Rice *(Oryza sativa L.)*

French: Riz; Spanish: Arroz, Italian: Riso; German: Reis

On a global basis, rice ranks second only to wheat in terms of area harvested, but in terms of its importance as a food crop, rice provides more calories per ha than any other cereal food grain.

Crop data

Annual grass with round culms, flat leaves and terminal panicles. Varieties of growth duration ranging from 70 to 160 days exist in diverse environments. The grain is a caryopsis in which the single seed is fused with the wall which is the pericarp of the ripened ovary forming the grain which is the seed. Each rice panicle (which is a determinate inflorescence on the terminal shoot), when ripened, contains on average 80-120 grains, depending on varietal characteristics, environmental conditions and the level of crop management.

The bulk of the rice in Asia is grown during the wet season starting in June-July and dependence on rainfall is the most limiting production constraint for rainfed culture. Rice areas in South and Southeast Asia may, in general, be classified into irrigated, rainfed upland, rainfed shallow water lowland and rainfed deep water lowland areas.

Irrigated conditions being the most assured, the productivity of irrigated rice is highest, being in the range of 5-8 t/ha during the wet season and 7-10 t/ha during the dry season when very well managed. Though the average is often only in the range of 3-5 t/ha. The productivity of rainfed upland and deep water lowland rice, however, continues to be low and is static around 1.0 t/ha.

Seedlings 25-30 days old, grown in a nursery are usually transplanted at 20 x 15 or 20 x 10 or 15 x 15 cm spacing in a well prepared main field and normally this will have a population of 335 000 to 500 000 hills/ha (33 to 50 hills/m2), each hill containing 2-3 plants. Direct seeding is also practised. Being a crop that tillers, the primary tillers (branches) grow from the lowermost nodes of the transplanted seedlings and this will further give rise to secondary and tertiary tillers.

The floral organs are modified shoots consisting of a panicle on which are arranged a number of spikelets. Each spikelet bears a floret which, when fertilized, develops into a grain. A crop producing on average 300 panicles per m2 and 100 spikelets per panicle, with an average spikelet sterility of 15 % at maturity and a 1 000-grain weight of 20 g will have an expected yield of 5.1 t/ha.

Nutrient removal

Modern high-yielding varieties producing around 5 t/ha of grain, in general, can remove from the soil about 110 kg N, 34 kg P2O5, 156 kg K2O, 23 kg MgO, 20 kg CaO, 5 kg S, 2 kg Fe, 2 kg Mn, 200 g Zn, 150 g Cu, 150 g B, 250 kg Si and 25 kg Cl per ha. Removals of Si and K2O are particularly large if the panicles and straw are taken away from the field at harvest. However, if only the grains are removed and the straw is returned and incorporated back into the soil, the removal of Si and K2O is greatly reduced, although significant amounts of N and P2O5 are still removed.

Nutrient uptake/removal - Macronutrients (high yielding variety)						
Plant part	kg/t grain					
	N	**P2O5**	**K2O**	**MgO**	**CaO**	**S**
Straw	7.6	1.1	28.4	2.3	3.80	0.34
Grain	14.6	6.0	3.2	1.7	0.14	0.60
Total	22.2	7.1	31.6	4.0	3.94	0.94
Source: Calculated from S.K. De Datta, 1989 Data computed from the nutrient uptake data of rice var. IR 36 at a yield level of 9.8 t/ha of grain and 8.3 t/ha of straw (in the Philippines)						

Nutrient uptake/removal - Micronutrients (high yielding variety)							
Plant part	g/t grain					kg/t grain	
	Fe	**Mn**	**Zn**	**Cu**	**B**	**Si**	**Cl**
Straw	150	310	20	2	16	41.9	5.5
Grain	200	60	20	25	16	9.8	4.2
Total	350	370	40	27	32	51.7	9.7
Source: Calculated from S.K. De Datta, 1989 Data computed from the nutrient uptake data of rice var. IR 36 at an yield level of 9.8 t/ha of grain and 8.3 t/ha of straw (in the Philippines)							

Nutrient removal* - with and without N-fertilizer						
N-fertilizer applied	Yield t/ha	Plant part	kg/ha			
			N	**P2O5**	**K2O**	**S**
No N	Grain: 3.4	Straw	18	4.6	71	0.8
	Straw: 2.8	Grain	34	22.9	12	1.0
		Total	52	27.5	83	1.8
174 kg/ha N	Grain: 9.8	Straw	75	11.5	278	3.3
	Straw 8.2	Grain	143	59.5	31	4.9
		Total	218	71.0	309	8.2
* Rice variety IR 36 in farmer's field, Laguna, Philippines, 1983, dry season. Adapted from S.K. De Datta, 1987						

Nutrient uptake by rice-based cropping systems (India)				
Cropping system	Grain yield t/ha	kg/ha/year		
		N	**P2O5**	**K2O**
Rice-Rice	6.3	139	88	211
Rice-Wheat	8.8	235	92	336
Rice-Wheat Greengram	11.2	308	89	336

Modern high-yielding varieties, in general, remove nutrients to a greater extent than did their traditional counterparts in the past and such a rate of soil exhaustion can limit the long-term sustainability of rice production, unless the removals are replenished by supplementary application of fertilizers.

Soil analysis and critical nutrient level concept

Among the soil analysis techniques, determination of soil pH is the simplest and most informative analytical technique for diagnosing a nutrient deficiency or toxicity problem. The various soil and plant analysis methods for evaluating the N, P, K, S, Zn and Si availability to lowland rice on submerged soils have been extensively reviewed by Chang (1978).

The determination of available N by the waterlogged incubation and alkaline permanganate method, available P by the Olsen and Bray P1 methods, available K by exchangeable potassium, available S with Ca (H2PO4)2.H2O, available Zn by extraction with buffered chelating agents or weak acids, and available Si by extraction with sodium acetate have been shown to record the best correlation with the response of rice to these elements.

Guidelines for N, P and K requirements based on soil analysis are:

Total N (%)	**N requirement**
< 0.1	high
0.1-0.2	moderate
> 0.2	low

Available N (ppm)	**N requirement**
50-100	high
100-200	moderate
> 200	low

Available P (Olsen, ppm)	**P requirement**
< 5	high
5-10	moderate
>10	low

Exchangeable K (me/100 g)	**K requirement**
> 0.2	low

The critical limits for micronutrients using soil analysis are presented below:

Critical deficiency levels in rice soils - Micronutrients			
Element	Method		Critical level (ppm)
B	Hot water		0.1 to 0.7
Cu	DTPA + CaCl2	(pH 7.3)	0.2
Fe	DTPA + CaCl2 NH4C2H3O2	(pH 7.3) (pH 4.8)	 2.5 to 4.5
Mn	DTPA + CaCl2 0.1 N H2PO4 and 3 N NH4H2PO4	(pH 7.3)	1.0 15 to 20
Mo	(NH4)2(C2O4)	(pH 3.3)	0.04 to 0.2
Zn	0.5 N HCl Dithizone + NH4C2H3O2 EDTA + (NH4)2CO3 DTPA + CaCl2	 (pH 7.3)	1.5 0.3 to 2.2 1.5 0.5 to 0.8
Source: Adapted from S.K. De Datta, 1989			

- If the soil pH is more than 6.8, Zn-deficiency is most likely to occur, particularly so if the variety grown is not tolerant and efficient to utilize the available Zn.

Plant analysis data

Deficiency or toxicity symptoms usually occur when plants are young and so the whole plant samples are drawn at that stage for chemical analysis. However, identification of the exact stage of growth is very important in determining the critical limits. It is also to be remembered that the critical concentration of nutrients determined from greenhouse experiments often tends to be high and, as such, these values may not really be extrapolated and used for field crops. Tanaka and Yoshida (1970) recorded a list of critical concentrations of various elements in the rice plant, which may be used as a rough guide for diagnostic purposes. However, whatever method is used, the correct correlation of the analytical data with yield data from reliable field experiments is decisive.

Plant analysis data (critical concentrations) - Macronutrients							
Plant part used for analysis	Growth stage	% of dry matter					
		N	**P**	**K**	**Mg**	**Ca**	**Si**
Leaf blade	Tillering	2.5 (D)*	0.1 (D)				
Straw	Maturity			1.0 (D)	0.10 (D)	0.15 (D)	5.0 (D)
* (D) = Deficiency							

Plant analysis data (critical concentration) - Micronutrients							
Plant part used for analysis	Growth stage	ppm dry matter					
		Fe	**Zn**	**Mn**	**B**	**Cu**	**Al**
Leaf blade	Tillering	(D)* 300(T)**					
Shoot	Tillering		10(D)	20(D) 2500(T)			300(T)
Straw	Maturity		1500(T)		3.4(D) 100(T)	6(D) 30(T)	
* (D) = Deficiency, ** (T) = Toxicity							

Nutrient absorption and translocation

A clear understanding of the different stages of growth and development of the crop and its nutritional requirements at these important stages is a pre-requisite for nutrient management.

In the case of N, the accumulation of N in the vegetative body is high during the initial growth stages and declines with age towards the later growth stages. Translocation of N from the vegetative organs to the grains becomes significant only after flowering. There is some translocation of carbohydrates from the vegetative plant parts to the grains after flowering and a large amount of carbohydrates acumulates in the grains. Protein synthesis is active during the vegetative stages and, during the reproductive stage, synthesis of cell wall substances (cellulose, lignin, etc.) becomes active, although the pace of protein synthesis also continues. It is only at the ripening stage that starch synthesis becomes active.

Nutrient mobility in the rice plant is in the sequence P > N > S > Mg > K > Ca. The elements that form immediate components of proteins have a high rate of mobility, while those that are continuously absorbed until senescence have a relatively low mobility. Thus, N, P and S, which are essential constituents of proteins, are absorbed rapidly during the active vegetative growth stage and are subsequently translocated to the grain after flowering. Other nutrients like Ca and K on the other hand, are absorbed at a rate matching the rate of dry matter production over the growth period.

Nutrient uptake at different growth stages

Based on temperate climate experience, Ishizuka (1965) has summarised nutrient uptake at different growth stages as follows:

- The percentage contents of N, P and K at the seedling stage increase progressively with growth and then decrease after reaching a maximum.
- The percentage of N in the plant decreases marginally after transplanting and then increases until the initiation of flowering. Subsequently the N content decreases continuously until the dough stage and then remains constant until ripening.
- The percentage of P declines rapidly after transplanting, then increases slowly and reaches a peak at flowering and then decreases until the dough stage.
- The percentage of K decreases gradually during the earlier growth of the plant but increases from flowering until ripening.
- Ca has a similar trend to K.
- The percentage of Mg is high from transplanting to the mid-tillering stage and then decreases gradually.
- The percentage of S decreases with growth.

Fertilizer management in rice

Rice farmers in India and most parts of South and Southeast Asia most commonly use N, P, K, S and Zn in the fertilizer schedule depending on soil types and seasonal conditions. Farmers in Japan, Korea and Taiwan also use silicon with advantage, although Si is not considered to be an essential element.

Since rice is pre-dominantly grown under wetland conditions, it is important to understand the unique properties of flooded soils for better management of fertilizers for this crop. When a soil is flooded, the following major chemical and electrochemical changes take place:

i) depletion of molecular oxygen,
ii) chemical reduction of soil,
iii) increase in pH of acid soils and decrease in pH of calcareous and sodic soils,
iv) increase in specific conductance,
v) reduction of Fe^{3+} to Fe^{2+} and Mn^{4+} to Mn^{2+},
vi) reduction of NO_3^- to NO_2^-, N_2 and N_2O,
vii) reduction of SO_4^{2-} to S^{2-},
viii) increase in supply and availability of N, P, Si and Mo,
ix) decrease in concentrations of water-soluble Zn and Cu, and
x) generation of CO_2, methane and toxic reduction products such as organic acids and hydrogen sulphide. These will have a profound influence on soil nutrient transformations and availability to rice plants.

The table below gives a broad indication of NPK recommendations for lowland rice in different countries:

Recommended/optimum levels of NPK for lowland rice (selected countries)					
Country	Region	Référence	Recommended/optimum levels (kg/ha)		
			N	**P2O5**	**K2O**
Bangladesh	Hathazari	Amin & Amin, 1990	80	28	17
Bhutan	Wangdipho-drang	Chettri et al, 1988	75	50	0
Egypt		Elgabaly, 1978	100	37	0
India	Haryana	Sharma et al, 1988	125	26	50
	Pattambi, Keraba	Alexander et al,1988	90	45	45
Indonesia	Lampang- Dry season Wet season West Java	Palmer et al, 1990	 140 80 115	 35 18 25	 30 30 40
Japan	Hyogo Prefecture	Sudo et al, 1984	170	122	170
Malaysia	MUDA	Jegatheesan , 1987	80	30	30
Pakistan	Muridke D.I. Khan Dist.	Zia, 1987 Gurmani et al, 1984	120 135	26 40	0 37
Philippines	Nueva Ecija Guadalupe, Laguna Tarlac	Aganon, 1987 UPCA, 1970	90 100 80	28 30 50	28 0 30
Sri Lanka		Balasuriya, 1987	73	58	58

Nitrogen

In lowland rice losses of applied N take place through: a) ammonia volatilization, b) denitrification, c) leaching, and d) runoff. The recovery of fertilizer N applied to rice seldom exceeds 30-40 %. Fertilizer N use efficiency in lowland rice may be maximized through a better timing of application to coincide with the stages of peak requirement of the crop, and placement of N fertilizer in the soil. Other possibilities, though much more costly, are the use of controlled-release N fertilizer or of urease and nitrification inhibitors, and finally, the exploitation of varietal differences in efficiency of N utilization.

Some general guidelines for efficient N management in rice	
Situation	Strategy
Upland (dryland)	Broadcast and mix basal dressing in top 5 cm of surface soil Incorporate topdressed fertilizer by hoeing-in between plant rows and then apply light irrigation, if available
Rainfed deep water	Apply full amount as basal dressing.
Lowland (submerged)	Use non-nitrate sources for basal dressing.
Soil very poor in N	Give relatively more N at planting.
Assured water supply	Can topdress every 3 weeks up to panicle initiation. Drain field before topdressing and reflood two days later.
Permeable soils	Emphasis on increasing number of split applications.
Short duration varieties	More basal N and early topdressing preferred.
Long duration varieties	Increased number of topdressing.
Colder growing season	Less basal N and more as topdressing.
Over aged seedlings used	More N at planting

N recommendations for dryland (rainfed upland) rice (India)		
Region	kg/ha	N application
Ranchi	60	in 3-4 split dressings
Bhubaneswar	75-90	in 3 split dressings
Dehradun	80	in 3 split dressings
Varanasi	80	50 % basal, 50 % 30-40 days after sowing
Source: AICRPDA, 1983		

General recommendations for N application to high yielding and improved varieties of lowland rice (India)		
State	kg/ha N	Application information
Andhra Pradesh	60-100	Rate depends on region, application in 2-3 split dressings.
Assam	60	For dry season rice: 1/3 basal, 1/3 at tillering, 1/3 at panicle initiation.
Haryana	120-150	1/3 basal, 1/3 3 WAP, 1/3 6 WAP.
Kerala	70- 90	For wetlands: Number of applications depends on varietal duration and soil type.
Karnataka	100	50 % basal, 25 % 25-30 DAP, 25 % at PI.
Meghalaya	60	Transplanted: 25 % basal, 50 % at tillering, 25 % at PI. Direct seeded: 1/3 20 DAS, 1/3 40 DAS, 1/3 at PI.
Orissa	50- 75	Medium and lowland; in 3 splits.
Punjab	125-150	1/3 basal, 1/3 3 WAP, 1/3 6 WAP.
Tamil Nadu	75-100	Rate depends on varietal duration. 50 % basal, 50 % topdressed.
Uttar Pradesh	100	50 % basal, 25 % tillering, 25 % at PI.
West Bengal	40-120	Rate depends on variety and soil test, in 2-3 applications.
Source: Compiled by Tandon, 1989		

Recommended rates of N for wet rice production (Taiwan)			
Variety	Region*	N rate** (kg/ha)	
		1st crop	**2nd crop**
Japonica (medium height)	CSE N	120-150 110-130	100-130 100-120
Japonica (in well drained soil)	CSE N	180-210 150	170-200 140
Indica (dwarf)	CSE	150-180	125-160
* C, S, E and N denote central, southern, eastern and northern Taiwan respectively. ** N rate should be raised by 10-20 % in direct-seeded culture, and by 20-40 kg/ha in calcareous soils. Conversely, it should¦ be decreased by 20-40 kg/ha in strongly acidic soils.			
Source: Lian, 1989			

During the recent past, a number of recommendations have evolved for increasing the efficiency of N use through non-conventional means, e.g. use of neem cake coated urea, urea supergranules (USG), soil-cured urea, etc. USG is recommended in Karnataka, Meghalaya and Orissa for root zone placement and for improving N-use efficiency in rice, although the material is yet to be commercially available. For neem-cake coated urea, 20-25 kg neem oil cake is needed per 100 kg urea.

Phosphorus

Although P availability generally increases in submerged soils, a significant response of lowland rice to P application is common in ultisols, oxisols, sulfaquept, andosol and some vertisols with high P fixation capacities. The response is higher during the cooler months of the dry season crop. Application of 60 kg P2O5 increases grain yield of rice in India, on average, by 0.50-0.75 t/ha (Pillai et al., 1985). In dryland rice, however, P use is particularly important and remunerative.

Specific P recommendations are usually based on soil-test values of available P. The soil-test based P recommendations may further be specified for different target yield levels. One such example is set out below.

P recommendations based on soil tests and target yields			
Target yield (t/ha)	kg/ha P2O5 recommended at different levels of Olsen P (kg/ha)		
	10	20	30
4.5	52	32	16
5.0	62	42	26
Source: Perumal Rani et al., 1985			

In wetland rice, the full rate of P fertilizer is generally recommended to be surface broadcast and lightly incorporated into the soil before planting, but some recommendations for split application are now emerging. In Haryana, India, it is recommended that P may also be profitably applied in two equal dressings - at puddling and 3 weeks after transplanting. In Bangalore, Kolar, Tumkur, Mandya and Mysore districts of Karnataka, India, application of 50 % at planting and 50 % at tillering is being recommended.

For upland (dryland) rice, the standard recommendation is to drill the full rate of P at or before sowing.

Factors like soil texture, P fertility status, seasonal conditions and duration of the variety are often taken into consideration. Examples are given below:

P recommendations for irrigated rice in Warangal District, India			
Variety	Season	P2O5 recommended kg/ha	
		Light soil	**Heavy soil**
HYV	Wet	50	<60
	Dry	45	60
Local	Wet	30	40
	Dry	40	50
Dept. of Agriculture, Hyderabad, 1985			

Recommended rates of P for wet rice production (Taiwan)			
Available P (Bray I)		P2O5 rate, kg/ha	
ppm	**Rating**	**1st crop**	**2nd crop**
0- 4	Very low	70-80	50-60
5-10	Low	60-70	40-50
11-20	Medium	40-60	20-40
21-50	High	20-40	0-30
Over 50	Very high	0-30	0-20
Source: Lian, 1989			

Potassium

Grain yield response to K is higher in dry season than in wet season rice. In India, average responses of 10 kg grain/kg K2O dry season and 8 kg grain/kg K2O wet season have been recorded in cultivators' fields (Pillai et al., 1985).

Although broadcasting and incorporating the whole K application at the time of puddling (before planting) is generally recommended, split application is also common in some areas.

General K recommendations (India)	
State	**Recommendation**
Andhra Pradesh	30-45 kg K2O/ha in K deficient and light soils.
Kerala	30-45 kg K2O/ha depending on variety and water regime.
Orissa	20-40 kg K2O/ha depending on variety and soil fertility.
Punjab	30 kg K2O/ha.
Tamil Nadu	38 kg K2O/ha for short duration varieties, 50 kg K2O/ha for medium-long duration varieties.
West Bengal	0-60 kg K2O/ha depending on variety, season and soil test.
Source: FAI, 1981	

Recommended rates of K for wet rice production (Taiwan)			
Available K (Mehlich's)		K2O rate*, kg/ha	
ppm	**Rating**	**1st crop**	**2nd crop**
0-15	Very low	60-70	80-90
16-30	Low	50-60	60-80
31-50	Medium	30-50	40-60
Over 50	High	0-30	0-40
* Plus 30 kg/ha K2O in the case of poorly drained soils.			
Source: Lian, 1989			

K recommendations for rice (Tamil Nadu, India), using the "per cent yield concept"			
District	Recommendations, kg/ha K2O for 87.5 % of the max. yield		
	Soil test	**Soil test**	**Soil test**
	160 kg/ha	**258 kg/ha**	**381 kg/ha**
	K2O	**K2O**	**K2O**
North Arcot	69	49	25
Ramnad	88	54	12
Tirunelveli	145	111	66
Source: Mosi & Lakshminarayana, 1987			

K application schedule (Kerala state, India) - example of split application of K		
Region	**Situation**	**Recommendation**
Kuttanad and Onattukara	Transplanted medium-late duration	50 % K before planting, 50 % 5-7 days before panicle initiation.
Wynad and hilly region	Transplanted long duration	50 % K one month after planting, 50 % before flowering.
Wynad and hilly region	Direct seeded	50 % 1 1/2 months after planting plus 50 % at panicle initiation.
Source: Kerala Agric. University, Package of Practices, 1986.		

Preferred nutrient forms

In the anaerobic environment of lowland rice soils, the only stable mineral form of N is NH4. Nitrate (NO3) forms of N, if applied, will enter the anaerobic zone and be subjected to heavy denitrification losses. At planting time, the basal dressing of N should never be supplied as nitrate. For topdressing the growing plants, however, NH4 and NO3 forms may be used with almost equal efficiency. Fully established rice can rapidly take up applied NO3 before it is leached down to the anerobic soil layer and can become denitrified.

Water soluble P sources such as single superphosphate (SSP) and diammonium phosphate (DAP) are generally recommended in neutral to alkaline soils. Water insoluble sources like rock phosphates are recommended for acid soils where they are effective at low pH values.

Muriate of potash is the most commonly used source of K.

Secondary and micronutrients

S deficiency has been reported from Bangladesh, Burma, Brazil, Indonesia, India, Nigeria, Philippines and Thailand (Jones et al., 1982). In Bangladesh, 20 kg/ha S is generally recommended in the form of gypsum for dry season rice, the residual effect of which can often meet the S requirement of the succeeding wet season rice crop. In Bangladesh, application of S along with NPK increases the grain yield by 30-79 % above that obtained by using NPK fertilizers alone (Bhuiyan & Islam, 1989). In India, although S is yet to be introduced to the regular fertilizer schedule for rice, researchers have suggested application of 30 kg/ha S per crop at Delhi and 44 kg/ha S per two crops at Bhubaneswar, Orissa. In general, application of S containing fertilizers is advocated during the final land preparation.

Yield response of lowland rice to sulphur application (India)		
Location/soil type	**Grain yield response to sulphur (averaged over three years)**	
	kg/ha	% increase
Barrackpore (alluvial soils)	415	12
Hyderabad (red soils)	213	9
Bhubaneswar (lateritic soils)	372	12
Pantnagar (terai soils)	308	6
Source: Compilation of Tandon 1989		

Zn deficiency is the most widespread micronutrient disorder in lowland rice and application of Zn along with NPK fertilizer increases the grain yield dramatically in most cases:

Response of lowland rice to Zn application			
Country	**Soil characteristics**	**Zn level (kg/ha)**	**Optimum Response (t/ha)**
India	Calcareous red, pH 7.5 Saline-alkali, pH 10.6 Aquic Camborthid	10 10 11.2	1.8 1.0 1.4
Pakistan	Calcareous	100	2.6
Philippines	Calcareous Hydrosol	10 Root dipping in 2 % ZnO	4.8 4.4
Thailand		15	0.4
USA	Norman clay Crowley silt loam Crowley silt loam	9 27 8	7.0 0.7 2.4
Source: Jones et al., 1982			

Zn recommendations for lowland rice (India)	
State	**Recommendations* (kg/ha zinc sulphate)**
Tripura	15
Maharashtra	17.75
Kerala, Jammu-Kashmir and Karnataka	20
Meghalaya	20-25
Bihar, Delhi, Haryana, Himachal Pradesh, Rajasthan and West Bengal	25
Tamil Nadu	30
Madhya Pradesh	25 (light textured soil) 50 (heavy textured soil)
Andhra Pradesh	50
Punjab	62.5 + topdress 25, if necessary
* For soil application once in 2-3 seasons, during final land preparation.	
Source: Tandon, 1989.	

Alternative recommendations for all the provinces:

1. Root dipping of seedlings in 1-4 % ZnO suspension before transplanting.

2. Foliar spraying of 0.5 % zinc sulphate (+ 0.25 % slaked lime) solution at 30, 45 and 60 days after planting or more frequently.

Complementary use of organic manures

Wherever feasible organic manures like compost, farmyard manure, green manure or azolla should complement mineral fertilizer. Organic manures should not be considered merely as suppliers of nutrient elements; they play an important role in maintaining the long term fertility of rice fields through improvement of the physical and biological properties of the soil. About 5-10 t/ha of organic manures may be regularly applied to rice fields, preferably during the wet season, for realizing the maximum benefit from mineral fertilizers.

Further reading

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