

Bio data of the Scientist

Division/ Section: CROP PRODUCTION

Personal information

1. Name (With Title): Dr. (Mrs.) SUSAN JOHN KUZHIVILAYIL

1. a. Qualification: MSc.(Ag), Ph.D

2. Designation: Principal Scientist (Soil Fertility/Soil Chemistry/Soil Microbiology)

3. Address (Personal): TC. 8/288(1), Kallooppara Vilayil, Sarvadhil Hills, Opposite Loyola School, Sreekariyam P.O. Thiruvananthapuram, Kerala 695 017

4. Phone Numbers:

(a) Residence: 0471-2594298 (b) Office: 0471-2598551- 122 (c) Mobile: 09446324298

5. Email: susanctcri@gmail.com

6. Countries visited: France, Greece, China, Italy, Vatican City, UAE, Australia, Brazil and Belgium

7. Awards Received:

1. International Potash Institute (IPI)-Fertilizer Association of India (FAI) Award 2014
2. International Plant Nutrition Institute (IPNI) Photo contest Award 2016
3. International Zinc Association (IZA)- Fertilizer Association of India (FAI) Award 2017

B. Professional information

1. Area of specialization :

Soil Science and Agricultural Chemistry

2. Area of specialization:

- a. Soil test based plant nutrient management
- b. Secondary and micronutrient management of tropical tuber crops (Soil and foliar)
- c. Diagnosis and correction of nutritional disorders
- d. Screening nutrient efficient genotypes for low input management
- e. Nutrient efficient microbial isolates as substitutes to chemical fertilizers
- f. Cassava starch factory solid waste management for nutrient recycling
- g. Development of customized fertilizer formulations for tuber crops under intercropping in coconut
- h. Cassava mosaic disease management through nutrient management
- i. Rationalization of fertilizer recommendations of tuber crops based on soil and plant requirement
- k. Long term fertilizer cum manurial experiments
- i. Low input management strategy in tropical tuber crops

3. Number of institute projects completed (Add list): 5

1. Mineralization and immobilization of nutrients in tropical tuber crops growing soils
2. Long term effect of manures and fertilizers in an acid Ultisol growing cassava (phase II)
3. Rapid appraisal of the nutrient status of cassava growing soils of Kerala
4. Mineral nutrition of Aroids
5. Screening potassium efficient genotypes for edible and industrial uses

4. Number of Institute projects being handled (Add list): 3

1. Long term fertilizer cum manurial experiment in cassava (phase III)
2. Screening nutrient efficient genotypes for low input management
3. Response of tropical tuber crops to secondary and micronutrients

5. Number of externally funded projects completed (Add list): 3

1. Integrated Nutrient Management Strategy for Tannia (*Xanthosoma sagittifolium* L. Schott) with Special Emphasis on Diagnosis of Nutritional Disorders
2. Soil based plant nutrient management plan for agro-ecosystems of Kerala
3. Application of microorganisms in agriculture and allied sectors: PGPR and Biocontrol

6. Number of externally funded projects being handled (Add list): 2

1. Enhancing the economic viability of coconut based cropping systems for land use planning in Kerala State
2. Response of cassava (*Manihot esculenta* Crantz) to polysulphates in Ultisols (Laterites) and Entisols (Sandy Plains) of Kerala

7. Number of students guided for a) Ph.D: 3 b) M.Phil: Nil c) M.Sc: 10

8. Number of students being guided for a) Ph.D: 4 b) M.Phil: Nil c) M.Sc: Nil

8. a. information about the students under your guidance

Name of the Student	Course Undergoing (Ph.D/M.Phil/M.Sc)	Title of the project/Thesis	E-mail address	Remarks
As Major Guide				
Shanida Beegum S.U.	Ph.D	Low input management strategy in cassava: Implications of rhizosphere dynamics and carbon sequestration under changing global climate	siyas31@gmail.com	Degree awarded
Chithra S	Ph.D	Cassava Starch Factory Solid Waste (Thippi): Prospects	r.chithra66@gmail.com	

		on Utilization for Nutrient Recycling in Cassava Cultivation		
Anju P.S.	Ph.D	Development of customized fertilizer formulations for cultivation of elephant foot yam (<i>Amorphophallus paeoniifolius</i> Dennst. Nicolson) in Kerala for better farm income and improved tuber and soil quality	p4anjusujatha@gmail.com	
Sruthi T	Ph.D	Crop nutrition approach in the occurrence, severity and management of cassava mosaic disease	t.sruthi04@gmail.com	
Remya, D	Ph.D	Integrated plant nutrition package for enhancing the crop and soil productivity of sweet potato and elephant foot yam		
As Co-guide				
Anjana Devi I.P.	Ph.D	Microbial inoculants in elephant foot yam (<i>Amorphophallus paeoniifolius</i> (Dennst. Nicolson) with special emphasis on potassium solubilizers	anjanactcri@gmail.com	Degree awarded
Neetha Soma John	Ph.D	Isolation, evaluation and characterization of bio control agent for the control of collar rot of <i>Amorphophallus</i>	Neethajohn22@yahoo.com	Degree awarded

9. Information on guide ship

Guide ship for Ph.D/	University	Subject
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M.Phil/MSc.		
Ph.D	University of Kerala	Environmental Science

10. Number of Research papers (Add list): 65

1. Susan John K., James George and Sreekumar, J. 2018. Soil test based low input management strategy : a decade experience in cassava (*Manihot esculenta* Crantz) in Ultisols of Kerala, India. *Indian Journal of Agronomy*, 63(2): 216-223.
2. Anju, P.S. , Susan John, K., Bhadraray, S., Suja, G., Jeena Mathew, Nair, K.M., Sunitha, S. and Veena, S.S. 2018. Development of customized fertilizer formulations for tuber crops grown as intercrops in coconut gardens. *Indian Journal of Fertilizers*, 14(10):50-54.
3. Susan John, K., Anju, P.S., Chithra, S., Shanida Beegum, S.U., Suja, G., Pallavi Nair, Sheela, M.N., Anjana Devi and Sruthi, T. 2018. Integrated nutrient management of tropical tuber crops. *Agriculture World*, 4(11):42-47.
4. Jyothi, A.N., Pillai, S.S., Aravind, M., Salim, S.A. and Susan John, K. 2018. Cassava starch graft-poly (acrylonitrile) coated urea fertilizer with sustained release and water retention properties. *Advances in Polymer Technology*, DOI: 10.1002/adv.21943
5. Susan John, K., Anju, P.S., Suja, G., Shanida Beegum, S.U., Chithra, S., James George, Ravindran, C.S., Manikantan Nair, M. and Jeena Mathew. 2018. Zinc nutrition of tuber crops in Ultisols of Kerala. *Indian Journal of Fertilizers* 14(3):50-57.
6. Anju, P.S., Susan John, K., Bhadraray, S., Suja, G. and Jeena Mathew 2018. Development of customized fertilizer formulations for elephant foot yam under intercropping in coconut for two agro ecological units of Kerala. *Indian Journal of Scientific Research*, 19(1): 6-9.
7. Susan John, K., Sheela, M.N. and Suja, G. 2017. 'Sree Pavithra', the first K use efficient variety in cassava. *Agriculture World*, 3(11): 52-55.
8. Chithra, S., Susan John, K., Manikantan Nair, M. and Sreekumar, J. 2017 Management of Cassava Factory Solid Waste (Thippi) through Composting to a Nutrient-Rich Organic Manure. *Communications in Soil Science and Plant Analysis*, 48(6)595-607
9. Chithra, S., Susan John, K. and Sreekumar, J. 2016. Low cost traditional cassava starch factory solid waste (thippi) composting: a possible strategy for organic nutrient management and economic security for tribal farmers. *Journal of Root Crops*, 42(2):52-58.
10. Anju, P.S., Susan John, K., Bhadraray, S., Suja, G., Jeena Mathew, Nair, K.M., Sunitha, S. and Veena, S.S. 2016. Development of protocol for custom mixed

fertilizers for elephant foot yam under intercropping in coconut gardens of the two agro ecological units of Kerala. *Journal of Root Crops*, 42(2):66-74.

11. Susan John, K., Shanida Beegum, S.U., Sheela, M.N. and Suja, G. 2016. Nutrient efficient genotypes in cassava: scope to substitute for chemical fertilizers and in C sequestration. *Acta Horticultura* 1118.ISHS. 2016. DOI 10.17660/ActaHortic.2016.1118.29. XXIX-Proc. Int.Symp.on Root and Tuber Crops: Sustaining Lives and Livelihoods into the Future (Ed.) J.R. Schultheis, pp. 193-200.
12. Susan John, K., James George, Shanida Beegum, S.U. and Shivay, Y.S. 2016. Soil fertility and nutrient management of tropical tuber crops-An overview. *Indian Journal of Agronomy*, 61(3):263-273.
13. Shanida Beegum, S.U., Susan John, K., Sheela, M.N. and Sreekumar, J. 2015. Low cost cassava production strategy through nutrient use efficient genotypes integrated with low input management. *Journal of Root crops*, 41(2): 42-48.
14. Susan John, K., Ravindran, C.S. and James George 2015. Soil test and plant analysis as diagnostic tools for fertilizer recommendation for cassava in an Ultisol of Kerala, India. *Communications in Soil Science and Plant Analysis*, 46:13, 1607-1627
15. Laxminarayana, K., Susan John, K., Mukherjee, A. and Ravindran, C.S. 2015. Long term effect of lime, mycorrhizae and inorganic and organic sources on soil fertility, yield and proximate composition of sweet potato in Alfisols of Eastern India. *Communications in Soil Science and Plant Analysis*, 46: 605-618
16. Anjana Devi, I.P., John, N.S., Susan John, K., Jeeva, M.L. and Misra, R.S. 2015. Rock inhabiting potassium solubilizing bacteria from Kerala, India: characterization and possibility in chemical K fertilizer substitution. *Journal of Basic Microbiology: Environment- Health- Techniques* : 55, 1-11.
17. John, N.S., Anjanadevi, I.P., Nath, V.S., Sankar, S.A.,Jeeva, M.L., Susan John, K. and Misra, R.S.2015. Characterization of Trichoderma isolates against *Sclerotium rolfsi*, the collar rot pathogen of *Amorphophallus*- A polyphasic approach. *Biological Control*, 90:164-172.
18. Parvathy, P. C., Jyothi, A. N., Susan John, K. and Sreekumar. J. 2014. Cassava starch based superabsorbent polymer as soil conditioner: Impact on soil physico- chemical and biological properties and plant growth. *Clean- Soil, Air Water*, doi:[10.1002/clen.201300143].
19. Rajasekharan, P., Nair, K.M., Susan John, K., Suresh Kumar, P., Narayanan Kutty, M.C. and Ajith, R.N. 2014. Soil fertility related constraints to crop production in Kerala. Accepted for publication in the *Indian Journal of Fertilizers*, 10(11): 56-62.

20. Susan John, K., Ravi, V., Shanida Beegum, S.U., Ravindran, C.S., Manikantan Nair, M. and James George. 2014. Recommended nutrient management practices in the carbon sequestration potential of cassava (Two decades experience from a long term fertilizer experiment). *Indian Journal of Fertilizers*, 10 (4), 28-33.
21. Chithra, S., Susan John, K. and Manikantan Nair, M. 2013b. Thippi compost: a possible avenue for cassava starch factory solid waste management. *Journal of Root Crops*, 39(2):87-92.
22. Imas, P. and Susan John, K. 2013. Potassium nutrition of cassava. *International Potash Institute Research Findings: e-ifc No. 34*.
23. Shanida Beegum, S.U. Susan John, K. and Sreekumar, J. 2013. Nutrient efficient genotypes and nutrient management practices in the carbon sequestration potential of cassava: a theoretical approach., *Journal of Root Crops* 39(2):68-72.
24. Susan John, K., Remya Raj, R.T. and Suja, G. 2013. Dolomite: the best soil ameliorant for tannia in an Ultisol of Kerala. *Indian Journal of Fertilizers*, 9(11):44-55.
25. Susan John, K., Ravindran, C.S., James George, Manikantan Nair, M. and Suja, G. 2013. Potassium: a key nutrient for high yield and better tuber quality in cassava. *Better Crops South Asia*, International Plant Nutrition Institute, 7(1):26-28.
26. Susan John, K., Laxminarayana, K. and Ravindran, C.S. 2013. Meeting nutrient demand of tubers. *Indian Horticulture*, 58(3):45-49.
27. Anjanana Devi, I.P., Neetha Soma John, Susan John K., Jeeva, M.L. and Misra, R.S. 2013. Isolation and characterization of N fixing bacteria from elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson) growing regions of South India. *Journal of Root Crops*, 39(2):154-162.
28. Susan John, K. and Suja, G. 2012. Optimum nutrient rate and nutritional constraints in tuber crops growing in Ultisol of India with special emphasis on tannia. *Communication in Soil Science and Plant Analysis*, 43 (22) : 2924-2934.
29. Suja, G., Sundaresan, S., Susan John, K., Sreekumar, J. and Misra, R.S. 2012. Higher yield, profit and soil quality from organic farming of elephant foot yam. *Agronomy for Sustainable Development*, 32:755-764.
30. Susan John, K., Bharathan, R., Manikantan Nair, M. And Suja, G. 2012. Soil based nutrient management plan for Pathanamthitta district of Kerala state. *Journal of Root Crops*, 38(1): 32-41.
31. Suja, G., Sreekumar, J., Susan John, K and Sundaresan, S. 2012. Organic production of tuberous vegetables: agronomic, nutritional and economic benefits. *Journal of Root Crops*, 38(2): 135-141.
32. Laxminarayana, K., Susan John, K., Ravindran, C.S. and Naskar, S.K. 2011. Effect of lime, inorganic and organic sources on soil fertility, yield, quality and nutrient uptake

- of sweet potato in Alfisols. *Communication in Soil Science and Plant Analysis*, 42(20):2515-2525.
33. Suja, G., Susan John, K. and Sreekumar, J. 2011. Impact of nutrient management based on soil test data on biomass production and partitioning and growth indices of short duration cassava (*Manihot esculenta* Crantz). *Indian Journal of Agricultural Sciences*, 81(3): 247-251.
 34. Susan John, K. 2011. Soil fertility management strategies for edible yams and aroids: a review. *Journal of Root Crops*, 37(1): 3-18.
 35. Susan John, K. 2012. Soil-plant nutrition of sweet potato and minor tuber crops: a review. *Journal of Root Crops*, 37(2):111-124.
 36. Suja, G., Susan John, K., Sreekumar, J. and Srinivas, T. 2010. Short-duration cassava genotypes for crop diversification in the humid tropics: Growth dynamics, biomass, yield and quality. *Journal of the Science of Food and Agriculture*, 90:188-198.
 37. Susan John, K. 2010. Integrated nutrient management strategy for tropical tuber crops. *Indian Journal of Fertilizers*, 6(11):88-96.
 38. Susan John, K. 2010. Dynamics of nutrients under cassava (*Manihot esculenta* Crantz) grown in an Ultisol of Kerala. *Journal of Root Crops*, 36(1): 1-13.
 39. Susan John K., Ravindran, C.S., Suja, G. and Prathapan, K. 2010. Soil test based fertilizer cum manurial recommendation for cassava growing soils of Kerala. *Journal of Root Crops*, 36(1): 44-52.
 40. Suja, G., Susan John, K., Ravindran, C. S., Prathapan, K. and Sundaresan, S. 2010. On farm validation of organic farming technology in elephant foot yam (*Amorphophallus paeoniifolius* Dennst. Nicolson). *Journal of Root Crops*, 36(1): 59-64.
 41. Susan John, K., Suja, G., Sheela, M.N. and Ravindran, C.S. 2010. Potassium: The keynutrient for cassava production, tuber quality and soil productivity- An overview. *Journal of Root Crops*, 36(2): 132-144.
 42. Suja, G., Susan John K. and Sreekumar J.2010. Soil test based nutrient management for short-duration cassava (*Manihot esculenta*). Analysis of growth, biomass, yield, quality, nutrient uptake and soil nutrient status. *Indian Journal of Agronomy*, 55(4): 66-72.
 43. Susan John, K., Ravindran, C.S. and Manikantan Nair, M.2009. Macronutrient status of cassava growing soils of Kerala. *Journal of Root Crops* 35 (1): 41-49.
 44. Suja, G., Susan John, K. and Sundaresan, S. 2009. Potential of tannia (*Xanthosomasagittifolium* L.) for organic production. *Journal of Root Crops* 35(1) : 36-40.

45. Susan John, K., Ravindran, C.S. and Manikantan Nair, M. 2009. Secondary and micronutrient status of cassava growing soils of Kerala. *Journal of Root Crops* 35(2):175-181.
46. Suja, G., Susan John, K., Ravindran, C. S., Prathapan, K. and Sundaresan, S. 2010. On farm validation of organic farming technology in elephant foot yam (*Amorphophallus paeoniifolius* Dennst. Nicolson). *Journal of Root Crops*, 36(1): 59-64.
47. Sheela. M.N., Radhika, V.S., Susan John, K. and Abraham, K. 2008. Variation in crude protein, dry matter and starch in inbred and backcross lines of cassava. *Journal of Root Crops*, 34(2): 115-119.
48. Susan John, K., Venugopal, V.K. and Saraswati, P. 2007. Yield maximization in cassava through a systematic approach in fertilizer use. *Communications in Soil Science and Plant Analysis*, 38(5&6):779-794.
49. Susan John, K., Venugopal, V.K. and Maikantan Nair, M. 2007. Dry matter production, nutrient uptake, tuber quality and soil nutrient status as influenced by substitution of common salt for muriate of potash for cassava in an oxisol of Kerala. *Journal of Root Crops*, 33(1): 20-25.
50. Ramesh, V., Susan John, K., Ravindran, C.S. and Edison, S. 2007. Agro techniques and plant nutrition of tannia (*Xanthosoma* sp.): An overview. *Journal of Root Crops* 33(1):1-11.
51. Susan John, K. and Venugopal, V.K. 2006. Nutrient use Efficiency and balance sheet of nutrients under MYR in cassava. *Journal of Root Crops*, 32(2): 154-161.
52. Susan John, K. and Venugopal, V.K. 2006. Response of cassava to lime in a typic kandiuistult of Kerala. *Journal of Root Crops*, 32(1): 65-71.
53. Susan John, K. and Venugopal, V.K. 2005. Optimizing the nutritional status of a typic kandiuistult of Kerala, India using sorption study. *Communications in Soil Science and Plant Analysis*, 36 (17&18) 2329-2342.
54. Susan John, K., Venugopal, V.K. and Manikantan Nair, M. 2005. Crop growth, yield and quality parameters associated with maximum yield research (MYR) in cassava. *Journal of Root Crops*, 31(1): 14-17.
55. Susan John, K., Venugopal, V.K. and Saraswathi, P. 2004. Critical levels of phosphorus and potassium in a Typic kandiuistult of Kerala. *Journal of Root Crops*, 30(1): 37-40.
56. Susan John, K. and Venugopal, V.K. 2005. Soil fertility evaluation of a cassava growing Typic kandiuistult of Kerala. *Journal of Root Crops*, 30(2):151-153.
57. Susan John, K., Shalini Pillai, P., Nair, G.M. and Chithra, V.G. 2004. Phosphorus and potassium deficiency symptoms in sweet potato under a sand culture experiment. *Journal of Root Crops*, 30(1): 5-9.

58. Susan John, K., Ravindran, C.S. and Mohan Kumar, C.R. 2003. Cassava starch content as modified by continuous application of manures and fertilizers. *Journal of Root Crops*, 29(2):64-68.
59. Susan John, K., Venugopal, V.K. and Saraswathi, P. 2003. Effect of substitution of common salt for muriate of potash on growth, yield, yield components and economics of cassava production in a Typic kandiustult of Kerala. *Journal of Root Crops*, 29(2):36-41.
60. Susan John, K., Shalini Pillai, P., Nair, G.M. and Chitra, V.G. 2001. Critical concentration as a reflect of potassium requirement of sweet potato in acid ultisol. *Journal of Root Crops*, 27(1): 223-228.
61. G. M. Nair., Potty, V.P. and Susan John, K. 2001. Influence of biofertilizer (*Azospirillum*) on the growth and yield of sweet potato. *Journal of Root Crops*, 27(1): 210-213.
62. Susan John, K., Ravindran, C.S. and Mohan Kumar, C.R. 1998. Yield, dry matter production and uptake of phosphorous as influenced by sources of phosphatic fertilizers in cassava (*Manihot esculenta* Crantz) in an acid ultisol. *Journal of Root Crops*, 23(2):89-94.
63. Susan John, K., Kabeerathumma, S. and Potty, V.P. 1996. Nutrient availability in relation to soil microbial biomass in a long term manurial trial of cassava cultivated in an acid ultisol. *Journal of Root Crops*, 22(2) : 88-92.
64. Susan John, K. and Alice Abraham. 1996. Effect of seasons on microbial population and nutrient availability in cassava soil. *Journal of Root Crops*, 22(1):40-44.
65. Susan John, K. and Alice Abraham. 1995. Microbial immobilization and mineralization of nutrients during different seasons of the year. *Journal of the Indian Society of Soil Sci.* 43(1):47-53.

11. Number of Books/Book chapters (Add list): 12

1. DOA, 2012. Department of Agriculture, Government of Kerala. *A Manual on Soil, Plant and Water Analysis (Vol.1)*, (eds.) V.K. Venugopal, K.M. Nair, M.R. Vijayan, **K. Susan John** and P. Suresh Kumar, pp.183
2. DOA, 2012. Department of Agriculture, Government of Kerala. '*A Manual on Organic Manure Analysis*' (Vol. 2), (eds.) V.K. Venugopal, K. Usha Kumari, M.R. Vijayan, **K. Susan John** and P. Suresh Kumar, pp.76
3. Geetha, K., Susan John, K., Dhanyamol, K., Praveena, N., Radhika, T.A., Manikantan Nair, M., Jibi Joseph, Sherin Paul and Anuroopa, S. 2013. Soil fertility: Kottayam district. In: *Soil Fertility assessment and information management for enhancing crop productivity in Kerala*. P.Rajasekharan, K.M. Nair, G. Rajasree, P. SureshKumar and M.C. Narayanan Kutty (Eds.), Kerala State Planning Board, Thiruvananthapuram, Kerala, pp. 284-304.

- 4.Nair, K.M., Saifudeen, M., Suresh Kumar, P., Narayan Kutty, M.C. and Susan John, K. 2013. Fertility of Soils of Kerala. In: *Soil Fertility assessment and information management for enhancing crop productivity in Kerala*. P.Rajasekharan, K.M. Nair, G. Rajasree, P. SureshKumar and M.C. Narayanan Kutty (Eds.), Kerala State Planning Board, Thiruvananthapuram, Kerala, pp. 136-168.
- 5.Susan John, K., Remya Raj, R.T. and Suja, G. 2013. Integrated nutrient management strategy for tannia (*Xanthosoma sagittifolium* L.Schott) in an Ultisol of Kerala, India. In: *Aroids: Opportunities and Challenges*, R.S. Misra and M. Nedunchezhiyan (Eds.), Allied Publishers Private Limited, New Delhi, pp. 170-183.
- 6.Susan John, K., Manikantan Nair, M., Sherin Paul, Anuroopa, S., Geetha, K., Dhanyamol, K., Praveena, N. and Radhika, T.A. 2013. Soil Fertility: Pathanamthitta district. In: *Soil Fertility assessment and information management for enhancing crop productivity in Kerala*. P.Rajasekharan, K.M. Nair, G. Rajasree, P. SureshKumar and M.C. Narayanan Kutty (Eds.), Kerala State Planning Board, Thiruvananthapuram, Kerala, pp. 377-399.
- 7.Susan John, K. and Suja, G. 2012. Tropical tuber crops: Response to acidic soil conditions and management. In: *Acid Soils of India: Distribution, Properties and Management for Sustainable Crop Production* (Eds. K. Sudhir, C.A. Srinivasamurthy, V.R. Ramakrishna Parama, N.B. Prakash, A. Sathish, S.C. Kotur), University of Agricultural Sciences, Bengaluru, pp. 79-94.
- 8.Priya Nair, Poornima, R., Misra, R.S. and Susan John K. 2010. Potential phosphate solubilising bacteria from various soils of Kerala. In: *Organic Horticulture Principles, Practices and Technologies* (Eds. H.P.Singh & G.V.Thomas), Westville Publishing House, New Delhi, pp. 279-281.
- 9.Ravindran, C. S., Suja, G. and Susan John K. 2008. Agro-techniques and quality planting material production in minor tuber crops. In: *Advance Techniques in Quality Planting Material Production and Commercial Cultivation of Tropical Tuber Crops* (Ed.) Nedunchezhiyan, M. Regional Centre, Central Tuber Crops Research Institute, Bhubaneswar, Orissa, India, pp.53-59.
- 10.Susan John, K., Ravindran, C.S. and James George 2006. Long term effect of organic manures on cassava : Yield, quality, sustainability and economics. In: *Root and Tuber Crops: In Nutrition, Food Security and Sustainable Environment* (Eds.) Naskar, S.K. Nedunchazhiyan, M., Rajasekhara Rao, K., Siva Kumar, M., Ray, R.C., Misra, R.S. and Mukherjee, A. Bhubaneswar, Orissa. pp. 139-147.
- 11.Kabeerathumma, S., Susan John, K., Mohan Kumar, C. R. and Ravindran, C. S. 1996. Long term effect of organic manures on tuber yield and soil fertility build up in cassava grown in an acid ultisol. In: *Tropical Tuber Crops: Food Security and Nutrition*, (Eds., Balagopalan, C., Nayar, T.V.R., Sundaresan, S., Prem Kumar, T. and Lakshmi, K.R.), Oxford and IBH Publishing Co. Ltd., New Delhi, pp.298-305.
12. Susan John, K., Mohan Kumar, C.R., Ravindran, C.S. and Prabhakar, M. 1998. Long term effect of manures and fertilizers on cassava production and soil productivity in an acid Ultisol. In: A. Swarup, D. Damodar Reddy and R.N. Prasad (Eds.), *Proceedings of a*

National workshop on Long term soil fertility management through integrated plant nutrient supply . Indian Institute of Soil Science, Bhopal, India, pp. 319-326.

12. Number of Technical Bulletins (Add list): 7

1. Susan John, K. 2017. An Agro Advisory Guide on Diagnosis and Correction of Nutritional Disorders in Tropical Tuber Crops, *Technical Bulletin Series No. 66*. ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 32p.
2. Susan John, K., Ravindran, C.S., Manikantan Nair, M. and James George. 2014. *Nutrient status of cassava growing soils of Kerala*. Technical Bulletin Series, 56, Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, India, 60 p.
3. Susan John, K., Ravindran, C.S., Manikantan Nair, M. and James George. 2014. *Soil test based fertilizer cum manurial recommendation for cassava growing soils of Kerala*. Technical Bulletin Series, 57, Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, India, 44 p.
4. Ravindran, C.S., Ramanathan, S., Susan John, K. and Sudha Devi, K.S. 2014. *Kizhangu vargangalude krishireethikal* (In Malayalam). Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, 40p.
5. Susan John K. 2012. Nutrient management plan for Elanthur block of Pathanamthitta District. A joint publication of Department of Agriculture, Govt. of Kerala, Kerala State Planning Board & Central Tuber Crops Research Institute, pp. 30.
6. Susan John, K. Suja, G., Edison, S. and Ravindran, C.S. 2006. Nutritional Disorders in Tropical Tuber Crops. Technical bulletin Series No. 48, Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, pp.74.
7. Susan John, K., Ravindran, C.S. and James George. 2005. Long term fertilizer experiments-Three decades experience in cassava. Technical bulletin Series No. 45, Central tuber crops Research Institute, Thiruvananthapuram, Kerala pp.

13. Consultancies offered (Add list and give a brief description):10

1. Chemical analysis of soil, plant, water and organic manures
2. Establishment of soil testing laboratories
3. Soil test based fertilizer cum manurial recommendation including secondary and micronutrients for tropical tuber crops
4. Diagnosis and correction of nutritional disorders in tropical tuber crops
5. Protocol for the development of customized fertilizer mixtures
6. Development of nutrient rich organic manure from cassava starch factory solid waste (thippi)

7. Soil and foliar application of nutrients for tropical tuber crops under INM
8. Integrated nutrient management on tropical tuber crops
9. Development of soil test based Soil health cards
10. Nutrient use efficient cassava genotypes

14. Technologies developed (Add list and give a brief description):

1. Soil test based fertilizer cum manurial recommendation for tropical tuber crops

a. Recommendation for farm yard manure (FYM) based on soil organic carbon

Table 1. Rate of application of FYM based on soil organic carbon status

Organic carbon (%)	Rate of application of FYM (t ha ⁻¹)
<0.50	12.5
0.50-0.75	10.0
0.75-1.00	7.50
1.0-1.5	5.00
>1.50	2.50

b. Soil test based recommendation for Mg, Zn and B

Table 2. Rate of application of Mg, Zn and B based on soil test data

Soil Mg status (meq/100g)	Rate of application of MgSO ₄ (kg/ha)	Soil Zn status (ppm)	Rate of application of ZnSO ₄ (kg/ha)	Soil B status (ppm)	Rate of application of Borax (kg/ha)
0-0.25	20	<0.2	12.5	<0.2	10
0.25-0.50	15	0.2-0.3	10.0	0.2-0.5	7.5
0.50-0.75	10	0.3-0.4	7.5	0.5-1.0	5.0
0.75-1.00	5	0.4-0.6	5.0	1-2	2.5
>1.00	2.5	>0.6	2.5	>2.0	0

Mg and Zn are included in the Package of Practices recommendations of Kerala Agricultural University Crops-2011, pp. 58.

2. Integrated nutrient management practices for tannia (*Xanthosoma sagittifolium* L. Schott)

Tannia is an important tuberous vegetable grown extensively as intercrop mostly in coconut and banana plantations. Though the crop fetches high price among the different tropical tuber crops, its growth and yield is affected by some nutritional disorders. Subsoil acidity due to Al³⁺ ions resulting Mg deficiency was diagnosed as the problem and application of dolomite @1 t/ha was found as the suitable soil ameliorant to rectify this problem. Since the crop was not having a nutrient recommendation, the INM strategy also was evolved as NPK @ 80:50:150 kg ha⁻¹ + 25 t ha⁻¹ farm yard manure (FYM). The strategy was standardised as application of dolomite as soil amendment @ 1 t ha⁻¹ (80 g/plant) during ploughing and keeps the land as such for 2 weeks, application of FYM @ 25 t ha⁻¹ in pits and P @ 50 kg ha⁻¹ as basal, plant the *Pseudomonas* treated cormel/corm, sow green manure cowpea immediately after planting tannia, apply N fixer within 1 month of planting tannia, apply neem cake in pits after 1 month of N fixer application, apply 1/3 fertilizer N and 1/3 fertilizer K within 2

months after planting (MAP), apply 1/3 fertilizer N and 1/3 fertilizer K within 4 MAP, apply the rest of 1/3 fertilizer N and 1/3 fertilizer K within 6 MAP.

3. Green manuring in situ with cowpea as the best organic manure source for cassava

In tropical tuber crops, application of organic manures are very important from the point of view of modifying the soil physical properties for better tuberization and tuber bulking. At ICAR-CTCRI, under the long term fertilizer experiment (LTFE) in progress since 1977, from 1990 onwards, among the different organic manures used to substitute for FYM viz., crop residue incorporation, green manuring in situ with cowpea, coir pith compost and vermicopost, green manuring in situ was found the best in terms of tuber yield, monetary benefit, improvement in soil properties and controlling weeds. The cowpea seeds can be sown @ 25 kg/ha after ploughing the field with application of full P, half N and half K of the recommended dose for cassava during the second week of April. If there is sufficient rain, there will be enough vegetative growth within 45-60 days to the tune of 15-25 t/ha which can be ploughed and incorporated into the soil while taking mounds for planting cassava.

4. Avoiding the use of P in high P soils

As regards to the nutrient uptake by cassava, it is found that, compared to N and K, the uptake of P is one tenth to the range of 15-25 kg/ha for a tuber production of 30 t/ha. Moreover, over N and K, there is no loss of P due to its immobile nature in soil, resulting its building up to several manifold on continuous application. Under the LTFE, since 2005, based on soil test data which was found very high to the tune 100-125 kg/ha due to continuous application from an initiation status of 30-40 kg/ha, P was omitted and the tuber yield data did not show any significant difference with P applied at the recommended dose of 50 kg/ha. Hence, if the soil test is far above high or very high, application of P can be skipped at least for 5 years till the level comes to the high (around 25 kg/ha).

5. Nutritional disorders due to deficiency of K, Ca, Mg, and B in cassava and its correction

In the acid laterite soils of Kerala, the deficiency of these nutrients are rampant if proper nutrient management involving these nutrients are not done. K deficiency is characterized by drying and necrosis of the tip and margins of lower leaves which can be prevented by balanced application of MOP. If symptoms are initiated, either apply MOP as per POP to soil and in severe cases, foliar application of sulphate of potash 0.5-1% can be resorted to. Ca and B deficiency usually seen in upper younger leaves due to the immobility of these nutrients in plant system. Ca deficiency is manifested as round appearance of the tip of the leaves instead of pointed tip. It can be prevented by either regular soil application of lime or dolomite @ 1 t/ha especially in the case of Ca sensitive varieties. After appearance, foliar spraying of calcium nitrate @ 0.5-1% is advised. Mg deficiency usually appear as interveinal chlorosis of mature lower leaves and is prevented by either soil application of dolomite @ 1-2 t/ha or magnesium sulphate @ 20 kg/ha. In severe cases, foliar application of magnesium sulphate @ 0.5-1% can be done. B deficiency usually appear as rosette look at the plant apex with small sprouts in clusters or bunches with reduced / crinkled leaves / distorted appearance affecting the growth of the plant. Soil application of either borax or boric acid @ 10 kg/ha to prevent the symptom and once appeared, foliar application of CaNO₃ (0.5%) along with solubor (0.05-0.1%) (combined) at fortnightly intervals till the plant recoup can be done. However, Ca, Mg and B deficiencies are variety specific.

6. Low input management strategy in cassava

A low input management strategy for cassava was developed involving NUE genotypes viz., CI 905 and CI 906, soil test based application of fertilizers including secondary and micronutrients as N:P:K:MgSO₄:ZnSO₄ @ 106:0:89:15:2.5kg/ha, green manuring *in situ* with

cowpea as organic manure source and nutrient use efficient bio fertilizers viz., N fixer (*Bacillus cereus*), P solubilizer (*Bacillus megaterium*) and K solubilizer (*Bacillus subtilis*). This strategy resulted in a tuber yield of 33.68 and 34.72 t ha⁻¹ with CI 905 and CI 906 respectively having a BC ratio of 4.43 and 4.57 respectively saving P, K, Mg and Zn to the tune of 100, 11.5, 62.5 and 80% respectively with reduction in input cost up to 55%.

7. Nutrient use efficient genotypes in cassava

The objective of identifying nutrient use efficient (NUE) varieties is to reduce the dependence on chemical fertilizers as these genotypes because of its unique root system or leaf architecture can scavenge the soil nutrients or harness the sunlight effectively. The experiments conducted at ICAR-CTCRI since 2007 in this line resulted in releasing the first K efficient variety by name 'Sree Pavithra' in 2015 which was an elite landrace (Aniyoor). Further experiments conducted could identify two N efficient genotypes viz., W-19 and CR 43-8 which require 50% of the recommended dose of N which are yet to release. Three NPK efficient genotypes viz., CI 905, CI 906 and 7 III E3-5 having good cooking quality were in pipeline which can reduce/ substitute for chemical NPK fertilizers up to 75%. The three NPK efficient genotypes are under farmers field trials in different districts of Kerala now.

8. Nutrient recycling in cassava through cassava starch factory solid waste (thippi) composting

In Tamil Nadu, cassava is used for the production of industrial starch and sago and there is large scale generation of starch factory solid waste (thippi) causing enormous environmental pollution. We explored the possibility of making some value added organic manures from thippi and among the various protocols tried, the cheap and traditional way of composting using earthworms gave better result in making it in to a nutrient rich organic manure. It had the highest plant nutrient content with low C:N ratio (8:1). The mean N, P, K, Ca and Mg, Fe, Mn, Cu and Zn content in thippi compost was 1.32, 3.82, 0.40, 2.18, 0.96, 1.11, 0.08%, 11.23 and 89.93 ppm respectively which is 3.5, 49.7, 32.5, 8, 185, 100, 2.5 and 12 times compared to raw thippi which is having a C:N ratio of 82:1. The mineralization pattern of nutrients from thippi compost indicated the maximum release of almost all nutrients during 5-7th month. Field experiments conducted for two seasons indicated thippi compost as an alternative to FYM, green manuring *in situ* with cowpea, crop residue incorporation, vermicompost and coir pith compost and even NPK fertilizers up to 50% of the recommended dose, MgSO₄ @ 2.5 kg/ha and ZnSO₄ @ 2.5 kg/ha.

9. Customized fertilizer mixtures for elephant foot yam (EFY) intercropped in coconut gardens

Customized fertilizer formulations contain the required plant nutrients together in one mixture where each granule of the mixture has the component nutrients in the specific grade formulated based on soil and crop requirement which in turn facilitates easy and timely application in one shot. Based on a series of experiments conducted for EFY under AEU 3 and AEU 9, which covers the major tuber crops growing tracts of Kerala, three grades of the mixtures were evolved viz., N : P₂O₅ : K₂O : Mg : Zn : B @ 8 : 11 : 21 : 3.5 : 1 : 0.3 (CF1), 7:12:24:2.5:1.25:0.4 (CF2) and 7:3:25:3:1.25:0.4 (CF3). Usually the CF is applied basally which contains N and K @ 20 and 70% respectively and the remaining N and K will be applied as top dressing. Experiments conducted with these three formulations at two rates viz., 500 and 625 kg/ha indicated CF2 @ 625 kg/ha is best for EFY. For cassava under intercropping in coconut, CF1 and CF2 @ 500 kg/ha was found good. This is yet to popularise among farmers.

10. NUE bio fertilizers in reducing chemical fertilizers in EFY

As in the case of NUE cultivars, NUE microbes viz., N fixers, P and K solubilizers also form a component of INM practices where in by using these microbes, we can reduce the use of chemical fertilizers. In this line also, the research work conducted at ICAR-CTCRI since 2007 resulted in the isolation, identification and characterization of *Bacillus cereus*, *Bacillus megaterium* and *Bacillus subtilis* respectively as N fixer, P and K solubilizers and experiments conducted using these microbes to substitute for chemical fertilizers in elephant foot yam and sweet potato resulted in saving 25% each of N and K and P up to 50-75%.

15. Patents/Copyrights obtained (Add list and give a brief description):Nil

Technologies included in Package of Practices (PoP) of Kerala Agricultural University

1. Soil test based fertilizer cum manurial recommendation for tropical tuber crops

Package of Practices recommendations of Kerala Agricultural University Crops-2011, pp. 58.

2. Integrated nutrient management practices for tannia (*Xanthosoma sagittifolium* L. Schott)

Tannia crop along with INM strategy developed for the crop by CTCRI was included in the **Package of Practices recommendations of Kerala Agricultural University, 'Crops 2016'** 15th Edition, Kerala Agricultural University, Thrissur, pp. 392