INTERNATIONAL JOURNAL OF PLANT PROTECTION
VOLUME 9 | ISSUE 1 | APRIL, 2016 | 306-309

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

IJPP

A CASE STUDY

DOI : 10.15740/HAS/IJPP/9.1/306-309

Mineral nutrition for the management of rice diseases

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ARITCLE INFO

Received : 02.02.2016
Accepted : 22.03.2016

KEY WORDS :
Mineral nutrition, Rice diseases, Yield

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ABSTRACT

Mineral elements are applied to improve the plant health and yield. Host nutrition plays a crucial role in the outcome of the interaction between plants and pathogens. Though resistance and susceptibility are controlled genetically, a minor change in the nutritional status of the plants can have a considerable effect on severity of the disease. Mineral nutrition plays a very important role in the prevention of plant disease. Balanced plant nutrition promotes plant vigour providing tolerance to pathogen infection, improve physiological resistance to pathogen and affect the pathogen growth and multiplication. Although disease cannot be totally eliminated by any particular nutrient, the severity of the disease can be greatly reduced by manipulating the mineral nutrition of the plants. The present paper reviews thematically the role of nutrients in such management of diseases. Growers must use proper fertilizer programs, based on soil tests, plant analysis and disease monitoring.

How to view point the article : Laha, G.S., Prasad, V., Muthuraman, P., Prasad, M. Srinivas, Brajendra, Yugander, A. and Babu, V. Ravindra (2016). Mineral nutrition for the management of rice diseases. *Internat. J. Plant Protec.*, **9**(1) : 306-309.

At least 16 elements are considered essential for the growth and functioning of plants. The elements like carbon, oxygen, hydrogen, nitrogen, potassium, phosphorus, calcium, magnesium and sulphur are required in fairly large quantity and are called macronutrients. On the other hand, the nutrients like chlorine, boron, iron, manganese, zinc, copper and molybdenum are categorized as micronutrients as they are required in notably smaller quantity. In addition to these 16 essential elements, there are some elements which have not been proven to be essential for plant growth, but offer some beneficial effects to plants e.g. silicon and sodium. These elements are categorized as 'beneficial elements'. Few plants under certain conditions require few other elements like cobalt, nickel, selenium and vanadium. However, these elements also have been put in the category of 'beneficial elements'. Several research results have reported that high dose of nitrogen increases susceptibility of plants to different diseases while K tends to reduce the intensity of the disease. Thus host nutrition can be an important component of plant disease management (Datnoff *et al*., 2007).

Effect of major nutrients on different rice diseases:

Majority of mineral nutrients which are necessary for plant growth have been found to influence the severity of different diseases of various crop plants (Palti, 1981). However, it is not possible to generalize the effect of any particular nutrient for all host pathogen combination. The sum of many interacting factors of the pathogen, host, environment and their coincidence determine the effect of a particular nutrient on the disease. Contradictory reports may occur due to use of different forms of nutrients or due to different environmental, plant or soil associated factors that affect the absorption/ uptake of the nutrients. 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:

Nitrogen is the fourth most abundant element in plants and most important for the growth and development of the plants. The biological mineralization of organic N to inorganic ammonium (NH_4) and its subsequent oxidation (nitrification) to nitrate (NO_3) makes N available in different forms for uptake by the plants. Plant roots can uptake N either as cation (ammonium, NH_4^+) or as anion (nitrate, NO_3^-). However, these two forms can have opposite effects on disease severity. 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 form of N can affect the soil pH and availability of other elements like manganese which in turn can affect the severity of a particular rice disease. The level of N can affect the phenolics content of plants which are precursors of lignin which give plants tolerance to diseases. In addition, at higher level of N, Si uptake is reduced which can affect disease tolerance. Ammonium form of N has been found to reduce blast severity while nitrate form increased it though contradictory results have been reported. 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 (Huber and Thompson, 2007).

Phosphorus:

Plants absorb phosphorus either as $H_2PO_4^-$ or HPO_4^{2-} depending on the soil pH. Uptake of $H_2PO_4^-$ predominates in soils with pH less than 7.2 while uptake of HPO_4^{2-} predominates where soil pH is more than 7.2. The amount of plant available P in soil is generally low as it makes insoluble complexes with cations like aluminium, iron and manganese in acid soils and with calcium in alkaline soil. Phosphate ions are strongly adsorbed by silicates in soils of near neutral pH. Thus soil may have considerable amount of P but not present in forms available to plants. 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 (Prabhu *et al.*, 2007 a and b).

Potassium:

Most of the soils contain large amount of potassium except sandy soils which generally contain less of K. However, most of the K in these soils are present in relatively insoluble form. Consequently, K deficiency can be recorded in plants growing in soils rich in K. Potassium is uptaken by plants as cations (K^+). Several workers have reported that increased uptake of K reduced the severity of bacterial bight and 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:

Although calcium (Ca) is usually applied as limestone to raise the soil pH or to neutralize the soil acidity, it can have a tremendous effect on intensity of some plant diseases. Calcium imparts stability of plant membranes. When there is Ca deficiency, the membrane becomes porous and there is leakage of low molecular weight compounds like sugars and amino acids which in turn stimulate the growth of plant pathogens. Ca is also an important component of cell wall and forms calcium polygalacturonates which gives stability of middle lamella and makes it resistant to enzymatic degradation and thus provides resistance against pathogen attack. 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:

Magnesium is taken up by plants as divalent cation Mg^{2+}. Structurally, Mg is a component of middle lamella and constituent of chlorophyll. Relatively, few reports are available on the role of magnesium on plant disease. In rice, Magnesium application has been found to reduce grain discoloration in ultisols while it increased the intensity of panicle blast (Walters and Bingham, 2007).

Effect of micro-nutrients on different rice diseases:

Among micronutirents, manganese is uptaken as Mn^{2+}. However, its availability is highly influenced by soil pH. At soil pH higher than 7, Mn^{2+} is oxidized to Mn^{4+} which is less available to plants. Manganese acts as cofactor of many enzymes. 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.

Plants uptake iron as Fe^{2+} although chelated Fe^{3+} are also present in most of the soils. The effect of iron on severity of brown spot has been ambiguous. 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 influences the intensity of many diseases. The biocidal effect of copper has made it a common component of many pesticides. However, copper plays an important role in plant's physiological process which affects the intensity of 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 bee reported to reduce the brown spot of rice and rice seedling blast.

Silicon (Si) is absorbed by the plants as monosilicic acid (also called orthosilicic acid) by diffusion and by the influence of transpiration-induced root absorption, known as mass flow. It is deposited as solid amorphous silica (SiO_2. nH_2O) in the cell wall matrix, cell lumen and extracellular spaces of shoot, leaf culm and root tissues. The mechanism of the Si-induced resistance in rice has been attributed to the formation of a silicated epidermal cell layer. This layer is believed to prevent physical penetration and makes the plant cell walls less susceptible to enzymatic degradation by fungal pathogens. In commercial rice production, Si is usually

Table 1 : 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											

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

broadcast applied to the soil as calcium silicate slag. Large number of reports indicated that application of Si application can significantly reduce the intensity of blast, brown spot, leaf scald, sheath blight and stem rot. There are some reports which indicate that Si application can also reduce the intensity of bacterial blight of rice and rice root knot nematode infection.

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