Research Article

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Effect of fertigation on the productivity of coconut

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Abstract

An experiment to study the effect of fertigation on the productivity of coconut was laid out at Horticulture Research Station, Arsikere, Karnataka during 2007-08 to 2011-12. Application of 25, 50, 75 and 100 per cent of recommended NPK through drip irrigation system was compared with the soil application of recommended NPK as well as control with no fertilizer application. Fertilizers were given through drip irrigation system throughout the year in ten equal splits at monthly interval excluding peak rainfall months of May and October. Application of 100 per cent NPK through drip irrigation recorded significantly higher number of female flowers and nut setting percentage compared to control and application of 25 per cent NPK through drip irrigation. The mean nut and copra yield per palm over five years was significantly higher with the application of 100 per cent NPK through drip irrigation compared to control and application of 25 and 50 per cent NPK through drip irrigation. However, the copra content was not significantly influenced by the fertigation treatments. Application of 75 per cent NPK through drip irrigation recorded nut and copra yield per palm on par with the application of 100 per cent NPK through drip irrigation and 100 per cent NPK through soil. The net returns and benefit-cost ratio in 75 per cent NPK through drip irrigation were also on par with the application of 100 per cent NPK through drip irrigation, but significantly higher than 100 per cent NPK through soil application. The study indicated the possibility of saving 25 per cent of the recommended fertilizers by adopting fertigation which ensures higher productivity in coconut.

Keywords: Coconut, copra yield, fertigation, productivity

Introduction

Water and nutrients are the main factors in irrigated agriculture and are the major inputs contributing to higher productivity of crops. The method of fertilizer application and irrigation affects the efficiency of these inputs. The use efficiency of these valued inputs is currently very low in India leading to low crop productivity, degradation of soil health and increased environmental pollution apart from wastage of substantial quantity of these costly and scarce inputs. The water use efficiency can be greatly improved through the adoption of drip irrigation system which is becoming popular in the arid and semi-arid regions of India particularly where canal irrigation systems are not developed. Application of fertilizers can also be done through drip irrigation system, which is known as fertigation.

Fertigation is the most advanced and efficient method of fertilizer application which ensures application of fertilizers directly to the root zone of the crop throughout the cropping period. Fertigation optimize the use of water and fertilizer enabling to harness higher crop yields and also ensure a healthy soil and environment. In fertigation, nutrient use efficiency could be as high as 90 per cent compared to 40-60 per cent in conventional methods. The amount of nutrients lost through leaching can be as low as 10 per cent in fertigation whereas, it is 50 per cent in the traditional system (Solaimalai *et al*., 2005). The studies on fertigation revealed significant fertilizer savings of 20-60 per cent and 8-41 per cent increase in yields of horticultural and vegetable crops (Singh *et al*., 2010). With expanding area under drip irrigation in India, fertigation has great scope in fertilizer saving and increased crop yield. Therefore,

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a field trial on fertigation in coconut was taken up at Horticulture Research Station, Arsikere, Karnataka to study the effect of fertigation on the productivity of coconut.

Materials and methods

The study was carried out during 2007-08 to 2011-12 at Horticulture Research Station, Arsikere, Hassan District, Karnataka, situated at 13° 15' N latitude and 76° 15' E longitude with an altitude of 808 m above mean sea level (MSL). The Research Station receives an annual rainfall of 816 mm distributed mainly during April to October. There are two peaks in rainfall distribution, one in May (93.9 mm in 5 rainy days) and the other during October (228.8 mm in 10 rainy days). The soil of the experimental site was red sandy loam with low in available nitrogen (253 kg N ha^{-1}) and medium in available phosphorous (24 kg P_2O_5 ha^{-1}) and potassium (295 kg K_2O ha^{-1}).

The experiment was laid out in RBD with six treatments and four replications. Application of 25, 50, 75 and 100 per cent of recommended NPK through drip irrigation was compared with the soil application of 100 per cent recommended NPK and the control without fertilizer application. The recommended fertilizer dose of 500:320:1200 g NPK $palm^{-1}$ $year^{-1}$ was adopted for fertigation as well as soil application. Fertigation was done using fertigation tank connected to pipe line of drip irrigation system. Fertilizers were dissolved in water and added to the fetigation tank after filtering the solution and applied to coconut through drip irrigation system in 10 equal splits in a year at monthly interval excluding peak rainfall months of May and October. Soil application of 100 per cent recommended NPK, the fertilizers were applied in two splits-1/3rd during May-June and 2/3rd during September- October. Urea, di-ammonium phosphate and muriate of potash were used as sources of nitrogen, phosphorus and potassium respectively. The coconut palms were 42 years old Tiptur Tall cultivar planted at a spacing of 7.5 m x 7.5 m (178 palms ha^{-1}).

The drip irrigation was given at 66 per cent of pan evaporation (Eo) and the quantity of water given was calculated based on 10 years average of mean monthly evaporation. The 1.8 m radius of coconut basin was taken as the effective root zone for calculating the water requirement (Kushwah *et al.,* 1973). Eo was highest during the month of April (7.37 mm day^{-1}) while it was lowest during December (4.39 mm day^{-1}) and the water requirement through drip irrigation at 66 per cent Eo level is 50 and 30 liters day^{-1} $palm^{-1}$ respectively. The drip irrigation system consisted of pumping of water from bore well and delivery after passing through water filter, main pipeline, sub pipeline, laterals and drippers. At the base of each palm four drippers were placed one metre away from the bole at equidistance with the help of 4 mm LDPE micro tubes. The daily duration of drip irrigation was fixed based on the quantity of water to be given at 66 per cent Eo and discharge rate of 4 litres per hour in a dripper. The water from drippers was allowed to drip up to 30 cm depth by putting the drippers in the conduit pipe. Mulching was provided to coconut basins using coconut leaves.

The observation on the number of functional leaves and annual production of bunches and female flowers per palm were recorded. Nut setting per cent was computed from the data on the number of female flowers produced per palm and the nut yield per palm. Soil samples were drawn from the basins of coconut at 0-25 cm, 25-50 cm and 50-100 cm for analyzing nutrient status of soil. Similarly, the coconut leaf samples were collected from the index leaf (14th leaf). The soil and leaf samples were analyzed for N, P and K content by adopting standard procedures (Jackson, 1973). The nuts were harvested periodically at maturity from July to June and pooled to get nut yield per palm per year. Copra content in a nut was recorded by drawing random sample of six nuts per treatment at each harvest, dehusking, separation of kernel from shell, drying in the shade and averaging over harvests. Copra yield per palm was computed based on the copra content in the nut in each treatment. The economics of fertigation was worked out considering the cost of inputs and market price of nuts prevailed during 2011-12. The data was analyzed statistically as per the procedure given by Gomez and Gomez (1984).

Results and discussion

Yield attributing characters of coconut

Fertigation had no significant influence on the number of functional leaves and bunches per palm (Table 1 and 2). The number of female flowers per palm

Table 1. Number of functional leaves in coconut as influenced by fertigation treatments

Treatment	No. of leaves per palm					
	2007-08 (1st yr)	2008-09 (2nd yr)	2009-10 (3rd yr)	2010-11 (4th yr)	2011-12 (5th yr)	Pooled
T_1 : Control (No fertilizer)	30.38	32.50	31.63	30.29	32.08	31.37
T_2 : 25% of Rec. NPK (Drip)	30.96	32.58	32.17	32.08	32.83	32.12
T_3 : 50% of Rec. NPK (Drip)	30.34	32.59	32.42	32.16	32.78	32.06
T_4 : 75% of Rec. NPK (Drip)	30.17	32.58	32.58	32.08	31.70	31.82
T_5 :100% of Rec. NPK (Drip)	32.67	33.83	33.34	33.50	33.50	33.37
T_6 :100% of Rec. NPK (Soil)	31.50	32.34	32.08	32.67	32.26	32.17
S. Em ±	0.93	0.86	0.74	0.67	0.80	0.37
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 2. Number of bunches in coconut as influenced by fertigation treatments

Treatment	No. of bunches per palm					
	2007-08 (1st yr)	2008-09 (2nd yr)	2009-10 (3rd yr)	2010-11 (4th yr)	2011-12 (5th yr)	Pooled
T_1 : Control (No fertilizer)	12.08	12.58	12.92	12.80	12.43	12.77
T_2 : 25% of Rec. NPK (Drip)	12.42	13.00	12.83	13.23	12.58	12.98
T_3 : 50% of Rec. NPK (Drip)	12.33	12.83	13.00	13.13	12.53	12.99
T_4 : 75% of Rec. NPK (Drip)	12.50	13.17	12.59	13.15	12.60	12.99
T_5 :100% of Rec. NPK (Drip)	12.25	13.67	13.00	13.63	12.73	13.32
T_6 :100% of Rec. NPK (Soil)	12.33	12.92	12.83	13.48	12.75	13.07
S. Em ±	0.36	0.27	0.17	0.22	0.13	0.09
CD (P=0.05)	NS	NS	NS	NS	NS	NS

and nut setting per cent were significantly influenced by fertigation from 3rd year of experimentation (Table 3 and 4). Significantly higher number of female flowers per palm was recorded with the application of 100 per cent NPK through drip irrigation compared to control and application of 25 per cent NPK through drip irrigation during 3rd year and to only control during 4th and 5th year of experimentation. The nut setting per cent was significantly higher with the application of 100 per cent NPK through drip irrigation compared to control during 3rd and 4th year

Table 3. Number of female flowers in coconut as influenced by fertigation treatments

Treatment	No. of female flowers per palm					
	2007-08 (1st yr)	2008-09 (2nd yr)	2009-10 (3rd yr)	2010-11 (4th yr)	2011-12 (5th yr)	Pooled
T_1 : Control (No fertilizer)	204.55	264.50	273.78	257.25	249.53	249.92
T_2 : 25% of Rec. NPK (Drip)	207.17	254.67	283.05	302.18	273.80	264.17
T_3 : 50% of Rec. NPK (Drip)	206.21	280.67	309.98	322.65	277.85	279.47
T_4 : 75% of Rec. NPK (Drip)	222.88	269.75	333.20	331.60	301.63	291.81
T_5 :100% of Rec. NPK (Drip)	237.46	283.17	359.55	339.00	302.65	304.36
T_6 :100% of Rec. NPK (Soil)	225.46	274.08	339.30	336.00	278.35	290.64
S. Em ±	10.03	12.57	16.65	15.44	10.55	5.94
CD (P=0.05)	NS	NS	50.18	46.54	31.79	17.91

Table 4. Nut setting per cent in coconut as influenced by fertigation treatments

Treatment	Nut setting percentage					
	2007-08 (1st yr)	2008-09 (2nd yr)	2009-10 (3rd yr)	2010-11 (4th yr)	2011-12 (5th yr)	Pooled
T_1 : Control (No fertilizer)	28.01	29.82	24.74	30.72	29.43	28.54
T_2 : 25% of Rec. NPK (Drip)	28.81	30.16	29.33	33.14	26.39	29.57
T_3 : 50% of Rec. NPK (Drip)	31.30	33.10	28.57	35.96	27.19	31.22
T_4 : 75% of Rec. NPK (Drip)	30.51	32.84	30.58	36.44	29.70	32.02
T_5 :100% of Rec. NPK (Drip)	34.07	34.80	31.18	36.35	31.52	33.58
T_6 :100% of Rec. NPK (Soil)	30.74	31.38	30.95	36.61	28.44	31.62
S. Em ±	1.65	2.44	1.67	1.75	1.63	0.84
CD (P=0.05)	NS	NS	5.02	5.29	NS	2.55

while during 5th year, the differences between treatments were not statistically significant. The mean data over 5 years from 2007-08 to 2011-12 showed that the application of 100 per cent NPK through drip irrigation recorded significantly higher number of female flowers per palm compared to control and application of 25 and 50 per cent NPK through drip irrigation. Similarly, the nut setting percentage was also significantly higher in 100 per cent NPK through drip irrigation compared to control and application of 25 per cent NPK through drip irrigation. The number of female flowers per palm and nut setting percentage in 75 per cent NPK through drip irrigation were on par with 100 per cent NPK through drip irrigation or soil application. Coconut palm normally produces one leaf and bunch per month that necessitates continuous supply of nutrients through out the year (Khan, 1993). The regular supply of nutrients coupled with optimum moisture in fertigation favoured higher number of female flower production and increased nut setting. The studies conducted at coastal Tamil Nadu also highlighted the superiority of fertigation over conventional method of fertilizer application on the number of bunches and female flowers produced per palm. Application of 50 per cent NPK through fertigation produced bunches and female flowers per palm comparable to 75 and 100 per cent NPK through fertigation and 100 per cent NPK through soil application (AICRP-Palms, 2011).

Soil and leaf nutrient status in coconut

The soil NPK status after 4 years of fertigation was significantly higher with the application of 100 per cent NPK through drip irrigation and soil application compared to other treatments and was on par with 75 per cent NPK through drip irrigation (Table 5). Similarly, the leaf NPK status was also significantly higher with the application of 100 per cent NPK through drip irrigation compared to control and application of 25 per cent NPK through drip irrigation (Table 6). The leaf N status

Table 5. Soil nutrient status as influenced by fertigation treatments in coconut (after 4 years- 2010-11)

Treatment	Nitrogen			Phosphorus			Potassium		
	0-25 cm	25-50 cm	50-100 cm	0-25 cm	25-50 cm	50-100 cm	0-25 cm	25-50 cm	50-100 cm
T_1:Control (No fertilizer)	234.4	239.4	241.9	23.45	20.08	13.28	312.9	269.3	248.5
T_2:25% of Rec. NPK (Drip)	246.3	245.0	248.1	23.67	20.34	16.17	314.9	272.0	239.2
T_3:50% of Rec. NPK (Drip)	266.3	239.4	245.0	28.51	22.95	14.89	381.7	328.5	277.4
T_4:75% of Rec. NPK (Drip)	269.1	261.9	255.0	34.44	26.36	15.77	389.9	349.7	266.6
T_5:100% of Rec. NPK (Drip)	323.1	314.4	258.8	33.66	26.62	16.67	453.6	367.1	318.2
T_6:100% of Rec. NPK (Soil)	326.3	321.9	275.6	31.12	20.90	16.63	471.7	387.9	355.1
S. Em ±	22.1	24.1	14.41	2.74	1.94	1.50	22.4	25.7	19.0
CD (P=0.05)	66.7	72.5	NS	8.25	NS	NS	67.4	77.4	57.2

Table 6. Leaf nutrient status in coconut as influenced by fertigation treatments (after 4 years: 2010-11)

Treatment	Leaf nutrient status (%)		
	N	P	K
T_1 : Control (No fertilizer)	1.35	0.105	0.94
T_2 : 25% of Rec. NPK (Drip)	1.63	0.111	0.94
T_3 : 50% of Rec. NPK (Drip)	1.88	0.140	0.98
T_4 : 75% of Rec. NPK (Drip)	1.88	0.161	1.10
T_5 :100% of Rec. NPK (Drip)	1.93	0.168	1.16
T_6 :100% of Rec. NPK (Soil)	1.70	0.144	1.01
S. Em ±	0.07	0.010	0.06
CD (P=0.05)	0.21	0.031	0.17

in 100 per cent NPK through soil application was significantly lower than 100 per cent NPK through drip irrigation. Application of 50 and 75 per cent NPK through drip irrigation recorded leaf NPK status on par with 100 per cent NPK through drip irrigation. Application of fertilizers in split doses through drip irrigation minimizes leaching losses of nitrogen and potassium and fixation of phosphorus in the soil. Hence, the nutrient availability in the soil will be maintained at higher level in fertigation compared to soil application of fertilizers. Higher nutrient availability in fertigation favours increased nutrient uptake resulting in higher nutrient content in coconut leaves. Similar results of higher soil NPK with fertigation in coconut was reported in coastal sandy soils of Kerala (CPCRI, 2011). In arecanut also, improved availability of nutrients due to fertigation was reported (Bhat *et al.,* 2007).

Yield of coconut

The nut and copra yield of coconut per palm were significantly influenced by fertigation treatments from 2nd year of experimentation (Table 7 and 9). Significantly higher number of nuts and copra yield per palm were recorded with the application of 100 per cent NPK through drip irrigation compared to control and application of

Table 7. Yield of coconut as influenced by fertigation treatments

Treatment	Yield of coconut (Nuts palm^{-1} yr^{-1})					
	2007-08 (1st yr)	2008-09 (2nd yr)	2009-10 (3rd yr)	2010-11 (4th yr)	2011-12 (5th yr)	Pooled
T_1 : Control (No fertilizer)	57.30	59.89	65.06	84.00	75.30	68.31
T_2 : 25% of Rec. NPK (Drip)	58.90	62.22	74.75	94.15	79.71	73.95
T_3 : 50% of Rec. NPK (Drip)	64.83	66.44	80.15	111.48	87.05	81.99
T_4 : 75% of Rec. NPK (Drip)	62.55	72.84	82.35	121.15	98.18	87.41
T_5 :100% of Rec. NPK (Drip)	70.53	82.16	87.76	129.60	106.26	95.26
T_6 :100% of Rec. NPK (Soil)	64.20	70.64	84.37	124.05	94.58	87.57
S. Em ±	3.77	4.71	3.84	6.74	3.97	2.69
CD (P=0.05)	NS	14.00	11.57	20.32	11.95	8.11

Table 8. Copra content in coconut as influenced by fertigation treatments

Treatment	Copra content (g nut^{-1})					
	2007-08 (1st yr)	2008-09 (2nd yr)	2009-10 (3rd yr)	2010-11 (4th yr)	2011-12 (5th yr)	Pooled
T_1 : Control (No fertilizer)	149.40	146.50	144.15	155.80	142.70	147.71
T_2 : 25% of Rec. NPK (Drip)	150.35	147.80	145.70	157.35	142.05	148.65
T_3 : 50% of Rec. NPK (Drip)	148.80	150.45	146.35	156.23	148.80	150.13
T_4 : 75% of Rec. NPK (Drip)	148.30	146.85	145.70	161.05	148.23	150.03
T_5 :100% of Rec. NPK (Drip)	151.55	148.45	150.30	161.60	150.33	152.45
T_6 :100% of Rec. NPK (Soil)	150.05	146.78	148.05	156.90	145.60	149.48
S. Em ±	3.11	2.87	3.63	3.71	2.49	1.43
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 9. Copra yield of coconut as influenced by fertigation treatments

Treatment	Copra yield (kg palm^{-1} yr^{-1})					
	2007-08 (1st yr)	2008-09 (2nd yr)	2009-10 (3rd yr)	2010-11 (4th yr)	2011-12 (5th yr)	Pooled
T_1 : Control (No fertilizer)	8.57	8.81	9.38	13.16	10.77	10.14
T_2 : 25% of Rec. NPK (Drip)	8.86	9.18	10.93	14.84	11.32	11.03
T_3 : 50% of Rec. NPK (Drip)	9.65	10.00	11.80	17.42	12.95	12.36
T_4 : 75% of Rec. NPK (Drip)	9.27	10.63	11.94	19.53	14.56	13.19
T_5 :100% of Rec. NPK (Drip)	10.62	12.22	13.14	20.93	15.96	14.58
T_6 :100% of Rec. NPK (Soil)	9.63	10.36	12.53	19.57	13.76	13.17
S. Em ±	0.52	0.67	0.71	1.31	0.49	0.48
CD (P=0.05)	NS	2.01	2.15	3.96	1.48	1.46

25 and 50 per cent NPK through drip irrigation during 2nd and 5th year and to only control and 25 per cent NPK through drip irrigation during 3rd and 4th year of experimentation. The pooled analysis of 5 years data indicated that the mean nut and copra yield per palm was significantly higher with the application of 100 per cent NPK through drip irrigation compared to control and application of 25 and 50 per cent NPK through drip irrigation. However, the copra content was not significantly influenced by the fertigation treatments (Table 8). Application of 75 per cent NPK through drip irrigation recorded nut and copra yield per palm on par with the application of 100 per cent NPK through drip irrigation and 100 per cent NPK through soil application indicating the possibility of saving 25 per cent of recommended NPK by adopting fertigation.

The higher nut yield with fertigation of 75 or 100 per cent of recommended NPK over conventional method of soil application of 100 per cent recommended NPK was mainly attributed to production of more number of female flowers and increased availability and uptake of nutrients. The studies conducted at Central Plantation Crops Research Institute, Kasaragod in coastal sandy soils indicated the possibility of 50 per cent saving of chemical fertilizer through fertigation in coconut. Application of 50 and 75 per cent of fertilizer application through fertigation recorded significantly higher nut and copra yield compared to soil application of 100 per cent fertilizer and were on par with 100 per cent fertilizer application through fertigation. The higher yield of coconut even in 50 per cent of recommended NPK through fertigation was attributed to increased availability of soil NPK, higher annual leaf production and higher photosynthetic activity and more number of female flower production (Subramanian *et al*., 2012). A fertilizer saving of 50 per cent due to

Table 10. Economics of fertigation in coconut (Mean of 5 years from 2007-08 to 2011-12)

Treatment	Mean coconut yield (Nuts ha^{-1})	Gross returns (₹ ha^{-1})	Cost of production (₹ ha^{-1})	Net returns (₹ ha^{-1})	Benefit-cost ratio
T_1 : Control (No fertilizer)	12159	72955	37800	35155	1.93
T_2 : 25% of Rec. NPK (Drip)	13162	78974	40225	38749	1.96
T_3 : 50% of Rec. NPK (Drip)	14594	87563	42600	44963	2.06
T_4 : 75% of Rec. NPK (Drip)	15559	93356	44975	48381	2.08
T_5 :100% of Rec. NPK (Drip)	16956	101738	47350	54388	2.15
T_6 :100% of Rec. NPK (Soil)	15587	93521	49600	43921	1.89
S. Em ±	435	2609	-	2609	0.06
CD (P=0.05)	1311	7863	-	7863	0.18

Note: The cost and returns were calculated based on 2011-12 prices; ₹ 6/- per nut.

fertigation has also been reported from coastal Tamil Nadu and Konkan region of Maharashtra (AICRP-Palms, 2011). Bhat *et al*. (2007) recorded higher arecanut yield under 75 per cent of the recommended dose of fertilizer through drip irrigation.

Economics of fertigation

The economics of fertigation worked out based on the mean nut yield of five years and market prices prevailed during 2011-12 (Table 10). The net returns were significantly higher with the application of 100 per cent NPK through drip irrigation compared to other treatments except 75 per cent NPK through drip irrigation. The benefit-cost ratio was also significantly higher with the application of 100 per cent NPK through drip irrigation compared to other treatments except application of 50 and 75 per cent NPK through drip irrigation. Application of 75 per cent NPK through drip irrigation recorded net returns and benefit-cost ratio on par with 100 per cent NPK through drip irrigation and significantly higher than 100 per cent NPK through soil application.

Conclusion

A fertilizer saving of 25 per cent is possible by adopting fertigation with 75 per cent NPK through drip irrigation. The number of bunches and female flowers per palm, nut and copra yield per palm and monetary returns are comparable to fertigation of 100 per cent NPK through drip irrigation and conventional method of 100 per cent NPK through soil application.

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