Original Research Article

Effect of cropping systems and integrated nutrient management on growth and yield of coconut in littoral sand

Abstract:

An experiment was carried out in a 38 years old coconut plantation of Sakhigopal Local Tall variety at All India Coordinated Research Project on palms, Konark (OUAT) during July 2017 to June 2019. The treatments comprised of three cropping system and three integrated nutrient management practices. The experiment was laid out in a Split Plot Design with three replications. The studies revealed that adoption of cropping system of coconut + sapota + pineapple with application of green manuring + biofertilizers + organic recycling + soil test based nutrients NPK (chemical fertilizers) application significantly increase the number of female flowers (245.83/palm/year), nut yield (65.21/palms/year), weight of whole nut (1206.54 g), weight of dehusked nut (603.01 g), kernel weight (293.41 g) and copra weight (168.33 g). Similarly minimum number of female flowers, nut yield, kernel weight and copra weight were recorded in treatment combination of monocrop of coconut with green manuring + biofertilizers + organic recycling (CS3N1)

Comment [A1]: Add one line of Introduction before this sentence!

Key word: Cropping system, integrated nutrient management, nut yield, copra weight

Introduction:

Coconut is generally grown in 17 States and 3 Union territories in an area of 2173.28 thousand hectares with an annual production of 20,308.70 million nuts (CDB, 2019-20) but the major share of production comes from the coastal tract of the East and West coast of the Peninsular India lying mostly in Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Odisha and Maharashtra. However, the potential productivity of some of the states is not realised where this crop is mostly grown in drained uplands, hill slopes and clay soils to coastal littoral sand (Khan *et al*., 1978). Among all the coconut growing belts, there is significant area under coconut in littoral sand of sea coast. Odisha is an important state with regard to the cultivation of this crop occupying 5th position in area and 7th position in production. Coconut is cultivated in an area of 51.71 thousand hectares with an annual production of 354.57 million nuts but the productivity of the coconut per hectare in the state is comparatively low i.e. 6857 nuts/ha compared to the national productivity of 9345 nuts/ha (CDB, 2019-20). One of the reason for such low productivity might be due to cultivation of this crop in poor soils of coastal littoral sand of 410 km long coast line. The general weather prevailing along the coastal belt is fabulous for growing coconut. But, the productivity status of such plantation is very low in the littoral sand ranging from 20-40 nuts/palm/year (Subramanian *et al*., 2009). The reasons for low productivity of coconut under littoral sand are low organic carbon content, high bulk density, poor aggregate stability, poor water holding capacity, high soil temperature and poor soil fertility status (Reddy and Upadhyay, 2002). Even regular application of chemical fertilizers failed in building up of soil nutrient status in littoral sandy soil which is mainly due to low nutrient retention capacity of the soil (Reddy *et al.*, 1999). The very low clay content leading to high infiltration and percolation rate coupled with low cation exchange capacity and low organic carbon content are subject to high leaching loses of applied nutrients during monsoon and severe moisture stress during summer. Also, the problem of poor productivity is aggravated by the loss of organic matter of soil due to hot and humid climate (Sahoo and Maheswarappa, 2020). So, improvement in soil organic matter content is essential for the successful management of coconuts on such soils. Hence, under these circumstances, sustainable crop production can be achieved through adoption of coconut-based cropping system with integrated nutrient management practices. Studies have revealed that sole crop of coconut with a spacing of 7.5 m X 7.5m effectively utilize only 22.3 % of land area while the average air space utilization by the canopy is about 30 percent and solar radiation interception is about 45-50 percent (Bavappa *et al*., 1986). So, adoption of coconut based intercropping system is one of the effective way to utilize the resources like sunlight, soil, water and labour. Unlike annuals, the potential for increasing productivity per unit area of land, time and inputs is considerably higher in perennial crops (Bavappa and Jacob, 1982). An agronomically desirable system should ensure that all the components of production are exploited at optimum level ensuring that the long-term production capability of the system as a whole is not affected. Integrated nutrient management includes the intelligent use of organic, inorganic and online biological resources so as to sustain optimum yields, improve or maintain soil chemical and physical properties and provides crop nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe (Tandon, 1990). For any adult bearing tree, organic manures supplemented with inorganic nutrients may be considered as best combination for more fruiting. To make coconut cultivation economically viable and sustainable under littoral sand, more emphasis should be given for improving the physical and chemical properties of soil. The productivity of coconut under littoral sand could be improved by the combined use of organic manures, green manuring crops and inorganic fertilizers. Hence, the present investigation was conducted to study the effect of cropping system and integrated nutrient management on growth, yield and nut quality under littoral sandy soil of Odisha.

Materials and methods:

The study was carried out in a 38 years old coconut plantation of Sakhigopal Local Tall variety the experimental site of All India Coordinated Research Project on palms, Konark operating under the department of Fruit Science and Horticulture Technology, College of Agriculture, OUAT, Bhubaneswar during July 2017 to June 2019 to find out the effect of cropping system and integrated nutrient management on the performance of coconut in littoral sand. The study was conducted following a Split Plot Design with 9 different treatment combinations of main plot and sub plot which are replicated thrice. Main plot comprised of three level of cropping system viz. CS1 (coconut + sapota + vegetable), CS2 (coconut + sapota + pineapple) and CS3 (monocrop of coconut) whereas, subplot comprised 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). 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), 3m X 3m beds were prepared in the interspace of the coconut. The required amount 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). 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. The recommended dose of fertilizers for crops (coconut and intercrops) is presented in the table 1. The observation on coconut palm were recorded at the end of June of respective years and mean was statistically analysed.

Comment [A2]: In literature? Please the author must be indicated

Table-1: Recommended fertilizer dose for coconut and component crops

Crops and variety	Recommended doses of fertilizers (g/plant/year)		
	N	P_2O_5	K_2O
Coconut (Sakhigopal Local Tall)	500	320	1200
Pineapple (Queen)	12	4	12
Sapota (Kalipati)	100	100	200
Cowpea for vegetable (Kashi kanchan)	40 (kg/ha)	60 (kg/ha)	60 (kg/ha)

Results and Discussion

The total number of leaves on the crown of the palm determines its capacity to built-up photosynthates which in turn carried over to nut production whereas, the rate of leaf production by a palm indicates its vigour as well as proper nutrient management of the soil around it. Among cropping systems, coconut + sapota + pineapple system had shown significant effect on number of functional leaves (31.72 leaves/palm) and number of leaves per palm per year (12.53) as compared to monocrop of coconut where it produces (29.61 leaves/palm) and (12.11 leaves/palm/year). Similar result was observed in the findings of Padma *et al.* (2016). There was significant influence of integrated nutrient managements on the number of functional leaves per palm and number of leaves produced per palm per year. Under integrated nutrient management, adoption of green manuring + biofertilizers + organic recycling + soil test-based nutrients application increased the number of leaves (31.87leaves/palm) and number of leaves produced per palm per year (12.65). The increase in leaves per palm might be due to increased availability of nitrogen as well as phosphorous under integrated treatment management practices as supported by Nambiar *et al.* (1983).

Coconut being a regular bearer crop that develops inflorescence in the axil of each leaf at monthly interval in fertile soil but there are exceptions to this under littoral sand which shows irregularity in flowering or bunch production. The present study shows that it was possible to increase more number of inflorescences of the palm in littoral sand by adopting cropping systems and integrated nutrient management practices. The data related to the reproductive characters of coconut showed that the number of inflorescences per palm per year was significantly affected due to cropping systems. The maximum number of inflorescences per palm per year (12.16) was noted in cropping system of coconut + sapota + pineapple (CS2). The increase in number of inflorescences per palm per year might be due to beneficial effect of intercrops to coconut palm through efficient use of natural resources. The finding of the present study is more or less similar to findings of Padma *et al*. (2016). The practice of integrated nutrient management had also shown a significant effect by increasing the production of inflorescences (12.36/palm/year) in treatment of green manuring + bio fertilizers + organic recycling + soil test based nutrients (chemical fertilizers) application as against the minimum number (11.21/palm/year) in green manuring + bio fertilizers + organic recycling + FYM. The more availability of nitrogen and potassium in littoral sand under the above integrated manuring practice might have induced the production of more inflorescences in the palm (Wahid *et al.*, 1993 and Bhalerao *et al.*, 2021).

It is the number of female flowers that influences the yield in the palm. In the present study, it was observed that adoption of cropping system was effective to promote more number of female flowers in the palm in littoral sand. The maximum number of female flowers (220.46/palm/year) was recorded in the cropping system of coconut + sapota + pineapple as against 191.68/palm/year in monocropping. This might be due to maximum utilization of natural resources available in coconut orchard. Similar result was observed by Padma *et al.* (2016). Imposition of integrated nutrient management resulted significant effect on production of female flowers in the palm as observed in the present study. The maximum number of female flowers per palm per year (230.81) was obtained in the treatment of green manuring + bio fertilizers + organic recycling + soil test-based nutrients (chemical fertilizers) application. The increase in number of female flowers per palm might be due to cumulative effect of organic and inorganic sources of fertilizer application which would increase the availability of more nitrogen in littoral sand and ultimately increased more female flowers in coconut palm. This is in line with the finding of Bose and Mitra (1990) and Wahid *et al*. (1993). Moreover, the increased availability of potash in the soil under the said integrated manuring practice also might have caused production of more female flowers in the palm in littoral sand. Similar results are in line with the findings of Sahoo *et al.* (2004) and Bhalerao *et al*. (2021).

The nut yield of coconut palm was improved due to adoption of cropping systems and the best result was obtained under CS2 (coconut + sapota + pineapple) with 58.70 nuts/palm/year as against 49.53 nuts/palm/year under CS3 (monocrop of coconut) in littoral sand. The increase in nut yield in the coconut might be due to change in micro-climate condition in the coconut garden. Non interference of the intercrops with main crops, regular watering, nutrient management, weed management, biomass addition and recommended management for coconut and the intercrops favored improvement in soil nutrient status and nutrient uptake by coconut palms which might have led to production of more nuts in the palm. Similar observations were made by Basavaraju *et al.* (2008), Maheswarappa *et al*. (2008) and Dhanpal *et al*. (2013). It is also likely due to the parts of fertilizers applied to the intercrops which would have been otherwise lost through runoff or by other means, had been absorbed by the coconut palm thereby there was improvement in the yield. The congenial micro climate with increased microbial activities, improvement in soil fertility and higher interception of sunlight might have favored the growth and yield of coconut. The improvement in nut yield of the main crop by intercropping is also supported by the findings of Basavaraju *et al.* (2011) and Rani *et al*. (2018). The traits number of nuts per palm per year was also significantly influenced by the integrated nutrient management as observed in both the years of study. Maximum nut yield (59.46 nuts/palm/year) was recorded in N2 (green manuring + bio fertilizers + organic recycling + soil test based nutrients NPK (chemical fertilizers) application) and minimum nut yield (50.37 nuts/palm/year) was recorded in N1 (green manuring + bio fertilizers + organic recycling + FYM). The increase in nut yield recorded under various integrated nutrient management practices could be due to increased availability of nitrogen and potassium, organic matter content, improvement in physical properties of the littoral sand thereby, preventing the loss of nutrients in the littoral sand as indicated by several workers like Manickam (1993), Shivaramu *et al.* (1994) and Sudhir *et al.* (1996). Increase in coconut yield due to application of inorganic fertilizer combined with organic manure has also been reported by many workers (Palaniswami *et al.*, 2007; Maheswarappa *et al.*, 2011; Farsanashamin and Anilkumar, 2016 and Shinde *et al*., 2020).

In the present study the average weight of whole as well as dehusked nut was relatively improved under different cropping systems. The maximum weights of whole and dehusked nut (1178.69 g and 591.76 g) were recorded in coconut + sapota + pineapple system and the minimum (1135.37 g and 578.24 g) were in monocropping. The increase in nut weight might be due to availability of more nutrients and water to palm under favorable micro-climate created by adoption of cropping system in the coconut garden. The weight of whole as well as dehusked nut was relatively increased by integrated nutrient management. The maximum weight of whole nut (1182.62g) and dehusked nut (594.56 g) were recorded in green manuring + bio fertilizers + organic recycling + soil test based nutrients NPK (chemical fertilizers) application and the minimum (1116.99 g and 571.51 g) weight of whole as well as dehusked nut in green manuring + bio fertilizers + organic recycling + FYM. The above result might be happened due to the increase in the availability of potassium in the soil under the above integrated nutrient management practices which have contributed to the increase in the nut size (Bose and Mitra, 1990; Wahid *et al.,* 1993). The interaction effect between cropping system and integrated nutrient management with respect to weight of nut was found significant. Maximum weight of whole nut (1206.54g) and dehusked nut (603.01 g) was noted in the treatment combination of cropping system of coconut + sapota + pineapple with green manuring + bio fertilizers + organic recycling + soil test-based nutrients NPK (chemical fertilizers) application. The increase in weight of nut might be due to positive cumulative effect of both the treatments.

In the present study the weight of kernel as well as copra was estimated under various cropping systems and integrated nutrient management practices. The weight of copra is proportionate to the weight of kernel in the nut and copra is considered as the actual yield parameter of coconut. Among various cropping systems, significantly maximum weight of kernel (285.47 g) and copra (162.59 g) was recorded in the cropping system of coconut + sapota + pineapple whereas, the corresponding values (272.84 g and 156.18 g) were minimum in monocropping of coconut. Among various integrated nutrient management practices, application of green manuring + bio fertilizers + organic recycling + soil test based nutrients NPK (chemical fertilizers) application was significantly effective in producing maximum weight of kernel (286.53 g) and copra (163.34 g/nut) in the pooled mean studies. The increase in copra yield corroborates with the findings of Ramanathan (1982) and Nallathambi *et al.* (1988). This might be due to increased availability of potassium under organic and inorganic treatments which contributed to the increase in kernel and copra content per nut. The results obtained are similar with the findings of Venkitaswamy and Khan (2002), Sahoo *et al.* (2004) and Kalpana *et al.* (2008). The increase in copra yield in coconut by potassium is also reported by Thampan (1984) and Wahid *et al.* (1993). The weight of kernel and copra per nut was influenced by the interface effect of cropping system and INM practice. The result revealed that adoption of coconut + sapota + pineapple system with green manuring + bio fertilizers + organic recycling + soil test based nutrients NPK (chemical fertilizers) application recorded maximum weight of kernel and copra per nut. This could be due to cumulative beneficial effect of cropping system and INM practice.

Conclusion:

In the light of the results obtained from the present investigation, it is concluded that adoption of cropping system of coconut + sapota + pineapple with imposition of green manuring + biofertilizers + organic recycling + soil test based nutrients NPK (chemical fertilizers) application were more effective in improvement of number of female flowers, nut yield, nut weight, kernel weight and copra weight.

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Table-2: Effect of cropping system and integrated nutrient management on growth and yield of coconut

Comment [A3]: Must be improved

Treatments	Pooled data (July 2017-June 2019)				
	Number of leaves per palm	**Number of leaves produced per palm per year**	**Number of inflorescences per palm per year**	**Number of female flowers per palm per year**	**Number of nuts per palm per year**
CS1	30.89	12.37	11.88	207.71	55.73
CS2	**31.72**	**12.53**	**12.16**	**220.46**	**58.70**
CS3	29.61	12.11	11.35	191.68	49.53
S.Em. (±)	0.13	0.029	0.135	1.782	0.455
CD (0.05)	**0.51**	**0.12**	0.46	**7.18**	**1.83**
N1	29.98	11.99	11.21	182.39	50.37
N2	**31.87**	**12.65**	**12.36**	**230.81**	**59.46**
N3	30.33	12.20	11.82	206.65	54.13
S.Em. (±)	0.15	0.044	0.077	1.719	0.362
CD (0.05)	**0.47**	**0.14**	**0.25**	**5.36**	**1.12**
CS1N1	30.14	12.02	11.44	182.24	52.43
CS1N2	31.72	12.60	12.27	223.85	59.69
CS1N3	30.47	12.49	11.93	207.05	55.7
CS2N1	30.59	12.08	11.42	188.58	53.20
CS2N2	33.48	12.88	12.82	**245.83**	**65.21**
CS2N3	31.08	12.64	12.25	226.97	57.70
CS3N1	28.96	11.88	10.79	176.36	45.48
CS3N2	30.41	12.46	11.99	212.75	53.49
CS3N3	29.46	11.97	11.28	185.93	49.62
S.Em. (±)	0.22	0.051	0.257	3.086	0.787
CD (0.05)	**NS**	**NS**	**NS**	**10.28**	**2.20**

Table 3: Effect of cropping systems and integrated nutrient managements on mature nut characters

Treatments	Pooled mean (July 2017- June 2019)			
	Weight of nut (gm)	**Weight of dehusked nut (gm)**	**Weight of kernel (gm)**	**Weight of copra kg)**
CS1	1152.70	584.49	278.45	158.95
CS2	1178.69	591.76	285.47	162.59
CS3	1135.37	578.24	272.84	156.18
S.Em. (±)	2.191	1.085	0.312	0.278
CD (0.05)	**8.83**	**3.77**	**0.99**	**1.12**
N1	1116.99	571.51	267.73	153.38
N2	1182.62	594.56	286.53	163.34
N3	1167.14	588.42	282.50	160.99
S.Em. (±)	1.828	1.487	0.158	0.163
CD (0.05)	**6.10**	**4.92**	**0.45**	**0.51**
CS1N1	1120.75	572.82	268.61	153.99
CS1N2	1178.53	592.77	286.25	162.13
CS1N3	1158.81	587.88	280.50	160.71
CS2N1	1137.01	576.17	272.97	155.36
CS2N2	1206.54	603.01	293.41	168.33
CS2N3	1192.51	596.09	290.02	164.08
CS3N1	1093.23	565.54	261.60	150.79
CS3N2	1162.79	587.89	279.94	159.55
CS3N3	1150.09	581.30	276.98	158.19
S.Em. (±)	3.495	2.186	0.326	0.482
CD (0.05)	**10.11**	**7.12**	**1.12**	**1.03**