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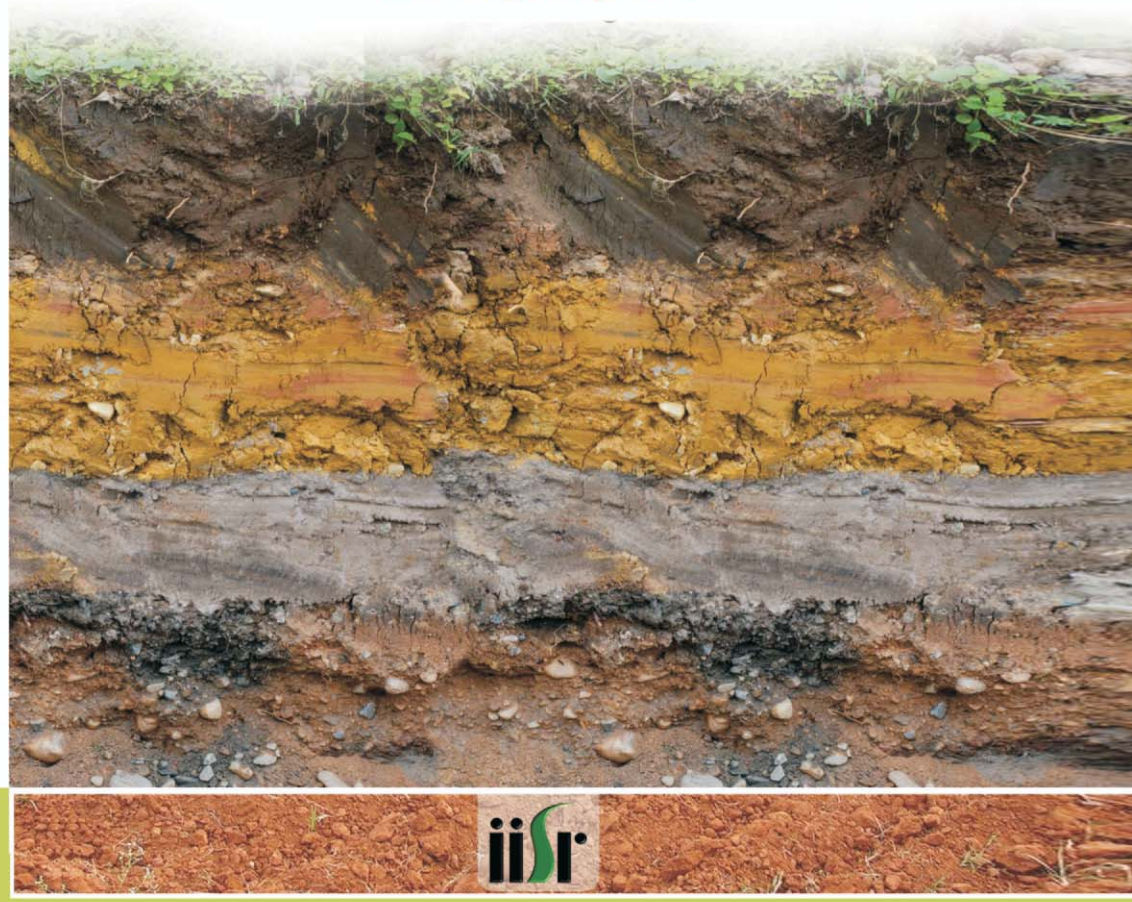
Soil Related Constraints and Management for Major Spices



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Soil Related Constraints and Management for Major Spices

India is the world's largest producer, consumer and exporter of spices. In our country they are mainly grown in humid tropics like Western Ghats and in north eastern, regions in about 3.88 million ha with a production of 8.12 million tonnes. Out of this, about 11 % is exported to more than 150 countries. Among the major spices though Kerala contributes major share of Black pepper and small cardamom, the North Eastern states contributes major share of Zingiberaceous spices. The productivity is largest for ginger followed by garlic, turmeric, chilli, cinnamon, fennel, fenugreek, coriander, celery, cumin, ajwain, nutmeg, clove, pepper, cardamom and least for saffron (DASD 2019).

Our productivity is low when compared to the competing countries in most of the spices. Droughts, floods, tropical cyclones, heavy precipitation events, hot extremes and heat waves are other challenges that affects agricultural production, and farmers' livelihood in India. It has been projected by the recent report of the IPCC and a few other global studies that unless we adapt, there is a probability of 10.0–40.0% loss in crop production in India by 2080–2100 due to global warming. The important factors causing reduced productivity are poor soil quality, climatic variability, improper management practices, besides pests and diseases.

Since the deficiency of major, secondary and micro nutrients is a yield limiting factor in addition to inherent problems of spice growing soils, a logical alternative for increasing food production is to develop, fine tune, and implement smart soil/crop management practices, which enhance and maintain the soil organic mater content and plant nutrient reserves at appropriate levels.

Soil and climatic suitability for spices

Except widely adapted turmeric and seed spices, which are grown in wide range of pH varying from 5.0 to 7.5, all the other major spices are grown in slightly acidic soils which are grouped under red loams or laterites.

Pepper requires a warm and humid climate. Though an annual rainfall of 250 cm is ideal for the proper growth of the crop, it can also come up well in low rainfall areas, if the pattern and distribution of rainfall are conducive. In India, pepper cultivation is mainly confined to Kerala, Karnataka, NEH and Tamil Nadu on a wide variety of soils with varying texture from sandy loam to clayey loam that are acidic in nature.

Cardamom grows well at an altitude of 600-1200 m above MSL with annual rainfall ranging from 1500-4000 mm and temperature range 10-35^{o} c. Forest loam soils having pH 5.75- 6.0 and rich in nutrients is ideal for the crop. Soils most suited for cardamom are red lateritic loam with layers of organic debris present in evergreen forests. In general, cardamom growing soils are fairly deep having good drainage.

Ginger grows well up to an altitude of 1500 m sand prefers a rich soil having pH 5.6-6.5 with high humus content and well distributed rainfall. In India it is grown on a wide variety of soils such as sandy loam, clay loam, black clay soils and lateritic soils of Kerala, Karnataka, Orissa, West Bengal, Maharashtra and North Eastern regions. Soils with moderate acidity (pH 5.7) and high organic matter (1.1%) are well suited for ginger.

Turmeric is a tropical herb and can be grown on different types of soil under irrigated and rainfed conditions up to an altitude of 1200 m and annual rainfall of 640 to 4290 mm is ideal. Telangana is the leading turmeric producing state in India followed by Andhra Pradesh, Karnataka,Tamil Nadu, NE States and Kerala. Well drained deep sandy or clayey loam or red loamy soils rich in humus having acidic to slightly alkaline pH of 6- 7.5 is ideal for the crop.

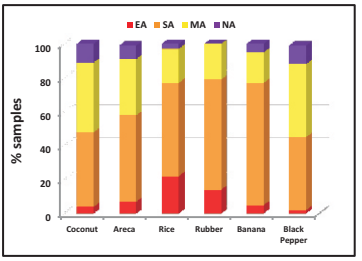
Soil related constraints

Soil erosion

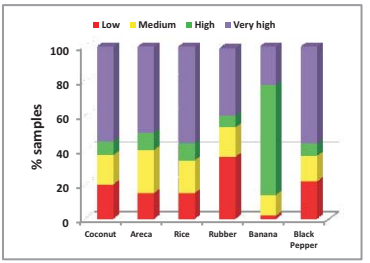
The main constraints faced in the potential zones for spices are steep sloping landform leading to excessive erosion, risk of water logging in valleys during heavy monsoon periods and soil acidity due to heavy leaching of bases from soil leading to low soil fertility status. The extent of soil erosion in spice growing tracts i.e. Western Ghats, Coastal and NEH region ranges from 20-80 t/ha/ year, rated to be very severe, affecting approximately 2.4 lakh km^{2} area in this region. Adopting soil and water conservation measures like terracing and bunding to reduce the degree and length of the slope and to reduce erosion is the primary measure. Soil erosion and associated nutrient losses is a serious issue.

Low fertility status

The major reasons for low productivity of spices are low soil pH, high clay and low sand content, low CEC, base saturation, low status of organic carbon, K, Ca, Mg and Zn. Unlike other spices, pepper and cardamom are perennial crops and the utilization pattern of nutrients over several years, could be uniquely different. Another constraint is the wide spread deficiency of micronutrients in spice growing areas, among which, deficiency of Zn is predominant in acid soils of India with highest deficiency rate of 57% in acid soils of Meghalaya followed by Jharkhand, Orissa and West Bengal (23-54 %). Fifty per cent of turmeric growing soils in Andhra Pradesh are Zn deficient, more than 80 % are deficient in Fe and 80 % of them are calcareous.Majority of the samples in Kerala are low in exchangeable Mg (53%), available S (29%), B (32%) and Zn (29%). Deficiency of micro nutrients in soil results in reduced accumulation of sugars, amino acids and organic acids and overall reduction in yield. Efforts to correct this imbalance have to be made through site specific nutrient management taking into consideration the initial soil fertility status.



(a)



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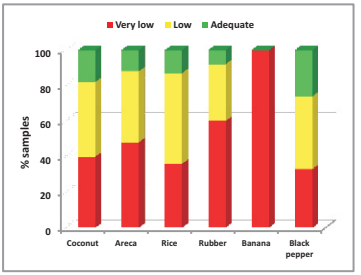
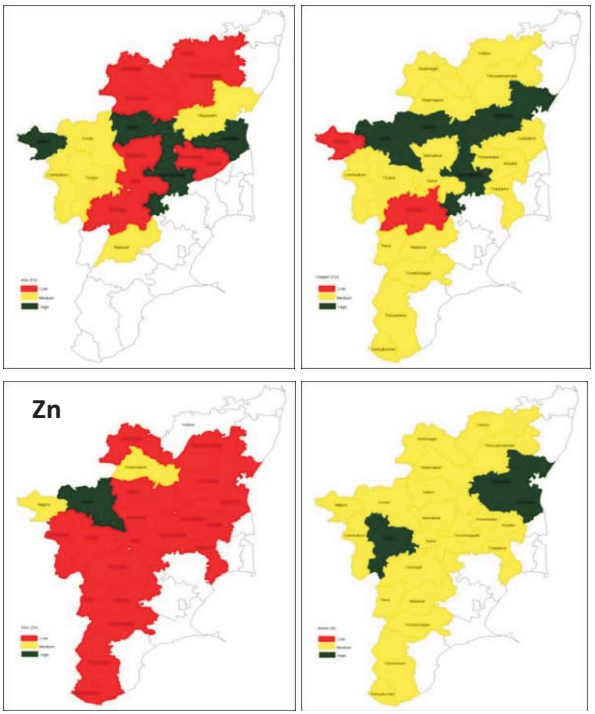


(C)

Fertility status in Kerala Soils (a) soil pH (b) available P (c) available Ca(d) Zn & B fertility map of ginger growing districts of Karnataka

Imbalanced fertilizer application

Recent studies on spice growing areas of Kerala showed an alarming trend of nutrient imbalance. Soils were generally acidic with more then 70% of samples falling below pH 6.0. Nine percent of the samples had high, 30% had very high, (36-100 kg/ ha) and 25% of the soils recorded extremely high available P. The exchangeable K levels were low-medium (69%) and 75% percentage of the samples were low in exchangable Mg and 59% in B (IISR, 2012).As per the ICRISAT survey (2011) the soils of major black pepper growing tracts of Karnataka (Uttara Kannada, Hassan, Chikmagalur, Shimoga, Kodagu districts) are acidic, high in organic carbon content, medium to sufficient in available P, low to medium in K, and just above critical limits in soil available Zn and B.Relatively excess/ indiscriminate and long term use of N & P straight fertilizers, which are generally free from micronutrients, ignoring potential soil amelioration with liming materials, has raised concern about preferential building up of P and imbalance of other nutrients, and created wide spread deficiencies of secondary and micronutrients especially Mg, B and Zn in major spice growing soils.



Fertility map of turmeric growing districts of Tamilnadu

Soil Acidity management

Soil acidity is one of the major factors affecting spice production. Except turmeric and seed spices all the spices are grown in slightly acidic soils.Optimum soil pH for major spice crops and lime recommendation are given in Tables 1 & 2.

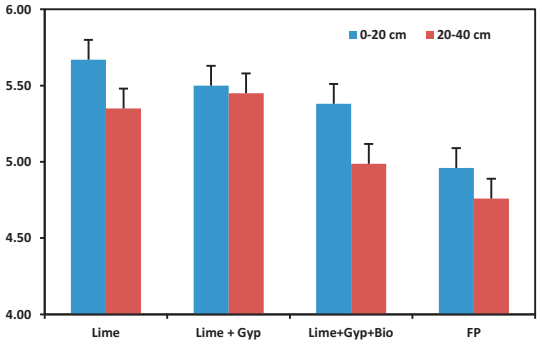
Table 1- Optimum soil pH for major spice crops

Crop	pH Range
Black pepper	6.0-6.8
Ginger	5.5-6.5
Turmeric	6.0-7.5
Cardamom	5.75-6.0
Tree spices	4.5-6.0

Table.2 General Recommendation of lime/ dolomite

Soil pH	Lime/dolomite (kg/acre)
Upto 3.5	1000
3.5-4.4	850
4.5-5.0	600
5.1-5.5	350
5.6-6.0	250
6.0-6.5	100
6.6-7.3	Nil

Application of lime/ dolomite @ 500 to 1000 g per standard in alternate years depending upon the soil pH is recommended for black pepper and @250 to 500g/ plant for cardamom when the soil pH is below 6.0. As most of the ginger and turmeric are grown in acidic soils (especially in NEH states) application of soil amendments like lime and dolomite @ 1-2t/ acre at the time of land preparation will help to improve the productivity of the crop.



Effect of Dolomite + Gypsum application on soil pH

Application of gypsum + dolomite (1:1) also helped in improving the soil pH and addition of gypsum helped in improvement of subsoil acidity in black pepper and nutmeg thereby helping to improve the root activity in the sub soil.

Soil Test based nutrient management in spices

Based on the nutrient uptake pattern it was also observed that more than 50% of the nutrient uptake was mainly distributed during developmental stages. In order to sustain the growth and production, nutrient application should be split evenly between the stages of nutrient demand like new flush production, flowering and berry development. As the soil fertility will be varying with the agro ecological conditions or management systems, site specific nutrient management based on soil test results for major nutrient is advocated.

Black pepper

Manuring and fertilizer application is critical for proper establishment and growth of black pepper plants. Organic manures in the form of cattle manure or compost can be given @ 10 kg/ vine during May. Neem cake @ 1 kg/vine can also be applied.

The targeted yield based recommended dose of nutrients for varying soil test values of N, P and K is given in Table 3. The fertilizers are to be applied in two split doses, one in May-June and the other in August-September and sufficient soil moisture must be ensured. When biofertilizer like *Azospirillum* is applied @ 50 g/vine, the recommended N dose may be reduced by half.

Table 3-Soil test based fertilizer recommendations for dry yield target levels

Soil test value for available nutrients (kg/ha)		Fertilizer nutrient recommended (kg/ha) for yield targets	
		3.0 t/ha	6.0 t/ha
Nitrogen	<150	50	100
	150-250	25	80
	250-400	10	55
	>400	-	20
Phosphorus (P_2O_5)	<10	40	80
	10-30	30	70
	30-50	10	55
	>50	-	30
Potassium (K_2O)	<110	150	310
	110-300	125	275
	300-500	80	250
	>500	35	110

Cardamom

In cardamom plantation it was estimated that 5-8 tonnes of dry leaves from shade trees as mulch contribute approximately 100-160 kg N, 5-8 kg P, 100-160 Kg K, 10-16 kg Ca, 25-49 kg Mg/ ha/ year. Organic manures like cowdung/compost @ 5 kg/plant may be applied during May/June along with rock phosphate and muriate of potash. Under irrigated condition, manuring can be done in two splits (May and September). Application of neem cake @ 1.0 kg + vermicompost @ 2 kg/plant improves plant growth and capsule yield. The general NPK recommendation for cardamom is given in Table 4

Table 4- Fertilizer recommendation for cardamom

Soil application NPK (kg/ha)	Soil-cum-foliar application	Time of application	
		Soil	Foliar
75:75:150 (rainfed - two splits)	NPK 37.5:37.5:75 kg/ha and Urea (2.5%)	May - June	September /
	Singlesuper phosphate (0.75%)	September - October	November /
125:125:250 (irrigated - three splits)	Muriate of potash (1.0%)	December - January	January /

Ginger

At the time of planting, well decomposed cattle manure or compost @ 25-30 tonnes/ha has to be applied over the beds prior to planting or applied in the pits at the time of planting. Application of neem cake @ 2 tonnes/ha at the time of planting helps in reducing the incidence of rhizome rot disease/ nematode and increasing the yield. As the soil fertility will be varying with the soil type, agro ecological conditions or management systems, site specific nutrient management based on the soil test results advocated as given in Table 5.The fertilizers are to be applied in 2-3 split doses. Full dose of P is applied as basal at the time of planting. Equal split doses of N and K is top dressed at 45, 90 and 120 DAP.

Table 5- Soil test based fertilizer recommendation

Soil test value for available nutrients (kg/ha)		Fertilizer nutrient recommended (kg/ha) for yield targets	
		25 t/ha	30 t/ha
Nitrogen	<150	250	340
	150-250	180	270
	250-400	90	175
	>400	-	50
Phosphorus (P_2O_5)	<10	55	75
	10-30	35	55
	30-50	15	25
	>50	-	5-10
Potassium (K_2O)	<110	100	130
	110-300	75	100
	300-500	35	50
	>500	5	15

Turmeric

At the time of planting, well decomposed cattle manure or compost @ 30 tonnes/ha has to be applied over the beds prior to planting or applied in the pits at the time of planting. Application of neem cake @ 2t /ha at the time of planting helps in reducing the incidence of rhizome rot disease/ nematode and increasing the yield. As the soil fertility will be varying with the soil type, agro ecological conditions or management systems, site specific nutrient management based on the soil test results advocated as given in Table 6.The fertilizers are to be applied in 2-3 split doses. Full dose of phosphorus is applied as basal at the time of planting. Equal split doses of N and K is top dressed at 45, 90 and 120 DAP.

Table 6- Soil test based fertilizer recommendation

Soil test value for available nutrients (kg/ha)		Fertilizer nutrient recommended (kg/ha) for yield targets	
		25 t/ha	30 t/ha
Nitrogen	<150	120	170
	150-250	95	125
	250-400	50	90
	>400	-	25
Phosphorus (P_2O_5)	<10	60	90
	10-30	18	50
	30-50	-	-
	>50	-	-
Potassium (K_2O)	<110	275	325
	110-300	230	300
	300-500	150	235
	>500	-	140

Manuring and fertilizer application for Tree spices

Nutmeg

A humid topical climate is the best for nutmeg and it grows up to an elevation of 1000 m above MSL. Nutmeg grows well in clay loam, lateritic clays and loamy soils that are well drained. Recommended fertilizer schedule for a mature plant is 1 kg of ammonium sulphate, superphosphate and muriate of potash along with 50 kg of compost per year. The fertilisers are to be applied during May-June and September-October.The Kerala Agricultural University recommended a fertiliser schedule of 20:18:50 g or NPK along with 15 kg of compost per year during the first year of planting which is to be gradually increased to 500:250:1000 g NPK and 50 kg compost per year from 15th year onwards. Trials under AICRPS revealed that 50 kg FYM+ 400, 350, 1200 g NPK together with 50 g bio fertilizer is optimal.

Cinnamon

Cinnamon is a high dry plant, which tolerates a wide range of climatic conditions and thrives well from 300 to 350 m above MSL. A hot and moist climate is highly suited for its cultivation. It flourishes in a wide range of soils, even in marginal soils with poor nutrient status. Sandy loam soil rich in organic matter is the best. For an adult plant, NPK in the

ratio of 100:18:100 g per year is recommended in Andaman condition. The Kerala Agricultural University recommended a fertiliser schedule of 20:20:25 g of NPK along with 20 kg of compost per year during the first year of planting which is to be gradually increased to 200:180:200 g NPK and 50 kg compost per year from 15th year onwards. Fertiliser may be applied in two splits during May-June and September-October.

Clove

Clove requires a humid climate and grows at 600 m to 1000 m above MSL with a rainfall of 1500-2000 mm and a mean temperatureof 20-30^0 C. Deep red loam, sandy soil and black soil with deep gravely sub soil are suitable without any water logging. Nutrient removal by adult clove tree is in the following trend: K>N>Ca>Mg>S>Mn>P>Fe>Cu>B>Zn.The Kerala Agricultural University recommended a fertilizer schedule of 200:180:200 g NPK and 50 kg compost per year from 15th year onwards.

Soil rhizosphere management in spices

The nature and the characteristics of nutrient release of chemical, organic and biofertilizers are different, and each type of fertilizer has its advantages and disadvantages with regard to crop growth and soil fertility. The significance of the rhizosphere arises from the release of organic material from the root and the subsequent effect of increased microbial activity on nutrient cycling and plant growth. The association between organisms and roots can be beneficial for water uptake, soil stabilization, growth promotion, nutrient mobilization etc.

ICAR-IISR has developed easy and reliable technology of storing and delivering PGPR bioagents as biocapsule. It is a preparation of viable microbial agents in a capsule form that enhances nutrient mobilization and use efficiency, growth and yield and provides protection against diseases at a negligible cost. These capsules are ecologically safe and easily applied by drenching in spices rhizoshere after dilution in 200 to 1000 liters of water for better growth and disease suppression.

Care should be taken to avoid injuries to the roots while performing intercultural operations to prevent infection. For cardamom mulching plant basins with dried leaf/weed materials need to be undertaken in summer. In areas where the roots are exposed due to soil erosion, earthing up the base with topsoil need to be undertaken followed by mulching. In ginger and turmeric, mulching to be done at the time of

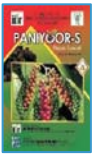
planting with green leaves @ 10-12 tonnes/ha. Application of dried coconut leaves after removing the midrib or paddy straw (2-3 kg/bed) as mulch in ginger is also recommended for effective weed control. Green leaf mulching is to be repeated @ 7.5 tonnes/ha at 45 and 90 days after planting after weeding, fertilizer application and earthing up.

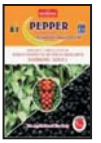
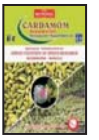
Micronutrient management in spices

Another major constraint in spices crop nutrition is the wide spread deficiency of micronutrients in spice growing soils. Based on research at ICAR-Indian Institute of Spices Research, soil application of zinc sulphate @ 25.0-30.0 kg/ ha is optimum for spices like black pepper, cardamom, ginger and turmeric in Zn deficient soil. Similarly, 10.0-20.0 kg borax/ ha is optimum for spices in boron deficient soil. ICAR-IISR has developed crop specific foliar micronutrient formulations for the major spices envisaging 15.0 to 25.0% yield increase. For one hectare approximately 6.0-8.0 kg mixture costing Rs 1200-1600 may be needed as foliar spray depending upon the crop canopy. For black pepper (IISR Power Mix BP) the formulation has to be applied as foliar spray at the rate of 5 g per litre of water once during flowering (May-June) and another after one month preferably (Aug-September) during berry development stages. Cardamom mixture (IISR Power Mix C) can be sprayed at the rate of 5 g/ litre of water two – three times, during specific stages preferably flowering (April-May) and capsule formation & developmental stages (June –Aug) for best results. Ginger and turmeric micronutrient mixtures were developed for different soil pH conditions as these crops are grown on soils of varying pH conditions. They are recommended as foliar spray at the rate of 5.0 g per litre water, twice, preferably during 60 th and 90 th day after planting of ginger or turmeric. These mixtures are available at ATIC, IISR, Kozhikode (email: atic.spices@icar.gov.in. 0495-2730704) and also with our licensees (see Appendix).

Appendix

List of Licensees producing crop specific micronutrient mixtures

S. No	Crop	Technology	Licensee address	
1.	Ginger	Micro nutrient mix for ginger (for soils with pH above 7)	M/s Hi-7Agro Bio Solutions, #832, Sapthagiri Nilaya, Vasanthnagar, Hessaraghatta, Bengaluru-560088, Karnataka Ph. No: 07799247145/ 08095890808 E-mail: hi7agri@gmail.com	
			M/s Natura Nursery & Agro Meppayur PO, Kozhikode-673524, Kerala Ph. No: 9495083753 naturanursery1@gmail.com	
			M/s. RLCO Innovative Agri Pvt Ltd., ICAR-IISR, Kozhikode Ph: 9496345414; 9995338282 agriblossoms@gmail.com	
2.	Ginger	Micro nutrient mix for ginger (for soils with pH below 7)	M/s Rainbow Agri Life 42-129-9, Jayanagar Colony Kadapa-516002, Andhra Pradesh Ph. No: 08562-245199 Mobile No.: 09848477199	
3.	Turmeric	Micro nutrient mix for turmeric (for soils with pH above 7)	M/s Natura Nursery & Agro Meppayur PO, Kozhikode-673524, Kerala Ph. No: 9495083753 naturanursery1@gmail.com	
4.	Turmeric	Micro nutrient mix for turmeric (for soils with pH below 7)	M/s Rainbow Agri Life 42-129-9, Jayanagar Colony Kadapa-516002, Andhra Pradesh Ph: 08562-245199&09848477199	
5.	Black Pepper	Micro nutrient mix for black pepper	M/s Shrey Agritech B-3, 1st Gate, Industrial Estate Gokul Road, Hubli-580030 Karnataka Ph: 0836-2237199; 09449800913	

			M/s Rainbow Agri Life 42-129-9, Jayanagar Colony Kadapa-516002, Andhra Pradesh Ph: 08562-245199&09848477199	
			Hi-7 Agro Bio Solutions #832, Sapthagiri Nilaya, Vasanthnagar, Hessaraghatta,Bengaluru-560088, Karnataka Ph: 07799247145/ 08095890808 E-mail: hi7agri@gmail.com	
			M/s. RLCO Innovative Agri Pvt Ltd., ICAR IISR, Kozhikode Ph: 9496345414; 9995338282 agriblossoms@gmail.com	
			M/s. Linga Chemicals 3, B-1, Police Station Lane, East Masi Street, Madurai – 625 001. Tamil Nadu. Ph: 0452 – 2321722; 98942 30050; 98940 30050 Email: lingachem@yahoo.com	
			M/s Natura Nursery & Agro Meppayur PO, Kozhikode-673524, Kerala Ph. No: 9495083753 naturanursery1@gmail.com	
6.	Cardamom	Micro nutrient mix for cardamom	M/s Rainbow Agri Life 42-129-9, Jayanagar Colony Kadapa-516002, Andhra Pradesh Ph: 08562-245199; 09848477199	
			Hi-7 Agro Bio Solutions #832, Sapthagiri Nilaya, Vasanthnagar, Hessaraghatta,Bengaluru-560088, Karnataka Ph. No: 07799247145/ 08095890808 E-mail: hi7agri@gmail.com	
			M/s. Linga Chemicals 3, B-1, Police Station Lane, East Masi Street, Madurai – 625 001. Tamil Nadu. Ph: 0452 – 2321722; 98942 30050; 98940 30050 Email: lingachem@yahoo.com	

			Raja G Enterprises #2, Venkitasamy Street, Fort, Salem -636001, Tamilnadu. Ph: 9442245663; 8072555925 rajagenter@gmail.com	
			M/s. A & N Traders Idukki, Kerala nelsonnirmal89@gmail.com Ph: 8848677587; 8593003381	
			M/s Natura Nursery & Agro Meppayur PO, Kozhikode-673524, Kerala Ph. No: 9495083753 naturanursery1@gmail.com	
7	All bioagents	Biocapsules	Codagu Agritech Plot No. 24 / 3 and 24 /4, KIADB Industrial Area, Kudlur, PB No.58 Kushalnagar – 571234 E-mail: codagu.agritech.giu@gmail.com Ph: 09449841800, 09886299801	
			SRT Agro Science Pvt Ltd, Vill: Funda, Tah: Patan,Durg, Chhattisgarh 491111, India srt.pvt.ltd@gmail.com +91 81200 08128