GOVERNMENT OF KERALA

THIRTEENTH FIVE-YEAR PLAN
(2017-2022)

WORKING GROUP ON

AGRICULTURE RESEARCH AND ICT IN AGRICULTURE

REPORT

AGRICULTURE DIVISION

STATE PLANNING BOARD
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CHAPTER1
AGRICULTURAL RESEARCH IN KERALA DURING THE 11TH AND 12TH FIVE YEAR PLANS: AN OVERVIEW

Introduction

1. Agricultural research and education in Kerala are spearheaded by the Kerala Agricultural University, which was established in 1972. Modelled after the land grant colleges in the US on the basis of the recommendation of the Second National Education Commission (1964-66) led by Dr D.S. Kothari, the then Chairman of the University Grants Commission, KAU had been the only in situation entrusted with research, extension and education in agriculture, animal husbandry, fisheries, forestry and cooperation till when the Kerala Agricultural University was trifurcated into Kerala Veterinary and Animal Sciences University (KVASU), Kerala University of Fisheries and Ocean Studies (KUFOS) and Kerala Agricultural University (KAU), in 2011.

2. Currently the KAU has six colleges (three Agriculture, one Agricultural Engineering, one Forestry, one Co-operation Banking & Management), six RARSs, seven KVKs, 15 Research Stations and 16 Research and Extension Units under the faculties of Agriculture, Agricultural Engineering and Forestry. In addition, one Academy on Climate Change Adaptation and one Institute of Agricultural Technology offering M.Sc. (Integrated) Climate Change Adaptation and Diploma in Agricultural Sciences respectively have also been established in KAU.

3. Research in agriculture in the state is also supported by the research centres of the Indian Council of Agricultural Research (ICAR) located in Kerala. While the KAU has the mandate of research in all the general aspects of agriculture, ICAR institutes are mandated to work on specific crops/enterprises. The ICAR institutions include the Central Plantation Crops Research Institute, Central Tuber Crop Research Institute and the Indian Institute of Spices Research. The ministry of commerce is also involved in research of a few major crops with IRRI involved in technology generation and dissemination in rubber and the Spices Board, Coffee Board and the Coconut Board involved in limited research on respective sectors.

4. In spite of its well defined mandate of extension and development administration, the Department of Agriculture also contributes to research and development in agriculture in a limited manner, mainly through the Biotechnology and Model Floriculture Centre and the network of Bio Control Laboratories, Soil Testing Laboratories, Fertiliser Quality Control Laboratories, Seed Testing Laboratories and Agmark Grading Laboratories. .Alongside, the Kerala Agro Industries Corporation (KAICO), a joint venture of the Government of India and the Government of Kerala promotes mechanisation and modern technology in agriculture through setting up of agro industries, infrastructure development, value addition, waste management, and so on. The Vegetable and Fruit Promotion council Keralam (VFPCK) also plays a key role in promoting production of fruits and vegetables, vegetable seeds, establishment and organising farmer markets, farmer participatory technology development and refinement etc. An overview of the existing institutional facilities of agricultural research in Kerala is given in Table1.

Table 1 *An Overview of Existing Institutional Facilities for Agricultural Research in Kerala*

Crop	Number of Research Centres	Major Agency
Rice	2	Kerala Agricultural University
Coconut	1	Kerala Agricultural University
	2	CPCRI
Spices	2	KAU
	1	IISR – ICAR
	1	Spices Board
Fruits and Vegetables	3	KAU
Cashew	1	KAU
Cocoa	1	KAU
Tubers	1	CTCRI –ICAR
Medicinal and aromatic plants	1	KAU
Farming Systems/Cropping Systems	2	KAU
General	8	KAU
Soils	23	Department of Agriculture
Seed quality	2	Department of Agriculture
	1	Kerala Agricultural University
Fertilizers	2	Department of Agriculture
Pesticides	1	Department of Agriculture
Pesticide Residueand Bio safety	1	KAU
AGMARK Grading	10	Department of Agriculture
Agricultural Engineering/ Mechanization	2	Kerala Agricultural University
Food Processing	3	
Protected cultivation	4	
Water Management	1	KAU
	1	CWRDM
All India Coordinate Research Projects	39	
Geographical Information System	Nil	

Source: Administrative and Annual Reports of the Kerala Agriculture University, the Department of Agriculture and the ICAR

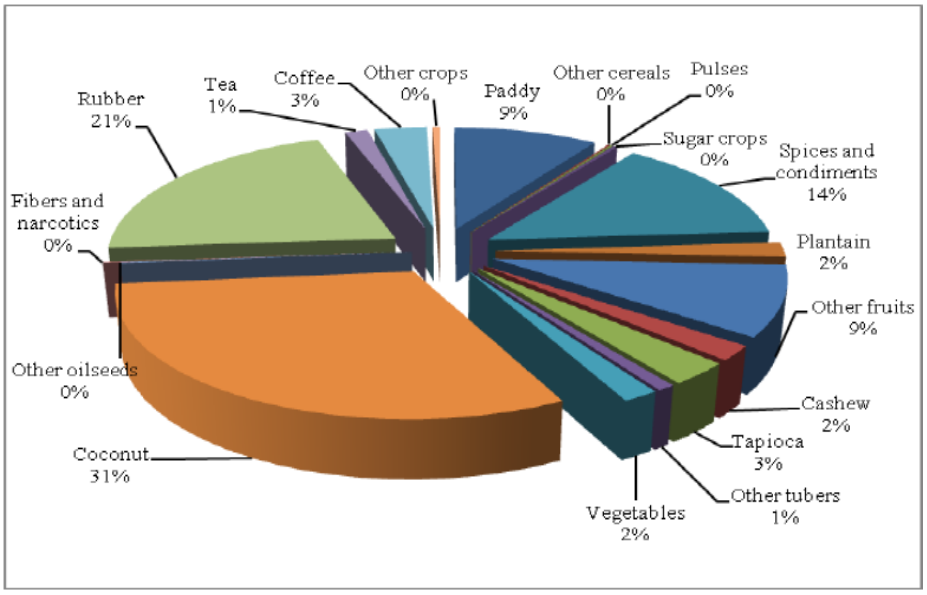
5. The five Regional Agricultural Research stations, three Agricultural Research stations and colleges of the Kerala Agricultural University are responsible for conducting research on crop improvement, crop production and crop protection. Emerging areas like mechanization, protected cultivation, water management, food processing and value addition etc. are also given due weightage in the R& D institutions in the state.

6. The Department of Agriculture is also deeply involved in capacity building and technology dissemination activities through its vast network of Krishi Bhavans, two Farmers' Training Centres, 10 Mobile Agro Clinics, and eight Sales-cum-Service Depots. The pest surveillance activities in the state are carried out by the Operational Research Project (Pest Surveillance Unit), at Mancombu. There are also five Regional Agricultural Technology Training Centres in operation in Kerala.

7. Though all these institutions would not be exclusively involved in agricultural research, most of these institutions provide significant inputs for research and development in agriculture.

8. Agriculture in Kerala is different from that of the rest of the country in terms of cropping pattern, with a highly diverse terrain spread across 27 distinct agro climatic regions ranging from high-altitude zones that have temperate climate to coastal regions with humid tropical climate. This physiographic diversity also accounts for the immense agro biodiversity which consists of submerged wetlands, mostly utilised for cultivation crops like paddy and sugarcane. In the lower slopes, where the water table is fairly high, but soil is drained, annual crops like tapioca, plantains, vegetables, minor roots and tubers, and perennial crops like coconut, rubber, mango, cashew, arecanut, etc., are preferred. The highlands of Kerala support crops like tea, coffee, cardamom, ginger, turmeric, and, even temperate vegetables, like cabbage and cauliflower. The geographical distribution of area under major crops of Kerala is presented in Figure-2. Coconut occupies the highest area among all other crops in Kerala with a share of 31 per cent area under it. This is followed by rubber (21%), which has gained considerable area under it in the recent years. Spices and condiments that include pepper, cardamom, turmeric, ginger, cinnamon, clove, vanilla, nutmeg, etc., claim a share of 14 per cent, whereas paddy, the main staple food of Kerala, has only 9 per cent area under its cultivation. Banana and other fruits together constitute an area share of 11 per cent, whereas all other crops-crop groups together have less than 14 per cent area under them.

Figure 1 *Distribution of cropped area under various crops in Kerala 2009-10*



Source: Agricultural Statistics at a Glance, 2011

9. The distribution of crops based on area indicates the relative importance of each crop in the economy of the state, and to some extent, the preference of the farming community. This is also influenced by the socio economic characteristics of the clientele system, which is predominantly constituted by small and marginal farmers. Agriculture in Kerala is mostly small holder oriented, which requires customized packages for each agro climatic zones and socio economic categories. This feature of agriculture in the state also warrants emphasis on procurement methods, storage, and value addition besides the usual emphasis on enhancement of production.

Financial Assistance to Kerala Agricultural University: An Overview

10. The changes in the allocation and utilization of funds made available by various agencies are given below Table2.

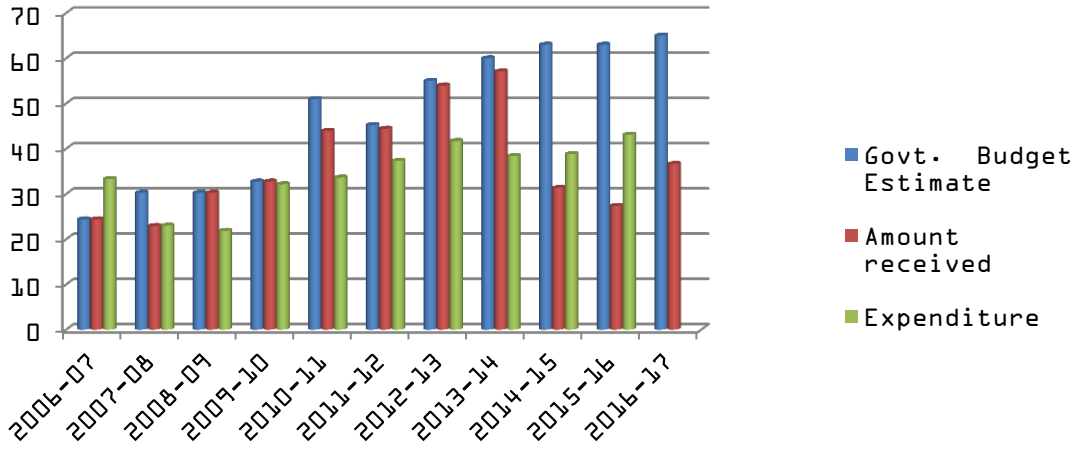
Table 2 *Allocation of Plan Funds to the KAU Since 2006-07* in rupees crore

Financial Year	Govt. Budget Estimate	Amount received	Expenditure
2006-07	24.40	24.40	33.31
2007-08	30.25	22.93	23.00
2008-09	30.25	30.25	21.85
2009-10	32.75	32.75	32.14
2010-11	51.00	43.94	33.63
2011-12	45.25	44.43	37.32
2012-13	55.00	54.00	41.71
2013-14	60.00	57.08	38.38
2014-15	63.00	31.33	38.81
2015-16	63.00	27.37	43.10
2016-17	65.00	36.64	

Source: Various Administrative and Annual Reports of Kerala Agriculture University

11. The decadal trends in the allocation, actual receipts and expenditure show that there had not been consistent and proportionate increase in the allocation. More surprisingly, the actual receipts had been much below the budget estimate in 2007-08, 2010-11, 2013-14, 2014-15, 2015-16 and 2016-17. This mismatch was very high in 2014-15 and 2015-16 as the KAU received only half of the plan allocation (See Fig 2).

Figure 2 *Distribution of plan fund allocation, receipts and expenditure in KAU across years*



Source: Various Administrative and Annual Reports of Kerala Agriculture University

12. The uneven distribution of plan fund allocation, receipts and expenditure in KAU across years show that the R and D programmes envisaged by the university on its own remain mostly unfinished or not even initiated for want of funds. Since the university cannot rely on plan funds solely, research is mostly realized by funds from external sources like the ICAR, DBT, DST etc. The trends in the availability of funds and the proportion of external funds to plan funds would clearly show the level of dependence of the KAU on external sources for accomplishing its research objectives.

13. It is evident from Table 3 that there has been consistent increase in the funds realized from external aided projects which is mostly contributed by ICAR. Financial assistance from other external aided projects has also increased except in 20011-12, 2013-14 and 2015-16 during which years a decrease from the preceding year was noticed.

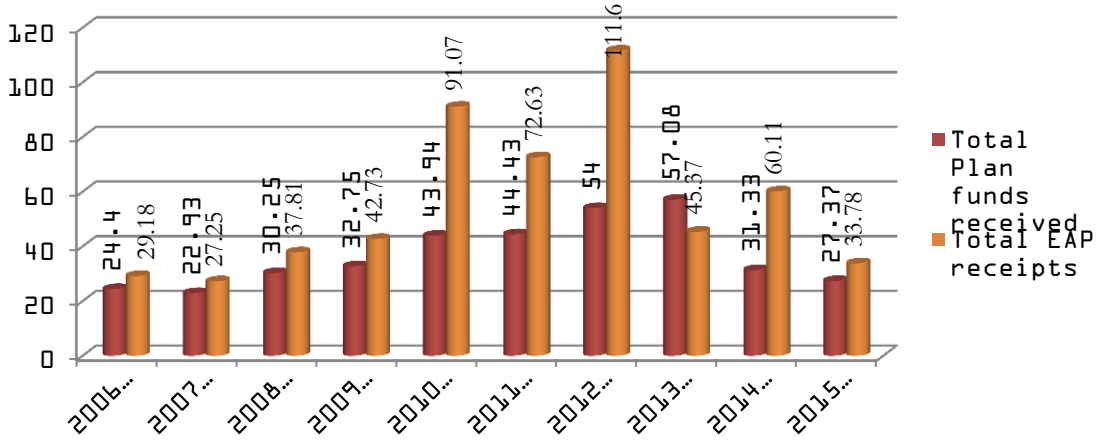
Table 3 *Distribution of funds from various external aided projects from 2006-07 to 2016-17*

Financial Year	ICAR	OEAP*	Total EAP Receipts	Expenditure ICAR	Expenditure OAEP	Total EAP Expenditure
2006-07	21.57	7.61	29.18	15.13	6.98	22.11
2007-08	17.18	10.07	27.25	11.95	7.22	19.17
2008-09	18.96	18.85	37.81	17.77	22.84	40.61
2009-10	19.05	23.69	42.73	21.42	19.91	41.33
2010-11	51.54	39.53	91.07	28.87	28.39	57.26
2011-12	69.04	3.59	72.63	33.84	25.38	59.22
2012-13	78.14	33.46	111.60	29.76	22.35	52.11
2013-14	20.49	24.88	45.37	37.89	37.10	74.99
2014-15	23.39	36.72	60.11	38.22	27.18	65.40
2015-16	16.58	17.20	33.78	33.91	20.94	54.85

Source: Various Administrative and Annual Reports of Kerala Agriculture University
Note: *Other Externally Aided Project

14. It is also seen that a considerable proportion of the financial assistance required to conduct research in KAU is realized from external sources as shown in Fig 3. The steep rise in EAP receipts in 2012-13 was the result of the special package of 100 crore granted to the KAU, out of which only around 40 per cent was released.

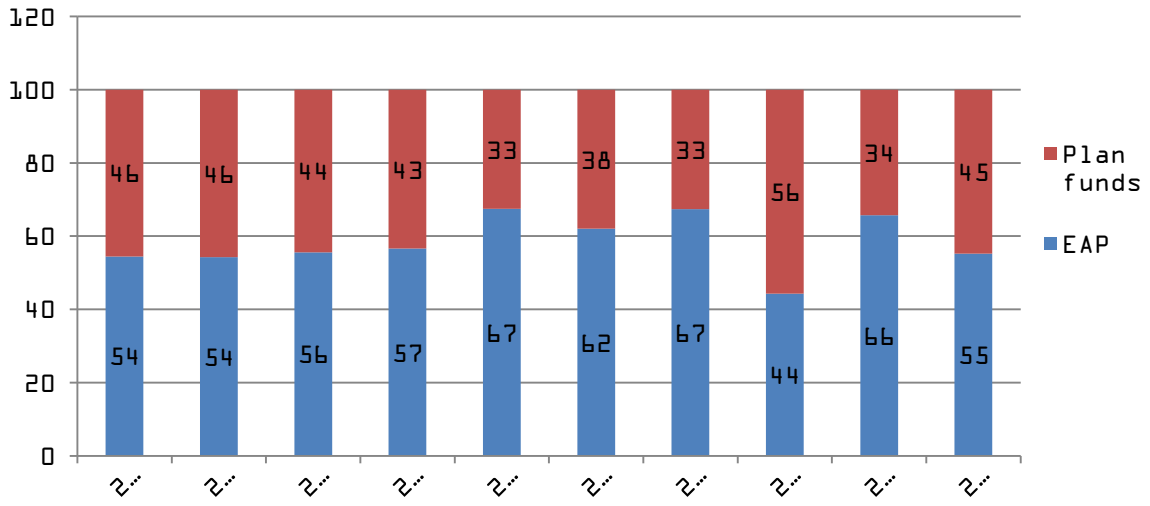
Figure 3*Yearly Distribution of Financial Assistance for Research in KAU from Plan Funds and EAPs*



Source: Various Administrative and Annual Reports of Kerala Agriculture University

15. As seen in Fig 4, the proportion of external aids for research has been on the rise, except in 2013-14. Needless to say, an ever increasing dependence on external aided projects for meeting the R&D requirement in the agricultural sector should be subjected to serious examination as the funds from external sources may vary based on the policy of the central government and/or other funding agencies, which would compel the research institutions in KAU to pursue projects as per the requirement and choice of funding agencies.

Figure 4 *Proportion of Plan Funds and External Aids Availed for Research in KAU*



Source: Various Administrative and Annual Reports of Kerala Agriculture University

Distribution of Plan Funds across the Major Mandates of the Kerala Agricultural University

16. Distribution of plan funds across various mandated functions of the university shows that during 2008-09 to 2010-11, educational institutions had been given more plan funds compared to other institutions and research was found to have received higher proportions in 2013-14 and 2014-15, though the aggregate amounts had been low.

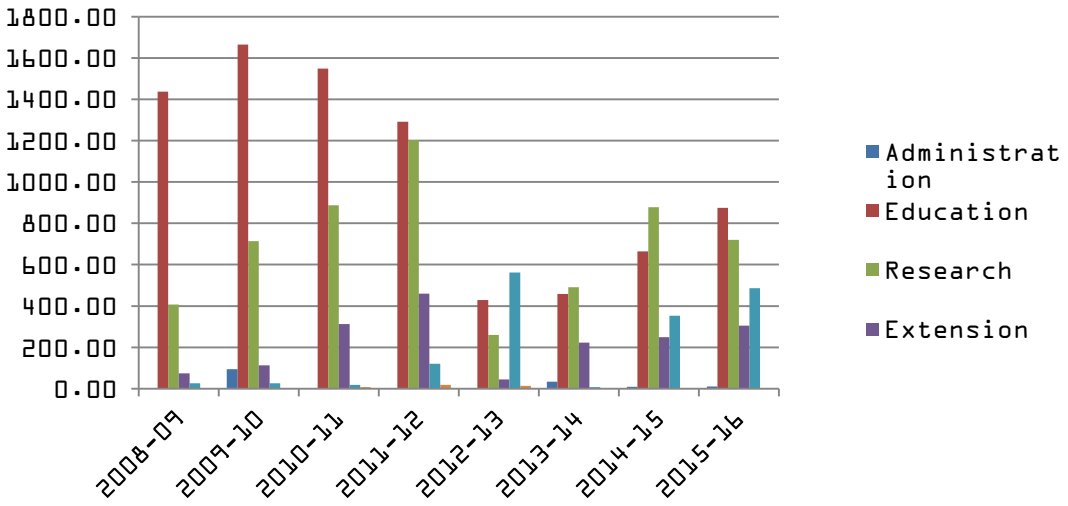
Table 4 *Allocation of Plan Funds During from 2008-09 to 2015-16 Across Major Mandates* in rupees lakh

Mandates	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Administration	0.06	94.65	1.57	3.59	1.25	33.84	9.27	10.33
Education	1437.30	1665.28	1548.75	1291.26	428.87	457.97	664.93	874.39
Research	407.15	714.18	886.62	1203.43	259.72	491.14	878.01	719.62
Extension	74.14	112.38	312.71	459.41	44.00	222.21	249.80	304.83
Mandates	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Civil	26.45	26.07	18.36	120.13	561.49	8.32	352.97	485.68
Estate	1.96	1.25	6.90	17.96	14.43	0.00	0.00	0.00
Others	0	0	0	0				

Source: Compiled from account reports of the KAU (Amounts in lakh)

17. Though the plan allocation during 2008-09 to 2015-16 has been segregated across major mandated functions, it would be still difficult to draw logical conclusions on the emphasis of the university as the accounts are presented in terms of contributions to institutions. For instance, the higher proportion of allotment to education during the initial years of this reference period could be due to the emphasis on infrastructure facilities at educational institutions during 2005-06 to 2010-11. However, distribution of plan funds in recent years shows relatively even distribution between education and research (See Fig 5)

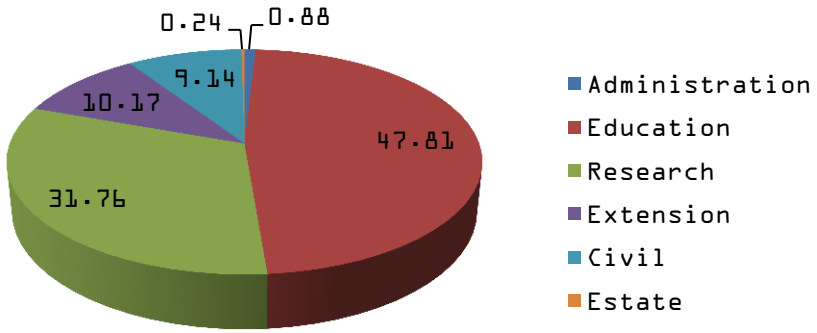
Figure 5 *Allocation of plan funds during from 2008-09 to 2015-16 across major mandates*



Source: Various Administrative and Annual Reports of Kerala Agriculture University

18. The overall distribution of plan funds during the period from 2008-09 to 2015-16 estimated as percentage of the total funds received show that the major activities of the university viz. education and research were given 47.81 per cent and 31.76 per cent of the total plan funds respectively. Extension institutions are found to have received 10.17 per cent of the plan funds. Project based funding by the State Planning Board initiated during the 12th five year plan period had helped to receive adequate assistance for research projects in the University. However undue delay in approving the projects at the government level and further release of funds to the University had adversely affected the implementation of projects. If the plan fund could be released during the first quarter of the financial year itself, this could have been avoided.

Figure 6 *Percentage Distribution of Plan Funds across Major Activities of KAU*



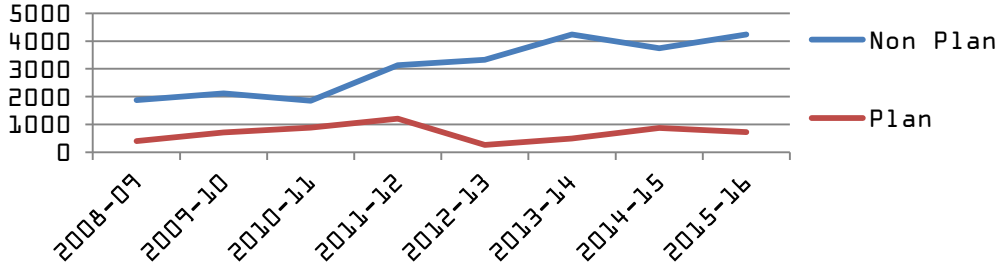
Source: Various Administrative and Annual Reports of Kerala Agriculture University

Trends in the Allocation of Plan and Non Plan Funds for Major Activities of KAU

19. Trends in the allocation of plan and non-Plan funds for major mandates of the KAU are shown in Figures 7, 8 and 9 shown below:

20. As evident from the Fig 7 below, the non-Plan allocation had been far above the plan allocation with consistent increase of the former and consistent decrease of the latter.

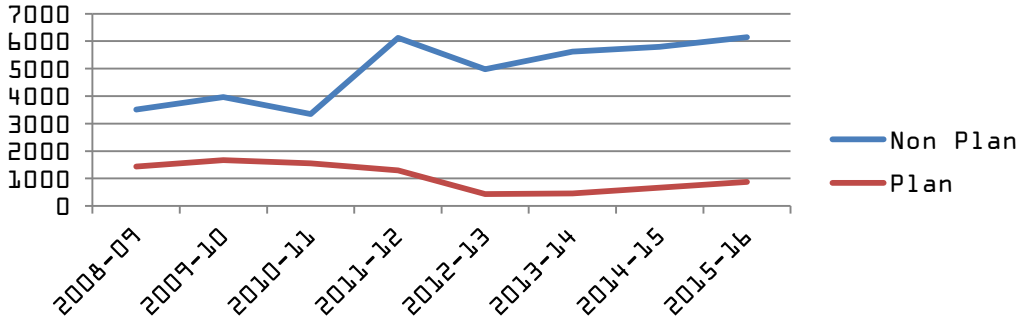
Figure 7 *Trend in the allocation of plan and non-Plan funds for research in KAU*



Source: Various Administrative and Annual Reports of Kerala Agriculture University

21. While the plan allocation has recorded general decline, the non-Plan segment of funding which is largely utilized for establishment and other over dues has been increasing, which indicates the gravity of resource crunch in designing and implementing research programmes by plan funds. This trend is not different from the decline in proportion of plan funds for education as well, as evinced by the pattern of fund allocation shown in Fig. 8.

Figure 8 *Trend in the Allocation of Plan and Non Plan Funds for Education in KAU*

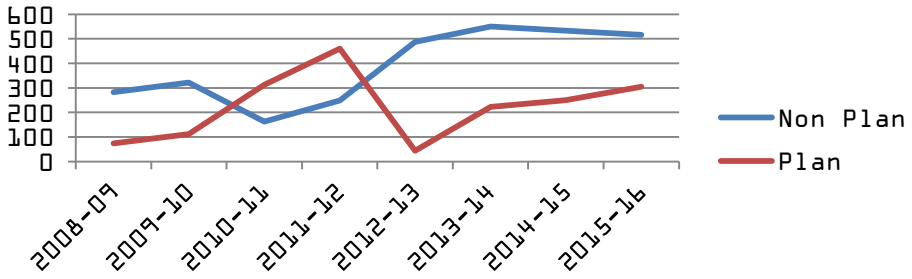


Source: Various Administrative and Annual Reports of Kerala Agriculture University

22. In education, allocation of plan funds showed a severe decline over a period from 2008-09 to 2015-16, with only marginal rise during the period from 2013-14 to 2015-16.

23. However, extension activities of the university were found to have been funded generously during the period from 2009-10 to 2011-12, mainly through plan funds for building up infrastructure facilities in extension institutions.

Figure 9 *Trends in the Allocation of Plan and Non Plan Funds for Extension in KAU*



Source: Various Administrative and Annual Reports of Kerala Agriculture University

24. The apparent rise in non-Plan allocation during the period from 2009-10 to 2011-12 was found to be followed by a severe decline in plan funds in subsequent years, with the non-Plan allocation recording consistent increase.

25. Pattern of fund allocation and expenditure presents a disturbingly grim picture, with the university reeling under unmanageable financial constraints. The financial management of the university should adopt a multi-pronged approach of enhancing internal revenue at least thrice its current position, reducing expenses in all possible ways, allocation of non-Plan funds as an one time contingent allocation for overcoming existing liabilities, consistent annual increase in non-Plan allocation by 20 per cent, enhancing plan funds to the tune of 100 crore, inter institutional collaboration in flagship projects with discernible outcomes in selected areas by exploring external sources of funds to the every possible extent. Diversifying the activities of the university to cater to diverse categories of end users would be a key approach towards accomplishing this goal.

Emphases of Agricultural Research in KAU during 2006-10

26. Research in the KAU is organized under well-defined project coordination groups, which covers all possible frontiers of existing and emerging research domains (See Appendix 1)

27. A review of research projects implemented by the KAU during 2006-10 and 2011-16 show that there had not been much difference in the emphasis on the thrust areas over a decade (Table 5). While taking the number of research projects initiated by the university during this period as an indicator of the emphasis on various key areas of research, it could be found that rice and rice based cropping systems accounted for 19 per cent of the total projects in 2006-10, which has got significantly reduced to 12 per cent in 2011-14.

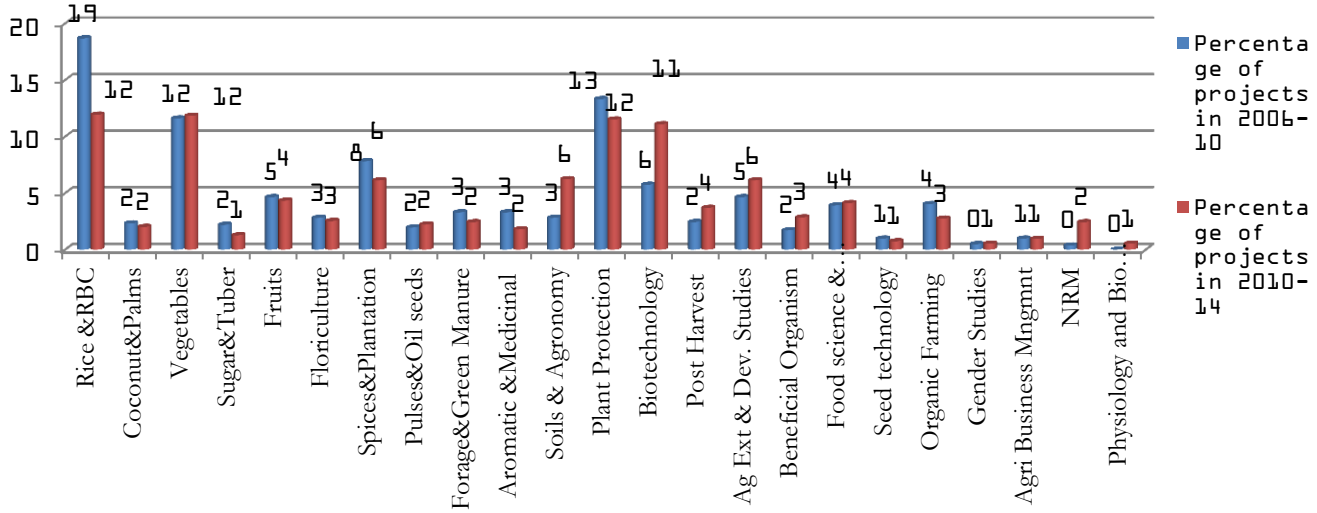
Table 5 *Project Coordination Group Wise Distribution of Research Projects During2006-2014**

Project co-ordination group	Number of projects in 2006-10	Percentage of projects in 2006-10	Number of projects in 2011-14	Percentage of projects in 2011-14
Rice and Rice-based cropping system(RBC)	153	19	113	12
Coconut and Other Palms	19	2	19	2
Vegetables	95	12	112	12
Sugar and Tuber crops	18	2	12	1
Fruits	38	5	41	4
Floriculture	23	3	24	3
Spices and Plantation Crops	64	8	58	6
Pulses and Oil seeds	16	2	21	2
Forage and Green Manure crops	27	3	23	2
Aromatic and Medicinal Plants	27	3	17	2
Soils and Agronomy	23	3	59	6
Plant Protection	109	13	109	12
Biotechnology	47	6	105	11
Post Harvest Technology	20	2	35	4
Agricultural Extension and Development Studies	38	5	58	6
Beneficial Organism	14	2	27	3
Food science & Nutrition	32	4	39	4
Seed technology	8	1	7	1
Organic Farming	33	4	26	3
Gender Studies	4	0	5	1
Agri Business Management	8	1	9	1
Natural Resource management	3	0	23	2
Crop Physiology and Bio chemistry	0	0	5	1
Total	**819**	**100**	**947**	**100**

*Note:**Compiled from the research reports of the Kerala Agricultural University from 2006-2014

28. The total number of projects during these two distinct periods has increased by 15.62 per cent. The change in the number of projects under each thrust area during the reference period is given below (Fig 5). Projects in vegetables, fruits, floriculture and pulses and oil seeds were found to increase by 18 per cent, 8 per cent, 4 per cent and 31 per cent respectively. However, number of projects in soils and agronomy, bio technology, post-harvest technology and beneficial organisms have increased substantially at the rate of 157 per cent, 123 per cent, 75 per cent and 97 per cent respectively. In social sciences, development and gender studies have also increased significantly.

Figure 10 *Percentage Distribution of Research Projects across Thrust Areas During 2006-07 to 2009-10 and 2010-11 to 2015-16*



Source: Various Administrative and Annual Reports of Kerala Agriculture University

29. The number of projects in organic farming was found to decrease by 21 per cent compared to the previous period.

30. Though the number of projects in a discipline would not clearly explain the actual emphasis on research, this trend shows the research gaps in some crops and enterprises that would be of importance to the state. For example, there is a pressing need to enhance research interventions in processing and value addition to evolve cost effective indigenous techniques of value addition, adaptation of exotic technologies and exploration of the market potential of value added projects. But the emphasis on processing and value addition is found to be very less. Similarly, research on coconut seems to have been given a low priority recently, which requires to be enhanced in collaboration with the CPCRI and the Coconut Board. The KAU, which has spearheaded coconut research earlier, has almost receded from this domain. Another important sector which requires immediate attention is research on pulses and oil seeds. With the production of pulses in Kerala going down heavily and the emphasis on pulses as a source of protein increases, research and extension on pulses requires. As understood from the pattern given above, low research contribution of the KAU on natural resource management, soil science, floriculture, etc. does not comply with the development potential of these sectors in Kerala.

CHAPTER 2
ACCOMPLISHMENTS OF AGRICULTURAL RESEARCH INSTITUTIONS IN KERALA

31. The status of research on major crops of Kerala and enterprises in agriculture is briefly described below. This has been compiled from the research reports of major research institutions in Kerala.

Major Research Accomplishments of the Kerala Agricultural Universityduring11th and 12th Five Year Plan

32. Research in the conventional as well modern frontiers of agriculture have been carried out by the university during the period from 2009 to 2014. Crop improvement programmes that had been zealously implemented by various research centres have yielded an array of high yielding, pest and disease resistant and stress tolerant varieties in all the major crops of Kerala as shown in Table 6 below:

Table 6 *Details of varieties released by KAU*

Crop	Number of varieties released	Crop	Number of varieties released
Rice	119	Garcinia	2
Coconut	7	Cocoa	15
Cashew	16	Sugarcane	6
Vegetables	69	Pulses	7
Banana	2	Oil crops	12
Jackfruit	1	Tuber crops	7
Pineapple	1	Medicinal and aromatic plants	9
Pepper	8	Fodder grass	2
Cardamom	2	Orchid	5
Turmeric	4	Mushroom	7
Ginger	2	Others	7
Cinnamon	1		

Source: Various Administrative and Annual Reports of Kerala Agriculture University

33. The details of improved varieties released from KAU during the 11th and 12th plan period are shown in Table 7.

Table 7*Improved Varieties from KAU during11th and 12th Five Year Plan*

Crop	11th five year plan	12th five year plan
Rice	Vaisakh	Ezhome 3
	Samyukta	Sreyas
	Prathyasa	Ezhome 4
	Thulam	VTL 9
	VTL 8	Amrutha
	Ezhome 1	Jaiva
	Ezhome 2	
Coconut		KeraMadhura
Cashew	Sree	
Vegetables- Chilli	Samrudhi	VellayaniThejas
		Keerthi
Brinjal		Ponny
Tomato		Akshaya
		Manu Lakshmi
		Manu Prabha
Vegetablecowpea		Githika
Snake gourd		Harithasree
Cucumber		F1 Heera
		F1 Shubra
Ash gourd		Thara
Water melon		F1 Shonima
		F1Swarna
Drumstick	Anupama	
Pulse cow pea	Sreya	
	Hridya	
Pepper		Panniyur 8
		Vijay
Ginger	Athira	Aswathi
	Karthika	
Garcinia		Amrutham
		Haritham
Jack fruit		Sindoor
Sugar cane		Abhay
		Aromal
Cocoa		CCRP 11
		CCRP 12
		CCRP 13
		CCRP 14
		CCRP 15
Fodder Cowpea		Aiswarya
Fodder Rice bean		Surabhi
Medicinal plant -Asoka		Aswani
Mushroom		Bheema
Total varieties	**14**	**37**

34. For popularizing improved varieties and bio control agents, the University had also taken up production of seeds and planting materials in a big way. Seeds and plating materials of more than 500 varieties/clones are in progress in 36 centres, and 12 tissue culture labs. Production of bio

control agents and bio inoculants for supporting organic farming was also organized in 14 centres in KAU.

35. Production of seeds and planting materials of major crops during the last five years are given below (Table 8):

Table 8 *Production of seeds and planting material during the period from 2011-12 to 2015-16*

Sl No	Crop varieties	2011-12	2012-13	2013-14	2014-15	2015-16
1	Paddy (MT)	393.857	174.796	106.008	254.3827	280.11
	BS	12.643	12.922	9.654	9.959	10.846
	FS	9.64	0.981	0.323	0.342	0.593
	TLS	371.574	160.893	96.031	244.0817	268.671
2	Vegetable seeds (MT)	10.987	12.693	10.971	12.843	14.067
3	Coconut seedlings(No.s)	108907	117259	98633	152688	163590
4	Pepper root cuttings(No.s)	624385	660923	392170	1308178	1280051
5	Mango grafts (No.s)	194562	144756	129194	255005	257784
6	TC Plants (Nos.)	203302	340163	413137	227828	347587
7	Bio control agents (MT)	5601	5259	18912	61435	101971

36. The other important accomplishments of the Kerala Agricultural University specifically during2009-14 are briefly described below:
    1. *GI registration.* Obtained GI registration for Pokkali rice, Jeerakasala rice, Gandakasala rice, Kaipad rice, Vazhakulam pineapple, Central Travan core Jaggary, Chengalikodan Nendran and was awarded Plant Genome Xaviour Award thrice and Community Award once.
    2. Besides KAU has also standardized structural designs of poly-houses and production technologies of protected cultivation, seedling production, open field precision farming; formulated ready to use micronutrient formulations, developed various composting inoculums, bio- inoculants and bio control agents, etc. suitable to the various or agro-climatic zones in Kerala. These technologies are being popularized among farmers.
    3. Interventions in honey bee cultivation, development of alcohol free inflorescence sap from Coconut (Keramrudham), addressing farmer's problems through the "KarshakaSanthwanam", decontaminating fruits and vegetables from pesticide residue using "Veggie-Wash" etc. developed in KAU were largely accepted by the public. A number of farm implements were also developed by the University in the area of farm mechanization.
    4. About 130 technologies have been approved in the mini PoP of KAU was recommended by the State PoP workshop and these are included in the KAU PoP Crops 2016.

Rice

37. Rice, the third important crop in terms of area under cultivation, way behind rubber and coconut had been on a consistent decline as majority have abandoned rice production due to various reasons. Though there had been a marginal increase in area and production, in 2014-15, it again showed a declining trend. Moreover, the productivity of the crop is very low in the State (2837kg/ha), though it is higher than the national average (2424 kg/ha). There has only been a marginal increase in the productivity of rice in the past four decades.

38. The Kerala Agricultural University has been engaged in research on improvement of rice through the network of research stations and educational institutions, employing a sizeable number of

scientists ever since its inception in 1972. The criteria for crop improvement as evident from the annual reports in 1970s and 1980s had been mainly enhancing productivity through genetic improvement, resistance to specific or a broad spectrum of pests and diseases, response to nutrients, and adaptation to various climatological and geographical features.

39. From the Inception of KAU during 1972, 119 rice varieties were released for the state, 7 during 11th five year plan period and 6 during 12 five year plan. However, trends in adoption of rice varieties released by KAU show that in spite of this massive crop improvement initiatives, only a very few varieties have been widely accepted by the farming community. Out of the 150 KAU varieties, only Jyothi, Uma, Kanchana, Aiswarya and Jaya are found to be adopted widely, with Jyothi and Uma together contributing to more than 90 per cent of the total varieties used by farmers in Kerala.

40. A few other accomplishments in rice research are furnished below:
    1. Five location specific rice varieties (Sreyas, Ezhome- 4, VTL- 9, Amritha and Jaiva) were released. Sreyas (MO 22) is a variety with a better cooking quality compared to Uma, which is the current leading variety and the yield is also comparable to that of Uma.VTL 9 is suitable to Pokkali lands; Ezhome 4 is for Kaippad regions and Amritha, for the submerged soil of Onattukkara region.
    2. Rice varieties suited for cultivation in the Kari lands of Kuttanad were identified. Uma, IR 47551 and IR 50138 for Karumady, Uma, Vytilla 2 and Krishnanjana for Purakkad Kari and Vytilla 6, IR 47544 and Uma for Vaikom Kari were included in POP 2015.
    3. Commercialized the 'KAU Weed Wiper' device for management of weedy rice. This technology was transferred to M/s Raid co Kerala Ltd. which is popular among farmers (*a Public - Public partnership programme)*
    4. Preliminary standardization of mushroom substrate sterilizer was completed. The equipment has a total capacity of sterilizing 13 kg of paddy straw using 18 kg of fire wood within a sterilization time of 45 minutes. The same has been filed for issue of patent.
    5. The media comprising of 80% Rice husk charcoal (RHC) + 20% Vermi compost (VC) was standardized best media for quality and cheap mat nursery production in rice.
    6. The concept of "Food security Army" for promoting of mechanization of transplanting and harvesting in rice cultivation was conceptualized and popularized by the University.

Coconut and Other Palms

    1. A semi dwarf coconut variety Kera Madhura is found highly suitable for tender coconut purpose
    2. A modified type of coconut climber viz. 'Kera Suraksha Coconut Climber' where the operator can sit, was developed
    3. Keramrutham – A non-fermented health drink from coconut inflorescence sap was developed and a 'Neera pilot plant' started functioning in College of Agriculture, Padannakkad and Instructional Farm Vellayani.

Vegetables

41. Apart from crop improvement, research in vegetables has focused on standardization of cultural practices and plant protection packages. The varieties released by the KAU are found to be extensively adopted in Kerala. Recently, research in vegetables has shifted to standardization of the

methods and protocols for protected cultivation and precision farming. A few technologies developed are given below:

1. Out of 69 vegetable varieties released for the state till date, 2 varieties were developed during 11th FYP and 13 during 12th FYP.
2. Released a bacterial wilt resistant tomato variety 'Manuprabha', a fruit and shoot borer tolerant brinjal 'Ponny', a chilli variety 'Keerthi' suitable for dry as well as green chilli purpose, long podded yard long bean 'Githika', a small fruited ash gourd 'Thara', twogynoecia's F1hybrids 'Heera' and 'Shubra' in salad cucumber, two seedless water melon hybrids (red fleshed 'Shonima' and yellow fleshed 'Swarna') during 2015.
3. Research is in the advanced stage to release parthenocarpic cucumbers suitable for poly house cultivation in the state
4. Apart from crop improvement, research in vegetables has focused on standardization of cultural practices and plant protection packages. The varieties released by the KAU are found to be extensively adopted in Kerala. Recently, research in vegetables has shifted to standardization of the methods and protocols for protected cultivation and precision farming. The extent of adoption of varieties released by KAU.
5. The structure and design of ply house suitable for the state was standardized by KAU. In addition technology for rain shelter cultivation was also standardized.
6. Technology for Pro tray seedling production, grafting in vegetables and open field precision farming widely adopted in the state was developed by KAU

Sugarcane

1. Two high yielding sugarcane varieties ***Aromal*** and ***Abhay***, suitable for jaggery production have been released and have been recommended for cultivation in central Travancore region.
2. Released varieties viz., Madhuri, Thirumadhuram, Madhurima , Madhumathi, Aromal and Abhay that are resistant to red rot disease.

Fruits

1. Released Jackfruit variety" Sindoor" suited for table purpose, with attractive sunset orange flakes. The trees bear fruits twice/ year; yields medium fruits 11-12 kg, 52 cm long; 25 fruits/ tree / year with distinct aroma, taste and sweetness.
2. Manjeri Nendran II , a superior French plantain selection, with high yield and tolerance to Eumusae (Sigatoka) leaf spot and pseudostem weevil
3. Two exotic banana varieties viz., 'Popoulu' and 'Cluvai Nov Khom' were found suitable for Kerala conditions.
4. For induction of flowering and improvement of yield in adult mango trees, the application of Paclobutrazol @ 5.0 g / tree (Cultar 20 ml/tree) during September after diluting in 10 liters of water and drenching in the soil at about 60 cm away from tree trunk, was found effective.
5. Standardized effective management of rhizome weevil of banana using Thiamethoxam 25 WG (1g/5 l) or Fipronil (0.3 G @ 10 g formulation/ plant) thrice at planting, 2 and 5 months after planting
6. Biological control of rhizome weevil of banana through sucker treatment with *Pseudomonas fluorescens (20* g/l) and application of Entomopathogenic nemato (*Heterorhabditisbacteriophora*) infected wax moth larvae (4 nos/plant) was found out.

Spices and Plantation crops

42. Entered into contract with Nagarjuna Herbals for research on value addition in ginger under the auspices of Biotechnology Industrial Research Council- typical case of public-private partnership
    1. Two inter varietal hybrids are found promising in black pepper and are at the pipeline for release. The hybrids PRS160 and PRS 161 were found to be promising with mean green berry yield of 4.35 kg/vine and 3.99 kg/vine respectively
    2. Identified25 superior types of nutmeg and planted the elite germ plasm of nutmeg Developed a minimal description for nutmeg for the first time an attempts were taken for registration of Passport data often accessions of nutmeg with NBPGR.GC-MS analysis of nutmeg kernel and mace volatile oil exhibited20-24 constituents.
    3. Standardized12 novel products from nutmeg pericarp.
    4. A statistical key was developed using 13 key quantitative characters which can serve as a preliminary tool for identification of an elite nutmeg tree.
    5. Four elite soma clones of ginger (SE 8640, SE 8681, SE 86131, SE HP 9) were identified and recommended for variety release in 37th ZREAC held at RARS, Pattambi.
    6. Chemo profiling of volatile oil of ginger soma clones revealed the presence of 44 aromatic compounds of which Zingiberine was predominant. Ginger soma clones 8640 and SE 86131 were found ideal for preparation of ginger candy and paste respectively.

Cocoa

1. Five high yielding cocoa hybrids were released (CCRP 11, CCRP12, CCRP 13, CCRP 14 & CCRP 15) which recorded an average yield ranging from86 to138 pods per tree.
2. Agro techniques of cocoa were transferred to farmers through training programmes.
3. The successful Public- Private Partnership mode for research and development programmes started during 1987 with the then Cadbury India Ltd. (now renamed as Modelez India Foods Pvt. Ltd.) is still being continued.

Medicinal and Aromatic Plants

1. Identified four promising hybrids of *Piperlongum* (Acc.9, 63,140 &141) for field evaluation.
2. Standardised the protocol for seed and vegetative propagation.
3. Standardisedtheprotocolforairlayeringin"maramanjal".Morphologyand reproductive biology of "maramanjal" was also standardised.

Soils and Agronomy

1. Ready to use micronutrient formulations were developed at RARS Pattambi and commercially marketed as "Sampoorna Rice" and "Sampoorna Banana" and that of College of Agriculture Padannakkad as "Ayar" for Banana.
2. Analysis of major, secondary and micro nutrients of soils collected from all the districts of Kerala indicated wide spread deficiency of secondary nutrient like calcium, magnesium and sulphur and micronutrients like boron and zinc. Specific nutrient recommendation was formulated for target production in major crops in the state. Considering wide spread occurrence of deficiency in secondary and micro nutrients in the State, KAU has formulated a recommendations for the need based application of secondary and micro nutrients. Critical levels of these nutrients for the above crops both in soil and plant are have been standardized.

3. Soil Health Monitoring System-Soil Health parameters of Wayanad, Malappuram, Thrissur and Palakkad districts are being monitored on timely basis. Relation between soil fertility and soil biological health has been established and technologies for soil health improvement are recommended, wherever such deficiencies exist.

Beneficial Organisms

1. *Azospirillum sp.* recorded maximum shelf-life (1.77 x 10 8 cfu/ml) with 15 metre ha lose in selective media at 10 months after inoculation and the population showed decline after10 months. However, PSB recorded maximum shelf-life (3.77 x 108 cfu/ml) with 2.0 % PVP as additive in the selective media at 9 months after inoculation.
2. Novel Nitrogen fixing bacteria (*Microbacterium, Paenibacillus* and *Cellulosimicrobium*), in combination with 50 per cent of the recommended dose of nitrogen, improved growth and yield of Amaranthus, Bhindi, black pepper and ginger in experiments conducted at College of Horticulture, Vellanikkara and the tribal settlements of Wayanad.
3. A novel cellulose degrading fungus *Gongoronellabutleri* was found to be an effective substitute for cowdung in recycling of bio solid waste to compost, by aerobic composting
4. The technologies for the production of liquid formulations of Pseudomonas fluorescen sand Trichoderma were transferred for commercialization.
5. Effective consortium of bioagents was developed for the management of bacterial wilt of tomato and for decomposition of agro wastes containing lignin and tannin.

Agricultural Engineering

1. KeraMitra, coconut dehusking machine developed by the University has reached almost all houses in the state. Mechanical devises like KAU puddle and, KAU bed former for facilitating mechanization in rice farming have been transferred to KAICO for large scale production and distribution in the state.
2. An amphibian type Pokkali harvester which can harvest rice in standing water needs further refinement for adoption at the field level.
3. Software for drip irrigation design named e-DID(electronic device for Drip Irrigation Device) was developed, which will give the water requirements of the crops, diameters of main pipe, sub main pipe, laterals, emitter specifications, layout sketch, pump horse power and finally the estimate, by providing the crop details, area of cultivation and location(district) as inputs. Research facilities and demonstration units established under Nodal Water Technology Centre at College of Horticulture, Vellanikkara. This user friendly software simplifies the tedious task of drip design for farmers. A *"Karshika-JalaSankathikaSena"* was formed to support farmers in installation and maintenance of drip irrigation
4. Motorized drum seeder was developed for sowing pre-germinated paddy seeds in the field which can work 1.25 acres in an hour
5. Multipurpose seed extractor was developed and tested for cucumber and ash gourd and is ready for transfer to small and marginal seed farms
6. Powder from fresh fruits of *Garciniacambogia* juice along with standardized limit of additive, followed by spray drying could get powder which packed in Aluminium pouches gives a storability of above 7 months with good reconstitution properties.
7. Development of microencapsulated whey-melon and banana pseudostem juice powders was executed. The UV assisted ohmic heating system for liquid juice (for pasteurization of pineapple juice) was fabricated.

8. Developed a protocol for ready to eat moringa leaves powder, extruded Ready to Eat (RTE) snack food from starch based food
9. Tractor operated multi grain raised bed planters are developed and are suitable for vegetable cultivation like okra, green pea and cow pea
10. Power tiller operated turmeric harvester was found suitable for harvesting turmeric, coleus and Ginger in ridge planting
11. Developed process protocol for kokum juice powder, banana flour based ethnic health mix, millet based nutraceutical pasta
12. A prototype of a pineapple harvesting equipment was developed
13. Standardized irrigation and fertigation requirement of salad cucumber and capsicum under Naturally Ventilated Poly House (NVPH) (confirmatory trial)
14. Developed precision farming package for rain shelter cultivation of bitter gourd and bottle gourd. Salad cucumber recorded maximum yield in poly house compared to rain shelter and in open field

Water Management

1. A farmer friendly irrigation system, low cost clog free and farmer friendly KAU micro sprinkler –simple in design, with less clogging susceptibility, ensuring uniform wetting of the basins of the crops
2. A new production technology in irrigated rice by introducing silica, lime and higher levels of potash was developed

Agro forestry

1. Silvopasture systems suitable for tropical home gardens have been developed for ushering fodder self- sufficiency for small scale dairy farmers in Kerala.
2. Wood quality variation in 4 species viz., *Pericopsismooniana*, *Pterocarpusdalbergioides* and *Swieteniamacrpohylla* grown in research trials of Kerala forest department was elucidated. *Pericopsismooniana* (Nedun Tree) was suitable for introduction in the state as it yields good quality timber for furniture and construction and similar in appearance and stronger than teak.
3. Intercropping of turmeric in bamboo plantation was found successful.
4. Successful integration of shade tolerant medicinal herbs viz. turmeric, ginger, kacholam and chittaratha in four prominent land management systems viz. mature coconut, rubber, cashew and home garden were standardized separately.
5. The potting media of soil + coir pith compost + vermin compost in 2:1:1 ratio found as a cheap alternative for production of quality planting stock in agro forestry species
6. Established a Fern House, a Medicinal Plant Garden with 100 plant species and a Bentham and Hooker Plant Taxonomy Garden

Value addition of fruits and vegetables

1. Standardized the development of Micro encapsulated Whey-melon and Banana Pseudo stem juice powders , Ready to cook tender jack fruit and Process protocol for banana flour production have also been standardized.
2. Developed the protocol for post harvest handling of Heliconias and identified ornamental gingers suitable for tropical landscapes.
3. Technology for enriched fruit bar and dehydrated jackfruit shreds were developed from ripe jackfruit (Varikkachakka)

4. Technologies on Osmotic dehydration of fruits (mango, jackfruit, aonla, and banana) were selected for commercialization.

Others

1. AINP on Pesticide Residues has been recognized as nationally accredited lab as well a state referral lab and serving to the entire needs of Pesticide Residues. Pesticide Residue Analytical and Research laboratory (PRRAL) has developed a formula as a household product 'Veggie Wash' for reducing pesticide residues from fruits and vegetables.
2. Five nurseries attached to Research Stations have received National Accreditation of Directorate of Arecanut & Spices Development Board and National Horticultural Board, Govt. of India. This include three for spices (Model Nursery on Spices at Vellanikkara, Black Pepper Nursery at Panniyoor & Spices Nursery at RARS Ambalavayal) and two for fruits (RARS, Ambalavayal & ARS Anakkayam).
3. KAU has conceptualized and popularized the concept of "food security army" for attracting youth to agricultural sector. The "Food Security Army" has established a reserve of trainee's manpower in mechanization to address the labour shortage in the state. Similarly, an "Agro machinery Service Centre" and training unit and 'Mobile Machinery Repair and Service Unit' have been established to address the problems of farm mechanization in Kerala.
4. Established a biocontrol & biofertilizer production unit at College of Agriculture, Vellayani in which mass production of biocontrol agents –*Pseudomonas* & *Trichoderma* and Biofertilizers - *Azospirillum, Azotobacter, P*-solubilizers and AMF and also quality analysis of microbial inoculants and samples are being undertaken. Consultancy service is also provided for production of biocontrol agents. KAU technology has been transferred to 34 microbial inoculant production centres.
5. The mother culture and production technology of these biofertilizer organisms have been transferred to State Biofertilizer Production Centre, Parottukonam and state Biocontrol Lab, Pattambi.
6. Many private entrepreneurs and FACT entered into an MoU with KAU for commercial production of Biofertilizers especially *Azospirillum*, AMF, *Azotobacter* and the recently developed consortium-PGPR mix I(for NP and K nutrition of crop plants), which are widely accepted by the farmers and the demand is increasing year after year.
7. In the field of solid waste management, a consortium of bacteria, fungi and actinomycetes capable of degrading waste was developed and pilot tested. The technology is successfully being used at Santhigiri Ashram for herbal and kitchen waste processing.
8. As effective protocol for solid waste management has been developed by KAU which also involves enrichment with graded dose of fertilizers to find ready application. This technology has been filed for patent.
9. Regarding the biological control of insect pests, efficient entomopathogenic fungi – *Beauveria, Verticillium*and*Metarhizium* capable of suppressing most of the insect pests of crop plants have been developed by KAU. These cultures are being mass multiplied and supplied to the farmers from most of the stations of KAU.
10. *Online Monitoring and Evaluation (ORMIS).* Directorate of Research have made a great stride in research monitoring, by the introduction of Online Research Management Information System (ORMIS), a web based on-line system for monitoring and evaluation of research projects implemented by KAU.
11. A model garden for a terrace (of house) was developed at CSRC Karamana with an area of 3 cents (120 m^2). The components include crops viz. vegetables (25 species), tuber crops (7),

spices (3), fruits (2), medicinal plants (3); azolla unit; vermin compost unit; fermented organic manure unit and household waste decomposition unit.

12. DNA isolation, quantification, PCR amplification and SSR assay was standardised for cow pea varieties and hybrids of cucumber and watermelon. DNA finger printing profiles were generated for cow pea varieties viz, Lola,Anaswara, Varun, Kanakamani, Mallika, Sarika, KMV-1, Bhagyalakshmi, Vyjayanthi and VellayaniJyothika,
    1. *Seed & Nursery Programme.* As a part of service KAU also helps the farming community through large scale multiplication and supply of high quality seeds and planting materials, bio fertilizers, bio control production, tissue culture plants etc. This include a network of 26 research stations/units involved in seed and nursery and programme, 12 TC labs for tissue culture plantlet production and 14 biocontrol labs for mass production of bio control agents.
13. *KarshakaSanthwanam.* Addressing farmer's problems through "KarshakaSanthwanam". The scientists at College of Agriculture, Vellayani actively involved in addressing and solving field problems of farmers within 24 hours on receiving the requests / messages.

An Overview of the Research Accomplishments of ICAR Institutes in Kerala

The Central Plantation Crops Research Institute, Kasargod

43. The CPCRI maintains the world's largest repository in coconut with 455 accessions (323 indigenous and 132 exotic genotypes) from 28 countries, 173 germ plasmcollections in arecanut of which 23 are exotic and 141 indigenous and 352 cocoagerm plasm collections. International Coconut Gene bank for South Asia (ICG-SA) was established under a tripartite agreement among ICAR-FAO-ITPGRFA. The Institute also hosts the national coconut gene bank (NCGB) and serves as the National Active Germplasm Site (NAGS) for coconut, arecanut and cocoa.

44. Through intensive breeding and evaluation, 19 improved coconut varieties including six hybrids involving talls and dwarfs as parents have been released for commercial cultivation. The high yielding varieties are capable of yielding 3.12 to 6.28 tonnes of copra ha-1 annually, as compared to 2.96 t copra ha-1 in West Coast Tall local. Ten improved varieties of arecanut, including eight selections and two dwarf hybrids, have been released. The improved varieties with annual average yield of 2.54 to4.15 kg dry kernel palm-1 yr-1 and higher dry kernel recovery have significantly improved arecanut productivity in the country. In cocoa, seven high yielding varieties have been released from the institute, three elite clones and four hybrids, which yield up to 2.5 kg dry bean tree-1 yr-1 with varying processing qualities, as compared to 1.0kg dry bean tree-1 yr-1 in existing cocoa plantations.

45. The institute has been producing quality planting materials in coconut, arecanut and cocoa for distribution to farmers and other stakeholders. Seed gardens of improved varieties have been established in the Institute as well as in farmer's garden to augment planting material production. ICAR-CPCRI nurseries at Kasaragod, Kidu, Kayamkulam and Vittal were graded with 'four-star' status in the five star scale by National Horticultural Board. Quality planting materials are produced to extent of 1.2 lakh coconut seed nuts including 40,000 hybrids, 5 lakh arecanut seed nuts including one lakh seedlings and 1.1 lakh cocoa seedlings annually.

46. The Institute has standardized embryo culture protocol for germ plasm exchange, standardization of regeneration protocol for inflorescence tissues of arecanut and cryopreservation of coconut embryo and pollen. In arecanut, the protocol developed for somatic embryogenesis and plantlet regeneration

from immature inflorescence explants has been commercialized. Asimple and easy vitrification protocol has been developed for cryopreservation of coconut zygotic embryos from both tall and dwarf accessions have been commercialized. The safe movement of coconut germ plasm through embryo cultures, instead of seed nuts, is recommended by FAO/ IPGRI.

47. Coconut or arecanut based inter/ mixed multi-storied multi-species cropping as well as mixed farming systems have been developed by integrating livestock to increase total productivity. The coconut based cropping system using multi-species cropping of coconut with black pepper, banana, nutmeg, pineapple, ginger, turmeric and elephant foot yam generated a net income of3.7 lakh ha-1, which is164% higher than that of coconut monocrop (1.4 lakh), while the coconut based mixed farming system (CMFS) comprising coconut, black pepper, banana, crossbred cows, poultry birds, goat, and pisciculture generated a net return of5.5 lakhha-1, reflecting 293% higher return than coconut monocrop.

48. The Institute has successfully evolved the methodology for recycling crop wastes in coconut, arecanut and cocoa through vermicomposting and mushroom production, which would help in disposing of wastes, improving soil fertility, reduction in use of chemical fertilizers and sustaining the yield besides enhancing nutritional security.

49. Developed the IPM protocols for reducing crop losses by diseases and pests. For instance, integrated disease management strategies involving farm and palm hygiene, application of soil test based nutrients NPK (N: 500 g, P: 300 g K: 1250 g palm-1 yr-1 in two splits in May – June and August – September), 250 g MgSO4 palm-1 yr-1, irrigating the palms (250 L water palm-1 week-1) during summer months, basin management with green manure crops like cowpea and control of leaf rot by application ofhexaconazole 5 EC @ 2ml in 300 ml water, which have been developed for root(wilt) and leaf rot affected coconut gardens, could increase the yield by 25-83%,depending on severity of the disease. Clean and green innovative pest management technologies have been developed and field validated for the bio-suppression of rhinoceros beetle, red palm weevil, leaf eating caterpillar and eriophyid mite infesting coconut.

50. A simulation model to study the climate change impact, on coconut viz. Info crop-coconut was developed. Evolved technologies to enhance value addition of coconut to 15 per cent by 2020.'Coco-sap Chiller' technology for collecting fresh, hygienic and unfermented coconut inflorescence sap called Kalparasaisvery promising. Its adoption by the farmers or producer companies demonstrated that either selling it as health drink or processing into coconut sugar and marketing is highly profitable.

51. Farm mechanization and various processing machineries developed at the institute would reduce the production cost, increased labour efficiency and enhanced product output and quality. The safety attachment incorporated by the model of climbing device has become an effective solution since it could be operated even by inexperienced women with proper training. Several machineries and gadgets have been developed for labour saving and gender main streaming viz., power operated coconut and areca nut husking machines, coconut de-shelling and shell removing machines for copra making and wet processing respectively, tender coconut punch and cutter, copra and coconut chips dryers of varying capacities and using different fuel sources, testa remover, manual and power operated coconut slicing machines, coconut milk expellers of various capacities, VCO cookers, VCO fermentation tank, copra moisture meter etc.

52. For technology transfer, efforts are made to adequately promote the mandate crops of the institute through effective extension activities including trainings, farmer participatory approaches in technology development and dissemination, participation in exhibitions and conducting kisanmelas, and production and distribution of planting materials of mandate crops. Training and frontline demonstrations on selected technologies, institutional and off campus training programmes for extension personnel and farmers and research-extension farmer interface programmes are conducted. Besides, the institute participates in exhibitions, radio talks, television interviews, phone-in programme and press meets.

The Central Tuber Crop Research Institute

53. The CTCRI is the only one of its kind in the world dedicated solely to the research on tropical tuber crops. The institute is celebrating its golden jubilee year and five decades of concerted research have led to the development of several production and processing technologies for tuber crops besides release of nearly 49 improved varieties. The target group of most of the technologies being marginal and resource poor farmers, adequate emphasis is also given for on farm evaluation and popularization of the technologies. In addition, several industrial Hi-tech technologies were also developed in the recent past enabling resource generation through consultancies.

54. The Institute has a wealth of germ plasm of tuber crops, totalling 6151. This has formed the basis of all the genetic improvement and variety development programme. The improvement work was exclusively based on conventional breeding programmes. Pioneering role of CTCRI in tropical tuber crops breeding attracts international collaboration in the breeding and genetic improvement of tuber crops.

55. CTCRI has released 50 varieties in eight different tropical tuber crops. Each variety has its own unique traits and preferences. The cassava starch and sago production in the country is mostly dependent on two major industrial varieties of cassava released from CTCRI, viz., H 165 and H226. Further new and improved triploids with high extractable starch content were developed which are under farmers' participatory selection process in Tamil Nadu. Two of such varieties, viz., 4-2and 5-3 are found to be promising and acceptable to farmers as well as industries and these are in the pre-release stage. Thus apart from the table varieties, the industrial varieties of cassava have made a major impact in adoption and utilization by the farmers.

56. The domestic and international training received in the use of Biotechnology in conservation, characterisation and Genetic improvement of tuber crops has contributed to a great extent the development of facilities and formulation of programmes using this advanced technology for the improvement of tuber crops. The Institute presently has very strong programmes in biotechnology which includes the development of diagnostic tools for viral and fungal diseases and transgenic plants for cassava mosaic disease.

57. A host of tuber crops production technologies are available for mono crop, intercrop and multi-crop cropping systems which help in enhancing the yield, soil fertility, employment opportunities for farm families and income levels. Integrated crop protection technologies developed for cassava mosaic disease and sweet potato weevil would help the farming community in extreme eventualities.

58. Besides, technology has been perfected for organic production of yam and elephant foot yam. Efforts in crop utilization have paid rich dividends in terms of value addition and diversified technologies suitable for big, small and cottage industries. Many of these technologies are capable of

ensuring food and nutritional security to the people of India. Technologies for the industrial sector include the latest products like superabsorbent polymers; graft copolymerized starches, cold water miscible starch, solid adhesives, bio ethanol, pasta products etc.

59. Aroids especially elephant foot yam is gradually gaining importance in different areas like Odisha, Bihar and Uttar Pradesh, Gujarat and north eastern States. Supply of quality planting material is ensured to farmers of all regions though revolving fund scheme and mega seed project. There exists a good research base in the country to sustain root and tuber crops research and development with CTCRI giving the leadership and AICRPTC to plan and coordinate region specific research and testing of technologies on these crops.

The Indian Institute of Spices Research

60. The major research accomplishments of the Indian Institute of Spices Research are given below:
    1. *Cardamom variety for high yield and disease resistance.* A high yielding cardamom hybrid "Appangala-2" with average yields of 985 kg/ha has been identified. The hybrid was evolved by crossing high yielding local cultivar with '*katte*' virus resistant variety.
    2. A nutmeg variety 'IISR- Keralashree' was release by AICRPS during the year through farmer's participatory breeding. This variety has bold nuts with whole, thick reddish mace. The mace and nut are rich in sabinene and myrcene.
    3. *High yielding short duration turmeric variety.* The high yielding short duration turmeric line (Acc. 48) was developed through germ plasm selection. In the yield evaluation trial during 2009-2012, maximum mean yield over three years was recorded in Acc. 48 (31.95 t/ha). The genotype, Acc. 48 (39.73 t/ha) is also performing well under multi locational farmers field trials (2013-15) in Tamil Nadu, Andhra Pradesh, Kerala and Karnataka compared to national and local checks. It is a short duration genotype (160-180 days) with high curcumin content (5%).
    4. *Breeding for Ralstonia resistance in ginger.* Four mutants resistant to *Ralstoniasolanacearum* infection and three resistant to *P. Myriotylum* were developed and being clonally multiplied for further yield evaluations.
    5. *Vertical column method for quality black pepper planting material production.* The continuous demand for quality planting material created a novel idea of producing orthotrope on vertical 2m column having one feet diameter made with half an inch plastic coated welded wire mesh filled with composted coco peat and vermicompost @ 3:1 ratio fortified with bio-control agent *Trichodermaharzianum* in hi-tech poly house of fan and pad system. Eight to ten cuttings can be planted around the each vertical column, allowed to trail and root on the column and in four months produce more than 20 nodes. Growing the vine on vertical column can be effectively utilized for the production of three types of planting material i.e., single node cuttings, top shoots (top 5 nodes can be used as orthotropic shoots) and lateral branch (1-2 for bush pepper). In four months' time, on an average 150 single nodes per column, one or two laterals and 10 top shoots can be harvested. In a poly house size of 320 sq.m (20 × 16 m), one can accommodate 300 such columns and in a year three harvests can be made. These cuttings can be rooted further for field planting using pro-trays.
    6. A novel transplanting technique in ginger by using single bud sprouts (about 5 g) has been standardized. The technique involves raising transplants from single sprout seed rhizomes in pro-trays and planting in the field after 30 days. The advantages of this technology are production of healthy planting materials and reduction in seed rhizome quantity and eventually reduced cost on seeds. The cost of production is 70 paise/seedling by taking into consideration of present ginger seed cost.

7. Potting medium for plug trays: Partially composted coir pith and vermicompost (75:25) enriched with *Trichoderma* (in talc formulation, 10^7cfu g^{-1} at the rate of 10 g kg^{-1}) is an ideal potting medium for black pepper nursery for healthy planting material production using plug-trays (cell dimension of 7.5 x 7.5 x 10.0 cm) compared to conventional multiplication. The cost of production is Rs 6.50 /plant.
8. Dried coconut leaves as mulch in ginger beds after removing the petiole at the time of planting enhanced yield by 10% compared to recommended green leaf mulch application. Also, application of paddy straw in ginger beds at the time of planting + green leaves recorded 36% increased yield compared to recommended green leaf mulch application.
9. *Crop specific micronutrient mixture for spices - Nutrient mix (IISR Power Mix) for enhanced growth, yield and quality of spices.* This is a novel soil pH based micronutrient mixture for promoting growth, yield and quality of turmeric, ginger, black pepper & cardamom. Under proper conditions it can be stored for up to one year/ one crop season. It is recommended as foliar spray at the rate of 5 g/litre on 60th and 90th day after planting in case of turmeric and ginger and as foliar spray at the rate of 5 g/litre in May-June and September-October every year in case of black pepper and cardamom. An approximate increase of up to 15% in yield and a cost benefit ratio of 1:2.5 are experienced by farmers. Patent for this delivery process has been filed and the technology is being commercialized through non-exclusive licenses.
10. *Novel and smart delivery method of bio control agents through encapsulation.* ICAR-IISR has made a significant breakthrough in the successful encapsulation and delivery of a plant growth promoting rhizobacteria for growth promotion and disease control in ginger and black pepper. The advantages include reduced cost and easy handling and transport, no harmful by products, less requirement of inorganic and inert material, storage at normal temperature and more importantly, enhanced shelf life. Besides, this encapsulation technique can be used to deliver all kinds agriculturally important microorganisms viz., N fixers, nutrient solubilizers/ mobilizers, PGPR, Trichoderma etc. Patent for this delivery process has been filed and the technology is being commercialized through non-exclusive licenses.
11. *Liquid formulation of Trichodermaharzianum. Trichodermaharzianum* the bio control agent for *Phytophthora* foot rot disease of black pepper is made into a liquid formulation, containing minimum population of 10^8 fungal spores per ml that can be stored up to one year without significant reduction in the viable cells. The recommended dosage for application is 20 ml of the formulation (10^8 spores per ml) mixed with 500 kg of well decomposed farmyard manure or vermicompost, incubate for 5-10 days and applied to the basin of the vine @ 2.5 kg (FYM) or 500 g (VC) in the field. For nursery, the formulation can be mixed with the potting mixture at the rate of 2 ml per 50 kg of potting mixture.
12. *Encapsulated Bio-consortium formulation for growth promotion in black pepper and cardamom nursery.* Biofertilizer consortia to supplement NPK for black pepper and cardamom were developed. The consortia for black pepper with *Azospirillumlipoferum* (N2 fixer), Bacillus subtilis (P solubilizer), *Paenibacillusglucanilyticus* (K solubilizer) and consortia for cardamom with*Azospirillumbrasilense*(N2 fixer,) *Acinetobacterboumanni* (P solubilizer) and *Bacillus* sp. (K solubilizer) as encapsulated formulations has been developed. The formulations can be stored up to one year without loss of viability. The consortia application @ 1g/plant (20-25 beads) along with vermicompost @ 100g is recommended.
13. *Control of Colletotrichum infection in black pepper nurseries.* Pre-planting treatment of two/three node cuttings of black pepper by immersing in the fungicidal solution of carbendazim + mancozeb (0.1%) for 30 minutes delays the initiation of anthracnose disease in nurseries. Spraying Bordeaux mixture (1%), alternating with carbendazim (0.1%) further prevents the spread of anthracnose disease.

14. *Management of nematodes in black pepper nursery.* Drenching of Carbosulfan 0.1 % @ 50 ml /poly bag containing 1.5 kg potting mixture is recommended for the management of plant parasitic nematodes in black pepper rooted cuttings in the nursery. The treatment ensures 100% kill of nematodes without any toxicity to black pepper plants. The cost of application is about Rs 0.04 per plant.
15. *Management of Cardamom thrips.* A technology for the control of cardamom thrips (*Sciothripscardamomi*) for Karnataka region using spinosad 0.0135% (which is derived from *Saccharopolysporaspinosa*) as 3 sprays during March, May and August is on par with imidacloprid 0.0089% andthiamethoxam0.0075% and can substitute synthetic insecticides for thrips control in cardamom.
16. *Management of leaf blight in Cardamom.* Spraying carbendazim + mancozeb (0.1%) at 30 day intervals was promising in reducing leaf spot incidence under cardamom nursery conditions. Combined application of hexaconazole 0.1% and soil application of *T. harzianum* thrice at 30 days interval was promising in reducing leaf blight incidence under field conditions.
17. *Biocontrol for cardamom thrips.* Field trials with an entomopathogenic fungus, *Lecanicilliumpsalliotae,* at different agro-climatic conditions in Kerala and Karnataka indicated that basal application of the fungus (3-4 applications during May – September) was effective in controlling the thrips and the treatment was on par with chemical insecticides. The technology is ideal for adoption in organic horticulture.
18. *Management of plant parasitic nematodes infesting black pepper.* Drenching 0.1% carbosulfan 25 EC (0.125 a. i.) @ 5 l/plant at the base of plant twice (pre monsoon -May and post monsoon - October) a year OR applying fipronil 0.3 GR @ 50 g/plant at the base of plant thrice (May, September and January) a year are effective for the management of plant parasitic nematodes infesting black pepper.
19. *Pre-split harvest and etherel treatment to prevent aflatoxin contamination in nutmeg.* A simple technique of hormone treatment was developed to split open nutmeg fruits without exposure to soil. The methodology involves harvesting physiologically mature fruits when the colour of the rind change from green to pale yellow/yellow and dipping them in 500 ppm ethrel (2-Chloroethylphosphonic acid) solution for 10 minutes and then storing them in shade. By this method, 90-100% of fruits will be split in 18-20 hours.
20. *Development of mechanical unit for white pepper.* A mechanical unit was developed and evaluated for production of white pepper from black pepper. The white pepper obtained had a dry recovery of 68.7% and the capacity of the pulping unit was 125 kg/h.
21. Curing of turmeric: Curing of fresh turmeric rhizomes in improved turmeric boiler (TNAU model- 100 kg capacity) by using steam and curing for 60 min duration, ensures that drying is completed in 10 days and produces dry rhizomes of optimum quality. Slicing of fresh turmeric rhizomes (5 mm thick) without curing reduces the drying time. This operation is to be performed only when there is a requirement from powdering industries or when used with in a short period of time.
22. *Turmeric curing with solar steam.* The renewable solar energy unit has solar thermal collectors with curved parabolic mirrors which concentrates solar radiation on to a central pipe called as the receiver. The unit has a cooking vessel of capacity 50 kg turmeric/batch and complete cooking of turmeric could be achieved in 45 min.
23. DNA based diagnostics for adulterants in spice products: A DNA based method has been perfected to detect chilli adulteration in traded black pepper powder, *Cinnamomum cassia* in commercial samples of true cinnamon (*C. verum*) and *Curcuma zedoaria* and cassava starch in branded market samples of turmeric powder and this method can detect adulteration even at very low levels of adulteration (0.5%).

24. *Quality evaluation using E-nose.* Hand-held electronic nose was modified with suitable sensor array for determining quality. Samples were analyzed using the modified hand-held electronic nose for essential oil content and could be graded into low (<4.0%), medium (4.0-6.0%) and high (>6%).
25. *Diagnostics for viral disease.* Loop-mediated isothermal amplification (LAMP) and real-time LAMP based assays were developed for quick and sensitive detection of virus diseases of black pepper and cardamom.
26. *Field diagnostics for Biovar specific detection of Ralstoniasolanacearum infecting ginger (Zingiberofficinale).* A strain specific and sensitive technique based on Real Time Loop Mediated Isothermal Amplification (Real Time- LAMP) was developed for detecting race 4 strain of *Ralstoniasolanacearum* causing bacterial wilt in ginger. The method can be used to index both soil, water as well as seed rhizomes. There is no need for extraction of the genomic DNA as the technique is standardized with soil supernatant as the template. The time taken for detection is only 3-4 hours and the detection limit is 10^3 CFU/g of soil or rhizomes. The technology can be easily adopted in field for pathogen-free site selection as well as selecting disease-free seed materials for planting.
27. *Complete genome sequencing of Cucumber mosaic virus.* The complete genome of *Cucumber mosaic virus* (CMV) was sequenced and compared with 27 CMV isolates reported worldwide from groups I and II and the current isolate belongs to subgroup IB.
28. *Occurrence of endogenous Piper yellow mottle virus (ePYMoV).* Studies based on polymerase chain reaction (PCR), reverse transcription (RT) PCR, and Southern hybridization of total DNA from PYMoV infected black pepper plants probed with PYMoV specific sequence indicated the occurrence of integrated PYMoV sequence in black pepper DNA.
29. *A new media for mass multiplication of entomopathogenic nematodes.* A new artificial media for the mass production of infective juveniles of entomopathogenic nematodes was developed. By this technique around 23 lakh infective juveniles of EPN can be recovered from a single flask (250 ml). The media is suitable to multiply infective juveniles of *Steinernema* spp., *Heterorhabditis* spp. and *Oscheius* sppat a very low cost. Ingredients for this media, are cheaper and locally available. The cost of production is just Rs 2 per flask.
30. *Dimethyl trisulfide a new compound for soil fumigation.* Soil fumigation assays with different concentrations of dimethyl trisulfide resulted in 100% inhibition of *Phytophthoracapsici*, *Pythiummyriotylum*, *Rhizoctoniasolani*, *Gibberellamoniliformis*, *Atheliarolfsii, Colletotrichumgloeosporioides*and*Radopholussimilis*at different concentrations.
31. *New species of Spilarctiaobliqua NPV*. A new species of group I tetrahedral shaped multiple nucleopolyhedrovirus isolate, belonging to the genus *Alphabaculovirus* of family *Baculoviridae*, infecting *Spilarctiaobliqua*, a polyphagous pest of ginger, turmeric and other crops was isolated and characterized based on morphological and molecular data.

CHAPTER 3
PROSPECTS OF AGRICULTURAL RESEARCH AND EXTENSION INTERVENTIONS IN KERALA

61. It is based on the review of the status of agricultural research, perspective plan of research institutions and deliberations of the working group with inputs from the farming and scientific community, the prominent areas of future intervention in agricultural research and extension have been outlined.

62. As reviewed earlier, agriculture in Kerala is riddled by a number of problems. The large number and diverse range of crops makes it extremely difficult to keep track of the innumerable issues that keep arising in connection with their cultivation. Problems related to crop husbandry, which can be tackled only through coordinated research, keep emerging with the passing of time. The complexity of these problems are distinct in the 23 agro ecological units spread across the State. In this context, an attempt was made to identify the issues that need to be addressed through research, as perceived by the farmers and officials of the State department of Agriculture. The assessment was undertaken by the Kerala Agricultural University as part of the State Planning Board funded project entitled "Classification and Characterization of Farming Systems in District Wise Agro ecological Units of Kerala".

Methodology

63. The period of the study (data collection) mentioned above extended from 2009 to 2013. The information was collected, in the first stage, from all the KrishiBhavans in the state using a proforma designed in consultation with the Kerala State Planning Board and the State Department of Agriculture. Subsequently focus group discussions involving all the officials of the State department of agriculture and key informant farmers were conducted in all districts of Kerala whereby the information collected were further validated and prominent researchable issues of each agro ecological unit zone were identified. Subsequently, "key informant farmers" were interviewed to ascertain field level problems, if any that were omitted during the earlier stages of data collection. In addition to collecting information from all the KrishiBhavans in the State and 864 officers from Department of Agriculture, 1347 key informant farmers were additionally interviewed directly.

64. In addition to this, a workshop of scientists and extension personnel was conducted by the Centre for Studies on Technology- Society Interface and Policy Research in Agriculture, Department of Agricultural Extension to assess the implications of the Kerala State Agricultural Policy on the research and extension priorities of the Kerala Agricultural University in 2015. This workshop also pointed out the gaps in agricultural research in the state in view of the policy recommendations. The studies held by the Centre for Gender Studies also have unearthed some key research gaps on gender mainstreaming of agriculture in Kerala.

Key Research Gaps in Agriculture in the State

65. The key research gaps in agriculture as reported by the farming community and the extension personnel are given below:

Varietal Improvement in Crops

1. Rice: short duration drought tolerant varieties for upland, saline tolerant varieties, hybrid varieties
2. Coconut: Dwarf early bearing varieties
3. Vegetables: Varieties suited for polyhouse, hybrid varieties, varieties of cool season crops adaptable to different regions
4. Application of bio technology and genetic engineering

Crop Management

1. Micronutrient recommendation for all crops
2. Scheduling of micronutrient application i.e., interval of applying
3. Strategies to cope with the climatic variations
4. Fluctuation in bearing habit in clove
5. Cropping systems based recommendation for nutrient management, water management
6. Organic POP for different crops
7. Organic POP for cool season vegetables (Marayoor, Vattavad, Kanthaloor)
8. Management of certain specific problem weeds eg. Wild rice, Cabomba and water lily in Kuttanad, Echinochloa in organic tract (Pokkali), newly emerging weeds
9. Substitutes for lime
10. Comprehensive POP for polyhouse cultivation
11. Develop cropping systems for increased water use efficiency, soil erosion ontroletc
12. Develop farming system models suited to marginal and small holdings
13. Develop more efficient strains of biofertilizers

Plant Protection

1. Organic measures/alternatives to the chemicals
2. Effective measures against red palm weevil, banana pseudostem weevil, gall wasp in Erythrina, mealy bug in papaya, Moringa, Gaint African snail
3. Diseases like bud root in coconut, lethal yellowing in coconut, horse hair disease in nutmeg
4. Develop and Validate botanicals/New biopesticides (existing and new)

Mechanisation

1. Small, user friendly, low cost machines for small holdings and homesteads
2. Machines for harvesting rice in marshy and water logged areas

Post-Harvest Technology/Production Diversification

1. Vegetables, banana, coconut
2. Safer ripening techniques for mangos
3. Validate farmers' innovations/varieties e.g. Kairali 99 variety of pepper in Kottayam

Land and Agrarian Relations

1. Comprehensive database on land to be made in order to trace the development potential and ownership of land

2. Ecological incentives to be assessed for the value of eco services by wet lands and paddy fields

Water Conservation and Management

1. Assessment of water resources and development of agronomic interventions and spatial databases for water shed development

Climate Change Mitigation

1. Assessment of the impact of climate change and development of mitigation packages for each crop and major cropping systems

Assessment of the Price Fluctuation, Impact of Trade Agreements, National and International Policies in Agriculture

1. Development of models to predict prices and implications of trade agreements and other international policies
2. Research on market intelligence

Development of Entrepreneurship Models for Private Agencies, Farmer Organizations and Women Collectives

1. Development of entrepreneurship models for different categories of beneficiaries with customized information support for entrepreneurship in agriculture and allied sectors

Standardization of Organic Practices

1. Extensive studies on alternate streams of agriculture and proving the efficacy of alternate farming practices
2. Development of protocols and practices for organic agriculture

Man-Animal Conflict

1. Wild boar attack damage to crops
2. Leech in rice fields
3. Attack of migratory birds
4. Attack of Nellikozhi/Purple Moor

Proposals for Research and Extension Interventions in Agriculture in Kerala During the Thirteenth Five Year Plan

66. Based on the issues reported by the farming community, researchers and extension personnel, about 15 major areas of research have been identified in agriculture. However, exhaustive reporting of field issues that would require research and extension intervention would require more efficient organizational mechanisms involving all the organisations involved in agricultural research in the state, including central government funded institutions. In this regard, formulation of a common forum/body is suggested to discuss the issues, progress and outcome of research by all the R&D organizations at least twice a year. Basic research related to agriculture problems also should be given due emphasis in the research agenda of all the R&D organisations during the13the five year plan.

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67. Priority areas of research identified by the working group on "Agriculture Research and ICT in Agriculture" during the 13th five year plan are listed below:

Priority Areas of Research for the 13th Five Year Plan

68. All the organisations involved in agricultural research in the state, including central government funded institutions have to work in coordination to address the problems related to the crops of the state. A common forum/body including that of funding agencies and Agricultural research Organizations suggested to discuss the issues, progress and outcome of research by all the R&D organisations and also for limiting agricultural research done by non-competent and non- agricultural research institutes. The body has to meet at least twice in a year. Basic research related to agriculture problems also to be given due emphasis in the research agenda of all the R&D organisations during the13the five year plan. Appropriate ICT methodologies are to be followed/developed for quick dissemination and adoption of technologies.

69. The Hon'ble Vice chairman during the introductory meeting has suggested to limit the priority areas of research for 13th five plan toten areas. Priority areas of research identified by the working group on "agriculture research and ICT in Agriculture" during the 13th five year plan are furnished below:
    1. Considering frequent droughts in the state research on drought mitigation studies, water management water shed management studies for enhancing water use efficiency and water availability may be given top priority
    2. Acute shortage of labour and high cost of labour is the major reason for setback of agriculture in Kerala. Hence Development/Introduction, testing and recommendation of user friendly small-farm machineries to reduce cost of production and to avoid drudgery of labour to be given adequate emphasis in the research agenda. Women friendly small machineries for homesteads should be given priority
    3. Development of location specific high yielding hybrids and varieties resistant to major pests, diseases and abiotic stresses in important crops; conservation of local cultivars and germ plasm; biotechnology research to address field problems
    4. Development of eco-friendly plant protection measures for major pests, diseases and nutritional disorders, Evolving GAP and standardizing organic farming techniques for different crops, pesticide residues and its mitigation, Identification of improved strains/ isolates of bio fertilizers, bio control agents, parasites, etc., and development of product formulations.
    5. Standardization of designs and structures of poly houses/protected structures and development of packages for hi-tech agriculture including fertigation, mulching etc. - Low cost design and materials are to be given emphasis for cost reduction and better adoption.
    6. Secondary agriculture- value addition and post-harvest handling in crops having marketable surplus and establishing incubation centres.
    7. Comprehensive management strategies to sustain and enhance productivity of crops and systems- IFS- crop combinations , development of farmer-friendly inputs like micro nutrient mixtures- tablets, ready to use sachet etc.
    8. Adaptability research on under exploited crops- fruits like rambutan, mangosteneetc, vegetables, root crops, medicinal plants and other crops rich in nutrients and medicinal properties.
    9. Social science research- Market intelligence studies in economic crops, Impact studies technologies /concepts evolved by agriculture research system, Price volatility in agricultural commodities and risk management, International trade, IPR, Changing policies and their impact on the farm sector. Research on technology- society interface in agriculture, etc.

10. Production of breeder seed and elite clones of improved varieties in different crops for meeting entire requirement of Kerala.
11. Action research to support state level missions like HarithaKeralam, to provide better technological solutions to problems faced by the LSGIs and other agencies involved in natural resource management, GAP (Good Agricultural Practices) based crop production, waste management etc.

70. In view of the above, it is suggested that the university shall formulate flagship research programmes to address prominent research gaps that have either missed the attention of the formal research systems or remained unaddressed because of lack of adequate support. These programmes would operate as network initiatives by partnering various institutions under KAU, ICAR, Development Departments, various Commodity Boards and LSGIs. Formulation, implementation, monitoring and evaluation of these projects would be done by a Research and Extension Management Council constituted with the representation of the partnering institutions. The flagship programmes would be working towards definite objectives to be accomplished in a time bound manner, with well-defined deliverables at each stage of implementation. These projects would be funded by the state government and other resources made available from ICAR, Commodity Boards, private firms, entrepreneurs etc. The Research and Extension Management Council shall formulate new programmes based on requirement from time to time.

71. Some examples of major flagship research and development programmes envisaged by the working group are given below:
    1. *Comprehensive Rice Production System Restoration Programme.* This would be a comprehensive strategy to massively transfer various sustainable and eco-friendly production technologies to rice farming tracts and to showcase varieties and practices developed by the research system. This may also include evolving methodologies for evaluation of eco- system services of paddy stretches, water bodies etc. so as to devise incentive structures and financial support to farmers.
    2. *Scaling Up Production of Breeder Seed and Elite Clones of Improved Varieties in Different Crops for Meeting Entire Requirement of Kerala.* This shall be done in various centres under KAU as a massive Seed Mission with the objective of making Kerala a hub of quality seeds in the tropics. A network of seed production facilities and seed laboratories with state of the art facilities shall be established to safe guard the interests of farmers and prevent excessive exploitation by multinational seed companies
    3. *Development of eco-friendly products for small scale homesteads and urban agriculture.* Standardization of production techniques, equipment and inputs for encouraging small scale production in homesteads and urban areas. The deliverables of this project would be massive production and supply of efficient readymade production packages to be supplied at the doorsteps of urban and rural agricultural enthusiasts through entrepreneurs.
    4. *Crop based value addition packages to be adopted by women collectives and a network of incubation centres in association with Kudumbasree.* Development of innovative value addition packages for each major crop in Kerala for large scale adoption by women collectives. This may require close review of technologies currently used by such collectives to fine tune them and make them more efficient, if not replace them with better options.
    5. *Development and standardization of microbial formulations to be extensively used for treating different types of waste.* Development of microbial formulations and standardizing the techniques for small scale producers and collectives. These products shall be distributed on a substantially large scale for waste management and composting by civic bodies.

6. *Development of secondary metabolites/humic acid based products/micro nutrient formulations for large scale adoption among farmers*. The micro nutrient formulations already developed by the KAU shall be scaled up for massive production and distribution among farmers.
7. *Introduction of a programme for providing consultancy services for Good Agricultural Practices for farmers and entrepreneurs through KAU Stations*. Establish a network of consultancy services for GAP for farmers and entrepreneurs throughout the state by equipping the research stations of the KAU with required facilities for communication with farmers through video conferencing, help desks, agro clinics, etc. in collaboration with KrishiBhavans, VFPCK, etc.
8. *Establishment of model homesteads and integrated farms in all the stations of the KAU for extension and training purpose and to enhance income*. Assess the development potential of each of the research and extension institutions in the state and prepare production and revenue enhancement plan under a special programme to be implemented in a period of one year, and sustained thereafter.
9. *A massive evaluation of the impact of the technological interventions of the Kerala Agricultural University and other research institutions*. A comprehensive study on the impact of the research and extension interventions of the Kerala Agricultural University and ICAR institutions in the state and find out the factors that determine the impact, with focus on research and extension gaps and prospects of new areas of intervention
10. *Strengthening social sciences research in agriculture to draw inputs to strengthen the extension and interface programmes of the university*. Strengthen research on socio economic dimensions of agriculture, with focus on providing the clientele system with useful information and advisory services, formulating policies and programmes, facilitating local level planning, fostering gender mainstreaming and addressing important social concerns

Institutional Mechanism for Coordination among KAU, GOI Institutions, and the Department of Agriculture in Research and Extension

72. Future initiatives in agricultural research cannot be done individually by anyone as the issues are complex and multi-disciplinary in character. The design of international agricultural research also envisages development of synergy by partnering different institutions. The institutional mechanism for coordinated efforts towards bridging the research and extension gaps shall consist of the following components:
    1. Establishment of a state level agricultural research and extension management council with the head of the institutions and selected faculty members of all the public sector institutions in agricultural research and officials of development departments, with the well-defined mandate of identifying researchable issues and proposing inter institutional network projects
    2. The chairmanship of this council shall rotate among various institutions for a term of two years
    3. The funding of these projects shall be shared based on proportionate weightage of responsibilities, financial commitment and human resource utilization
    4. Quarterly meetings to evaluate the progress of inter institutional projects and to share the usable research findings with the extension system
    5. Publication of state level communiqué of agricultural research by the research council on quarterly or half yearly basis with inputs from all partnering institutions
    6. The council shall associate with SAMETI and other training institutions in the state to impart training on specific crops and domains based on seasonal requirements, priority areas etc
    7. The method of conducting Zonal Research and Extension Advisory Council should be revamped with provision for objective listing of problems and documenting the status of solutions

8. Earmark plan funds exclusively for research problems found important by the research council based on a set of scientific criteria for prioritization like extent of area, population affected, economic value, etc.
9. The research agenda of the university to be streamlined with the action plan envisaged in ATMA, with provisions for brief studies on efficacy testing, adaptation trials, standardization of protocols, etc.

CHAPTER 4
AGRICULTURAL EDUCATION IN KERALA

73. Education in agriculture in the state is spearheaded by the Kerala Agricultural University with three colleges of agriculture, one diploma centre and an array of vocational higher secondary schools specialized in agriculture under the Directorate of Vocational Higher Secondary Education. The major work force of the state Department of Agriculture & Framers' Welfare and Department of Forest and Wildlife are trained by the KAU, with its faculties of Agriculture, Forestry and Agricultural Engineering and Technology. The educational institutions of the Kerala Agricultural University include College of Agriculture, Vellayani, College of Horticulture, Thrissur, College of Agriculture, Padannakkad, Kelappaji College of Agricultural Engineering and Technology, Tavanur, College of Forestry, Vellanikkara, College of Cooperation, Banking and Management, Vellanikkara, Academy of Climate Change Education and Research, Vellanikkara and the Institute of Agricultural Technology, Regional Agricultural Research Station, Pattambi. A brief description of the educational institutions under the Kerala Agricultural University is given below:

Faculty of Agriculture

College of agriculture, Vellayani

74. College of Agriculture, Vellayani established in 1955 as the Agricultural College and Research Institute has facilities for teaching, research and extension education. The courses offered are B Sc. (Hons.) Ag, M Sc. (Ag.), B Sc.- M Sc. (Integrated) Biotechnology and Ph.D. The college also has an instructional farm with a total area of 215.68 ha provides basic instructional facilities to students and researchers in the college and now undertakes multifarious activities like production and distribution of good quality seeds, seedlings, farm produce, participation in exhibitions, providing farm advisory services etc. The college has facilities such as an indoor stadium, the largest of its kind in the University, an open stage for conducting arts and stage programmes, soil museum and documentation centre, crop museum, medicinal plants museum, model organic farm units, seed laboratory, instrumentation laboratory, pesticide residue laboratory, plant virus indexing laboratory, nematology laboratory, biocontrol laboratory, molecular biology laboratory, centre for microbial technology, agromet unit and meteorological observatory, automatic weather station, livestock, pig and poultry farm, agricultural engineering workshop and a sales cum information centre.

College of Horticulture, Vellanikkara

75. The College of Horticulture established in 1972 offer courses viz. B Sc. (Hons.) Ag, M Sc. (Ag.) and Ph.D. The college has the centre of plant biotechnology and molecular biology, central library, radiotracer laboratory, centre for e-learning, bio control lab, ornithology research centre, cocoa research centre, centre of excellence in environmental economics, state of the art seed testing laboratory, centre for gender studies, etc. in agriculture and farm women in agriculture entrepreneurship development, distributed information System, student computer centre, etc.

College of Agriculture, Padanakkad

76. The College of Agriculture, Padanakad started in 1994, as the third agricultural college under the Faculty of Agriculture of the Kerala Agricultural University serves the North Malabar region commendably. The courses offered are B Sc. (Hons.) Ag and M Sc. (Ag.) with state of art facilities for training, value addition and other field experiments in crop production, crop protection, soil science, etc.

College of Co-operation, Banking & Management, Vellanikkara

77. The College of Co-operation, Banking and Management, a constituent institution of the Kerala Agricultural University established in 1981 caters to the need formulti-disciplinary academic and research programmes in cooperation, rural development, agri business management, etc.

78. Presently the College offers a four year professional management degree viz. B.Sc. (Hons.) Cooperation &Banking, M.Sc. (C & B) with three specializations (Co-operative Management, Rural Marketing Management, Rural Banking and Finance Management), a doctoral programme in Rural Marketing Management, and a MBA in Agribusiness Management on a cost sharing basis.

Academy of Climate Change Education and Research, Vellanikkara

79. The Academy of Climate Change Education and Research (ACCER) offers M.Sc. (Integrated) programmes in Climate change Adaptation with the objective of providing quality education and research in climate change adaptation and mitigation in agriculture and allied sectors. It is an academic and research exchange programme with the collaboration of various national and international institutes on a cost sharing basis.

Institute of Agricultural Technology, Regional Agricultural Research Station, Pattambi

80. The station with its legacy and international reputation for research in rice offers excellent facilities for education as well as research. The institute offers a two year diploma course in Agricultural Sciences (DASc)

Faculty of Agricultural Engineering and Technology

Kelappaji College of Agricultural Engineering and Technology, Tavanur

81. Kelappaji College of Agricultural Engineering and Technology established in 1985 under the Faculty of Agricultural Engineering and Technology offers courses viz. B.Tech (Agrl.Engg.), B.Tech. (Food Engg) (Self financing), M Tech and PhD in soil &water engineering, farm power machinery, agricultural processing and food engineering. The college has facilities like instructional farm with 40 ha of land, dairy farm, sales counter, indoor court, computer lab and language lab, farm implements museum, centre of excellence in post-harvest technology, incubation centre for start-up programs, processing laboratory, remote sensing laboratory, workshops for carpentry, smithy, fitting, etc., hydraulics laboratory, ergonomics laboratory, etc.

Faculty of Forestry

College of Forestry, Vellanikkara

82. The College of Forestry established in 1986 is located in the Main Campus of the Kerala Agricultural University at Vellanikkara. The college has grown to the status on a centre for excellence in forestry and the only educational institution in this domain. The courses offered are B Sc (Hons.) Forestry, M.Sc (Forestry) and Ph. D. in Forestry. The college has state of the art wood laboratory, library etc.

83. The courses offered by these institutions and the strength of students in each course are given in Table 9 below:

Table 9 *Details of educational programmes held by the Kerala Agricultural University*

Name of Institution	Courses offered and yearly enrolment							
	BSc/ BTech/ Diploma	M Sc/ M Tech	PhD	Integrated MSc (Biotech)	Integrated MSc (Climate Change)	B Tech (Food Engg)	MBA	Diploma (Agri)/(Organic Agri)
College of Agriculture, Vellayani	102	79	25	20	-	-	-	20
College of Horticulture, Vellanikkara	53	66	27	-	-	-	-	-
College of Agriculture, Padannakkad	52	10	-	-		-	-	-
College of Cooperation, Banking and Management	40	10	1	-	-	-	40	-
Academy of Climate Change Education and Research Kelappaji	-	-	-	-	20	-	-	-
College of Agricultural Engineering and Technology	51	15	5	-	-	30	-	-
College of Forestry	31	15	6	-	-	-	-	-
RARS, Pattambi	-	-	-	-	-	-	-	50
Total	**329**	**195**	**64**	**20**	**20**	**30**	**40**	**70**

84. Apart from this, trained manpower in agricultural sciences are produced by the Department of Vocational Higher Secondary Education as well, with about hundreds of certificate holders coming out of the vocational higher secondary schools across the state, every year.

85. As understood from the table above, the Kerala Agricultural University does not have any undue emphasis on self-financing courses as seen in other universities. However, there have been attempts to initiate new courses and institutions without taking into cognizance prospective job opportunities or the human resource requirement in the agricultural sector. There are recommendations to establish more colleges in the discipline of agriculture at different parts of the state, but without any allotment exclusively for this purpose. New courses and institutions shall be thought of only based on the resources at hand and the magnitude of human resource required in the sector. In fact Keralites who graduate from institutions outside the state to the tune of around 3000 per annum also add up to the trained man power in agricultural sciences and related domains.

86. Agricultural education in Kerala faces several challenges. Major constraints are inadequate funding and lack of sufficient teaching faculty. Lack of adequate manpower in technical, administrative and supporting sections also prevents the university from accomplishing its targeted goals. This even

affects curriculum implementation in the KAU. Apart from this, the faculty gets very little opportunities for Faculty Improvement programmes in other leading national and international institutions. Poor communication network, absence of smart class rooms, outdated equipment in laboratories, inadequate library facilities, lack of fire-fighting equipment, barrier free environment for physically disabled, absence of grievance redressal mechanisms, problem of employability and recognition of new courses, poor linkages between line departments and inefficient natural resource management also appear to be the bottlenecks in ensuring quality education in agriculture.

Proposals for Improving Agricultural Education in Kerala

87. In view of the above issues, the following proposals are put forth to improve agricultural education in Kerala
    1. Enhance allocation for agricultural education for improving infrastructure facilities
    2. Recruitment of teaching and technical staff against all existing vacancies
    3. Creation of new faculty positions for the newly declared courses and institutions
    4. Instituting career advancement training programmes for faculty members and technical staff on research and extension management, IPR, project formulation etc by establishing an Academic Staff College
    5. Establishment of multimedia labs, smart class rooms, video conferencing facilities, wi fi facilities, computer labs etc for inter institutional interaction in teaching and research
    6. Initiating on line courses on agriculture for the general public, farmers, students and entrepreneurs
    7. Establishment of Centres of Excellence in disciplines such as nanotechnology, GIS, natural resource management, crop modeling, high tech agriculture, micro nutrient research, precision farming, processing and value addition etc
    8. Establishment of entrepreneurship development centre

ICT Applications in Agriculture in Kerala: Status and Prospects

88. Kerala as per the reports of TRAI, has the highest mobile penetration with more than 30 million connections for a population of 33 million, with a rapid increase in the use of smart phones. It also has high Internet penetration, covering about 20 per cent of the households through broadband and another 15 per cent through mobile. Moreover, Kerala is among the top five states with regard to tele density (95.70 persons with telephone connections for every 100 individuals), 34.71 Internet subscriptions per 100 population, 12.31 million Internet subscriptions, 2.68 million wire line subscribers of which 65 per cent is rural and 31.13 million wireless subscribers.

89. In spite of this encouraging scenario, the application of ICTs in agriculture has been low with only around15 per cent of the farming community regularly depending on ICT applications of any kind to retrieve information on agriculture for their daily farming operations. Though active users of the Internet and other social media have been steadily increasing, lack of customized and location specific information for various needs of the farmers has hindered the penetration of ICTs among the farming community. This calls for substantive changes in the strategy of ICT use in agriculture, with scope for developing multitude of applications addressing various target groups and functions. Compared to other states where agriculture is the main stay, the applications that cater to the needs of farmers from authentic sources like the university or the ICAR are less in Kerala. A recent survey held by the Kerala Agricultural University has revealed that the proportion of extension agents who use ICT applications for transfer of technology is very low and the content in agriculture is not customized and updated. The farming community at large does not seem to rely on ICT applications

for their decision making in farming and related enterprises. This indicates the huge gap that exists with respect to adoption of ICTs and digitized content required for various stakeholders of farming.

Status of ICT Applications Developed By the Kerala Agricultural University

90. Though the Kerala Agricultural University had pioneered ICT enabled research, education and extension even as early as 1999, by establishing a virtual university, those efforts could not be sustained for various reasons. However, the domestic ICT infrastructure has been considerably upgraded with an intranet connection at the headquarters, which was eventually enhanced to universal access to the Internet at all the institutions and hostels almost round the clock. Research and educational institutions also have connectivity and gadgets, which have installed by making use of externally aided project funds. The current status of ICT infrastructure and services in the Kerala Agricultural University is briefly described below:

The Centre for E-Learning

91. The Centre for e- Learning was established consequent to the closure of the virtual university. The objective of the centre for e-learning is to make local and frontier areas of farm technology available to farmers free of cost through ICT applications. The centre has developed the following applications

Agri info tech portal for kerala

92. The KAU Agri InfoTech portal is an ICT enabled platform for demand driven technology information and advisory service of farmers, extensionists, researchers, students and all other stakeholders in the field of agriculture.

E-karshakajalakam

93. This is an interactive web portal in Malayalam for the farmers of Kerala, with content on crops, cultural practices, extension services, etc.

Online courses

94. Online courses are extended for the benefit of farmers, extensionists, students and entrepreneur groups. Important online courses include organic agricultural management, pest harvest management and marketing of fruits and vegetables.

Advance e-training centre

95. The centre imparts training in frontier agricultural technological areas through direct and online methods.

Production and supply of multimedia

96. Multimedia presentation materials are produced for the purpose of agricultural education and transfer of technology.

Agro tech database and interactive cyber platform

97. The database is intended for knowledge sharing.

KAU market intelligence

98. KAU Market Intelligence for black pepper, coconut and tapioca are available through the portal.

Others

99. Useful information on animal husbandry, fisheries, farm machinery and other e-resources such as crop health decision support system are made available by the centre. The Centre also triestoimpart training on vegetable cultivation online. A farmer's corner where farmer's innovation and success stories are documented, etc. are periodically updated in the portal. Daily district wise weather parameters are available from the portal. The Kerala Agricultural Directory includes important contact numbers of the centres and institutions under agricultural, animal husbandry, fisheries etc. A crop almanac giving monthly operations of eighteen important crops of Kerala (pepper, cocoa, coconut, mango, pineapple, nutmeg, cashew, arecanut, ginger, spices, tapioca etc.) is also incorporated into the portal.

100. Kerala Agricultural University fertulator is application software for the easy calculation of fertilizers needed for different crops. Important websites related to agriculture, forestry, animal husbandry, agro machinery, bio diversity are part of the portal.

101. Apart from this, there are several applications developed by individuals and institutions to serve various purposes. For example, the KVK Activity Management Information System (K-AMIS) developed by the KVK Kollam would help manage the activities of KVKs to a considerable extent by creating administrative and research reports. The m- application namely Farm Extension Manager (FEM) Mobile recently launched by KVK Malappuram has proven to be a handy tool for easy and ready reference on cultural practices of major crops of Kerala.

ICT Tools for Knowledge Management in KAU Libraries

102. ICT applications in the libraries of KAU have been grossly inadequate. As of now, the libraries in all the educational institutions have been networked for sharing student theses. However, this network would be useful only if the research stations are also integrated into it with provisions to share the results of research projects among institutions. A repository of research results would be a great step towards effective knowledge management in the university.

103. Libraries in KAU are also constrained by lack of subscription to international research data bases. The KAU subscribes only to CAB abstracts. There is a pressing need to subscribe to databases such as AGRICOLA and AGRIS. Needless to say, subscription to journals is also found to be grossly inadequate given the prospects of the diversity of research topics that could be taken up by the institution and the level of inter institutional interaction required to garner new knowledge and information. The computer systems in students' laboratories require immediate upgrading as most of them are quite old.

E- Governance in Research, Extension and Academic Management

104. The Kerala Agricultural University has deployed applications for financial management and research management at the central administrative unit and other offices viz. University Functional Accountability SysTem(U FAST) and Online Research Management Information System(ORMIS). This has enabled on line consolidation of data on finances, accounts and establishment to a great extent. However, the functionality of ORMIS is still to be enhanced. The comprehensive Academic Information Management System is yet to become fully functional and the Extension Management System has not taken off.

Kissan Kerala

105. The Karshaka Information System, Service and Networking is a project by the Department of Agriculture, Govt. of Kerala. This is integrated multi model agricultural information system for Kerala which includes streaming videos, television episodes of Krishideepam, GIS based weather information, planting materials, availability, virtual markets among other important information. This has been conceptualized and developed by IIITM-K, Thiruvananthapuram. Kissan has also a tele advisory service.

106. Most ICAR institutions such as CPCRI, CTCRI, IISR have their own information portals. Mobile applications, decision support systems, management information systems etc. have been developed by R&D institutions independently for the benefit of the farming community. The Agricultural Ministry of the Govt. of India launched two mobile apps "1. Crop insurance 2. Agri Market" for the benefit of farmers. However the State Government is yet to come out with a comprehensive mobile app that can bring co-ordination and convergence between the various agencies. Social media platforms such as Face book, WhatsApp, etc. have witnessed a spurt in organic farmer groups vegetable farming group, etc. All these need to be integrated to the application tools developed for the farming community.

107. Considering all the above, it seems that there are immense possibilities for ICT applications in agriculture

Proposals for Enhancing ICT Applications in Agriculture

108. Focus should be on improving the interface of the research &development agencies with development departments, commodity boards, institutions such as VFPCK, local self government institutions and various farmer collectives by leveraging advancements in ICTs. This should also include strengthening of processes and infrastructure deployed for agriculture development and support needs. The coverage of the information is to be state wide across all the 14 districts. Any ICT project in agricultural research and extension must encompass three components, one: strengthening of processes, infrastructure, logistics and manpower for the research and development departments, two: assured delivery of mobile applications, hardware, software, solution implementation and support services for a web based decision support system as well as mobile applications. The outcome of the project would be improved effectiveness and efficiency of KAU's extension and outreach initiatives and enhanced alignment of research with the developmental needs. This will in turn improve visibility, co-ordination and convergence among agencies.

109. Any ICT solution must enable easy, quick and reliable access to agricultural technology for the farming community as well as for the various research and development agencies. It should be user-friendly, intuitive and interactive. Cyber extension initiatives should necessary have state of the arton-line platforms that enable web based and mobile applications. Other important prerequisites

for this would be state of the art infrastructure, trained manpower to manage systems, comprehensive knowledge databases, protocols for knowledge sharing among institutions, pro-active and customized content generation, design of applications for various target groups, etc.

110. In view of this, the ICT programmes that are proposed to be developed and implemented during the 13th Five Year Plan are given below:

Table 10 *ICT Programmes in Agriculture Proposed to be Implemented in Kerala*

Feature	Description
Inter Institutional Knowledge Management	Applications to store and retrieve research findings by the institutions under KAU
Call Centre Management	Level 1 support and related operations management on a two shift by seven days basis for meeting the information requirements by farmers, KVKs, KB, etc.
Query Management	Online interactive facility for managing queries – reporting, resolving, tracking, monitoring -raised by Farmers/KVK/RS/KB on portal and mobile
Self-Service Calculators	Mobility applications for Self Service Calculators/POP Help for enabling quick and reliable information access to Farmers/internal staff/field staff
Service Request Management	Facility for user groups to request for services - training, consultancy, farm trials, etc.
Alert Management	Near real time automated alert mechanism for escalations, events, need based mass communication
Analytics	Data driven Analytics to carry out various trend analysis, aid action planning/decision making and co-relate action effectiveness
Field Personnel Management	Ability to allocate field tasks and monitor activity of the field force
Publications Management	Document management for KAU publications -POP, farm journals
Extension Programme Management	Facility to maintain schedules of extension programmes like training, farm schools, agri clinics, mobile exhibitions, etc. and capture outcome
Master Farmer Management	Information management of master farmers and their activities
TOT Management	Facility to capture seed attributes and yield performance against seed attributes
Feedback Management	Facility to capture and analyze objective and subjective feedback from various user groups against specific service dimensions
Services & Schemes	Information of services and schemes available at each KB
Marketing Support	Provision for user groups to register for availing marketing facility of mobile exhibitions & Information of market/price trend and details of VFPCK sales outlets
Academic Information System	With provisions for syllabus management, course management, online tests, examinations, compilation of grades and calculation of OGPAs, student data management, etc.

Source: Various Administrative and Annual Reports of Kerala Agriculture University

111. As stated in the first chapter, paucity of funds for research demands substantial enhancement of financial resources required for the Kerala Agricultural University. The customary plan and non-Plan allocation for the university had been only just adequate for essential functions and had not been sufficient to initiate any large scale research programme. The trifurcation of the university has led to a situation where the assets have been divided among the three institutions, with no distribution of liabilities. The entire liabilities of the mother institution still remain with the KAU. This may require exclusive allocation of non-Plan funds to clear liabilities either as a onetime intervention or in a phased manner.

112. The crisis of the university is also deepened by acute shortage of manpower. Even in positions financed by External Aided Projects, the university has not been able to place adequate human resources. Streamlining agricultural research, education and front line extension by the most important institution in the state therefore requires liberal support from the government, complemented by measures to enhance generation of the institution's own revenue several fold.

113. Considering all the above concerns, the proposal for plan fund allocation for the thirteenth five year plan shall be as given below:

Table 11 *Proposal for Plan Fund Allocation to the Kerala Agricultural University during the 13th Five Year Plan*

Sub Heads	2017-18	2018-19	2019-20	2020-21	2021-22
Academic activities	1000	1200	1440	1728	2074
Research	4275	5130	6156	7387	8864
Extension	1527	1832	2198	2638	3166
Infrastructure development	2672	3206	3847	4616	5539
Students' Welfare	225	270	324	389	467
Governance and administration	301	361	433	520	624
Total	10000	11999	14398	17278	20734

Source: Various Administrative and Annual Reports of Kerala Agriculture University

CHAPTER 5
CONCLUSION

114. Agricultural research, extension and education in Kerala are at cross roads, with vast possibilities for modernization and diversification. The prime concerns of agricultural development in Kerala are accomplishment of food security, ensuring livelihood security of small holders and utilization of the rich agro biodiversity of the state with an eye on global market. Given the complex socio economic and agrarian characteristics of the state, key objectives of research in agriculture would be intensification of production in small holdings and maximization of profit through product diversification and value addition. This throws open prospects of employing state of the art technologies which may require extensive adaptive research. As of now, this would be possible only through collective action, with the appropriate institutional mechanisms to harness the resources and efforts of farmers.

115. Research and extension support is also required for creating conducive situations for triggering sustainable growth in this sector; by means of conserving the natural environment managing and optimizing the use of resources. Development of cost effective indigenous solutions to attain self-reliance in agriculture has also been pointed out as an important priority of research in this context. Research on the socio economic dimensions of agriculture in emerging situations is also a priority.

116. A comprehensive plan for research and extension in agriculture in the forthcoming five year plan should necessarily include strategies for transforming the research and development institutions to make them capable of taking on these challenges. Enhancing the financial resources with well laid out mechanisms to monitor the deliverables would be a major step towards this direction. This may also require development of synergy among various institutions to formulate and implement joint research ventures through collaborative network programmes. Linkages among the research, extension and development institutions with provisions for consultation with one another in common platforms are also necessary. It is in view of the above concerns that the draft proposal has attempted to put forth a comprehensive programme for improving the capability of the state in agricultural research and development.

ANNEXURE 1

List of thrust areas

1. Rice
    1. Collection, conservation and cataloguing of rice germ plasm
    2. Breeding for higher yield, quality and resistance to biotic/abiotic stresses
    3. Research on hybrid rice, transgenic rice and speciality rice
    4. Development of location specific agro techniques for sustainable rice production
    5. Management of abiotic stresses
    6. Management of biotic stresses
    7. Physiological approaches for enhancing crop productivity
    8. Mechanisation in rice cultivation
    9. Post-harvest technology in rice
    10. Socioeconomic dimensions of rice cultivation in Kerala

2. Spices and Plantation Crops
    1. Germplasm collection, conservation and evaluation
    2. Breeding for high yield and quality
    3. Breeding for pest and disease resistance / tolerance
    4. Propagation and nursery techniques
    5. Agrotechniques for yield and quality improvement
    6. Integrated nutrient management
    7. In situ moisture conservation and irrigation management
    8. Integrated pest and disease management
    9. Good agricultural practices and organic farming
    10. Post-harvest handling and value addition
    11. Biotechnology aspects
    12. Developing user friendly machines

3. Vegetables
    1. Development of F1 hybrids in major vegetables
    2. Development of vegetable varieties with resistance to major biotic and abiotic stresses
    3. Development of packages for protected cultivation / precision farming for high productivity
    4. Site specific crop management strategies in vegetables for targeted yields
    5. Adaptability, improvement and large scale multiplication of under-exploited and ethnic vegetables, and cool season vegetables
    6. Developing technologies for homestead, kitchen garden, grow bag and terrace vegetable cultivation including soil-less production technologies
    7. Eco-friendly technologies for plant protection in vegetables with special emphasis on pests, diseases, birds and nutritional and physiological disorders
    8. Seed production, processing, storage, testing and quality enhancement in vegetables
    9. Collection, characterization and maintenance of germ plasm of major vegetables

4. Fruits
    1. Collection, characterisation, documentation, conservation and evaluation of germ plasm of major and minor fruits
    2. Identification/development of improved varieties for commercial cultivation and utilisation.
    3. Refinement of propagation and management methods
    4. Development of organic management practices.
    5. Management of pest and diseases

6. Domestication, evaluation and management of exotic fruits.
7. Identification of subtropical fruit varieties for plains, development of agro techniques for subtropical and temperate fruits
8. Identification of fruit crops and varieties suitable for homestead cultivation
9. High tech fruit culture (high density planting, fertigation, tree size control, protected cultivation, canopy regulation etc)
10. Biotechnological interventions in fruit crops.
11. Development of pre and post-harvest technologies for enhancing shelf life of major fruit crops.
12. Product diversification, by-product utilisation and waste management of fruit crops.
13. Mechanisation in fruit cultivation, harvesting, postharvest handling and processing
14. Influence of climatic variations in the performance of fruit crops

5. Field Crops – Cereals (other than rice), Millets, Pulses, Oil seeds, Fodder Crops and Green Manure Crops
    1. Cereals (other than rice) and millets
        1. Screening and agro-techniques for millets and cereals other than rice for changing climatic conditions / major cropping systems of Kerala.
        2. Development of package of practices for baby corn, sweet corn and sweet sorghum.
    2. Pulses
        1. Screening varieties for stress situations and high yield
        2. Identification/ development of suitable varieties for rice fallows
        3. Agro techniques for yield maximization and quality improvement including mulching, fertigation and weed management
        4. Development of photo insensitive varieties in pulses
        5. Isolation and formulation of native bio fertilizers for pulse crops
        6. Plant protection methods including botanicals and microbial consortium
        7. Management of storage pests and diseases
    3. Oil Seeds
        1. Collection, conservation and cataloguing of germ plasm of oilseed crops
        2. Developing high yielding varieties with tolerance to biotic and abiotic stresses suitable for rice based cropping system
        3. Weed management in oil seeds
        4. Harvesting and processing technology for oil seeds
        5. Investigating therapeutic and nutraceutical value of sesamum / ground nut
        6. Developing value added products
        7. Agrotechniques for under exploited oilseeds
    4. Fodder crops
    1. Identifying high quality fodder crops / varieties.
    2. Developing varieties suited to biotic and abiotic stresses and for soil conservation.
    3. Developing package for plant protection, higher yield and quality.
    4. Improving seed setting in cereal and legume fodders.
    5. Fodder preservation techniques.
    5. Green manure crops
        1. Green manuring in major cropping systems of Kerala for soil health and productivity.
        2. Soil carbon sequestration and micro nutrient addition potential of green manure / green leaf manure crops.
        3. Exploitation of green manure potential of non-conventional sources like mimosa, mikania, merrimia, wild coccinia etc.

6. Floriculture
    1. Protected cultivation and precision farming in commercial flowers and foliage
    2. Standardization of production technology and improvement of cut flowers and other ornamentals
    3. Evaluation of indigenous flora and introduction of new ornamentals
    4. Post-harvest handling, value addition and market studies
    5. Interior plant scaping and pollution abatement studies
    6. Landscape horticulture

7. Aromatic &Medicinal Plants
    1. Exploration, conservation and evaluation of germ plasm
    2. Genetic improvement for yield and quality
    3. Nursery and agro techniques in Medicinal & Aromatic Plants
    4. Management of pest and diseases in Medicinal & Aromatic Plants
    5. Post-harvest technology, value addition and product development
    6. Chemical characterization and quality studies in medicinal and aromatic plants and their products
    7. Economics and marketing of Medicinal & Aromatic Plants

8. Biotechnology, Biochemistry & Plant Physiology
    1. Plant Tissue Culture for
    2. Micro propagation of recalcitrant species and commercially important crops
    3. Crop improvement
    4. Secondary metabolite production
    5. Molecular characterization, diversity analysis and Marker Assisted Selection.
    6. Genome mapping, gene annotation and genetic transformation
    7. Genome, Transcriptome, proteome metabolome and phenome analysis
    8. Bioinformatics resources and applications in agriculture.
    9. Nano biotechnology and molecular diagnostics
    10. Physiology of crops in precision farming/protected cultivation/organic farming/aerobic system and tissue culture
    11. Physiological approaches for increasing crop productivity and stress tolerance
    12. Physiological basis of crop response and resilience to climate change
    13. Biochemical basis and characterization of
    14. Important disorders / diseases in crop plants
    15. Agro products / New phytocompounds / Biomolecules
    16. Integrated biotechnology- Integration of Plant Biotechnology with industrial, environmental, animal, medical, food, algal biotechnology and metagenomics

9. Soil health and organic farming
    1. Basic Studies on Soils.
    2. Soil Fertility evaluation and nutrient management for sustaining soil health and yield maximization.
    3. Plant nutrition and nutrient use efficiency.
    4. Nutrient management in high tech agriculture and soilless media.
    5. Natural Resource management for sustainable development and resource conservation.
    6. Characterization and management of constrained/ problem soils.
    7. Waste management for improving soil health and productivity.
    8. Environmental pollution and remediation measures.

9. Organic farming and good agricultural practices for soil health and safe food production.
10. Soil ecology and ecosystem conservation.

10. Farming system research and climate studies
    1. Cropping systems research
    2. Multi-enterprise farming systems/Homestead Farming
    3. Urban and peri-urban cropping/ farming systems
    4. Conservation agriculture
    5. Integrated resource management in cropping/farming systems
    6. Component interactions in cropping/farming systems
    7. Agroecological characterization and watershed research
    8. System based precision farming
    9. Crop weather studies, meteorological parameter interactions and forecasting/simulation models
    10. Climate resilient agriculture/climate change adaptation studies
    11. Ocean – climate interactions and animal response studies

11. Crop pests and beneficial insects
    1. Ecology and Biosystematics
        1. Morphological characterization and documentation of insect pests/ natural enemies and noninsect pests of important crops
        2. Molecular systematics for identification of crop pests and natural enemies
        3. Exploration and collection of Insect and non insect biodiversity
    2. Climate change and changing pest scenario
        1. Pest surveillance, short term and long term forecasting of pests
        2. Population dynamics of crop pests in relation to weather parameters
        3. Change in pest status and modes of attack
    3. Strategy for Pest management
        1. Estimation of crop loss and data base generation
        2. Eco friendly methods of pest control & Ecological Engineering
        3. Chemical interventions
        4. Screening germ plasm of major crops for resistance to pests, identification of resistance mechanisms including biotechnological approaches
        5. Chemical ecology
        6. Pest management under protected cultivation and High Tech Agriculture
        7. Vector plant interaction
        8. Spatial distribution, invasion dynamics and management of newly emerging and alien pests
        9. Post harvest Entomology
    4. Pesticide toxicology
        1. Monitoring pesticide residues in crops and environment and its management
        2. Impact of pesticides on non target organisms
        3. Bio efficacy and chemo dynamics of pesticides
        4. Nanotechnology in pesticide formulations
        5. Insecticide resistance and its management
    5. Biological Control of Insects, Non insect pests and weeds
        1. Potential indigenous natural enemies
        2. Formulation technologies of bio pesticides and bio herbicides
        3. Conservation techniques of bio control agents under field conditions

4. Studies on in-vitro production for obligate entomopathogens using cell line culture and molecular tools
5. Studies on multiple tolerant bio control agents and entomopathogens
6. Tritrophic interactions

6. Apiculture
    1. Honey bees for pollination of different crops in field and polyhouses
    2. Location specific research on bee management
    3. Quality control and value addition of honey
    4. Cataloguing of floral calendar
    5. Meliponiculture
7. Non-insect pests (mites, nematodes, rodents, birds, snail and slugs)
    1. Population dynamics of depredatory birds and its conservation management
    2. Beneficial birds
    3. Rodents and other Vertebrate pest management
8. Insects as Bioresources
    1. Medicinal and edible insects
    2. Insects as indicators of water pollution
9. Molecular approaches in Entomological Research
    1. DNA fingerprinting to study population structure, biotype studies and monitoring genetic changes in insect pest population
    2. Mapping of insecticide resistant genes in insects

12. Plant pathogens and beneficial microbes
    1. Detection, identification, characterization, molecular and Nano technological studies of plant pathogens and beneficial micro-organisms for crop nutrition, crop protection and microbial biotechnology.
    2. Development of novel strategies, beneficial microbes, their improved strains and biomolecules for eco-friendly management of crop diseases, crop nutrition, crop growth enhancement and bio control of weeds.
    3. Development of efficient microbial formulations and delivery systems for enhanced crop production and protection.
    4. Post harvest and seed borne diseases, mycotoxins and their management.
    5. Crop loss assessment, disease mapping, epidemiological aspects and integrated management of major and emerging diseases of crop plants of Kerala.
    6. Mushroom production technology and its application in biodegradation, nutraceuticals and pharmaceuticals
    7. Molecular basis of beneficial microbial associations and host- pathogen interaction.
    8. Role of plant nutrition and climate change in the development and management of plant diseases.
    9. New generation fungicides, development of fungicidal resistance, non -target effects, compatibility and role of residues with respect to food safety and environmental concerns.
    10. Exploitation of microbes for bioremediation, biological waste management and waste water recycling.

13. Post harvest technology
    1. Postharvest management
        1. Postharvest management in major and minor crops
        2. Pre- harvest factors affecting post harvest quality
        3. Utilisation of microbial agents in post harvest management

4. Application of biotechnology in post harvest management
5. Post harvest management in organic crops

2. Processing and value addition
    1. Processing and value addition
    2. Packaging and storage of processed commodities
    3. Bioactive compounds and development of functional foods
    4. Waste utilisation
    5. Development of novel, organic and convenient food products
    6. Quality control studies

14. Food Science and Nutrition
    1. Food security, food consumption pattern and nutritional status
    2. Nutritional problems of the community
    3. Quality evaluation of foods & Food products
    4. Food Processing, Value addition and product diversification in foods.
    5. Diet in Health and Diseases
    6. Bio active components in foods – Antioxidants and phytochemicals
    7. Food hygiene and safety
    8. Bio waste utilization.
    9. Traditional foods - in changing food habits.
    10. Toxicological studies in foods and food products.
    11. Wellness foods /Functional Foods/Nutraceuticals/Probiotics
    12. Application software/apps for nutrition education and dietary package
    13. Developing regional standards for anthropometric indices

15. Agricultural Economics, Agricultural Statistics and Agribusiness Management
    1. Agricultural Economics
        1. Impact assessment of KAU technologies/other programmes
        2. Analyzing International/National/State policies and sensitizing its impact on farm sector
        3. Cost of production and marketing of major crops/inputs/technologies
        4. Natural resources and environmental economics
    2. Agricultural statistics
        1. Developing innovative methods for analyzing scientific data Agricultural statistics of Kerala and India
        2. Theoretical and applied studies
    3. Agribusiness Management
        1. Agribusiness Management Studies
        2. Evaluation of rural financing scenario and financial institutions
        3. Management of co-operatives and group initiatives
        4. Value analysis of Agribusiness
        5. Evaluation of Agricultural and rural development programmes

16. Agricultural Extension and Development Studies
    1. Agricultural crisis and policy research
    2. ICT in Agriculture and media studies
    3. Participatory approaches
    4. Innovations and technology management
    5. Subaltern and Gender studies

6. NRM and sustainable development
7. Entrepreneurship and skill development
8. Extension management and development studies

17. Sugar Cane and Tuber Crops
    1. Sugarcane
        1. Developing varieties suitable for different agro climatic situations of Kerala
        2. Cost effective and input efficient technologies for high yield and quality in sugarcane
        3. Developing technologies for processing, product diversification and by products utilisation of sugarcane
        4. Management of biotic and abiotic stresses in sugarcane
        5. Mechanization in sugarcane cultivation and harvesting
    2. Tuber crops
        1. Development of high yielding, location specific and pest and disease resistant varieties in tuber crops
        2. Development of package of practices including organic package of practices in tuber crops
        3. Eco-friendly technologies for plant protection with special emphasis on vertebrate pests and virus diseases
        4. Development of technologies for large scale production of planting materials of tuber crops
        5. Utilisation of underexploited tuber crops

1. Agriculture Engineering Faculty
    1. Farm Power Machinery & Energy (FPME)
        1. Farm machinery
            1. Soil manipulation
            2. Inter-cultural operations
            3. Sowing and planting
            4. Harvesting and post harvesting operations
            5. Ergonomics and safety

        2. Farm Power and Energy Studies
            1. Solar energy
            2. Bio-energy
            3. Wind energy

    2. Soil and Water Engineering (SWE)
        1. Soil and water conservation
        2. Irrigation & drainage
        3. Precision farming & protected cultivation
        4. Vertical farming and Soil less cultivation
        5. Rain water harvesting and conservation
        6. Land and water resource development and management
        7. Environmental Engineering and management
        8. Climate change and natural resource management
        9. Watershed management

    3. Food and Agricultural Process Engineering (FAPE)

1. Design and development of equipment suitable for small/ medium scale processing units
2. Development of ready to eat foods using advanced engineering principles
3. Application of advanced drying principles in food processing
4. New techniques in packaging and storage
5. Innovative extraction methods for bio-active compounds and its encapsulation
6. Application of non-thermal processing for food preservation
7. Non-destructive quality evaluation of foods
8. Application of nanotechnology in processing and preservation
9. Entrepreneurship development in food processing sector
10. Food safety and quality management
11. By-product utilization of agricultural/food industry

ANNEXURE 2

PROCEEDINGS OF THE MEMBER SECRETARY
STATE PLANNING BOARD
(Present: Sri. V. S. Senthil IAS)

Sub: Formulation of 13th Five Year Plan – Constitution of Working Groups – reg.
Ref: Note No. 260/2016/PCD/SPB dated 06.09.2016 of the Chief (i/c), Plan Co-ordination Division, State Planning Board

Order No. 300/2016/AGRI (W2)/SPB Dated: 19.09.2016

As per the reference cited, State Planning Board has constituted Working Group on 'Agriculture Research and ICT in Agriculture' to formulate the draft proposals in the sector for inclusion in the Thirteenth Five Year Plan.

The Working Group on **"Agriculture Research and ICT in Agriculture"** is hereby constituted with the following members.

Co – Chairperson

1. Dr Raju Narayanaswamy IAS, Principal secretary, Agriculture
2. Dr T R. Gopalakrishnan, Former Director of Research, Kerala Agricultural University, Trissur

Members

1. Dr Sajan Kurien, Director of Research, KAU, Trissur
2. Dr B.R. Reghunath, Dean, Agriculture, College of Agriculture, Vellayani, Thiruvananthapuram
3. Dr James George, Director-CTCRI, Thiruvananthapuram
4. Dr P Chowdappa, Director-CPCRI, Kasaragod
5. Dr Kantipudi Nirmal Babu, Director-IISR, Kozhikkode
6. Dr Hajilal M.S, Dean, College of Agricultural Engineering, KAU, Thavanoor, Malappuram
7. Dr Uma Maheswaran, Associate Director, NARP, College of Agriculture, KAU, Trivandrum
8. Dr Jiju P Alex, Professor, College of Horticulture, Vellanikkara, Trissur
9. Dr Sreevalsan J Menon, Professor and Officer on Special duty, ATIC, KAU, Mannuthy
10. Dr Jacob John, Professor and Head, CSRC, Karamana, KAU, Thiruvananthapuram
11. Dr C Gokulapalan, Retired Professor, College of Agriculture, Vellayani, Thiruvananthapuram
12. Dr V Surjit, ICRISAT, Hyderabad
13. Dr Geethakutty, Professor, Department of Agriculture Extension, KAU, Trissur.

Convener

Dr P Rajasekharan, Chief (Agriculture), State Planning Board

Co-Convener

Smt Roshni Pdmanabhan, Research Officer, State Planning Board

Terms of reference

1. To review the development of the sector with emphasis as to progress, achievements, present status and problems under its jurisdiction during the 11th and 12th Five Year Plan periods.
2. To evaluate achievements with regard to the plan projects launched in the sector, both by the State Government and by the Central Government in the State during these plan periods.

3. To list the different sources of data in each sector and provide a critical evaluation of these data sources, including measures for improvement.
4. To identify and formulate a set of output and outcome indicators (preferably measurable) for each sector and base the analysis of the previous plans on these indicators.
5. To examine the status, problems and potential of agricultural education and research in the State at University and research institution level. It will also examine issues of the technological and human resource links between these institutions and the line departments on the one hand and between them and working farmers on the other. It will examine the multiple scientific and technological possibilities in this regard. The Group will pay particular attention to the possibilities opened up by ICT in this sphere.
6. To suggest, in particular, a set of projects that can be undertaken during the 13th Plan period in the sector.
7. The Co-Chairperson is authorised to modify terms of reference with approval of State Planning Board. The Co- Chairperson is authorised to invite, on behalf of the Working Group, experts to advise the Group on its subject matter. The non-official members of the Working Group will be entitled to travelling allowances as are applicable to class I officers of the Govt. of Kerala. The class I officers of GoI will be entitled to travelling allowances as per rules if reimbursement is not allowed from Departments.
8. The working group will submit its draft report by 1st December 2016 to the State Planning Board.

Sd/-
Member Secretary

To

The Person concerned
The Sub treasury Officer, Vellayambalam

Copy to:-

The Accountant General, Kerala (A&E) with C/L
All Divisions, State Planning Board
PS to VC
PA to Member Secretary
Stock file

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Forwarded by order
Sd/-
Chief (Agriculture)