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Full Research Article

Nutrient Management in High Density Cashew Plantation under Coastal Zones of Odisha

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Abstract

A field experiment was conducted at Cashew Research Station of AICRP on Cashew, OUAT, Bhubaneswar, Odisha, India during 2000 to 2013 study about the effect of different plant density with different dose of fertilizer on growth and yield of cashew variety BPP 8 (H 2/16). The experiment was laid out in a split plot design with three planting densities [10×5 m^2 (200 plants ha^{-1}; 6×4 m^2 (400 plants ha^{-1}) and 5×4 m^2 (500 plants ha^{-1})] along with three levels of fertilizer (75-25-25, 150-50-50 and 225-75-75 kg NPK ha^{-1}) replicated four times. The results revealed that adoption of high density planting system significantly decreases the tree height (5.71), stem girth (69.16 cm), number of flowering laterals m^{-2} (4.52), nuts $panicle^{-1}$ (7.63), nut weight (7.6 g), cumulative yield at 11th harvest (26.77 kg $tree^{-1}$) than wider spacing of 200 plants ha^{-1}. Similar trends were observed for fertilizer dose of 150-50-50 kg ha^{-1} for all the parameters under study, irrespective of plant densities. However maximum cumulative yield of 15,140.50 kg ha^{-1} with BCR of 3.04, closely followed by 14,052.05 kg ha^{-1} with BCR of 2.61 was observed at high density planting (500 plants ha^{-1}) and moderately to high fertilizer dose (150-50-50 to 225-75-75 kg NPK ha^{-1}) over 11th harvest of cashew under Odisha condition. The study also indicated that, in case of high density planting system, pruning should be done after 5th harvest while 8th harvest in wider spacing in order to maintain the productivity of plants at optimum levels.

1. Introduction

Cashew (*Anacardium occidentale* L.) is an export oriented crop of our country which has earned a foreign exchange of ₹ 3677.1 crores during 2012-13. Although India ranks 1st in production, processing and export of kernel in the World, but productivity of existing cashew plantation is very poor, hardly 722 kg ha^{-1} as compared to the other countries. The leading states of cashew production in India includes Maharastra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Odisha and West Bengal etc. The state Odisha contributes about 0.164 mha with a production of 0.1 m MT with production share of 14% (Hubballi, 2013). Among the several factor influence the cashew productivity in the country as well as state, use of traditional varieties of low yield potential, lack of production and protection technologies etc. are the major causes. Even new plantation of cashew with high yielding varieties (HYV), the low productivity is contributed by improper planting density as well as nutrient management practices. In India usually cashew is grown as a rainfed crop cultivated in neglected land which otherwise unsuitable for any other crop (Rejani and Yadukumar, 2010). Adoption of high density planting (HDP) system has been practised in other perennial crops like mango, coffee etc. in order to increase yield per unit area (Gunjate et al., 2009; Paulo and Furlani, 2010). Maintenance of optimum plant population is seems to be an important aspect to be studied for this export oriented crop in order to increase the productivity. As most of the cashew plantations are senile plantation and cultivated in marginal and waste land with least fertility status, further aggravated the productivity of the crop. In most parts of the country including Odisha, the farmers hardly apply any fertilizer or organic manner as per requirement of the plant. Hence, keeping these problems in view, the present study was undertaken to study the efficiency of plant density and fertilizer dose to increase the production and productivity of cashew.

2. Materials and Methods

The field experiment was conducted at Cashew Research Station (CRS), AICRP on Cashew of Orissa University of Agriculture and Technology, Bhubaneswar for the period from 2000 to 2013 to study the efficiency of planting density and manurial requirement of cashew plantation. The experiment was laid out in split plot design with three planting density of

S_1:(10×5 m^2), S_2:(6×4 m^2) and S_3:(5×4 m^2) in main plots while three doses of fertilizer such as M_1:(75-25-25), M_2:(150-50-50) and M_3:(225-75-75) NPK kg ha^{-1} as subplot, replicated four times. Each treatment consists of six plants. The grafted cashew plants of variety BPP 8 (H 2/16) was planted during 2000. The soil sample was red lateritic in texture with pH of 4.8. All the mentioned practices except plant density and nutrient were adopted uniformly in all the treatment. The vegetative growth parameters such as plant height, trunk girth, canopy height and canopy diameters in E-W and N-S directions were recorded. Then the ground coverage by canopy was worked out using following procedure;

Radius of canopy (m), $r=(D_1+D_2)/4$

D_1: Canopy spread in E-W direction (m)

D_2: Canopy diameter in N-S direction (m)

Ground coverage by canopy (m^2), $A=r^2$

$$\% \text{ ground coverage by canopy} = \frac{\text{Ground coverage by canopy}}{\text{Actual area on the ground}}$$

Similarly, nut yield and yield attributing parameters were recorded from individual plants from each treatments year wise and mean data were considered for statistical analysis. Fresh and dry weight of a subsample of 50 nuts from each tree was determined. The dry weight was recorded after sun drying the nuts for at least 5 to 6 days. The weight per nut including shell was determined at 14% moisture as per the industrial standard (Kuppelwieser, 1989). The nut yield $tree^{-1}$ was calculated as follows:

Nut yield=Mean nut weight×Total number of nuts $tree^{-1}$

Economics of plant density cum fertilizer trial was also calculated. The statistical analysis was carried out by adopting the procedure suggested by Panse and Sukhatme (1989).

During the initial years of growth, lower branches were removed uniformly for convenience of cultural operations and also to give a proper canopy shape to the plantation. The cashew tree was detopped first after attending a height of near about 3 m. Pruning was adapted uniformly to all the plants in the experiment as per the requirements.

3. Results and Discussion

The result data presented in Table 1 revealed significant of plant density for stem girth, flowering laterals m^{-2} and nuts $panicle^{-1}$ while only nuts $panicle^{-1}$ for fertilizer dose under study. Planting density of 10×5 m^2 (S_1) accommodating 200 plants ha^{-1} recorded significant impact on stem girth, flowering panicle m^{-2} and nuts $panicle^{-1}$ than rest of the planting density except planting density of 6×4 m^2 (S_2), 400 plants ha^{-1} for nuts $panicle^{-1}$ which was statistically at par with S_1.

Similarly, although tree height and canopy coverage recorded non-significant variations as influenced by different plant density, but higher trend was recorded with S_1 for the height while S_3 for canopy coverage in cashew plantation. The results indicated that by adoption of high density planting system, there will be reduction in tree height, stem girth, flowering laterals m^{-2} and nuts $panicle^{-1}$ etc. Although levels of fertilizer had non-significant influence except nut $panicle^{-1}$ (Table 1) but an increasing trend was observed for all the parameters under study including influence of these parameters at higher levels of fertilizer i.e. M_3 @ 225-75-75 kg NPK ha^{-1}.

The results on interaction influence of both plant density and levels of fertilizer presented in Table 2 revealed only significant effect on tree height and nut weight (g). The plant density of S_1 (200 plant ha^{-1}) revealed significantly highest tree height of 6.44 m (S_1M_1) than rest of the treatments except S_1M_2 (6.36 m), S_2M_2 (6.09 m), S_2M_3 (6.10 m) and S_3M_3 (5.53 m) which were statistically at par. Similarly, S_1M_2 (200 plants with 150-50-50

Table 1: Effect of spacing and levels of fertilizer on vegetative growth in cashew plantation after 11th harvest

Treatment	Mean tree height (m)	Mean trunk girth (cm)	Ground coverage by canopy (%)	No. of flowering laterals m^{-2}	Nuts $panicle^{-1}$
Spacing					
S_1:10×5 m^2 (200 plant ha^{-1})	6.26	83.30	122.20	6.68	8.96
S_2:6×4 m^2 (400 plant ha^{-1})	6.04	71.63	128.92	5.93	8.68
S_3:5×4 m^2 (500 plant ha^{-1})	5.71	69.16	128.56	4.52	7.63
SEm±	0.22	1.864	0.690	0.198	0.29
CD (*p*=0.05)	NS	6.45	NS	0.68	0.99
Fertilizer					
M_1 (75-25-25)	5.98	73.61	118.14	5.17	7.92
M_2 (150-50-50)	5.99	75.81	128.58	5.95	8.65
M_3 (225-75-75)	6.03	74.67	132.96	6.00	8.70
SEm±	0.08	0.97	5.124	0.31	0.23
CD (*p*=0.05)	NS	NS	NS	NS	0.683

kg NPK ha^{-1}) recorded maximum trunk girth (84.62 cm) and nut weight (9.1 g). Regarding percentage of ground cover by canopy was maximum with S_3M_3 (144.29%) while nuts panicle^{-1} with S_1M_3 (6.98). For most of the parameters under study, treatment with 500 plants ha^{-1} with lower levels of fertilizer i.e. M_5(75-25-25 kg NPK ha^{-1}) was recorded lowest value indicating that perhaps due to more plants per unit area with lower fertilizer reduces the growth and yield attributing parameters in cashew plantation due to heavy competition among plants.

The results on effect of plant density and levels of fertilizer on nut yield of cashew presented in Table 3 indicated significant variations for all the years under study except the year 2012, which was due to failure in flowering. Significantly maximum yield was recorded with higher spacing accommodating 200 plants ha^{-1} (S_1) than rest of the treatments from 2007 to 2013, except S_2 (400 plants ha^{-1}) during 2007 which were statistically at par with each other. The data also indicated drastic reduction in nut yield during 2012 onwards because of due to unfortunate climate factor as well as overlapping of individual plants by canopy area. The results clearly indicated that high density planting in cashew plantation decreases the plant nut yield significantly over the years.

Similarly, cumulative nut yield (kg tree^{-1}) at 11th harvest revealed maximum yield of 45.95 kg tree^{-1} with 200 plants ha^{-1} followed by 400 plants ha^{-1} (30.77 kg tree^{-1}) and lowest being 500 plants ha^{-1} (26.77 kg tree^{-1}). The study conducted by Paulo and Furland (2010) showed that plant densities increased with decreased in plant yield in coffee plantation.

Similar trend was also observed for nut yield over the year from 2007 to 2013 as influenced by different doses of fertilizer (Table 3). Application of fertilizer @ 150-50-50 kg plant^{-1} (M_2) recorded significantly highest nut yield plant^{-1} in all the years under study except the year 2012 where non-significant result was observed, closely followed by M_3 @ 225-75-75 kg NPK ha^{-1} in most of the year. This present findings revealed that application of higher levels of fertilizer yielded better nut yield in cashew.

The combined effect of plant density and fertilizer levels on cashew crop for nut yield over 2007 to 2013 indicated non-significant influence in all the year except the year 2009. Significantly highest nut yield of 11.91 kg tree^{-1} was recorded in plot of S_1M_2 (200 plants ha^{-1} with 150-50-50 kg NPK ha^{-1}) closely followed by S_1M_3 (200 plants ha^{-1} with 225-75-75 kg NPK ha^{-1}) than rest of the interactions. In all the other years, similar trend were recorded, although non-significant statistically.

The maximum cumulative nut yield of 52.78 kg tree^{-1} was recorded with S_1M_2, closely followed by S_1M_3 (46.77 kg tree^{-1}) while minimum of 24.86 kg tree^{-1} with S_3M_1 (500 plants ha^{-1} with 75-25-25 kg NPK ha^{-1}). The present data clearly indicated that after 11th harvest the cumulative yield tree^{-1}was maximum with lower plant density (200 plants with fertilizer dose of 150-50-50 kg NPK ha^{-1}) and decreases with increasing plant density (Table 3 and Figure 1 to 3). A similar observation was also reported by Paulo and Furland (2010) in coffee plantation.

The graph presented in Figure 1 to 3 also indicated that there was sharp decline in the plant^{-1} nut yield in cashew with different spacing and fertilizer levels after certain period of harvest. The polynomial curve clearly indicated that, in case of high density planting system, pruning should be done after 5th harvest while 8th harvest in normally spaced crop in order to maintain the productivity of plants at optimum levels for a longer period of time.

On the other hand, the cumulative nut yield at 11th harvest on hectare basis indicated maximum nut yield of 15,140.50 kg tree ha^{-1} with high density planting and moderate fertilizer i.e. S_3M_3 (500 plants ha^{-1} with 150-50-50 kg NPK ha^{-1}) closely followed by S_3M_3 (14052.05 kg ha^{-1}). Lowest cumulative yield

Table 2: Interaction effect of spacing and levels of fertilizer on vegetative growth in cashew plantation after 11th harvest

Treatments	Fertilizer dose NPK (kg ha^{-1})	Tree height (m)	Trunk girth (cm)	% Ground coverage by canopy	No. of flowering laterals m^{-2}	Nuts panicle^{-1}	Nut weight (g)
S_1:10×5 m^2	M_1:75-25-25	6.44	83.33	126.24	6.23	3.00	8.63
(200 plant ha^{-1})	M_2:150-50-50	6.36	84.62	121.49	6.83	2.70	9.18
	M_3:225-75-75	5.98	81.95	118.85	6.98	2.6	9.08
S_2:6×4 m^2	M_1:75-25-25	5.93	71.46	118.62	5.08	2.50	8.23
(400 plant ha^{-1})	M_2:150-50-50	6.09	72.03	132.40	6.33	2.60	8.83
	M_3:225-75-75	6.10	71.42	135.73	6.38	2.40	8.98
S_3:5×4 m^2	M_1:75-25-25	5.58	66.04	109.56	4.20	2.00	6.90
(500 plant ha^{-1})	M_2:150-50-50	5.53	70.79	131.83	4.70	1.80	7.95
	M_3:225-75-75	6.00	70.65	144.29	4.65	1.60	8.05
SEm±	-	0.14	1.69	8.88	0.314	-	-
CD (p=0.05)	-	0.42	NS	NS	NS	-	-

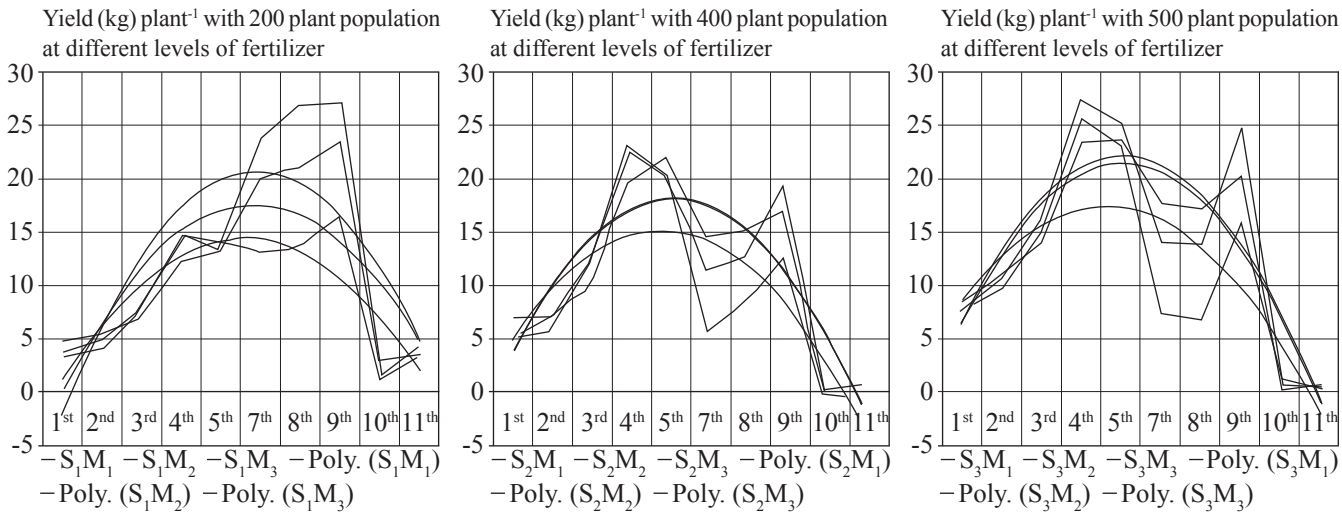

Figure 1 to 3: Effect of spacing and levels of fertilizers on plant^{-1} yield^{-1} in Cashew

Table 3: Effect of spacing and levels of fertilizer on nut yield in cashew plantation after 11th harvest (from 2007 to 2013)

Treatment	2007	2009	2010	2011	2012	2013	Cumulative nut yield (kg tree^{-1}) at 11th harvest
S_1:10×5 m^2 (200 plant ha^{-1})	6.93	9.45	10.28	11.17	1.70	3.65	45.95
S_2:6×4 m^2 (400 plant ha^{-1})	6.86	3.45	3.93	5.22	1.16	1.78	30.77
S_3:5×4 m^2 (500 plant ha^{-1})	5.76	2.99	2.92	4.63	1.30	1.23	26.77
SEm±	0.07	0.98	0.87	0.93	0.40	0.15	-
CD (*p*=0.05)	0.26	3.41	3.02	3.22	NS	0.54	-
M_1 (75-25-25)	6.8	3.39	3.75	5.32	1.26	1.81	30.33
M_2 (150-50-50)	6.89	6.27	6.94	8.48	1.31	2.46	38.28
M_3 (225-75-75)	5.87	6.23	6.44	7.23	1.59	2.39	34.88
SEm±	0.07	0.48	0.38	0.40	0.34	0.12	-
CD (*p*=0.05)	0.23	1.45	1.14	1.20	NS	0.38	-

Table 4: Interaction effect of spacing and levels of fertilizer on nut yield in cashew plantation after 11th harvest (from 2007 to 2013)

Treatment	Fertilizer Dose NPK (kg ha^{-1})	2007	2009	2010	2011	2012	2013	Cumulative nut yield (kg tree^{-1}) at 11th harvest	Cumulative nut yield (kg tree^{-1}) at 11th harvest
S_1:10×5 m^2	M_1:75-25-25	7.30	6.43	6.80	8.20	1.03	3.25	38.30	7898.50
(200 plant ha^{-1})	M_2:150-50-50	7.39	11.91	13.48	13.63	1.35	4.08	52.78	10823.00
	M_3:225-75-75	6.10	10.10	10.55	11.63	2.71	3.62	46.77	9707.00
S_2:6×4 m^2	M_1:75-25-25	7.30	2.01	2.80	4.08	0.83	1.24	27.82	11665.00
(400 plant ha^{-1})	M_2:150-50-50	7.10	3.72	4.15	6.18	1.30	2.08	38.12	13788.00
	M_3: 225-75-75	6.20	4.64	4.85	5.40	1.36	2.03	31.36	13261.00
S_3:5×4 m^2	M_1:75-25-25	5.80	1.74	1.64	3.68	1.92	0.94	24.86	13099.80
(500 plant ha^{-1})	M_2:150-50-50	6.20	3.20	3.20	5.63	1.28	1.24	28.94	15140.50
	M_3:225-75-75	5.30	4.04	3.93	4.60	0.69	1.52	26.50	14052.05
SEm±	-	0.13	0.76	0.70	0.59		0.22	-	-
CD (*p*=0.05)	-	NS	1.98	NS	NS		NS		-

The data on cumulative nut yield (kg tree^{-1}) at 11th harvest revealed that application of fertilizer @ 150-50-50 kg NPK ha^{-1} (M_2) recorded maximum yield of 38.28 kg tree^{-1} followed by M_3-(225-75-75 kg NPK tree^{-1}) of 34.88 kg tree^{-1}. Hence, application of fertilizer level of M_2 may be suitable for cashew plantation for higher yield

of 7898.50 kg ha^{-1} at 11th harvest was recorded with wider spacing and low dose of fertilizer i.e. S_1M_1 (200 plants with 75-25-25 kg NPK ha^{-1}. Similar report of higher nut yield was also reported by Yadukumar et al. (2000); Yadukumar et al. (2011) and Rejani et al. (2013).

The economics on plant density cum fertilizer in cashew plantation over 11th harvest are presented in Table 5 revealed maximum BCR of 3.04 with high density planting (500 plant ha^{-1}) and moderate fertilizer application (M_2-150-50-50 kg NPK ha^{-1}) closely followed by S_3M_1 (2.86) and S_2M_2 (2.79). Similar report also reported by Despande (2002) in high density planting on cashew.

Table 5: Effect of spacing and levels of fertilizer on economics in cashew plantation after 11th harvest

Spacing (Density)	Fertilizer dose NPK (kg ha^{-1})	Cum. nut yield (kg ha^{-1}) (11th No. of harvests)	Cum. cost of cultivation (₹ ha^{-1}) over 11th no. of years	Cum. total return of cashew (₹ ha^{-1})	Cum. net return (₹ ha^{-1})	Benefit:cost ratio
S_1:10×5 m^2	M_1:75-25-25	7898.50	154803	276447.50	121644.50	1.79
(200 plant ha^{-1})	M_2:150-50-50	10823.00	168817	378805.00	209988.00	2.24
	M_3:225-75-75	9707.00	182838	339745.00	156907.00	1.86
S_2:6×4 m^2	M_1:75-25-25	11665.00	158655	408275.00	249620.00	2.57
(400 plant ha^{-1})	M_2:150-50-50	13788.00	172669	482580.00	309911.00	2.79
	M_3:225-75-75	13261.00	186690	464135.00	277445.00	2.49
S_3:5×4 m^2	M_1:75-25-25	13099.80	160581	458493.00	297912.00	2.86
(500 plant ha^{-1})	M_2:150-50-50	15140.50	174595	529917.50	355322.50	3.04
	M_3:225-75-75	14052.05	188616	491821.75	303205.75	2.61

4. Conclusion

It may be concluded from the present study that planting density as well as levels of fertilizer have significant influence on growth and yield in cashew. Lower plant density (200 plant ha^{-1}) with moderate level of fertilizer (150-50-50 kg ha^{-1}) increases vegetative growth, yield and yield attributing parameters on plant basis. But significant maximum cumulative nut yield ha^{-1} basis with BCR was observed in high density planting accommodating 500 plant ha^{-1} with moderate fertilizer level of 150-50-50 kg NPK ha^{-1} over a period of 11th harvest in cashew under Odisha condition. The study also indicated that, in case of high density planting system, pruning should be done after 5th harvest while 8th harvest in wider spacing in order to maintain the productivity of plants at optimum levels

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