by broadcasting leaves or seeds of custard apple. The smell of leaves act as repellent, where as, leaves are toxic in nature to plant parasites. Leaves are used raw, whereas seeds are processed and used as powder.
10. Farmers of Hatma village of Ranchi district use this practice for controlling the insect /pest attack and damping off in the nursery. Paddy straw is burnt in the nursery plots after the first ploughing. Due to burning of straw the soil becomes sterilized and free from insects/pests. Ash acts as potash source.
11. Farmers burn discarded rubber tyre in the field by holding it in their hands. Gundhi bug (*Leptocorsia acuta*) are attracted towards it. This method is effective in protecting rice crop from gundhi bug. This is age old practice, adopted by farmers of Tamar block of Ranchi district in Jharkhand.
12. Farmers use kerosene oil soaked chord to control case worm (Nymphala depunctalis) in rice. About 70-80% pest control is observed with this practice. It is practiced for the last several years by maximum number of farmers in Tamar block of Ranchi district, Jharkahand.
13. Majority farmers of Ranchi district of Jharkahnd use branches of bhelwa tree to protect rice crop from lahi and gundhi bugs. They collect branches from bhelwa tree and plant these in rice field. This practice keeps insects away from rice crop because of the repellent character of bhelwa.
14. Sindwar leaves are locally available, which act as intoxicant on the insects. In this practice, sindwar leaves are boiled in water and the solution is cooled. It is sprayed on the crops (1kg leaves per 5 liters water for 0.06 acre) with the help of broom to control caseworm (*Nymphala depunctalis*). By this practice 60% case worm is controlled. This is in practice for last 25 years by maximum number of farmers in the village.

15. Rice hispa damages rice crop severely during early stage of cropping. To control the rice hispa people of Kunchi village of Dhanbad district (Jharkhand) use basi mar spraying on the plot. Alternatively farmers fill up their plots with water in early morning. They shake the crop with silver oak or maize stick. Later stick is fixed in the middle of the plot. Then water is allowed to drain from this field. They continue this practice for 2 to 3 days. All the farmers of the village are using this age old practice.
16. Farmers of Bara sigdi village of East Singhbhum district face a problem of gundhi bug during milky stage in paddy crop. This problem is controlled by placing neem (*Azadirachta indica*) or kujri flowers in small bundles in 5-6 places. Bugs are repelled by using this and about 98% farmers practice it in the village.
17. Rice hispa (or white patches) are very common in paddy crop. They can be controlled by dusting sand and kerosene oil mixture (5:1). The success rate of this practice is almost 20-25 %. It is practiced for the last 40-50 years by maximum number of farmers in the Oraina village of Nawada district of Bihar.
18. People of Fumdapokher village of West Singbhum district of Jharkhand use this practice for protecting rice crop from gundhi bug. In this practice, a dead snake is hung by the side of rice field. Great risk is involved in trapping and killing the snake.
19. Farmers of Raipur district in Chhattisgarh use Kodo straw to spread over stagnant water to control pests. Salfi palm and karla sticks are also installed in stagnant water to reduce the pest attack in rice field. Salfi palm, kodo straw and karla sticks have some insecticidal properties which reduce the insect population.
20. The swarming caterpillars in paddy is controlled by broadcasting pellets made of boiled rice mixed with hen blood. Smell of blood and rice attracts birds to the fields and they pick up swarming caterpillars.
21. By keeping one effigy per acre (a man like toy made of rice straw wearing white dress) at the center of the paddy field at the time of milky to grain filling stage, bird menace can be reduced. As the effigy appears human, the birds fly off; thereby damage is reduced.
21. Application of tobacco plant powder at 7-10 days after transplanting of rice in kharif effectively controls the stem borer and leaf folder as it contains nicotine sulphate, which acts as a repellent. This practice is prevalent in Andhra Pradesh.
22. Erecting fishtail palm branches, jeeluga @ 25-30kg/ acre, scattered once in the rice in rainfed uplands control the leaf folder and stem borer. This contains an alkaloid which acts as a repellent.

23. The farmers in Pandri Halwa village of Bareilley district in Uttar Pradesh use kerosene oil (2.5 liters/acre) in the termite affected paddy at the time of irrigation. Kerosene acts as pesticide or repellent for termites. This practice is in use for the last 304 years by 15-20% families in this village. Others do not follow the practice due to non-availability of kerosene oil, lack of knowledge and also due to use of chemical pesticides.
24. Farmers know that standing water in fields helps in controlling termites. In paddy fields if there is no standing water, the termite attack is prevalent and drying up of paddy crop is the visible symptom. Where cow dung manure is used extensively when there is water shortage, the termite infestation is common. Flooding helps in reducing the population of termites by disrupting their life cycle. The success rate of this practice is 98 percent and it is age old practice followed by 65 percent of the farmers in the Bara Sigdi village of East Singbhum district.
25. This is practiced in Bara sigdi village of East Singhbhum district of Jharkhand. Termite and insect /pests of root zone in paddy are controlled by fruits and leaves of ashan. These are broadcasted in paddy fields infested with termites and other soil borne insects. Fruits and leaves of ashan are bitter, acrid and toxic to insect pests, which help in checking their population. This is age old practice, highly successful and adopted by maximum number of farmers.
26. The jute capsularies seed extract is used for controlling stem borers.
27. Crabs live in standing water or moist paddy fields and snip off the paddy stems. Farmers crush the flowers of Keshuda (*Butea manosperma*) and put them near crab burrows. It is believed that this practice reduces the damage to the crop. This is in practice in Rajasthan.
28. Farmers pulverize neem seed kernal and soak in equal amount of water over night and spray it on the rice crop after filtration to control Brown Planthoppers and Green Leafhoppers.
29. Neem seed kernal is soaked in kerosene over night. In the next day morning the suspension is filtered and sprayed by adding sufficient quantity of water to control insect pests of rice.
30. Neem cake is applied as basal manure which helps to protect the rice from BPH at later stages.
32. Sacks filled with neem cake are immersed in irrigation channel to control termites by the farmers of Tamil Nadu.
33. Neem oil, Pungam oil, and soapnut powder mixture is used to control leaf folder at 1:1:0.5 ratio.
34. Pungamia, which grow on river sides, road sides and in forests are incorporated in water logged paddy fields before transplanting. The leaves thoroughly get

mixed during the puddling operation and decay within 2-3 days. Once they decay the smell from the waste repels paddy pests.

35. Paddy crop is exposed to the smoke of burnt leaves of custard apple and *Vitex nugundo* for better control of insects and rats. This is practiced by the farm families of the village for the last 20 years. Leaves of these plants are put in a pot and burnt near rat burrows. By this practice, rats are killed and insects fly away from plants. About 5 kg dry leaves are required to give smoke in 1 acre land.
36. In Assam, leaves of kohu gans (*Grewea* sp) are collected and ground to control insects and pests in rice. A few liters of water is added and the extract is sprayed in the affected field. Erection of stems of this plant in the affected field also gives good results.
37. Farmers of Pasighat block in Arunachal Pradesh use crabs as insect attractant. Farmers collect 40-50 crabs and kill them. After killing, these crabs are tied with bamboo sticks and placed randomly in the field. Insects are attracted with the smell of crabs and they sit over the body to suck the sap. Thus the crop is saved from the insects.
38. Farmwomen of Mishing tribe of East Siang district, Arunachal Pradesh spread the leaves of markati plant (*Baccaurea ramiflora*) randomly after transplanting paddy in the field. By spreading these leaves, the paddy crop is saved from various diseases and the insects are repelled from paddy field. This practice is used since time immemorial and 80-85% farmers rely on this practice.
39. White grub is a major problem of rice grown in the hills. It causes severe losses in yield. To control white grub infestation in field, farmers use common salt. A solution is prepared by mixing 1 kg of common salt in 5 liters of water, which is sprayed in about 200m^2 area after ploughing and before sowing.
40. For control of aphids farmers of this area dip the dried fish in water for 1-2 days. Afterwards this fish soaked water is filtered and some quantity of water is added and then it is sprayed in the field, which repels aphids from paddy field.
41. Farmers of Pasighata area pluck pumello fruits (Citrus grandis) and cut its skin into small pieces. These pieces are fixed on bamboo sticks, which are inserted in paddy field. Insects are controlled by this practice.
42. Rhizome of Jamalakhuti (*Costus speciosus*) is crushed to make a paste and the juice is extracted out of it. This juice extract is diluted and sprayed in paddy field to control rice hispa. This practice is followed by the people of Amtola village in Kamrup district of Assam.
43. A paste is prepared by mixing 1 kg leaves each of chaste tree (*Vitex negundo*), garden quinine (*Clerodendrum inerme*) Indian aloe (*Aloe vera*) and seed of neem (*Azadiracta indica*). This paste is diluted in 100 liters water for spraying in 1

acre after 25-30 days of planting (the mixture is kept overnight before using for spraying). This formulation effectively controls pests as well as diseases in paddy.

44. Green twigs of Calotropis gigantea plants are placed in the paddy fields to control aphids and they are replaced once in 10 days. This is practiced in Gujarat.
45. To control stem borer in paddy fields, branches of Erythrina indica plants are placed in the soils.
48. About 30 kg of common salt is applied in 1 hectare area of paddy crop to protect it from stem borer by the Rice farmers in Tripura.
49. During panicle formation stage in paddy, the flowers of Cycas circinalis are placed on sticks in paddy fields @4/ac. Its unpleasant odour repels earhead bugs.
50. To protect the paddy crop from grass hoppers, *Sesbania aegyptiaca* is grown as a hedge all around the paddy fields. This practiced in Uttar Pradesh.
51. To save paddy crop from mealy bugs farmers take a discarded tyre and burn it They drag it around the field and put it on windward direction. The smoke and smell are assumed to repel the pest.
52. Vasambu (Acotus calamus) is powdered and dissolved in water and kept over night. The next day, the clear solution is mixed with 200 ml of neem oil and is sprayed on the paddy crop to prevent pest attack by the farmers of Tamil Nadu.
53. To control stem borer and leaf folder in rice, 500 ml of neem oil is mixed with 4 kg soil and some fresh cow dung. It is dried in shade for two days. Thereafter, it is dissolved in 50 litres of water, and about 200 grams of soap is dissolved in this mixture and is sprayed on the crop.
54. Neem leaves are mixed with equal quantity of Pirandai (*Cissus quadragularis*) leaves. This mixture is ground well and soaked in cow urine for one week and afterwards it is filtered. The filtrate is mixed with water at 1:9 ratio and is sprayed twice at 15 days interval to control all the pests of paddy.
55. Cow dung slurry is prepared by mixing 1kg cow dung in 10 liters of water. The slurry is mixed with 1 kg crushed karada (*Xylia xylocarpus*) leaves. This solution is sprayed at weekly intervals for controlling major insect pests of rice.
56. Bhang (*Cannabis sativa*) plants are used for controlling thread worms in paddy. Bhang plants are uprooted and kept in standing water in paddy fields. If the problem is severe, then crushed leaves are put in the standing water to kill the worm.
57. Rice farmers in Andhra Pradesh are using plant materials like fish tail palm leaves (*Caryota urens*) and Jeelugu for the control of leaf folder and stem borer

in paddy. They spread/ scatter 25-30 leaves per acre in the paddy field. This fish tail leaves exudes alkaloids, which prevents pests.

58. 'Musidi leaves' (*Nux vomica*) are broadcasted in the field if termite attack is observed in paddy.
59. When paddy is infested with leaf folder and gall midge , farmers drag thorny bushes in the field to shed the insects pests.
60. Neem cake (20kg/ac) is applied as basal manure which helps to protect paddy crop from BPH and improves soil fertility. This is prevalent in Tamil Nadu.
61. Uprooting gall midge affected seedlings and burning in the nursery before transplanting is practiced by the farmers of Andhra Pradesh.
62. Farmers in Andhra Pradesh believe that presence of the Gaviribethi snake improves crop yields because it predates on rodents.
63. Castor seed cake is mixed with urea by the farmers to repel soil borne insects like 'white grubs' and termites. This also provides good nutrient to soil since castor seed cake is rich in minerals.
64. Tribal farmers of Bihar destroy major rice pests by applying the extract of the kachoo plant (*Colocasia esculenta*) and Bihlangani (*Polygonum glabram*) into the water inlets to field.
65. Rice farmers plant every 10th row with a variety of rice which is highly susceptible to 'stem borers'. The insect feeds only on these rows of rice and leave the rest untouched.
66. A solution made of extracts of 1 kg of garlic, 200 grams of tobacco leaves and 200 grams of washing powder is dissolved in 200 litres water and sprayed on the affected crop of paddy. One spray controls the insect pest by 80 percent. This practice is used by the progressive farmers and well to do farmers in Bihar and Uttar Pradesh.
67. Fresh leaves of Parsa (*Cleistanthus collinus*) and Sali (*Boswellia serrata*) are spread on the insect infested field of about 5 kg leaves per 100 m^2. About 70-80 percent of the insect pests are controlled with this practice by the farmers of Jharkhand.
68. Wild sugarcane *Saccharum spontaneum* twigs of height 4 to 5 ft and 4 to 5 cm diameter are planted after 15 days of transplanting in rice field for control of leaf folder. These erected branches harbour the predators of leaf folder at the time of it occurrence, thereby suppressing the incidence of the pest. This practice is prevalent in Orissa.
69. Banki or rice caseworm infestation in paddy is common near Ranchi area of Jharkhand, which cuts paddy leaves, make pipe like encasings and feeds inside. In case of severe attack 90 percent of yield losses are experienced. To control the pest, Sandhana is mixed with water. The water is then sprayed or sprinkled on the affected paddy plant.

70. Gallfly (*Pachydiplosis oryzae*) is very harmful to rice crop. It regularly damages in endemic areas and the losses may go upto 50 percent in case of severe attack Farmers in Jharkhand use parso/persu (*Ceistanthus collinus*) leaves for controlling gallfly. In this practice, fresh leaves of persu are colleted and spread in the infested field with out processing. About 10 kg leaves are required for 1000m^2 area and controls 70-80 percent of the insects.
71. Application of 76-150 kg parso/persu (*Ceistanthus collinus*) leaves by broadcasting once in the rice field at 3 days after transplanting controls yellow stem borer during kharif. This is practiced in Jharkhand.
72. Herbal pesticide is prepared by farmers of Uttar Pradesh by mixing cow urine, nirgandi (*Vitex negundo*) leaves and hing (asafetida). This mixture in appropriate proportion is considered effective bio-pesticide for rice pests. It contains certain ingredients having insecticidal as well as insect repellent property, which makes it useful for control of insects-pests of paddy crop. About 30-40 leaves of nirgandi (*Vitex negundo*) are boiled in 10 litre water till it condensed to one litre. About 10 gram of asafoetida is then mixed in it. These ingredients are mixed in about 5 litres of cow urine. The mixture is then filtered and sprayed as bio-pesticide over affected crops. This spray is for all sowing seasons i.e., early sowing, normal or late sowing seasons of rice crop.
73. To control leaf folder and stem borer in paddy, spraying of kerosene is in practice. Five liters of kerosene is mixed with soap and water to spray one hectare.
74. 7.5 kg of neem seeds, 4 kg leaves of Kattunochi (*Vitex negundo*) 2 kg siru thumbai (*Leucus aspera*) and 2 kg peru thumbai (*Leucus marincenis*) are pounded well and soaked in mud pot containing 10 litres of cow urine. The mixture is allowed to ferment for a week. One litre of this filtrate is filled in a sprayer tank along with soap water (prepared with 100g of washing soap scraps soaked in water and diluted). Five litres liquid mixture is sufficient for spraying in one acre of paddy field. Four times application at 10 days interval from 25th day of planting is practiced to control pest and diseases in paddy field.
75. Farmers of Baramati Block of Pune district in Maharashtra practice a method to scare away the birds from the crop. The audio cassette tape is tied tightly above the rice crop. The light reflection in the tape due to the sunlight and scattering noise due to the wind are used to scare the birds. The losses due to birds are minimized upto 15% by this method.

Reference

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Summary

Keeping above picture and facts it is assumed that unpuddled mechanical transplanting of rice is a promising technique of rice transplanting for all rice growing states if timely and efficient agronomic management practices are taken into account. Due to labour shortage and water scarcity, this technology is assumed as star technology for rice cultivation in next 10 years as it has capacity to lessen the labour drudgery and promotes rice cultivation with less water. Unpuddled mechanical rice transplanting provides better returns over zero tilled direct sown rice (ZTDSR) or puddle transplanted rice while yield level of unpuddled mechanical transplanted rice is same as that of puddle transplanted rice and more over ZTDSR. In addition to above facts it provides better physical condition of rice fields due to less disturbance of soil which has positive response on succeeding crops.