Factsheet for Physiological Disorders of Rice in East Africa

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Nitrogen Deficiency in Rice Production

**Importance**
- Nitrogen (N) enhances plant growth, grain yield and grain quality.
- Nitrogen is the most limiting element in almost all soils.
- Proper application of N fertilizers is vital in improving crop growth and grain yields.

**Prevalence**
Nitrogen deficiency is common in most agricultural soils in East Africa. In Kenya, it is particularly deficient in:
- Coarse textured soils with low organic matter content (less than 0.5% organic C) in Kirinyaga, Embu, Kisumu, Busia, siaya and in parts of Teso in Busia county.
- Calcareous and alkaline soils with low soil organic matter and high potential for ammonia volatilization prevalent in Kwale, Kilifi, Tana River, Taita Taveta and Lamu counties.
- Soils with particular constraints to inherent N supply for example acid sulfate soils, saline soils, P-deficient soils and poorly drained wetland soils.

**Deficiency Symptoms**
- Discoloured leaves and stunted plants.
- Older leaves or the whole plant turn yellowish green.
- Older leaves are chlorotic at the tips moving towards the midrib in a V-shape.
- Reduced tillering and reduced grain number.

N/B. These indicators are sometime confused for Sulphur, Iron and Nitrogen visual deficiency. Sulphur deficiency first appears on young leaves, Iron deficiency first appears on emerging leaves while Nitrogen deficiency first appears on older leaves.

**Management Strategies**
- Analyze soils (at least in every three years) and plant tissue (whenever symptoms are noticed) to establish the N level in soils.
- Apply recommended N fertilizer efficiently, in splits and at right timings, based on the soil test report.
- Apply farm yard manure, crop residue and compost on low soil organic matter soils particularly in lowland rainfed rice areas.
- Carryout dry shallow tillage within 2 weeks of harvesting to enhance soil oxidation and crop residue decomposition in irrigated rice.
- Keep fields flooded to prevent N losses through denitrification and runoff immediately after fertilizer application.

![Fig 1. Deficient Pale green (L), Healthy dark green (R) (Wasilwa LA, KALRO)](image-url)
Phosphorus Deficiency in Rice Production

Importance
- Phosphorus (P) is important for root formation, flowering, tillering and ripening
- Deficiency is widespread in both upland and irrigated rice and is a major growth-limiting factor in acid upland soils
- It may be as a result of low P uptake due to soil acidity (low pH), iron toxicity, zinc deficiency and soil salinity and/or low use of phosphorus fertilizer
- Carrying away of grains and straw lead to P mining resulting to its deficiency in the soil

Prevalence
- Course-textured calcareous soils with low organic matter and small P-reserves in suc areas as Kilifi, Kwale and Vanga
- Highly weathered clayey acid upland soils with high P-fixation in areas such as Embu, Busia, Siaya, Homabay, Migori counties

Deficiency Symptoms
Common indicators of P deficiency are:
- Stunted, retarded plants with reduced tillering
- Red-purple colouration on leaf margins moving towards the midrib
- Narrow, short, and erect older leaves
- Thin and spindly stems
- Poor grain filling and delayed maturity
- In severe phosphorus deficiency, plants fail to flower or husks remain empty

Fig 1. Stunted growth (a), thin spindly stems (b), + and –P plants (c) (Dobermann and Fairhurst, (2000))

Effects excessive application
- Application of excess P fertilizers may result in lowering of grain iron (Fe) content in rice (Binay et al, 2012)

Management Strategies
- Analyze soils (at least in every three years) and plant tissue (whenever symptoms are noticed) to establish P status in soils
- Replenish P removed in crop products by applying P fertilizers based on soil test report.
- Apply optimum doses of N and K and correct micronutrient deficiencies that trigger Phosphorus immobilization
- Apply farm yard, compost manure or apply lime in acid upland soils
- On acid, low-fertility rainfed lowland and upland soils, correct soil fertility problems as per the soil test report for positive phosphorus response
- Judiciously apply P to prevent Fe-induced malnutrition
- Incorporate rice straw to help maintain a positive P balance

### Importance
- Potassium (K) is utilized in movement of water and nutrients (carbohydrates and proteins) during photosynthesis.
- Potassium deficiency in rice production is caused by use of high rates of nitrogen and phosphorus fertilizers with low potassium fertilization.
- Under direct seeding, the deficiency is common during early stages of growth, when plant population is high and the root system is shallow.
- Potassium deficiency is caused by crop removal with no replenishment by fertilization or crop residue incorporation.

### Prevalence
- Coarse-textured soils with low cation exchange capacity and small potassium reserves existing in Homabay, Migori, Embu, Siaya, Busia, Kilifi and Kwale counties in Kenya.
- Lowland clay soils with high K-fixation (Vertisols) prevalent in Mwea, Ahero, Bura irrigation schemes.
- Lowlands with high cation imbalance (high Ca and Mg in relation to K) as in Mwea Irrigation Scheme in Kenya.

### Deficiency Symptoms
- Dark green plants with yellowish brown margins and tips.
- Stunted plants with small leaves, short and thin stems.
- Dark brown necrotic (dead) spots appearing at leaf tips on older leaves.
- Patchy damage patterns appear in zones of severe deficiency on the farm.
- Increased lodging incidences.

### Effects of excessive application
- Similar to excess P, application of excess K fertilizers may result in lowering of grain iron (Fe) content in rice (Binay et al., 2012).

### Management Strategies
- Analyze soils (at least in every three years) and plant tissue (whenever symptoms are noticed) to establish required K application rates.
- Apply potassium based fertilizers based on soil test reports.
- Increase potassium uptake by deep tillage.
- Apply farm yard manure to balance potassium taken up by the crop.
- Incorporate rice straw on the farm. In case of burning, spread evenly the straw on the farm then burn.
- Judiciously apply N and P fertilizers and correct any micronutrient deficiencies.

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Sulphur deficiency in Rice

Importance
- Sulphur (S) is a key constituent of chlorophyll and affects protein synthesis, plant function and structure.
- Its deficiency can lead to delayed plant development, maturity and yield.
- Sulphur deficient rice plants confer less resistance to adverse conditions such as cold temperatures.
- Sulphur deficiency symptoms are often confused with those of nitrogen deficiency.

Prevalence
- Sulphur deficiency is not common in irrigated rice.
- In soils containing allophane.
- In soils with low organic matter status.
- Highly weathered soils with large amounts of iron oxides.
- Low levels of Sulphur are found in Coastal sandy soils of Kwale and Kilifi counties.

Symptoms Deficiency
- Symptoms appear first on young leaves as opposed to N deficiency which appears first on old leaves.
- In the nursery, seedlings appear yellowish, and stunted growth.
- Young leaves are chlorotic or light green colored with the tips becoming necrotic (dead).
- Yellowing or pale green color of the whole plant.
- Lower older leaves do not show necrosis.
- Reduced plant height and stunted growth (but plants are not as dark-colored as in Phosphorus or Potassium deficiency).
- Reduced number of tillers, fewer and shorter panicles, reduced number of spikelets per panicle.
- Delayed maturity by 1-2 weeks.

Management Strategies
- Test soils and leaf samples for deficiency in Sulphur.
- Apply Sulfur containing fertilizers (ammonium sulfate, single super phosphate) on rice nurseries.
- Apply N and P fertilizers that contain sulphur such as Ammonium sulfate [24% S], single super phosphate) as sources of nutrients.
- Incorporate straw instead of completely removing or burning it.
- Maintain sufficient percolation (~5mm per day), to avoid excessive soil reduction.
- Carry out dry tillage after harvesting, to increase the rate of sulfide oxidation during the follow period.

Fig 1. Yellowing of young leaves
Source: Dobermann and Fairhurst, (2000)
Silicon Deficiency in Rice

Importance
- Silicon deficiency negatively affects the development of a thick silicate epidermal cell layers making the plant weak and susceptible to fungal, bacterial diseases, mites, pests
- The deficiency is more common in upland rice than in paddy rice
- Si deficiency also negatively affects development of strong leaves, stems and roots
- It makes rice vulnerable to stress like drought, storms and salt

Prevalence
- Low levels are found in low silicon weathered soils such as Oxisols and Ultisols
- Deficiency is common in areas with poor soil fertility in upland rice cultivated systems and also in old and degraded paddy soils
- This nutrient is likely in upland rice growing areas of Busia, Kwale and Kilifi counties

Symptoms
- The rice panicle bends over, breaks and dies (a condition known as neck blast)
- Leaves become soft and droopy
- Grain sterility normally observed in deficient plants resulting in empty white spikelets called “white heads”
- Deficient plants often show increased incidences of rice blast (Magnaporthe oryzae) and brown spot (Helminthosporium oryzae) leading to low yields
- Decreased photosynthetic activity and reduced yields
- Plants are susceptible to lodging and exhibit low number of panicles

Management Strategies
- Carry out soil and plant sample testing to confirm Silicon deficiency status
- If deficient, apply silicon at recommended rates (500 kg/ha of Silicon)
- Use recommended rates of nitrogen fertilizer. Do not apply excess of it as it predisposes the crop to insect and disease attack
- Incorporate straw and rice husks into the soil instead of completely removing or burning it
- If available, apply rice hulls and rice hull ash into the soil to replenish Si in the soil
- Incorporate rice straw (5-6% Si) and husks (10% Si) in soil after harvest
- Apply Phosphorus to enhance soil Manganese and Aluminium uptake
- Application of silicon rich materials to enhance yields biomass production and reduce neck blast infection

Iron Deficiency in Rice

Importance
- Iron is essential for biological nitrogen fixation, protein synthesis, increases leaf thickness and chlorophyll production
- Iron deficiency is relatively rare in irrigated rice systems but is prevalent in upland and lowland rainfed rice systems
- It is caused by the application of high doses of phosphorus fertilizer, excessive application of lime, low organic matter content and often seen in soils with high soil pH (>7.5)

Prevalence
- Iron deficiency is prevalent in neutral, calcareous and alkaline upland soils in parts of Kwale, Kilifi and Vanga
- It is also common in alkaline and calcareous lowland soils and in soils with low organic matter status in Kwale, Kilifi, Migori and Homabay

Deficiency Symptoms
- Symptoms are first seen in young leaves
- Plant leaves exhibit interveinal yellowing and chlorosis of emerging leaves. (interveinal yellowing while veins remain green)
- In severe deficiency, the leaves become chlorotic then pale (whitish - yellow)
- The deficiency causes decreased plant size, resulting in low dry matter and yield production
- If not corrected, chlorosis results in the eventual death of the entire plant.

Management Strategies
- Regularly monitor fields and conduct soil test analysis to detect the levels of iron in the soil
- Apply iron as foliar feed once symptoms appear on the young plant leaves (as iron sulphate)
- Apply iron chelate fertilizers such as Fe-EDTA (pH <6.0), Fe-DTPA (pH=7), Fe-EDDHA (pH>7)
- Incorporate farm yard manure and crop residues in soils.
- Apply acidifying fertilizers such as ammonium sulphate or ammonium sulphate nitrate on alkaline soils to reduce pH
- Avoid planting rice in calcareous soils and avoid liming as this will increase soil pH
- Judiciously apply P to prevent Fe-induced malnutrition
### Importance
- Iron toxicity is a syndrome of disorder associated with large concentrations of reduced iron (Fe\(^{2+}\)) in the soil solution.
- Iron toxicity is common in permanently flooded lowland rice production systems.
- It is also induced by deficiency of phosphorus, potassium and zinc in low fertility soils.
- Iron toxicity results in stunted plants, reduced tillering.

### Prevalence
- Iron toxicity is prevalent in soils with high organic matter content especially black cotton soils found in Mwea, Ahero and Bura irrigation schemes.
- It is also common in upland and lowland acid sandy soils in Busia, Siaya, Embu, Teso counties.

### Toxicity Symptoms
Toxicity symptoms are manifested by:
- Bronzing of rice leaves.
- Tiny brown spots appear on lower leaves starting from tip spreading toward the leaf base.
- Leaves turn orange-brown and die.
- Leaves become narrow with leaf tips turning brown-yellow and eventually dry up.
- In severe iron toxicity, leaves appear purple-brown.
- There is stunted growth and reduced tillering.
- Freshly uprooted rice hills often exhibit poor root showing black appearance.

### Crop Loss
- In severe cases, yield losses of 15% to 30% are recorded.

### Management Strategies
- Test soils and plant tissue for iron toxicity.
- Apply additional phosphorus and magnesium fertilizers to soils.
- Incorporate lime in the topsoil to raise pH in strongly acid soils.
- Incorporate 100–200 kg MnO\(_2\) per hectare in the topsoil to decrease free iron in soil (Fe\(^{3+}\) reduction).
Magnesium deficiency in Rice

Importance
- Magnesium (Mg) improves grain quality, protein and starch content of rice
- It is a constituent of chlorophyll, facilitates carbon assimilation and protein synthesis
- Magnesium deficiency is induced by crop removal, reduced soil pH, high rates of ammonium and potassium application
- Magnesium deficiency is relatively rare in irrigated rice systems in the field because adequate amounts are usually supplied through irrigation water

Prevalence
- Is common in rainfed lowland and upland rice where it is depleted by crop removal and low use of magnesium containing fertilizers
- Prevalence in acid soil and low cation exchange capacity (CEC) soils
- Coarse-textured sandy soils in upland and lowland areas such as Busia, Teso, Homabay, Migori, Embu and Siaya counties

Deficiency Symptoms
- Appears on old mature leaves as orange to yellow interveinal chlorosis (yellowing)
- Pale green interveinal chlorosis in young leaves under severe cases
- Green colouring starts to appear as strings of beads in which green and yellow stripes parallel to the leaf
- Leaf edges may show as thin tinge of red purple colouration

Calcereous soils with inherent low magnesium in such areas as Kwale and Kilifi counties

Management Strategies
- Test soils for magnesium deficiency
- Apply Magnesium mineral fertilizers before planting based on the soil test report
- Apply farm yard manure to balance magnesium removed by crop products and straw
- Reduce losses from erosion and surface runoff by appropriate soil and water conservation methods in upland systems
- Apply Magnesium containing fertilizer such as Magnesium sulphate, Dolomite, Magnesium carbonate.
- Magnesium deficiency symptoms can be corrected by foliar application of liquid fertilizers containing Magnesium such as MgCl₂

Importance
- Zinc (Zn) is important for early vigour and grain formation
- Zinc deficiency is associated with Sulphur deficiency
- It is the most widespread micronutrient disorder in rice
- Symptoms vary with soil, variety and growth stage
- Soils high in acidity (pH>7) predispose plants to zinc deficiency

Prevalence
- Zinc is deficient in areas with low zinc parent material and high salt concentration
- In areas where zinc has formed complexes with high organic matter due to large applications of organic manures and crop residues
- In soils with high pH (>7) and with high evapotranspiration rates such as Bura and Hola irrigation schemes and in Kwale county
- Soils with high available P and Si status
- Peat soils and cold wet conditions

Symptoms
- The midrib at the base of the youngest leaf of zinc-deficient rice becomes chlorotic (dies) 2 - 4 weeks after sowing or transplanting
- Brown spots appear as scattered light yellow spots in older leaves, later turn deep brown
- Entire leaf turns rusty and dusty brown and dry within a month
- White lines may appear sometimes along the leaf mid-rib starting from the 2nd or 3rd fully matured leaves
- Stunted with reduced tillering compared to normal plants
- Spikelet sterility and delayed maturity under severe cases

Management Strategies
- Carry out soil test and apply its recommendations
- Grow recommended Zn-efficient varieties.
- Contact your local agriculture office for an up-to-date list of available varieties.
- Use fertilizers that generate acidity in the soil (lower pH (e.g. Ammonium sulfate)
- Apply organic manure before seeding or transplanting or applied to the nursery seedbed a few days before transplanting
- Allow permanently flooded fields, especially where three crops per year are grown, to drain and dry out periodically
- Broadcast ZnSO4 in nursery seedbed
- Dip seedlings or presoak seeds in a 2−4% ZnO suspension such as 20−40 g ZnO L⁻¹
- Apply 0.5-1.5 kg/ha of ZnSO4 as foliar spray in 2-3 repeated applications at intervals of 10-14 days
- Regularly monitor irrigation water quality
## Copper Deficiency in Rice

### Importance
- Copper (Cu) is essential for grain formation, water movement and protein synthesis
- Its deficiency is induced by high soil pH, high zinc in the soil, high lime high nitrogen and phosphorus fertilizer application
- Copper deficiency is relatively rare especially in irrigated rice systems
- Deficiency reduces pollen viability and increase in spikelet sterility, leading to unﬁlled husk (empty spikelets)
- Deficiency symptoms are common on young leaves

### Deficiency Symptoms
- Chlorotic streaks on either side of the midrib
- Dark brown necrotic lesions on leaf tips
- Bluish green and chlorotic streaks near the leaf tip
- Rolling of new leaves
- New leaves do not open and the upper portion of leaves having a needle like appearance, while the lower portion of the leaf is normal
- Plants show reduced tillering
- Reduced pollen viability
- The spikelets exhibit unfilled grain

### Management Strategies
- Copper deficiency is rare in irrigated systems but damage caused by deficiency affects the whole growth cycle
- Test soil and plant tissue for copper deficiency
- Dip seedling roots in 1% CuSO₄ suspensions for 1 hr before transplanting
- Avoid over liming of acid soils as this inhibits Cu uptake
- Broadcast CuO or CuSO₄ (5–10 kg Cu per hectare at 5-year intervals) for long-term maintenance of soil Copper

### Prevalence
- Soils with high organic matter (Vertisols-black cotton soils) such as those in Mwea, Ahero, Bura irrigation schemes
- In upland lateritic highly weathered soils such as those in Busia, Teso, Homabay, Migori counties
- In sandy textured soils in Kwale, Kilifi counties
- In soils derived from marine sediments and in calcareous soils

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**Fig 1** Chlorotic streaks and dark brown lesions on young tips
Source: Dobermann and Fairhurst, (2000)

**Fig 2.** Wilting leaf tips (Yara.com.gh/crop-nutrition/rice)
Manganese deficiency

Importance

• Manganese deficiency interferes with photosynthesis and protein synthesis resulting in stunting of plants.

Prevalence

• This condition is relatively common in upland rice since its solubility increases under submerged conditions.
• It is prevalent in acid upland weathered soils (ultisols and oxisols).
• Alkaline and calcareous soils with low organic matter status and small amounts of Manganese.
• Degraded paddy soils with large amounts of manganese.

Deficiency Symptoms

• Leaves exhibit pale grayish green interveinal chlorosis spreading from the tip to the leaf base.
• Dead brown spots develop later and leaf becomes dark brown.
• Plants are short, stunted, have fewer leaves and small root system at tillering.
• Affected plants are more susceptible to brown spot (Helminthosporium oryzae).

Management Strategies

• Test soils and plant tissue for manganese deficiency.
• Apply farm yard manure or rice straw and incorporate it into soil to balance Manganese removal from the soil.
• Use acid forming fertilizers such as Ammonium Sulphate instead of Urea.
• Spray foliar spray of MnSO₄@1-2%.

Economic loss due to drought

- Drought depending on the crop stage reduces grain and biomass yields
- It can cause even up to 100% yield loss depending on the severity
- Loss of income
- Reduce hydropower supply
- More bush fires
- Low businesses in water fronts due to reduced volumes
- High food prices
- Desertification and overgrazing
- Increased human-wildlife conflicts
- Population migration, anxiety and stress

Predisposing factors

- Reduced rainfall or irrigation
- Sandy soils are more prone to water stress due to high percolation and evapotranspiration
- Shallow rooting due to hardpans
- Low humidity coupled with high & low temperatures and strong sunlight
- Salinity
- Air circulation move water from place to place
- Weather pattern such El Nino & La Nina
- Human activities like deforestation
- Global warming

Management Strategies

- Irrigation through either sprinkler, drips or farrow
- Rain water harvesting & recycling
- Avoiding over cropping
- Priming of seed
- Use of tolerant rice varieties such a deeper variety, 1-DRO1
- Mulching
- Use of green manure such tithonia
- Building of water reservoirs
- Re-afforestation
- Soil moisture conservation techniques
- Control of migrations
- Water rationing
- Reduce water pollution

Symptoms

- Cracking of soil especially black cotton soils indicate water stress disrupting root growth
- Plant wilting, the leaves look flaccid and in severe cases roll up like onion leaves
- Spikelet’s sterility and low 1000 grain weight
- Leaf turning from green to pale green and finally scorching in case of severe stress
- Reduced leaf size & stunted growth due to reduced internode growth
- Lodging due to loss of turgidity
- Plants tend to mature early to complete life cycle
- Reduced spikelet’s per panicle and panicle size

Importance

- Drought is a period of low moisture last from as low as 15 days to years causing extreme dryness
- Drought is a major global challenge
- Rice requires more water than any other crop
- Drought could appear at seedling, vegetative, reproductive and terminal drought based on plant phenological stage causing varying levels of damage
- Drought is severe under upland, followed by lowland and sometimes irrigated fields.
- With climate change areas that had reliable rains are now faced with erratic rainfall patterns
- Moisture stress causes changes in the physiological, morphological, biochemical, and molecular traits in plants

Signs of damage

- Black cotton soils
- Yellowing of leaf indicates severe water stress
- Wilting on seedlings
- Spikelet and panicle death
- Reduced shoot and root growth
- Overall plant death

Rice seedling

- Crude lying in the soil
- Leaves curling
- Stunted growth

Rice in severe drought

- Lodging
- Reduced leaf size
- Lower 1000 grain weight

Roots of rice crop

- Infested
- Drought (water) stress effect in rice

Fig 1. A. Seedling drought
(http://www.knowledgebank.irri.org/ricebreedingcourse/Breeding_for_salt_tolerance.htm)

Fig 2. Severe drought effect

Fig 3. Dried panicles and leaves

Fig 4. Rice Desiccation in Taita Taveta

Fig 5. C. Drought stress and cracked soil (Wasilwa LA-KALRO)

Fig 6. Lodged rice plant

Fig 7. Useful sites & references:
A,B,C (www.knowledgebank.irri.org/rice.htm)
www.lsuagcenter.com
(http://www.kalro.org/ricknowledgelink/countryhome.aspx)

Fig 8. Useful sites & references:
A,B,C (www.knowledgebank.irri.org/rice.htm)
www.lsuagcenter.com
(http://www.kalro.org/ricknowledgelink/countryhome.aspx)
Cold damage in rice

Importance
- Cold damage in rice is a widespread phenomenon affecting over 25 countries globally.
- It occurs during germination, seedling, vegetative, reproductive and grain maturity stage when temperatures drop to below 17°C.
- It affects seedling vigour and pollination resulting in week crop and empty spikelets thus reducing grain formation.
- This phenomenon affects irrigated and upland rice and is severe in high land regions of East Africa (EA) such as Central Kenya.
- Cases of zero grain formation per plant have been observed in farmers fields, un aware farmers spray thinking it is a disease.

Predisposing factors
- Panicle initiation coinciding with cold season.
- Application of cold irrigation water.
- Flowering during cold season.
- When the sky is clear at night resulting in temperature inversion of below 17°C.

Symptoms
- The filled spikelets normally turn from green to brown as they mature.
- Pollen abortion during pollen formation (microsporogenesis) at booting stage.
- There is generally delayed maturity.
- Reduced chlorophyll content.
- Leaf blade has a white line where soil was during cold period due to cold injury.

Management Strategies
- Crop calendar: Planting should be planned in a way that the cold season does not coincide with PI, flowering or early reproductive phase in EA.
- In Central Kenya, between 15th February to Mid May, it is not advisable to plant during this period.
- Planting cold tolerant varieties: Generally Japonica varieties are cold tolerant compared to the popular Indica varieties.
- Use of Nitrogen fertilizer: This has been shown to reduce cold damage.

Damage on rice crop
- In normal cases (no cold damage), the panicle bends from upright to inverted U due to weight of filled spikelets.
- Causes abnormalities at anthesis & non-functional anthesis.
- There is chlorosis, necrosis and growth retardation.
- Panicle sterility. Sterility is determined by comparing/estimating the proportion of empty spikelets to filled grain. e.g. if 70 spikelets are unfilled out of 100, it means 70% yield loss (red).
Salinity stress damage in rice

Causes of salinity
- Rock weathering is primary source of salts
- Water table fluctuation can lead to salinity
- Use of saline irrigating water
- Low rainfall to leach salts accumulated due to high evaporation rate
- Inundation/ waves of sea water into inland
- The problem is severe in Hola – Bura region, Tana River, but there are isolated area in Kilifi (Malindi) county
  - With climate change and rise in sea water level, flooding of agricultural land by salty water is expected to bring more area under salinity.
  - Semi-arid areas where heavy irrigation and evaporation occur

Symptoms
- Morphological symptoms include: plant death, low tillering, reduced spikelets per panicle, leaf scorching, spikelet sterility and low 1000 grain weight
- The plants may be affected uniformly under sodicity and salinity but not in all cases
- White leaf tip resulting in tip burning like is the major sign of salinity stress
- Stunted growth
- Transplanting old seedlings help avoid seedling stage damage but not at flowering stage
- Plants tends to mature early to complete life cycle

Economic loss
- Loss of Chlorophyll and photosynthetic area leads to reduced grain and biomass yields (A, B)
- Sterility can result into up to 100% grain loss and panicle death (B, C, & D)
- Incase of seedling damage this can result into complete crop loss or partial loss depending on salinity distribution.

Predisposing factors
- Saline soils dominated by sodium cations with electrical conductivity (EC) more than 4 dSm⁻¹, but the dominant anions are usually soluble chloride and sulphate
- Exchangeable Sodium Percentage (ESP < 15) and pH values of these soils are much lower than in sodic soils

Management Strategies
Use of tolerant varieties such as:
- Changing the growing saline environment to make it normal and suitable for the normal growth of crops
- Combined use of tolerant varieties and changing the saline production environment (this involves less resource use)
- Early seedling vigour is key to lowering stress effect at this sensitive stage

Useful sites & references


(b) [http://www.knowlwdgebank.irri.org](http://www.knowlwdgebank.irri.org)


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Useful sites & references: [http://www.knowlwdgebank.irri.org](http://www.knowlwdgebank.irri.org)

[http://www.knowlwdgebank.irri.org](http://www.knowlwdgebank.irri.org)
[https://ariesagro.com/paddy/](https://ariesagro.com/paddy/)

Knowledge Bank

(b) [http://www.knowlwdgebank.irri.org](http://www.knowlwdgebank.irri.org)


Useful sites & references: [http://www.knowledgebank.irri.org/training/fact-sheets/pest](http://www.knowledgebank.irri.org/training/fact-sheets/pest)