INTERNATIONAL JOURNAL OF PLANT PROTECTION
VOLUME 9 | ISSUE 1 | APRIL, 2016 | 337-342

● e ISSN-0976-6855 | Visit us : *www.researchjournal.co.in*

IJPP

A CASE STUDY

DOI : 10.15740/HAS/IJPP/9.1/337-342

# Key biotic and abiotic stresses and rice germplasm tolerance

■ S.P. GIRI*, BRAJENDRA[1], K.V. RAO[1], ALOK PANDEY AND HIMANSHU PATEL[2]

Crop Research Station (N.D. University of Agriculture and Technology), MASODHA (U.P.) INDIA
[1]Indian Institute of Rice Research, Rajendranagar, HYDERABAD (TELANGANA) INDIA
[2]Indira Gandhi Krishi Vishwavidyala, RAIPUR (C.G.) INDIA

ARITCLE INFO

**Received** : 02.02.2016
**Accepted** : 25.03.2016

KEY WORDS :
Key biotic, Abiotic steess, Rice germplasm

***Corresponding author:**

**How to view point the article :** Giri, S.P., Brajendra, Rao, K.V., Pandey, Alok and Patel, Himanshu (2016). Key biotic and abiotic stresses and rice germplasm tolerance. *Internat. J. Plant Protec.*, **9**(1) : 337-342.

## INTRODUCTION

The productivity of rice and per capita availability in India is quite low. The yield level of a crop reflects many facets of crop growth including environmental factors such as rainfall, temperature, sunlight and humidity and cultural factors such as planting date, row spacing, cultivar selection and tillage method. As a result, the interpretation of a relationship is difficult; however response is likely at low yields at high soil test values. The manuscript attempts to highlight the key soil stresses in rice production of India and comes out with names of some of the promising cultivars/germplasms established all along for addressing such issues.

**Soil degradation and related production constraints:**

Physical degradation like soil erosion, soil crusting and compaction, chemical degradation like loss of organic matter, soil fertility, multi nutrient depletion and deficiencies, salt accumulation, pollution, etc., are some of the major soil and management-related problems reported which account for nearly 60 per cent (188 M.ha) of the total land area. Soil acidification is a natural soil-forming process accelerated by high rainfall, low evaporation, leaching of bases, and high oxidative biological activity that produces acid. The soil acidity plays major role in determining the nutrient availability to plants and in many instances by specific mineral stress problems. Production constraints are more intense on acid soils, which cover 30 per cent of the world's land area. Acid soil infertility is a syndrome of problems that affect plant growth in soils with low pH. This complex of problems arises from toxicities and deficiencies in acid soils are related to:

– Presence of the toxic concentration of Al and to a lesser extent Mn toxicity in many species,

– Deficiency of bases (Ca, Mg, K) and their poor retention power,

– High P fixation capacity of soil caused by highly active Al and Fe surfaces, rendering it unavailable to

**Table 1 : Soil resources of India and their major constraints**

| Soil group | Soil order | Land area (M.ha) | Soil related constraints |
|---|---|---|---|
| Red and lateritic soils | Inceptisols, Alfisols Ultisols | 172.2 | Erosion by water, weak soil structure, nutrient imbalances, low OM, crusting, compaction, acidification, P fixation, loss of bases (Ca, K, Mg), nutrient (Fe, Al, Mn, $H_2S$) toxicities |
| Black soils | Vertisols, Inceptisols | 73.5 | Massive structure, poor tilth, drought stress, water erosion, nutrient deficiencies, salt accumulation, |
| Tarai Soils | Mollisols | 8.0 | Micronutrient deficiency, |
| Alluvial soils | Entisols, Inceptsols | 58.4 | Erosion, nutrient depletion, low OM, secondary salinization |
| Desert soils | Aridisols, Entisols | 30.0 | Drought stress, nutrient depletion, wind erosion, desertification, secondary salinization |

**Table 2 : Estimated area (M ha) affected with soil physical constraints**

| Constraint | Area | Distribution |
|---|---|---|
| Crusting | 10.25 | Haryana, Punjab, West Bengal, Orissa, Gujarat |
| Hardening | 21.57 | Andhra Pradesh, Maharashtra, Bihar |
| Sub-surface hardpan | 11.34 | Maharashtra, Punjab, Bihar, Rajasthan, West Bengal, TN |
| Shallow depth | 26.4 | Andhra Pradesh, Maharashtra, West Bengal, Kerala & Gujarat |
| High permeability | 13.75 | Rajasthan, West Bengal, Gujarat, Punjab& Tamil Nadu |
| Water logging | 6.24 | MP, Maharashtra, Punjab, Gujarat, Kerala, Orissa |

plants,

– Deficiency of Mo, especially for the growth of legumes,

– Reduction of soil biological activities,

– Impairment of $N_2$-fixation by legumes caused by poor survival of microsymbiont and inhibition of nodulation, and

– Fe and Mn toxicities in submerged rice.

Soil acidity is the primary factor limiting crop productivity on acid soils, which comprise large areas of the world land, particularly in the tropics and subtropics

– About 149 M.ha is affected due to water erosion, 13.5 M.ha by wind erosion, 14.0 M.ha by chemical degradation and about 12 M.ha by physical degradation (Yadav, 2007).

– Loss of fertile top soil by water erosion is about 5000 M.tons per year of which about 29 per cent is lost into sea, 10 per cent deposited in reservoirs, 59 per cent is deposited as alluvium.

– About 3.5 per cent of the total land area is affected by water logging and 18.2 M.ha are wastelands not suitable for agricultural production

– Chemical degradation of the soil due to human intervention is around 13.6 M. ha of which salinization accounts for 10.1 M.ha, and nutrient and organic carbon loss in 3.7 m.ha.

– Salinity and alkalinity are soil problems associated with low rainfall and high evaporative demand, improper drainage and excessive flooding causing significant loss to crop and soil productivity

– More than 90 per cent of NEH region is acidic of varying degrees which restrict the crop choice. Fertilizer use in the region and its efficiency are poor.

– Poor structural stability of the fine textured clay soils (Vertisols) renders agricultural practices very difficult.

– Unscientific crop intensification with imbalanced use of fertilizers has led to much management related nutrient problems like decline in productivity and sustainability,

– Extensive use of ground water through tube wells has resulted in significant lowering of water table which could result in serious productivity declines during low rainfall years.

## Loss of soil organic carbon (SOC):

In India SOC content is most of the soils range from 0.2 to 0.5 per cent (2-5 g/kg soil) which works out to 21 and 156 billion tons up to 30 and 150 cm soil depth, respectively while total soil inorganic C pool (SIC) is about 196 billion tons. Loss of SOC is alarming due increasing atmospheric temperature and changing rainfall pattern. Extensive mining of soil fertility, removal or burning of crop residues, soil degradation, inappropriate soil tillage and poor crop management, besides accelerated soil erosion (34 – 50 Tg C/yr) are the major reasons for loss of SOC and decline in crop productivity. Technological options for soil C sequestrations in India include INM, green manuring, mulch farming, conservation tillage, residue recycling, and choice of cropping systems, balanced nutrient use with high nutrient use efficiency etc.

Available information on loss of productivity due to soil degradation indicates that it is higher in red soils compared black and alluvial soils. This warrants a knowledge based alleviation of soil problems, and management of soils and inputs keeping in view the resource quality, cropping system, and nutrient flows in the system for the overall sustainability.

**Soil and management related constraints in rice production in India can be delineated in following points:**

– Increasing area under soil salinization (8-10 M ha) (salt affected) - major portion is cropped to rice,

– About 15 M.ha of rice soils are acidic associated with toxicity of Fe, Al, Mn, As, deficiency of K, Ca, Mg, B, Si, and P fixation,

– About 8.0 M.ha of rice area is deficient in zinc (Zn)

– Nearly 50 and 80 per cent of Indian soils are responsive (low to medium) to potassium and phosphorus, respectively,

– Blanket fertilizer management/recommendation over large domains,

– Nutrient depletion (N, K, S) and loss of soil organic matter in intensive cropping systems,

– About 3.0 M ha in northwestern states under rice-wheat cropping system affected by Mn deficiency

– Nutrient problems of deficiency of N, P, K, Zn, Fe, S, Ca, B, and toxicity of Fe, Al, $H_2S$, As, Se and

– Overall stagnation or deceleration of growth in productivity of crops and cropping systems

– Wet season rice followed by dry season fallow causes considerable buildup of nitrate in soil profiles. This $NO_3$ gets lost from the soil when fields are reflodded and puddled for planting rice in the following wet season

Data indicate that iron (Fe) content of ground water in all the districts is high due to high content of Fe-bearing minerals in soils, and such ground water is not suitable for irrigation unless properly managed Continuous use of such irrigation water causes Fe- toxicity and other nutrient imbalances in crop plants. It also greatly reduces P-availability in the soil. Precipitation of iron in surface and subsurface layers may clog the pores of the soils. As a result, drainage is impeded and crop plants suffer from inadequate $O_2$ supply in the root zone.

While the diversity in agro ecological environment in the country provide opportunities for growing numerous commercially viable cropping and farming systems towards a robust agriculture, efficient and sustainable management of natural resources especially

**Table 3 : Expected loss of productivity due to soil acidity**

| Soil pH | Degree of acidity | Loss in productivity (%) |
|---|---|---|
| >6.5 | Nil | Nil |
| 5.5-6.5 | Slight | Upto 10 |
| 4.5-5.5 | Moderate | 10-25 |
| 3.5-4.5 | Strong | 25-50 |
| <3.5 | Extreme | >50 |

**Table 4 : Distribution of problem soils in India cropped to rice**

| Soils | Area(M.ha) | States |
|---|---|---|
| Sodic | 2.5-3.0 | Uttar Pradesh, Punjab, Haryana, Andhra Pradesh, Bihar, Maharashtra, Karnataka, Tamil Nadu |
| Inland Saline | 2.4 | Uttar Pradesh, Haryana, Punjab, Rajasthan, |
| Potential | (15.0) | Maharashtra, Gujarat, Karnataka, Andhra Pradesh, |
| Coastal saline | 2.5-3.0 | West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Maharashtra |
| Acid soils | 49.0 | North East Hills, West Bengal, Orissa, North Coastal Andhra Pradesh, Kerala, Karnataka, Goa, Bihar |
| | (15.0) | |
| Acid saline | 0.5-1.0 | Kerala, West Bengal |
| Nutrient problems | Deficiency | N,P,Zn,Fe,S,K,Ca,Mn |
| | Toxicity | Fe,$H_2S$,Al, As,Se |

soil and water for enhanced soil productivity is vital for over all economy of the country. Although soil productivity depends largely on a number of its diverse physico - chemical and biological characteristics, the ultimate output is governed by the precise agronomic operations, matching production systems with land capability, efficient management of external inputs like seed, water, nutrient etc. and maintaining a synergy between conservation and exploitation of resources such as soil and water.

**Nutrient mining status :**

The soil fertility status of Indian soils has declined drastically over the years following the era of green revolution and is marked by a negative balance of 8-10 M. tons between nutrients removed by the crops and those added through manures and fertilizers leading to mining of soil nutrient capital and steady reduction in soil nutrient supplying capacity. The situation is further aggravated by the depletion of major soil nutrients like N and K in intensive cropping systems and emergence of wide spread deficiencies of secondary (S, Ca) and micronutrients (Zn, Fe, Mn, Cu and B). Soil test data available for major part of the country for the major nutrients (N, P, K) show that 89 and 80 per cent of the soils are low to medium in N and P, and about 50 per cent of the soils are responsive to K supply. District wise soil fertility status of Indian soils also indicates a similar trend.

**Micronutrient status of Indian soils :**

Systematic survey and analysis of more than 2.50 lakh soil samples in 20 states by All India Co-ordinated Research Project indicated deficiency of zinc to the extent of 49 per cent, 33 per cent of B, 13, 7 and 4 per cent of samples rating low in Fe, Mo, and Mn. These, in general, point to the micronutrient problems, the extent and severity could, however, vary across soil types, agro ecological zones and more importantly management and productivity of crops and cropping systems. Coarse texture, calcareous, low organic carbon content, high pH and excessive leaching often accentuate zinc deficiency. It is wide spread in the calcareous soils of Bihar, Vertisols and Inceptisols of Andhra Pradesh, Tamil Nadu, Alfisols of Karnataka, swell-shrink soils of Maharashtra and Madhya Pradesh, and Aridisols of Haryana resulting in low crop yields. Zinc is a crucial component of the package of practices recommended for sodic soils reclamation. Deficiencies of Fe, Mn and Cu are much less extensive than that to zinc. The deficiency of Mo is common in acid soils of humid region. Deficiency of Cl and Ni has not been reported so far in the Indian soils. Although deficiency of these micronutrients is not an acute nutrient disorder today, production of nearly 300-350 Mt of food grains by 2025 definitely constrain the finite reserves in the soils (Rattan *et al.*, 2008).

Distribution of micronutrients deficiencies across AEZ indicate zinc deficiency to be about 40 per cent in 1, 2, 5, 15, 16, 18 and 19 zones; 40-50 per cent in 9,11and 12 zones; 50-55 per cent in 4, 7, and 13, and 55 per cent in the remaining zones. Soils of indo-gangetic plains showed 55, 47 and 36 per cent zinc deficiency in trans-northern, central and eastern parts of IGP, while boron deficiency is 8, 37 and 68 per cent in these regions of IGP. Boron deficiency varies from 2 per cent in AER 2; 24-48 per cent in highly calcareous soils of AEZ 2, 9, and 14 and is most wide spread (39-68 %) in red and lateritic soils of AEZ 6, 13, 16, 17 and 19. Deficiencies of Cu and Mn were found sporadic. The problem of Fe and Mn deficiency has emerged in Trans-northern IGP (zone 9) more so under rice-wheat cropping while most of the soils tested adequate in available iron. Its deficiency in all AEZs as well as toxicity in some coastal, submontane and red-lateritic soils is quite common (Table 5).

**Effect of major nutrients on different rice diseases ( Source Credit: Dr. G.S. Laha, DRR) :**

The sum of many interacting factors of the pathogen, host, environment and their coincidence determine the effect of a particular nutrient on the disease. Both inorganic and organic forms of the nutrients can affect the disease severity, although the organic forms may have more complex interaction on the outcome of the disease. A specific nutrient may increase the intensity of some diseases and reduce the intensity of some others.

**Nitrogen:**

In general, higher dose of N (total N) results in increased intensity of most of the rice diseases except RTV and rice scald (Table 1). The time of application of N also influence the disease severity e.g. excess N as late top dressing increased the severity of bacterial blight.

**Phosphorus:**

Phosphorus application has been found to reduce the blast severity especially when the nutrient is limiting. A moderate level of P application has been found to reduce severity of bacterial blight though some workers reported that P application did not have any effect on bacterial blight of rice. Sub-optimal dose of P can affect the incidence of brown spot of rice in irrigated condition.

**Potassium:**

Several workers have reported that increased uptake of K reduced the severity of bacterial bight and

**Table 5 : Extent of micronutrient deficiencies in different agro-ecological zones (AEZ) of India**

| Sr. No. | Agroecological zones | Soil type | Per cent deficiency | | | |
|---|---|---|---|---|---|---|
| | | | Zn | Cu | Mn | Fe |
| 1. | West.Himalayas | Hill | 21.0 | - | - | - |
| 2. | West.plains and Kutch Peninsula | Desert and Saline | 36.0 | 3.6 | 8.3 | 16.6 |
| 3. | Deccan Plateau | Red and black | 57.5 | 0.1 | 0.6 | 4.8 |
| 4. | North.Plain and Central Highlands | Alluvial derived | 54.6 | 2.4 | 4.3 | 9.6 |
| 5. | Central highlands and Kathiawar Peninsula | Med. and deep black | 64.2 | 0.7 | 1.9 | 3.0 |
| 6. | Deccan Plateau | Sh. and med. black | 64.6 | 0.5 | 1.9 | 11.8 |
| 7. | Deccan Plateau and Eastern Ghats | Red and med. black | 51.6 | 0.1 | 2.6 | 4.0 |
| 8. | TN uplands and Deccan Plateau | Red loam | 57.0 | 17.6 | 8.4 | 19.9 |
| 9. | Northern Plain | Alluvium desired | 44.2 | 2.4 | 5.4 | 9.4 |
| 10. | Central highlands and Deccan Plateau | Med. black clay | 76.5 | 0.3 | 0.7 | 6.1 |
| | | Red soil | 58.0 | 1.0 | 0.6 | 2.5 |
| 11. | Eastern Plateau (Chhatisgargh) | Red and yellow | 44.5 | 0.7 | 0.1 | 0.9 |
| 12. | Chhota Nagpur and Eastern Ghats | Red loam | 49.1 | 0.9 | 1.8 | 0.5 |
| 13. | Eastern Plain | Alluvium derived | 54.7 | 1.6 | 17.6 | 19.6 |
| 14. | Western Himalayas | Brown hill and forest | 45.0 | 18.0 | 17.6 | 16.4 |
| 15. | Assam and Bengal plains | Alluvium derived | 34.0 | 0.5 | 0.2 | 0.3 |
| 16. | Eastern Himalayas | Brown red and hill | 20.0 | 0.4 | 1.0 | 0.6 |
| 17. | Nort .h-Eastern hills (Purvanchal) | Alluvial derived | 57.0 | 2.1 | 2.3 | 0.2 |
| 18. | Eastern Coastal Plains | Alluvium derived | 15.0 | 4.2 | 3.6 | 4.0 |
| 19. | Western Ghats and Coastal Plains | Red, Lat. and Alluv. | 36.0 | 24.0 | 1.0 | 0.8 |
| 20. | A and D and Lakshadweep | Red loamy | 20 | - | - | - |
| All | All | All | 45.4 | 3.3 | 4.5 | 8.3 |

**Table 6 : Effect of different nutrients on different rice diseases**

| Disease | Effect (I= Increase; D= Decrease) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total N | $NH_4$-N | $NO_3$-N | P | K | Ca | Mg | Mn | Fe | Cu | Ni | Si |
| Bl | I | D | I | | D | | | D | | D | D | D |
| NBl | | | | | | | I | | | | | D |
| BS | | D | I | D | D | D | D | D | D/I | | D | D |
| Shbl | I | | | | D | | | | | | | D |
| StR | D/I | | | D/I | D | | | | | | | D |
| ShR | I | | | | D | D | | | | D | | |
| Bak | I | | | | | | | | | | | |
| LS | I/D | | | | | | | | | | | D |
| FS | I | | | | | | | | | | | |
| NBLS | | | | | D | | | | | | | |
| GD | | | | | | | D | | | | | D |
| BB | I | | | D | D | | | D | | D | | D |
| BLS | I | | | | | | | | | | | |
| RTV | D | | | | | | | | | | | |

sheath rot of rice. Application of K early in the crop season enhanced the control of stem rot of rice. A low N ; K ration (0:30) resulted in higher incidence of brown spot while a ligher N; K ratio (45:30) substantially reduced the disease. A combination of silica and K significantly reduced the leaf blast severity.

**Calcium:**

Calcium reduces the diseases caused by *Rhizoctonia* and *Pythium*. In rice, intensity of brown spot severity was reduced when a solution containing 30 ppm calcium was used. Calcium application was also found to reduce the intensity of sheath rot disease of rice.

**Magnesium:**

In rice, Magnesium application has been found to reduce grain discoloration in ultisols while it increased the intensity of panicle blast.

**Effect of micro-nutrients on different rice diseases:**

Increased uptake of manganese under flooded condition reduces blast severity. Foliar application of manganese has been found to reduce brown spot of rice. Mn application has also been found to reduce bacterial blight of rice. Nutrient solution of iron concentrations of 2.5 ppm reduced brown spot severity while an increase in concentration from 2.5 to 10 ppm promoted the disease. Copper has been found to reduce the intensity of bacterial blight, sheath rot and rice blast. Application of small quantity of less concentrated nickel salts has been reported to reduce the brown spot of rice and rice seedling blast. Application of Si can significantly reduce the intensity of blast, brown spot, leaf scald, sheath blight and stem rot as shown in Table 6.

Bl- Blast (*Magnaporthe grisea*); NBl- Neck Blast (*Magnaporthe grisea*); BS- Brown Spot (*Drechslera oryzae; Cochliobolus miyabeanus*); Shbl-Sheath blight (*Rhizoctonia solani*); StR-Stem Rot (*Sclerotium oryzae*; *Magnaprthe salvanii*); ShR-Sheath Rot (*Sarocladium oryzae*); Bak- Bakanae (*Gibberella fujikuroi*); LS-Leaf Scald (*Microdochium oryzae*); FS-False smut (*Ustilaginoidea virens*), NBLS-Narrow brown leaf spot (*Cercospora janseana*); GD- Grain discolouration (Many fungal species); BB- Bacterial blight (*Xanthomonas oryzae* pv. *oryzae*); BLS-Bacterial leaf streak (*Xanthomonas oryzae* pv. *oryzicola*); RTV-Rice Tungro virus

**Management of soil stresses with germplasms tolerances :**

*Saline and sodic soils :*

– Grow saline tolerant high yielding varieties such as CSR 10, CSR 13, CSR 27, CSR 30, Sarjoo 52, Vikas,

– In coastal saline soils, growing of tolerant rice varieties like Panvel 1, 2 and 3, CSR 6, 10,13, 23, Rasmi, IET 11353, Lunisree, Vytilla 2, 3, Sumathi improve crop productivity.

**Management of sodic soils :**

– Tolerant rice varieties such as CSR 13, CSR 23, Vikas, CSR 27, CSR 30, Kalanamak, etc. enhance rice productivity in such soils.

**Acid sulfate soils :**

– Planting Al-tolerant cultivars such as IR43, CO 37, and Basmati 370 which have the capacity to complex soluble Al by root exhudates and accumulate selectively P, Mg and Ca

– Tolerant rice varieties such as IR-64,MTU1010,IET20556,IET20997

## REFERENCES

**Fert, B. (2000).** Soils of India and Their Management. News, **48** (5) : 23-24, 27-34, 37-41.

**Kanwar, J.S. and Katyal , J.C. (1997).** Plant nutrients needs, supply, efficiency and policy issues. 2000-2025, NAAS, New Delhi, pp329.

**Katyal, J.C. (2001).** Fertilizer use situation in India. *J. Indian Society Soil Sci*., **49** : 570-592.

**Prasad, R.N. and Biswas, P.P. (2000).** In Singh, G.B. and Sharma, B.R. (eds). 50 years of natural resource management research, ICAR. New Delhi, pp 644.

**Smaling, E.M.A. (1993).** In the role of plant nutrients for sustainable food production in Sub-Saharan Africa, H. Van Reulen and W.H.Prins (Eds.) Leidschendan, The Netherlands: VKP.

**Sharma, U.C.,Datta, M. and Samra, J.S. (2006).** Soils and their management in North east India.

**Tandon, H.L.S. (2004).** Fertilizers in Indian Agriculture – from 20th to 21st century. FDCO, New Delhi, India. pp. 240.