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Economics of coconut based cropping system with integrated nutrient management under littoral sandy soil of Odisha

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Abstract
An experiment was conducted in a 38 year old coconut garden of Sakhigopal Local Tall variety planted at a spacing of 7.5 m x 7.5 m to evaluate the effect of cropping system and integrated nutrient management on yield and economics in littoral sandy soil during July 2017- June 2019. The experiment was laid out in split plot design with three replications. The main plot comprised of cropping systems of CS1 {coconut + sapota + vegetable (cowpea)}, CS2 (coconut + sapota + pineapple) and CS3 (monocrop of coconut) whereas subplot consists of different nutrient management practices i.e. N1 ((Green manuring + Biofertilizers + Organic recycling + FYM), N2 (Green manuring + Biofertilizers + Organic recycling + Soil test based nutrients NPK (chemical fertilizers) application) and N3 (Green manuring + Biofertilizers + Organic recycling + 100% RDF). The study revealed that highest coconut equivalent yield (39777 nuts/ha), gross return (Rs. 318184/ha), net return (Rs. 201493/ha) and B:C ratio (2.72) were recorded in coconut + sapota + pineapple with soil test based fertilizer application (CS2N2).

Keywords: Coconut, cropping, integrated nutrient, littoral sandy soil

Introduction
Coconut (*Cocos nucifera* L.) is an important small holder crop that significantly contributes to food security, improved nutrition, employment and income generation to at least 10 million farm families. Coconut is supposed to be one of the five legendry Devabrikshas and is eulogized as "Kalpavriksha". The coconut palms are generally planted at a wider spacing of 7.5 m X 7.5 m or more due to morphological features such as crown shape and length of leaves. However, the effective root zone of the adult bearing palm is confined laterally within a radius of 2 m around the base of the palm (Kushwah *et al.*, 1973 and Anilkumar and Wahid, 1989) [6 1]. Over 95% of the roots are found in the top 0-120 cm depth out of which 18.9% and 63% roots are confined to top 0-30cm and 31-90 cm depth respectively (Maheswarappa *et al.*, 2000). Hence, from the land utilization point of view, the sole crop of coconut with a spacing of 7.5 m x 7.5 m effectively uses only 22.3 percent of land area by leaving considerable inter and intra row space for proper utilization by intercrops. Even though coconut is a widely spaced crop, the interspaces cannot be utilized for growing of intercrops in littoral sand under normal conditions due to poor water retention capacity and poor soil fertility status. However, by adopting proper soil and water conservation measures selective intercrops can be raised in the coconut garden in littoral sand. In India, coconut is grown by small and marginal farmers and the average land holding for coconut cultivation is 0.2 ha. In the present scenario of fluctuation in coconut price and high wage rate for labourers, the monocrop of coconut is no more economical. Hence, intercropping in coconut garden becomes indispensable for augmenting the income of the coconut farmers. So well designed cropping system in spite of monocropping gives better option to the farmers as it generates more biomass yield, more economic produce, steady and higher total income even at low market price of main crop (coconut) (Maheswarappa *et al*., 2003) [8]. There will be improvement in the soil properties and biological activities in the root region due to intercropping which modify the soil environment for the benefits of plant growth (Maheswarappa *et al*., 1998). In monocropping of coconut, the unutilized interspace could be profitably used by growing annuals and perennial intercrops suitable for particular agro climatic conditions (Padma *et al*., 2016) [11]. The crops such as different pulses, oilseeds, root crops, legumes and vegetables, spice crops like nutmeg, cinnamon, pepper; fruit crops like pineapple, banana, lime, pomegranate, sapota, guava, papaya, mango, jackfruit and shrub like cocoa can be successfully grow as inter/mixed crop in

coconut garden (Bavappa, 1990). But the crops suitable for intercrops under littoral sand are fodder grass, glyricidia as green manuring crop, vegetable crops (amaranthus, pumpkin and ash gourd) and fruit crops (sapota, banana and pineapple) following adoption of appropriate soil moisture conservation measures viz., husk and coir pith application at the planting zone. Based on the above fact, an experiment was carried out to evaluate the effect of integrated nutrient management on yield and system productivity in coconut-based cropping systems under Odisha condition.

Material and Methods

The present experiment was carried out in the experimental site of All India Coordinated Research Project on palms, Konark (OUAT) during July 2017 to June 2019 in a 38 years old coconut plantation of Sakhigopal Local Tall variety which was planted at a spacing of 7.5 m X 7.5 m. The experimental station is suited at $19^0$53'27" N latitude and $86^0$06'01" E longitude with an altitude of 2 m above mean sea level. The study was conducted following a Split Plot Design with 9 different treatment combinations of cropping systems (CS) and integrated nutrient management practices (N) which are replicated thrice. Cropping systems comprised of CS1 (coconut + sapota + cowpea), CS2 (coconut + sapota + pineapple) and CS3 (monocrop of coconut) whereas, integrated nutrient management practices consist of N1 (Green manuring + Biofertilizers + Organic recycling + FYM), N2 (Green manuring + Biofertilizers + Organic recycling + Soil test based nutrients NPK (chemical fertilizers) application) and N3 (Green manuring + Biofertilizers + Organic recycling + 100% RDF). Generally in littoral sand, the soils are low in primary and secondary nutrients, so in soil test based fertilizer application, extra 25% chemical fertilizers are applied. The component crops such as sapota, pineapple and cowpea were raised in the interspaces as per their respective place according to the treatments during July 2016 leaving exclusively 2 metre radius from the bole of coconut as per the spacing of component crops. The sapota plants (cv. Kalipati) were planted at the center of four coconut palms. For raising of cowpea (cv. Kashi Kanchan) and pineapple (cv. Queen), 3 m X 3 m beds were prepared in the interspace of the coconut. The required quantity of organic manures (FYM) and inorganic fertilizers (NPK) were applied to coconut and component crops as per the treatments. The sources of inorganic nutrients were urea (for N), single super phosphate (for P_2O_5) and muriate of potash (for K_2O). The vermicompost used in the experiment was prepared from the recyclable biomass produced in the system as per the procedure explained by Prabhu *et al.* (1998) [13]. The two biofertilizer stains Azospirillum and Phosphobacterium were used in coconut and component crops. Fodder cowpea was used as *in situ* green manure crops in the basins of palm as well as in the interspaces in monocropping plots. Yield can be obtained from coconut, cowpea and pineapple whereas, sapota plant in in vegetative stage, The gross return from the economic produce of coconut, cowpea, pineapple and sapota were worked out by considering the market price prevailed during 2017-18 and 2018-19. The cost of production was calculated considering labour charges, cost of manures, fertilizers, seed, sucker and other inputs used for raising the crops. The net return was computed as the difference between the gross return and the cost of production. The benefit-cost ratio was calculated by dividing the gross return by the cost of production. The coconut equivalent yield (CEY) of system was calculated based on selling price of intercrops and coconut.

$$\text{Coconut equivalent yield} = \frac{\text{Yield of intercrops x Market price}}{\text{Prevailing market price of nut}}$$

Results and Discussion

Yield of intercrops

The mean data of cowpea yield followed the similar pattern as in year of 2017-18 and 2018-19. Under coconut + sapota + cowpea based cropping system, where the cowpea received the integrated nutrient management of green manuring + biofertilizers + organic recycling + soil test based nutrients NPK (chemical fertilizer) application estimated the maximum cowpea yield (4518.33 kg/ha). On the other hand, the minimum cowpea yield (3754.5 kg/ha) was obtained in practice of green manuring + biofertilizers + organic recycling + FYM.

From the pooled mean, under coconut + sapota + pineapple system, maximum yield of pineapple (9364.66 kg/ha) was recorded in plots receiving soil test based nutrients (N2) and the minimum yield (6371.99 kg/ha) was noted in organic treatment.

Coconut equivalent yield of system:

The equivalent yield is regarded as an index of productivity in terms of the actual price of main crop. The monetary return gained from each component crop was converted to the number of nuts that can be earned the same. In this way system productivity can be calculated in terms of coconut yield. Among cropping systems, highest coconut equivalent yield (33836 nuts/ha) was obtained in coconut + sapota + pineapple cropping system whereas, the lowest coconut equivalent yield of the system (8870 nuts/ha) was noted in monocrop of coconut. The increase in coconut equivalent yield in above cropping system might be due to higher yield and also better market price of pineapple. Similar increase in coconut equivalent yield in coconut based cropping system was reported by Basavaraju *et al*. (2008) and Krishnakumar *et al*. (2011) [5]. Irrespective the effect of cropping system, adoption of integrated nutrient management practices produced the highest coconut equivalent yield (23710 nuts/ha) particularly in treatment of green manuring + bio fertilizers + organic recycling + soil test based nutrients NPK (chemical fertilizers) application and the lowest coconut equivalent yield (18317 nuts/ha) was obtained in imposition of green manuring + bio fertilizers + organic recycling + FYM. This might be due to positive response of pineapple to organic and soil test based fertilizer application providing higher monetary return. Among interaction effects, adoption of coconut + sapota + pineapple with green manuring + bio fertilizers + organic recycling + soil test based nutrients NPK (chemical fertilizers) application produced highest coconut equivalent yield of the system (39777 nuts/ha) and the lowest coconut equivalent yield (7963 nuts/ha) was estimated in monocropping of coconut with green manuring + bio fertilizers + organic recycling + FYM combination.

Economics of coconut based cropping system

The economics of the cropping system was estimated based on the prevailing market price of the different commodities. Among cropping systems, highest gross return (Rs. 270675/ha), cost of production (Rs. 106608/ha), net return (Rs. 164067/ha) and B:C ratio (1:2.52) were calculated under

coconut + sapota + pineapple system whereas, the lowest gross return (Rs. 69358/ha), cost of production (Rs. 43167/ha), net return (Rs. 26192/ha) and B:C ratio (1:1.60) were in monocrop of coconut. Increase in net return, gross return and B:C ratio due to adoption of coconu t based cropping system were also reported by Hore *et al.* (2001) [4]; Palaniswami *et al.* (2007) [12]; Nath and Deka (2010) [10], Ghose and Bandopadhyay, 2011 [3] and Padma *et al.* 2016 [11]. So far as the effect of integrated nutrient managements is concerned, the highest gross return (Rs. 189003/ha), cost of production (Rs. 84069/ha), net return (Rs. 104934/ha) and B:C ratio (1:1.09) were estimated in green manuring + bio fertilizers + organic recycling + soil test based nutrients NPK (chemical fertilizers) application whereas the lowest gross return (Rs. 146535/ha), cost of production (Rs. 72721/ha), net return (Rs. 73815 /ha) and B:C ratio (1:1.91) were estimated under green manuring + bio fertilizers + organic recycling + FYM treatment. The maximum gross return (Rs. 2,94,532), net returns (Rs. 1,85,051) and B:C ratio (2.69) were recorded in cropping system of coconut + sapota + pineapple with green manuring + bio fertilizers + organic recycling + soil test based nutrients (chemical fertilizers) application. The cost of production (Rs. 1, 07,022) was also maximum in the same treatment which might be due to higher cost of different inputs. The increase in the net return and gross return is mainly due to higher coconut equivalent yield of pineapple in addition to coconut yield. Similar results of increased economic income through integrated nutrient management in coconut based high density multi species cropping system was reported by Maheswarappa *et al.* (2013) [9], Selvarani *et al.* (2019) [14] and Shinde *et al.* (2019) [15].

Table 1: Yield of cowpea (vegetable) in coconut based cropping system

Treatment	Cowpea yield (kg/ha)		
	2017-18	2018-19	Mean yield
CS1 N1	3669.00	3840	3754.50
CS1 N2	4356.66	4680	4518.33
CS1 N3	4098.66	4436	4267.33

Table 2: Yield of pineapple in coconut based cropping system

Treatment	Pineapple yield (kg/ha)		
	2017-18	2018-19	Mean yield
CS2 N1	7644.66	5098.33	6371.49
CS2 N2	10803.33	7926.00	9364.66
CS2 N3	9277	6233.33	7755.16

Table 3: Effect of cropping system and integrated nutrient management on equivalent yield of coconut

Treatments	Coconut equivalent yield of the system (Number of nuts/ha)		
	2017-18	2018-19	Pooled Mean
CS1	18672	21909	20291
CS2	32163	35508	33836
CS3	7495	9844	8670
S.Em. (±)	30.36	24.52	26.23
CD (0.05)	119.18	96.26	102.97
N1	17214	19420	18317
N2	21760	25660	23710
N3	19356	22182	20769
S.Em. (±)	23.03	18.45	11.80
CD (0.05)	70.95	56.86	36.35
CS1N1	17368	19739	18554
CS1N2	20079	23904	21992
CS1N3	18568	22084	20326
CS2N1	27433	29437	28435
CS2N2	37104	42450	39777
CS2N3	31953	34638	33296
CS3N1	6841	9084	7963
CS3N2	8097	10626	9362
CS3N3	7548	9823	8686
S.Em. (±)	44.52	35.81	31.09
CD (0.05)	154.66	124.52	114.47

CS1:	Coconut + Sapota + Vegetable	N1:	Green manuring + Biofertilizers + Organic recycling + FYM
CS2:	Coconut + Sapota + Pineapple	N2:	Green manuring + Biofertilizers + Organic recycling + Soil test based nutrients NPK (chemical fertilizer) application
CS3:	Monocrop of coconut	N3:	Green manuring + Biofertilizers + Organic recycling + 100% RDF

Table 4.4: Effect of cropping system and integrated nutrient management on economics of the system

Treatments	Gross return			Cost of production			Net return			B:C ratio		
	2017-8	2018-19	Pooled mean	2017-18	2018-19	Pooled mean	2017-18	2018-19	Pooled mean	2017-18	2018-19	Pooled mean
CS1	149373	173803	161605	83727	84522	84125	65645	89314	77480	1.78	2.05	1.91
CS2	257287	284063	270675	104660	108555	106608	152626	175508	164067	2.45	2.60	2.52
CS3	59962	78755	69358	42817	43517	43167	17145	35231	26192	1.40	1.80	1.60
S.Em. (±)	1445	1331	1360	-	-	-	1582	1236	1057	0.022	0.015	0.016
CD (0.05)	5827	5368	5487	-	-	-	6379	4983	4261	0.09	0.06	0.065
N1	137713	155358	146535	72025	73417	72721	67755	81941	73815	1.79	2.03	1.91

N2	174059	203947	189003	82919	85219	84069	91140	118728	104934	1.94	2.25	2.09
N3	154850	177348	166099	76261	77958	77110	78589	99390	88990	1.89	2.16	2.03
S.Em. (±)	875	1262	715	-	-	-	1683	561	474	0.013	0.012	0.006
CD (0.05)	2727	3933	2229	-	-	-	5242	1743	1475	0.04	0.037	0.019
CS1N1	138942	157916	148429	78825	79500	79163	60117	78415	69266	1.76	1.98	1.87
CS1N2	160633	187232	173933	89807	90574	90191	70826	96658	83742	1.78	2.06	1.92
CS1N3	148543	176360	162452	82550	83491	83021	65993	92869	79431	1.79	2.11	1.95
CS2N1	219470	235484	227477	96124	99100	97612	123346	136384	129865	2.28	2.37	2.32
CS2N2	296766	339602	318184	113974	119408	116691	182792	220194	201493	2.60	2.84	2.72
CS2N3	255624	277103	266364	103883	107157	105520	151741	169946	160844	2.46	2.58	2.52
CS3N1	54726	72674	63700	41125	41650	41388	13601	31024	22313	1.33	1.74	1.54
CS3N2	64778	85008	74893	44975	45675	45325	19803	39333	29568	1.44	1.86	1.65
CS3N3	60382	78582	69482	42350	43225	42788	18032	35357	26695	1.42	1.81	1.62
S.Em. (±)	2518	2306	2357	-	-	-	2740	2141	2355	0.038	0.026	0.028
CD (0.05)	5525	7528	4592	-	-	-	9899	6658	7526	0.081	0.072	0.04

During 2017-18: Sale price of coconut @ Rs. 8/nut, cowpea @ Rs. 20/kg and pineapple @ 20/kg
During 2018-19: Sale price of coconut @ Rs. 8/nut, cowpea @ Rs. 20/kg and pineapple @ 30/kg

Conclusion

The study revealed that, adoption of cropping system of coconut + sapota + pineapple with application of green manuring + biofertilizers + organic recycling + soil test based chemical fertilizer application was found to be productive and profitable system under littoral sandy soil of Odisha.

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