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Performance of Cassava, Sweet Potato and Chinese Potato in Rice Based Cropping Systems of Southern Kerala

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Abstract

A five year field study was undertaken in the wetland rice fields of Cropping Systems Research Centre, Kerala Agricultural University, Thiruvananthapuram during 2006 *virippu/kharif* to 2011 summer. The treatments were eight rice based cropping sequences viz., T_1: rice-rice-fallow, T_2: rice-rice sweet potato (var. Kanhangad), T_3: rice-rice-pumpkin (var. Ambili), T_4: rice-rice-sesamum (var. Thilarani), T_5: rice-rice-amaranthus (var. Arun), T_6: rice-rice-vegetable cowpea (var. Vellayani local), T_7: rice-Chinese potato (var. Nidhi)-daincha, T_8: rice-cassava (var. Vellayani Hraswa)-daincha. The experiment was laid out in randomized block design and treatments were replicated thrice. The performance of the crops over the years was analysed through the stability index (based on yield). The economics of cultivation was also worked out. From the stability analysis, ancillary observations and economic analysis over the past five years (2006-2011), it can be concluded that rice-rice-amaranthus and rice-rice-sweet potato were the best cropping sequences. This is followed by rice-rice-cowpea and rice-rice-pumpkin. The sequences, rice-rice-sesamum and rice-Chinese potato-daincha were not suitable for southern Kerala. Stability index for Chinese potato was very low.

Key words: Cassava, Chinese potato, cropping sequence, rice, stability index, sweet potato

Introduction

Rice fields in Kerala are typical wetland ecosystems with numerous significant ecological and economic functions that benefit the society. During the last three and a half decades, rice area in Kerala has shrunk from 8.5 lakh ha to 2.1 lakh ha.The biggest challenge is to make rice a remunerative crop-a scenario with multiple benefits. Crop diversification is a practical means to increase crop output under different situations and is intended to give wider choice in the production of a variety of crops in a given area, to expand production related activities on various crops and to lessen risk. An earlier five year study conclusively confirmed that a third crop of vegetable crop of bhindi, groundnut or green gram is profitable than keeping the field fallow (CSRC, 1989). Investigations carried out at Rice Research Station, Kayamkulam to identify the most suitable rice-based cropping system for Onattukara tract proved that rice-rice groundnut was the most efficient cropping system followed by rice-rice-bhindi in terms of production efficiency and benefit-cost ratio (Shalini, 1998). In another recent study of rice-based diversified cropping systems, the highest production potential and net income were obtained from one crop of rice followed by two crops of *Nendran* banana, followed by two crops of rice and bhindi (Varughese, 2006). The primary objectives during the process of diversification are to generate new

technologies that improve productivity and farmer income and provide farmers the flexibility to make crop choice decisions. Certain tuber crops and vegetables have been found to be potential candidates for including in rice based sequences in different parts of Kerala. In this context, a study was undertaken to assess the performance of different crops, including tubers crops, as components of rice-based cropping sequences in southern Kerala.

Materials and Methods

A field study was undertaken in the wetland rice fields of Cropping Systems Research Centre, Karamana, Thiruvananthapuram for five years (2006 *virippu/kharif*) - 2011 summer). The soil type of the site is riverine alluvium. The initial pH, organic C, available N, P and exchangeable K contents were 5.4, 0.71%, 146 kg ha^{-1}, 7.6 kg ha^{-1} and 80.9 kg ha^{-1} respectively. The treatments comprised eight rice based cropping sequences viz., T_1: rice-rice-fallow, T_2: rice-rice sweet potato (var. Kanhangad), T_3: rice-rice-pumpkin (var. Ambili), T_4: rice-rice-sesamum (var. Thilarani), T_5: rice-rice-amaranthus (var. Arun), T_6: rice-rice-vegetable cowpea (var. Vellayani local), T_7: rice-Chinese potato (var. Nidhi)-daincha, T_8: rice-cassava (var. Vellayani Hraswa)-daincha. The rice varieties Aiswarya (medium duration 120-125 days) and Kanchana (short duration 105-110 days) were raised during the first (*kharif*) and second (*rabi*) crop seasons respectively. All crops were raised as per the Package of Practices Recommendations for crops of Kerala (KAU, 2007). The experiment was laid out in randomized block design and the treatments were replicated thrice. Observations on yield were recorded and the data analyzed statistically. The weather data during the experiment period was recorded for relating to the crop performance. The average annual maximum temperature, minimum temperature, relative humidity and rainfall during the study period were 31.1°C, 23.7°C, 83.8 % and 1570 mm respectively. The performance of the crops under different treatments over the years was analysed through the stability index calculated over a five year period (Gangwar, 2008).

Stability index = (Avg Y-SD)/Ymax

Where, Avg Y=Average yield over five years, SD=Standard deviation and Ymax=Maximum yield over the five years

A stability index value towards unity indicates greater stability. The rice equivalent yield, net income, system profitability under various cropping sequences was also worked out. The rice equivalent yield data were subjected to analysis of variance for randomized block design.

Results and Discussion

The performance of rice during *virippu* season was more or less consistent in all the treatments (Table 1). Rice-rice-sesamum and rice - cassava - daincha had the highest stability index (0.71 and 0.70, respectively) Rice-rice-amaranthus had low stability index (0.59) only due to the increasing rice yield under this treatment over the years (4.2 t ha^{-1} in first year to 6.3 t ha^{-1} by fifth year) as a consequence of the residual effects of the high quantity of organic manure (50 t ha^{-1}) added while raising amaranthus during summer. Actually this is not a negative point. Stability index value happens to be low owing to the increasing yield over years due to the residual effect only.

For a valid inference, stability index was calculated at the end of the fifth year only using average values of yield of all replications of all five years. Inferences are drawn based on nearness towards unity. Also in the second season, Chinese potato and cassava were not compared with rice. Hence, being a rice based system, the comparison was made on rice equivalent yield basis, which has been statistically analysed.

During *rabi* season, stability index values for rice were lower (0.4-0.58) than that for *kharif* (0.59-0.71). During *rabi*, over the years, rice yield was low (3-3.5 t ha^{-1}) and also varying due to the erratic rainfall pattern. Stability index for Chinese potato was very low (0.21). Crop establishment was severely affected during 2007, 2009 and 2010 due to the heavy rain immediately after planting the vine cuttings. As a result, subsequent crop growth and yield were very poor. Moreover, there was quick establishment of weeds. During the first (2006) and third years (2007), tuber yield exceeded 13 t ha^{-1}, whereas during the other years it was less than 5 t ha^{-1}. On examining the rainfall pattern during the first three weeks after planting Chinese potato, it was observed that the total rainfall was 42 mm (during the first two weeks only 14 mm), 236 mm, 20.4 mm, 93.1 mm (70.7 mm during the first two days itself) and 133.8 (124.2 mm in the first week itself) during 2006, 2007, 2008, 2009 and

Table 1. Yield and stability index of crops during different seasons (2006-2011)

Treatments	Crop	Yield (t ha^{-1})					Stability index
		1styr	2ndyr	3rdyr	4thyr	5thyr	
Kharif							
T_1	Rice	4.43	4.25	2.84	2.55	4.41	0.63
T_2	Rice	4.94	6.66	4.31	4.44	4.88	0.62
T_3	Rice	4.72	5.75	4.08	4.05	5.98	0.67
T_4	Rice	5.01	5.39	3.59	4.83	3.95	0.71
T_5	Rice	4.21	4.44	3.66	5.32	6.33	0.59
T_6	Rice	4.79	4.70	3.76	4.87	6.50	0.60
T_7	Rice	5.01	5.13	3.76	4.57	5.92	0.69
T_8	Rice	5.01	5.72	3.99	4.02	4.85	0.70
Rabi							
T_1	Rice	3.03	4.02	3.14	2.91	2.03	0.58
T_2	Rice	2.65	4.86	3.27	3.01	2.71	0.49
T_3	Rice	2.99	4.83	3.76	3.56	2.65	0.56
T_4	Rice	2.53	4.50	3.01	3.40	2.52	0.53
T_5	Rice	2.87	5.10	3.89	3.79	3.10	0.56
T_6	Rice	2.49	5.67	3.27	3.27	2.81	0.40
T_7	Chinese potato	13.15	4.51	14.86	4.45	4.89	0.21
T_8	Cassava	11.43	12.46	12.57	7.66	6.40	0.57
Summer							
T_1	Fallow	-	-	-	-	-	-
T_2	Sweet potato	17.50	21.30	32.45	2.92	15.05	0.22
T_3	Pumpkin	16.08	17.01	11.97	21.80	8.53	0.46
T_4	Sesamum	0.34	0.23	0.23	0.08	0.14	0.31
T_5	Amaranthus	17.75	33.39	31.70	23.97	12.61	0.45
T_6	Veg cowpea	7.01	5.19	8.02	8.46	2.99	0.48
T_7	Daincha	19.20	20.06	26.60	38.52	43.02	0.43
T_8	Daincha	20.62	20.25	23.02	41.98	47.90	0.37

2010, respectively. The high rainfall immediately after planting during the second, fourth and fifth year affected the establishment of the planted vines of Chinese potato and hence resulted in a low productivity. This clearly depicts the dependence of Chinese potato on rainfall immediately after its planting (especially during the first three weeks). Hence, the non-suitability of Chinese potato in lowland rice fields during *rabi* can be inferred from the inconsistent performance of the crop. Performance of cassava was better than Chinese potato, as evident from the higher stability index (0.57). During 2010 and 2011 the prolonged dry period from January to March reduced the yield.

Among the summer crops, cowpea (0.48), pumpkin (0.46) and amaranthus (0.45), had higher stability index values. Excluding the fifth years yield, the performance of amaranthus was the best and would have the highest stability index value (0.61). During the fifth year, germination, establishment and yield of amaranthus in one replication was very low and this in turn reduced stability index value. In cowpea, heavy summer rains coinciding with period of flowering severely affected the yield. This was observed during the second (2008) and fifth (2011) years when the rainfall received between 2-3 months after planting was 91 mm and 96.5 mm respectively, which caused heavy flower shedding. In pumpkin, during 2010 and 2011, greater rainfall to the tune of 96.5 mm and 110.6 mm respectively after flowering and before harvest (last one month of crop period) caused severe rotting of the developing fruits and hence, low yield. Sweet potato resulted in the lowest stability index. However, this was due to the very low yield (2.9 t ha^{-1}) produced during the fourth year (2010), which was a consequence of heavy sweet potato weevil attack. If the yield of 2010 would not have been

Table 2. Annual rice equivalent yield (t ha^{-1}) of the different cropping systems

	Cropping systems	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	Mean	Rank
T_1	Rice-Rice-Fallow	7.46	8.27	7.45	6.58	7.69	7.49	8
T_2	Rice-Rice-Sweet potato	22.90	26.43	29.87	10.50	19.91	21.92	2
T_3	Rice-Rice-Pumpkin	15.75	19.09	20.52	27.25	16.41	19.80	3
T_4	Rice-Rice-Sesamum	8.17	10.36	8.51	9.94	8.17	9.03	7
T_5	Rice-Rice-Amaranthus	24.83	42.93	41.03	32.83	22.16	32.76	1
T_6	Rice-Rice-Veg Cowpea	14.30	14.53	20.28	20.99	15.36	17.09	4
T_7	Rice-Chinese potato-Daincha	19.36	9.74	24.66	12.20	13.58	15.90	5
T_8	Rice-Cassava-Daincha	12.01	11.71	12.93	10.36	13.11	12.02	6
	CD (0.05)	3.10	5.09	3.50	3.54	4.33		

considered, sweet potato would have a stability index as high as cowpea. On the other hand, the stability index for sesamum was low (0.31) owing to the consistently poor performance during all the years. Excess weed growth, non uniform maturity and heavy shedding were the problems that affected sesamum, which resulted in extremely low yields (average of 202 kg ha^{-1}). Daincha, raised after Chinese potato and cassava, consistently generated substantial biomass (average 30 t ha^{-1}) for recycling.

The highest average annual rice equivalent was obtained in the sequence rice-rice-amaranthus followed by rice-rice-sweet potato (Table 2). Rice-rice-pumpkin and rice-rice-vegetable cowpea ranked third and fourth respectively.

The highest net income was obtained from rice-rice-amaranthus system, followed by rice-rice-sweet potato system (Table 3). Rice-Chinese potato-daincha and Rice-rice-pumpkin ranked third and fourth respectively. The annual net return depicts a different picture when compared to the annual system rice equivalent. The high cost of cultivation results in a relatively lesser profit in rice-rice-cowpea system. System profitability has a trend similar to the annual net return (Table 4). The

Table 3. Annual net income (₹ ha^{-1}) of the different cropping systems

	Cropping systems	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	Average	Rank
T_1	Rice-Rice-Fallow	22783.06	48117.74	31386.49	17745.12	40426.21	32091.72	8
T_2	Rice-Rice-Sweet potato	123252.18	208174.64	250527.43	31592.65	145154.10	151740.20	2
T_3	Rice-Rice-Pumpkin	42098.04	107141.92	119554.23	198619.68	88467.49	111176.27	4
T_4	Rice-Rice-Sesamum	19933.58	62077.81	32523.88	45395.74	33072.58	38600.72	7
T_5	Rice-Rice-Amaranthus	91537.98	316214.95	318303.75	232988.48	123391.81	216487.40	1
T_6	Rice-Rice-Veg Cowpea	6641.59	33464.59	89329.25	90031.37	29496.54	49792.67	6
T_7	Rice-Chinese potato-Daincha	111317.51	52533.07	215881.79	78673.89	115798.09	114840.87	3
T_8	Rice-Cassava-Daincha	51095.05	72552.56	84040.85	54623.82	106700.24	73802.50	5

Table 4. System profitability* (₹ ha^{-1} day^{-1}) of the different cropping systems

	Cropping systems	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	Average	Rank
T_1	Rice-Rice-Fallow	62.42	131.83	85.99	48.62	110.76	87.92	8
T_2	Rice-Rice-Sweet potato	337.68	570.34	686.38	86.56	397.68	415.73	2
T_3	Rice-Rice-Pumpkin	115.34	293.54	327.55	544.16	242.38	304.59	4
T_4	Rice-Rice-Sesamum	54.61	170.08	89.11	124.37	90.61	105.76	7
T_5	Rice-Rice-Amaranthus	250.79	866.34	872.07	638.32	338.06	593.12	1
T_6	Rice-Rice-Veg Cowpea	18.20	91.68	244.74	246.66	80.81	136.42	6
T_7	Rice-Chinese potato-Daincha	304.98	143.93	591.46	215.54	317.26	314.63	3
T_8	Rice-Cassava-Daincha	139.99	198.77	230.25	149.65	292.33	202.20	5

*calculated based on number of days

small sized plots and growing of cassava between other crops in an experiment layout were limiting factors, as far as cassava yield was concerned. Hence, cassava is expected to perform well when the rice-cassava-daincha sequence is adopted in an extensive area. This is supported by the finding of Babu (2006) which evidently proved the suitability and sustainability of an alternate cropping system with rice-rice-cassava in southern Kerala.

Conclusion

The study revealed that rice-rice-amaranthus and rice-rice-sweet potato are the best rice based cropping sequences in wetlands of southern Kerala. Alternately rice-rice-cowpea and rice-rice-pumpkin may be followed. The sequences, rice-rice-sesamum and rice-Chinese potato-daincha are not suitable for southern Kerala due to its very poor performance and heavy dependence on the rainfall pattern.

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