Fertilizers

Chemical fertilisers

Choice of a fertiliser depends on unit cost of nutrient present in it and its agronomic efficiency under a given situation. Fertiliser is a valuable input and measures should be taken to reduce its losses and to increase its uptake and utilisation by the crop. Selecting a situation-specific fertilizer and choosing the time and method of application according to crop demand would minimize losses and increase its efficiency.

Nitrogenous fertilisers

Most crop plants recover only 25-35% of the nitrogen applied as fertilizers. Losses occur by ammonia volatilisation, denitrification, immobilization to organic forms, leaching and run off. Utmost care should be bestowed in selecting the type of fertiliser as well as the timing and method of application.

Choice of the nitrogen fertilizer

1. In submerged rice soil, ammoniacal and ammonia-producing fertilizers like urea are most suitable since ammonia is the most stable form of nitrogen under such conditions.

2. For acidic upland soils, ammoniacal fertilizers are most suitable during rainy season since ammonium is adsorbed on soil particles and hence leaching losses are reduced. Adsorbed ammonium is gradually released for nitrification and thus becomes available to crops for a longer period.

3. In highly acidic upland soils, urea is preferred to ammonium sulphate as the former is less acid forming.

4. In alkaline upland soils of low rainfall regions, nitrate fertilizers are preferred to ammoniacal fertilisers or urea since ammonia may be lost by volatilization under alkaline conditions

Management of nitrogenous fertilisers

1. Almost all the nitrogenous fertilizers are highly amenable to losses and since most of the crops require nitrogen during the entire growth period, split application is necessary to ensure maximum utilization by crops.

2. More number of splits may be given for long duration crops as well as perennial crops.

3. Nitrogen losses from fertilisers are more in coarse textured soils with low cation exchange capacity (CEC) than in fine textured soils. Hence more number of splits is necessary to reduce loss of fertilizer nitrogen from sandy and other light soils.

4. For medium duration rice varieties, nitrogenous fertilizers should be given in three splits, as basal, at maximum tillering and at panicle initiation stage.

5. In coarse textured sandy or loamy soils, the entire dose of nitrogenous fertilizers may be applied in 3-4 splits at different stages of growth of rice crop.

6. In areas where split application of nitrogen is not feasible due to water stagnation after planting/sowing, full dose of nitrogen as basal may be given in the form of neem coated or coal tar coated urea.

7. In double-cropped wetlands, 50% of N requirement of the first crop may be applied in the organic form.

8. As far as possible, liming should be done one or two weeks prior to the application of ammoniacal or ammonia forming fertilizer like urea since ammonia is likely to be lost by volatilization if applied along with lime

9. Almost 70% of N in urea applied by broadcast to flooded soil is lost by

5. Almost 70% of N in urea applied by broadcast to flooded soil is lost by volatilization, immobilization and by denitrification

Measures to reduce the loss of N from applied urea

1. Urea super granules or urea briquettes may be used in places where soil is clayey and has cation exchange capacity more than 10 cmol (+) per kg of soil.

2. Sulphur or lac coated urea is suitable where soil is liable to intermittent flooding and in situations where water management is difficult. This is more suitable for direct sown crop.

3. Urea may be mixed with moist soil and kept for 24-48 hours before application to the field. Alternatively, urea may be mixed with moist soil, made into balls of about three-inch diameter and dried under shade. The balls may be placed deep into subsoil.

4. Mixing urea with five times its weight of neem cake prolongs the period of nitrogen availability to the crop.

5. For submerged soils, coating urea with coal tar and kerosene (100 kg urea is mixed with 2 kg coal tar dissolved in one litre kerosene) before mixing with neem cake is preferred to simple mixing with neem cake.

6. Coating urea with neem extract (containing about 5% neem triterpenes) at 1% rate and shade-drying for 1 to 1.5 hours before applying in direct-seeded puddled lowland rice increases nitrogen use efficiency.

7. As far as possible, urea may be applied by deep placement or plough sole placement. Deep placement of prilled urea or super granules during the last ploughing followed by flooding and planting is beneficial in light soils. Urea briquettes or super granules may be placed between four hills of transplanted rice, whereas sulphur coated or lac coated urea may be broadcast on the surface.

8. Foliar spray of 5% urea solution can be practised in situations where quick response to applied nitrogen is required. If power sprayers are used, the concentration may be increased to 15%. Fresh urea should be used to avoid toxicity due to biuret.

Phosphatic fertilizers

Fertilizer phosphorus is an expensive input and its management poses serious problems due to several complexities in its behaviour in different types of soil. This often results in its poor recovery from applied fertilizers.

Choice of phosphatic fertilizer

1. In slightly acid, neutral or mildly alkaline soils, water-soluble phosphatic fertilizers are more suitable.

2. In wetland rice soils, water-soluble phosphatic fertilizers are preferable as pH of most of the submerged soils is near neutral.

3. In strongly acidic soils whose pH does not rise above 5.5 to 6.0 even on submergence, phosphatic fertilizers containing citrate soluble form of P like basic slag, dicalcium phosphate, steamed bone meal etc. are suitable.

4. For highly acidic upland soils or submerged soils whose pH will not rise above 5.5 even on submergence, powdered rock phosphate is suitable. Soil acidity converts tricalcium phosphate in rock phosphate to plant available monocalcium form.

5. For short duration crops where quick response is required, water-soluble phosphatic fertilizers are most suitable.

6. For perennial crops like rubber, oil palm, coffee, tea, cardamom etc.

6. For perennial crops like rubber, oil palm, coffee, tea, cardamom etc. phosphorus in the form of rock phosphate can be applied.

7. In black soil (Chittur taluk of Palakkad District) phosphatic fertilizers containing water-soluble phosphate like single superphosphate are most suitable.

Management of phosphatic fertilizers

1. Acid soils have to be amended with lime, dolomite or magnesium silicate and alkali soils with iron pyrite or sulphur before application of phosphatic fertilizers. This will help to reduce fixation and increase availability of P.

2. Surface application or broadcasting is preferred for shallow rooted crops whereas placement in the root zone is advantageous in deep-rooted crops.

3. Rock phosphates can be used advantageously in rice grown in acid soils during the virippu season. Powdered rock phosphate may be applied and mixed thoroughly with soil by ploughing. After two or three weeks, the field may be flooded, worked up and planted with rice. Under this situation, phosphorus in rock phosphate gets converted to iron phosphate, which on subsequent waterlogging becomes available to the rice crop.

4. Rock phosphate can be used successfully as a phosphatic source for leguminous crop since its root system can extract phosphorous from rock phosphate.

5. In single crop wetlands where rice is grown in the virippu season, application of phosphatic fertilizers can be dispensed with for the rice crop, if the second crop (usually legume or green manure) is given phosphatic fertilizers.

6. In case of rice-legume cropping sequence in acid soils, application of rock phosphate to the pulse crop helps to skip phosphatic fertilizers in the succeeding rice crop.

7. Since phosphorus requirement of seasonal crops is confined to the early stages, phosphatic fertilizers are to be applied at the time of seeding or planting. Topdressing of phosphatic fertilizer leads to wastage of the fertilizer nutrient. Further, excessive phosphates may lead to deficiency of micronutrients such as zinc, boron etc.

8. Under adverse soil conditions and where quick result is required, spraying water-soluble phosphatic fertilizers like triple superphosphate or hot water extract of superphosphate can be resorted to.

Potassium fertilizers

For most crops, potassium can be supplied as muriate of potash. But in crops like tobacco and potato, muriate of potash may cause chloride injury, reducing quality of the produce. In such cases, K may be applied as potassium sulphate.

Management of potassium fertilizer

1. In coarse textured soils and in heavy rainfall regions, potassium fertilizers should be applied in as many splits as possible, to reduce loss of potassium.

2. In fine textured soils, the entire dose of potassium fertilizers may be applied as basal.

3. In acid soils, potassium fertilizers should be applied only after lime application to prevent loss of potassium by leaching.

Average nutrient content of common fertilizers

Material	Nutrient content (%)

Material	N	P2O5	K2O
Ammonium sulphate	20.5	-	-
Ammonium sulphate nitrate	26.0	-	-
Ammonium nitrate	33.5	-	-
Ammonium phosphate	20.0	20.0	-
Calcium ammonium nitrate	20.5 / 25.0	-	-
Nitrate of soda	16.5	-	-
Urea	46.0	-	-
Superphosphate (single)	-	18.0	-
Superphosphate (double)	-	35.0	-
Superphosphate (triple)	-	46.0	-
Mussooriephos	-	18-20	-
Rajphos	-	18-20	-
Muriate of potash	-	-	50 / 60

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Organic manures

Organic manures are waste or by products (animal/birds waste, litter, crop refuse or any other organic matter) either decomposed or treated or fresh, which enriches soil. They are bulky i.e. nutrient contents are low per unit volume. Concentrated OM contains higher % of nutrients such us oil cakes, blood/bone/fish meal important effects are:

1. improve the physical properties of the soil
2. supply all nutrients for plant growth
3. enhances soil microbial activity
4. provide a buffering action in soil reactions
5. improve nutrient holding capacity of the soil

Green manures

Green manuring refers to the practice of incorporating plant materials while they are green. It is practiced as green leaf manuring and green manuring insitu.

Average nutrient content of common Organic manures

MAJOR NUTRIENTS IN ORGANIC MANURES			
	N	P2O5	K2O
Neem cake	5.2	1	1.4
Coconut cake	3	1.9	1.8
Groundnut cake	7	1.5	1.3
Gingelly cake	6.2	2	1.2
Castor cake	4.3	2	1.3
Mahua cake	2.5	0.8	1.8
Farm yard manure	0.5 - 1.5	0.4 - 0.8	0.5 - 1.9
Compost (Rural)	0.4 - 0.8	0.3 - 0.6	0.7 - 1.0
Compost (Urban)	1.0 - 2.0	1	1.5
Cowdung (fresh)	1.5	0.3	0.2
Biogas slurry	--	--	--
(cowdung based)	1.6 - 1.8	1.1 - 2.0	0.8 - 1.2
Sheep manure	0.8 - 1.6	0.4 - 0.6	0.3 - 0.4
Poultry manure	1.2 - 1.8	1.4 - 1.8	0.8 - 0.9
Bone meal	3.5	21	--
Fish meal	4.1	3.9	0.3
Meat meal	11	1.5	0.6
Blood (dried)	11.5	--	0.6

Blood (dried)			
Sun hemp	2.6	0.5	2
Daincha	3.3	0.7	1.3
Kolinji	3.2	0.3	1.3
Sesbania	2.7	0.5	2.2
Gliricidia	2.9	0.5	2.8
Paddy straw	0.36	0.08	0.71
Household ash	0.5 - 1.9	1.6 - 4.2	2.3 - 12.00
Coir pith Compost	1.26	0.06	1.2

Note: Composition of organic manures vary widely

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Bio-fertilizers

The use of biofertilisers is quite important while practicing the concepts of integrated plant nutrient management and organic farming. Some of the commonly used biofertilisers in Kerala are as follows.

1. Rhizobium (Bradyrhizobium and Azorhizobium)
It induces better root nodulation and stem nodulation (Azorhizobium) in inoculated plants and thereby brings down the requirement of nitrogen fertilizer for the cultivation of pulses, oil seeds and legume green manures. Commercially it is available as carrier based inoculums. Method of application is seed treatment.

2. Azotobacter
Suitable only for upland crops like vegetables, tapioca, plantation and orchard crops. It is available as carrier-based inoculum. It fixes N about 15-20 kg/ha under ideal upland conditions and thereby reduces the requirement of nitrogen fertilizers by 10-20 per cent. Methods of application are seed treatment, seedling dip and direct soil application.

3. Azospirillum
It is suitable for both upland and wetland conditions and is available as carrier-based inoculum. It fixes N about 20-25 kg per ha under ideal conditions thereby effecting a reduction of 25 per cent in the quantity of N fertilizers required. Treatment with Azospirillum also induces better root formation in inoculated plants. Hence this biofertilizer is also recommended for root induction in polybag-raised seedlings of plantation and orchard crops and also for vegetable crops. The isolates of Azospirillum brasilense strains AZR 15 and AZR 37 from Kuttanad soils are highly effective for rice, vegetables and nursery plants. The strains AZ 1 and AZ 2 are effective in vegetable and nursery plants.

Method of application

Seed treatment: For treating 5-10 kg seeds, 500 g culture is required. Moisten the seeds by sprinkling water or rice-gruel water. Take 500 g culture in a plastic tray/basin, add moistened seeds, mix well and dry in shade for 30 minutes. This may be sown immediately.

Seedling root dip (for transplanted crops): Slurry of the culture is prepared by mixing 500 g culture with 50 ml of water and the roots are dipped in the slurry for 15-20 minutes before transplanting.

Soil application: Mix the culture with FYM or compost in the ratio 1:25 and apply directly in the soil.

Inoculation for paddy
Mix 2 kg of culture in 60 litres of water and soak the seeds required for 1 ha (60 kg) for 24 hours before sowing. At the time of transplanting, dip the roots of seedlings for 15-20 minutes in the culture slurry prepared by mixing 2 kg inoculum with 40 litres of water. This slurry can be used for treating seedlings required for 1 ha. Another 2 kg culture may be applied to the field along with FYM or compost.

4. Blue green algae(BGA)

4. Blue green algae(BGA)
Mainly recommended for wetland rice cultivation. However, the use of this biofertilizer is not feasible in acidic soils with pH below 6.0. It is available as carrier-based inoculum and it fixes N about 25-30 kg/ha under ideal conditions.

Method of application: Direct broadcasting in the rice fields @ 10 kg/ha one week after transplanting the seedlings.

5. Azolla
It is suitable for wetland rice cultivation. The required quantity of azolla will have to be raised in the farmers' field itself. Fixes N about 25 to 30 kg / ha.

Method of application: Apply fresh azolla @ 10 t/ha before transplanting the rice seedlings at the time of ploughing.

6. Phosphate solubilising bacteria and fungi
Recommended mainly for upland crops raised in neutral and slightly alkaline soils. Available as carrier-based inoculum. Enables the efficient utilization of cheaper sources of phosphatic fertilizers such as rock phosphate by crop plants in neutral and alkaline soils.
Method of application: Seed treatment and direct application.

7. Vesicular / arbuscular mycorrhiza (VAM/ AM)
Vesicular arbuscular mycorrhiza is mostly recommended for upland especially for raising container and tissue culture plantlets and transplanted crops. It mainly improves the uptake of available P by inoculated plants. There is also an enhanced absorption of water and other nutrients such as N and K and certain micronutrients. Mycorrhiza inoculation can improve the survival and establishment of tissue culture plantlets under field conditions. Also induces better resistance against certain soil borne plant pathogens. It is commercially available as granular inoculum consisting of infected roots and soil with mycorrhizal spores. It is given as soil application.

VAM fungus Glomus microcarpum var. microcarpum is suitable for tropical tuber crops. The inoculation can be done by placing inoculum (3-5 g/sett) beneath the sett before planting. The rate of spore load in the inoculum should be to the tune of 50 to 400 spores per 100 g soil medium. Method of application is the rooted infected cutting technique.

Application techniques of biofertilisers

1. Seed treatment
Five hundred grams of commercially available inoculum will be required for treatment of seeds for one-hectare area. For this, thick slurry of the carrier-based inoculum is initially prepared by mixing 500 g of the inoculum in 1.25 litre of water. The stickiness of the biofertilizer on seed surface can be significantly improved by using 10% jagerry solution or 5% sugar solution supplemented with 40% boiled and cooled gum arabic solution or rice-gruel water. The required quantity of seed material is then gently mixed with this slurry by taking care not to damage the seed coat. The treated seeds are spread evenly over a gunny bag and dried in shade and sown immediately in moist soil. Under no circumstances, the treated seeds are exposed to direct sunlight for a longer period of time since the UV rays of solar radiation will reduce significantly the population of inoculated bacteria on seed surface.

2. Seedling treatment
This method of application is mainly recommended for transplanted crops. In this procedure, the roots of seedlings to be transplanted are dipped in loose water slurry of the biofertilizer (500 g in 2.5 litre of water) for 20 minutes, prior to transplanting.

3. Soil application
Soil application is generally recommended for all types of biofertilisers except Rhizobium, Bradyrhizobium and Azorhizobium. The method is to apply the biofertilizer after mixing with dried FYM, compost or

vermicompost @ 1:25. For crops of six-month duration, the recommended dose is 1-2 kg/ha. This can be increased to 2-4 kg/ha for crops of more than six-month duration. For perennial crops, 10 to 25 g of the biofertilizer is to be applied in the root zone during the first year and 25 to 50 g during subsequent years. This can be done at the time of sowing, transplanting or during intercultivation.

Factors influencing the efficient use of bio-fertilisers in Kerala

1. Use adequate quantity of organic manure (as per the recommendation for each crop) along with biofertiliser application. This is essential to ensure better survival, growth and activity of the introduced microbial inoculums in acidic soils.

2. Liming is essential if the soil pH is below 6.0. In moderately acidic soils, the application of lime @ 250 kg/ha is recommended along with biofertilizer treatment.

3. Irrigation is essential during summer months after biofertilizer application to ensure the survival of the introduced microbial inoculum in the soil.

4. Since N biofertilisers can supplement only a part of the nitrogen requirement of the inoculated plant, low dose of nitrogen and full doses of phosphorus and potassium as per the recommendation may be applied. This is essential to ensure better plant growth and yield. Similarly, in the case of P biofertilisers, the full doses of nitrogen and potassium should be applied. However, there should be a gap of at least one week between biofertilizer and chemical fertilizer applications.

5. Use only biofertilisers, which are manufactured as per the quality parameters prescribed by the Bureau of Indian Standards. In the case of bacterial biofertilisers, the prescribed standard is that in the final product, the population of the desired bacterium should not be less than ten million per gram of the carrier material and there should not be any contamination with other microorganisms when examined at 1:100000 dilution. Further, it should have a shelf life of at least six months.

6. The commercially available biofertiliser should always be used before the expiry date marked on the culture packet.

7. Topdressing with super phosphate 25 kg/ha 10 days after inoculation of BGA will enhance its growth under field conditions.

8. Since the occurrence of green algae in rice field can affect the normal growth and proliferation of BGA, the population of green
algae should be controlled initially by applying copper sulphate @ 4 kg/ha.

9. In moderately acidic soils of pH around 6.5, root nodulation by Rhizobium and Bradyrhizobium can be improved by pelleting with finely powdered calcium carbonate. (See recommendation under cowpea)

10. Application of P2O5 @ 1 kg/ha is recommended once in 4 days in P2O5 deficient soils to ensure good growth of azolla. The development of a reddish purple colour in azolla is a typical symptom of P2O5 deficiency.

11. Since a floating population of azolla can release its bound nutrients only during decay in the soil, it is essential to incorporate azolla in the soil prior to the transplanting of rice seedlings.

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Liming

Lime

Acid soils are characterised by high saturation of the exchange complex with hydrogen and aluminium. Crops grown in such soils suffer due to unavailability of most plant nutrients, especially calcium. Application of liming materials increases the availability of nutrients and alleviates Ca

liming materials increases the availability of nutrients and alleviates Ca deficiency.

Liming materials

Burnt lime [CaO], slaked lime [Ca(OH)2], powdered limestone [CaCO3] and dolomite [CaMg(CO3)2] are some of the materials used as sources of calcium.

Management

1. In acidic submerged soils, flooding brings about rise in soil pH and hence response to lime is less marked.

2. Legumes are benefited most by liming.

3. For better results, liming materials should be incorporated into the soil.

4. For seasonal crops and in situations where immediate results are required, burnt lime or slaked lime may be used. For perennial crops, powdered limestone or dolomite is sufficient.

5. Extreme care should be taken while broadcasting burnt lime and slaked lime as they can cause scorching of leaves.

6. In case of wetland rice, drain the field prior to lime application and re-flood after 24 hours. Flushing the soil by sequential flooding and draining will help to wash out the displaced acid from the soil.

7. In extreme case of calcium deficiency, a 1% solution of calcium chloride may be applied by foliar spraying.

Neutralizing value of liming materials

Liming material	Chemical formula	Neutralizing value
Calcium carbonate (powdered lime stone)	CaCO3	100
Burnt lime (quick lime)	CaO	179
Slaked lime	Ca(OH)2	136
Dolomite	CaMg(CO3)2	109