



Effect of fertilizer application through micro-irrigation technique on nutrient availability and coconut productivity

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Abstract

An investigation was conducted to study the response of drip fertigation in West Coast Tall variety of coconut for growth, nutrition, physiological parameters and yield at Central Plantation Crops Research Institute, Kasaragod during 1996-2008. The application of fertilizers either through drip fertigation or soil application resulted in significantly higher trunk height and girth at base than control (no fertilizer). However, no significant difference was observed among different dose of fertigation and soil application treatments. The number of leaves on the crown was significantly higher (32.6) under 75 per cent of NPK through drip fertigation which was on par with 50 per cent and 100 per cent NPK through drip fertigation and 100 per cent NPK through soil application and significantly differed from 25 per cent NPK through drip fertigation and control. Fertigation to coconut resulted in a marked increase in available nitrogen, phosphorus and potassium status in soil. Different levels of fertigation did influence significantly physiological parameters like net photosynthesis (P_N), transpiration (E) and stomatal conductance (g_s). The treatment, 100 per cent NPK applied through fertigation resulted significantly higher P_N , E and g_s and which was on par with 50 per cent and 75 per cent through drip fertigation and significantly differed from 100 per cent NPK through soil application and control. Among the fertigation levels, coconut yield was significantly higher in 100 per cent NPK fertigation (131nuts/palm/year) which was on par with 75 and 50 per cent NPK applied through drip irrigation and significantly differed from 100 per cent NPK through soil application, 25 per cent NPK through fertigation and control. The study indicated that adoption of fertigation increases the productivity with 50 per cent saving of chemical fertilizers which ensure the higher efficiency of nutrients in crop production.

Keywords: Coconut, drip fertigation, growth, photosynthesis, soil fertility, transpiration, yield

Introduction

The coconut palm (*Cocos nucifera* L.) is one among the crops that provides a variety of useful products like food, fuel and timber. Every part of the tree is being utilized for some purpose or other. The coconut crop is grown in 12.5 million hectares of land which constitute about 0.7 per cent of net cropped area of the world. The crop is grown in the coastal lowlands of continental South Asia and is spread along the Indian and Pacific Ocean, the cultivation is mostly done by small and marginal farmers. India contributes about 15.46 per cent in area and 21 per cent in terms of production of

coconut in the world. The coconut crop is grown in eighteen states and three Union Territories covering an area of 1.9 million hectares of land, with a production of 15780 million nuts and productivity of 8303 nuts/ha in the country (GOI, 2010). It contributes 6 per cent to the national vegetable oil pool and about 10 million families depend on it for their livelihood. About 90 per cent of the acreage lies in the four southern states *i.e.*, Kerala, Tamil Nadu, Karnataka, and Andhra Pradesh. Kerala ranks first in area (41.58%) and production (36.9%) followed by Tamil Nadu, Karnataka and Andhra Pradesh. There is lot of

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scope to improve the productivity to more than 20000 nuts/ha by adopting improved agro-techniques. Crop yield is a complex function of many factors where soil moisture and fertility are the major yield determinant. Water and nutrient use efficiencies show dramatic increase through the synergism existing between them. Since water and nutrients are the two key and costly inputs, it is imperative to develop agro technologies which will optimize the use efficiencies of both water and nutrients and maximize the crop yields.

Coconut palm produces fronds and nuts throughout the year and hence, it demands continuous supply of nutrients from the soil (Khan, 1993). However, the general recommendation from Central Plantation Crops Research Institute for fertilizing the matured bearing palms is 500 g N, 320 g P₂O₅ and 1200 g K₂O palm/yr, to be applied in two split doses *viz.* one-third in May-June and two-thirds in September-October (Nelliath, 1973). The fertilizer use efficiency by employing this method is very low. However, it is mainly recommended to utilize the sufficient soil moisture during the monsoon season. At the same time, heavy down pour immediately after the application of fertilizers will result in leaching of nitrogenous and potassic fertilizers. This necessitates for finding suitable ways to increase the fertilizer use efficiency. Drip fertigation is one of the options. The advantage of fertigation over conventional method was emphasized by several workers (Shigure *et al.*, 1999; Mohammed, 2004). Fertigation is an efficient method of fertilizer application through drip system. Drip fertigation increases the fertilizer use efficiency, saving fertilizer cost, reduced labour requirement, supplying nutrients according to the crop demand at different growth stages, precise and direct application to root zone, correction of micronutrient deficiencies *etc.* Soluble fertilizers *viz.*, urea and potassium chloride can be combined and supplied through drip irrigation. The other possibility is to use liquid fertilizers which are highly soluble, hence no interference and no clogging except for the high cost. Keeping this in view an experiment was conducted to examine the effect of fertigation on West Coast Tall variety of coconut on growth, nutrition and yield.

Materials and Methods

The field experiment was laid out in a randomized block design (Gomez and Gomez, 1984) with four replications in the Research Farm of Central Plantation Crops Research Institute at Kasaragod located at 10.7 m above MSL with an average rainfall of 3500 mm, and mean maximum and minimum temperatures of 36 °C and 22 °C, respectively. The soil is deep red sandy loam (*Arenic Paleustults*) with pH 5.4, clay 22 per cent and CEC 4.7 C mole/kg soil. It contained 90, 5.2 and 41.5 mg available N, P and K per kg soil, respectively, at 0-50 cm soil depth. High yielding coconut variety West Coast Tall (WCT) was used for this study. The treatments were T₁: no fertilizer, T₂: 25 per cent of recommended NPK through drip fertigation, T₃: 50 per cent of recommended NPK through drip fertigation, T₄: 75 per cent of recommended NPK through drip fertigation, T₅: 100 per cent of recommended NPK through drip fertigation T₆: 100 per cent of recommended NPK through soil application. The palms were planted at a distance of 7.5 m x 7.5 m in a square system. Each treatment consisted of a plot size of six palms (337.5 m²), replicated four times. The drip fertigation system consisted of one 10000 L tank, sand filter, venturi, screen filter and two pressure gauges. From the main pipeline, the laterals of convenient length were laid for each treatment with a valve to control the treatment application. At the base of each palm four emitters were placed one metre away from the bole at equidistance with the help of 4 mm LDPE micro-tubes. The water from the emitters was allowed to drip at the rate of 2 litres per hour upto the 30 cm depth by putting the emitters in 30 cm x 30 cm x 30 cm pits with the help of conduit pipe. Palms were irrigated at 66 per cent open pan evaporation (E_o).

The fertilizers used were, urea for nitrogen, phosphoric acid for phosphorus and muriate of potash for potassium. Fertilizers were injected in to the drip system through venturi in case of fertigation treatments. In case of 100 per cent NPK soil application, the N, P and K were applied in the form of urea, Mussoorie-phos and muriate of potash, respectively, in two splits *viz.*, one-third in May-June (beginning of monsoon) and two-third in September-October (receding monsoon).

Leaf samples were collected from two palms in each plot during May 2007 and soil samples were taken from two opposite sides of the palm, from the circular basin at 1.0 m distance away from the bole, at two depths *viz.*, 0-25 cm and 25-50 cm using a tube augur. The soil samples were air dried in the shade, ground to pass through a 2 mm sieve and analysed for available nitrogen, phosphorus and potassium status. Available nitrogen in the soil was determined by alkaline permanganate method (Subbiah and Asija, 1956). The available phosphorus was estimated (Bray - 1) following the procedure outlined by Bray & Kurtz (1945) and Jackson (1973), and available potassium was determined in the IN NH₄OAC (Hanway and Heidel, 1952) flame photometrically. The leaf samples were collected from index leaf (14th leaf) of the palm using a specially designed knife, by cutting 4-5 leaflets from the middle of the frond on both the sides (Chapman, 1975). The leaf samples were washed with distilled water, oven dried at 65 °C for 72 h and powdered using a Tecator Cyclotec sample mill. The powdered fraction (0.5 mm) of leaf sample was digested in HNO₃: HClO₄ (3:1) and analysed for phosphorus and potassium content (Jackson, 1973). The nitrogen content in the plant sample was estimated according to the modified Kjeldahl procedure as described by Jackson (1973).

Photosynthetic parameters *viz.*, photosynthesis rate, transpiration rate and stomatal conductance were measured using LI-6200 portable photosynthesis system (Li-Cor Inc., Nebraska, USA) during March between 10.00 and 11.30 h. The yield data was recorded every month from all the palms and annual yield per palm was computed. The growth observations such as height and girth of the trunk at bottom, number of leaves on crown, leaf length,

number of leaflets per leaf and petiole length were recorded from two palms per plot in 2007.

Results and discussion

Growth parameters

The data on growth parameters are presented in Table 1. The application of fertilizers either through drip fertigation or soil application led to significantly higher trunk height and girth at base than control (no fertilizer). However, no significant difference was observed among the different dose of fertigation and soil application treatments. The number of leaves in the crown observed significantly higher (32.6) under 75 per cent of NPK through drip fertigation which was on par with 50 per cent and 100 per cent NPK through drip fertigation and 100 per cent NPK through soil application and significantly differed from 25 per cent NPK through drip fertigation and control. This indicates that 50 per cent of the NPK is sufficient through drip fertigation thus saving 50 per cent of the fertilizer dose. When there was adequate supply of water and nutrients, positive response in growth characters, had resulted in higher leaf production. Coconut palm in general produces one leaf per month that necessitates continuous supply of nutrients out the year and drip fertigation treatments from 50 per cent onwards favours the optimum and regular supply of nutrient coupled with optimum moisture. Sujatha *et al.* (2000) recorded higher level of growth parameters under 50 per cent NPK fertigation in arecanut. The other growth parameters of palm, such as leaflets/leaf, leaf length and petiole length, did not differ significantly due to fertilization.

Soil nutrient available status

The available soil nitrogen, phosphorus and potassium at two depths (0-25 cm and 25-50 cm)

Table 1. Effect of drip fertigation on growth parameters

Treatments	Height (m)	Girth	No. of leaves on crown	Length of leaf (cm)	No. of leaflets/leaf	Petiole length (cm)
No Fertilizer	13.06	86.1	26.3	428	208	93
25% NPK (drip)	14.93	103.6	30.1	471	223	102
50% NPK (drip)	15.23	110.3	32.1	476	230	104
75% NPK (drip)	15.48	110.5	32.6	446	231	95
100% NPK (drip)	15.67	113.1	31.8	454	236	91
100% NPK (soil)	15.57	115.3	31.4	487	227	102
CD (5%)	1.17	14.6	2.1	NS	NS	NS

and leaf nutrient status are presented in Tables 2 and 3. Available N concentration was highest at 0-25 cm compared to 25-50 cm depth. No significant difference was observed among the different levels of fertigation treatments (25, 50, 75 and 100% NPK) and soil application at both the depths for available N. However, no fertilizer treatment was recorded significantly lower available nitrogen. No significant difference was observed in the leaf N content among treatments. However, the increase in fertigation level will result in increase levels of soil and leaf nutrient status.

Table 2. Available soil nutrient status in different depths as influenced by drip fertigation (ppm)

Treatments	N		P		K	
	0-25 cm	25-50 cm	0-25 cm	25-50 cm	0-25 cm	25-50 cm
No Fertilizer	77	72	68	27	96	78
25% NPK (drip)	95	90	110	66	126	98
50% NPK (drip)	99	92	140	75	136	116
75% NPK (drip)	94	88	137	94	159	135
100% NPK (drip)	103	95	172	137	169	140
100% NPK (soil)	89	83	172	102	146	123
CD (5%)	16	14	37	31	18	16

Table 3. Effect of drip fertigation on leaf nutrient status (%)

Treatments	Nitrogen	Phosphorus	Potassium
No Fertilizer	1.48	0.11	0.90
25% NPK (drip)	1.51	0.12	1.04
50% NPK (drip)	1.64	0.11	1.20
75% NPK (drip)	1.70	0.13	1.21
100% NPK (drip)	1.70	0.12	1.24
100% NPK (soil)	1.63	0.11	1.17
CD (5%)	NS	NS	0.13

For phosphorus, higher concentration was observed in 0-25 cm compared to 25-50 cm soil depth and the difference between depths was higher because lesser mobility of phosphorus. Similar to nitrogen availability, no significant difference was observed among the different levels of fertigation treatments (25, 50, 75 and 100% NPK) and soil application at both depths. The studies of Khan *et al.* (1992) showed that the available soil phosphorus (0-30 cm) had been increased from 84 ppm to 121 ppm when annual fertilization of P was done at the rate of 320 g P₂O₅/palm for 14 years. For leaf phosphorus content, no significant difference was observed among the fertigation levels, soil application and control. This was mainly due to the

soil available phosphorus content (more than 20 ppm) which would have been sufficient to maintain the critical level in leaf. Khan *et al.* (1983) indicated that phosphate fertilizer application can profitably be skipped (withheld) for at least six years in situations where soil available P is around 20 to 25 ppm in 30-60 cm depth at coconut basin. Thus, the foliar P content was optimum at the lower fertilizer levels also. Available K concentration was highest at 0-25 cm soil depth and decreased at 25-50 cm depth irrespective of the dose of fertigation and soil application. For leaf potassium, the treatment 100 per cent NPK applied through fertigation recorded higher level which was on par with 50 per cent and 75 per cent through fertigation and 100 per cent through soil application and significantly differed from 25 per cent NPK through drip fertigation and control. Bhat *et al.* (2007) reported that drip fertigation places nutrients in active root zone besides maintaining favourable soil moisture level resulting in much greater movement of phosphorus and potassium in arecanut rhizosphere.

Physiological parameters

The physiological parameters are presented in Figures 1, 2 and 3. Different levels of fertigation did influence significantly physiological parameters like net photosynthesis (P_N), transpiration (E) and stomatal conductance (g_s). Treatment, 100 per cent NPK applied through fertigation resulted significantly higher net P_N, E and g_s and which was on par with 50 per cent and 75 per cent through drip fertigation and significantly differed from 100 per cent NPK though soil application and control. This indicated the role of continuous availability of soil moisture and nutrient availability for sustaining the physiological parameters of coconut. The role of major nutrients on regulation of stomatal functioning

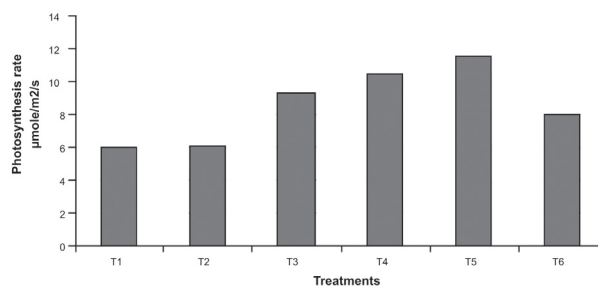


Fig. 1. Effect of drip fertigation on photosynthesis rate (CD (p=0.05)=2.4)

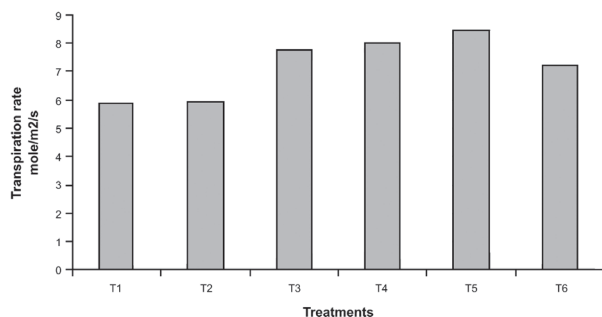


Fig. 2. Effect of drip fertigation on transpiration rate (CD ($p=0.05$)=0.71)

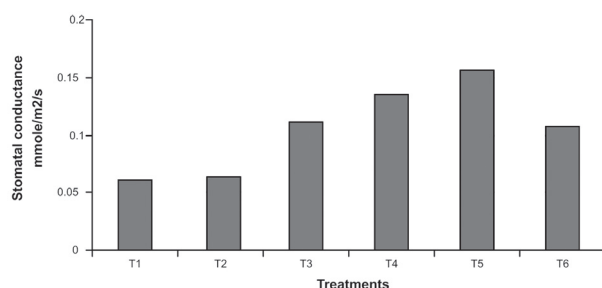


Fig. 3. Effect of drip fertigation on stomatal conductance (CD ($p=0.05$)=0.047)

has been reported earlier (Peaslee and Moss, 1968; Houman *et al.*, 1990; Bednarz and Oosterhuis, 1999). Bhat *et al.* (2008) also reported significant variation in physiological parameters in arecanut due to drip fertigation.

Nut yield of palms

The female flower production and yield of palm as influenced by fertigation are presented in Table 4. The pooled analysis of 10-year data indicated significant influence of drip fertigation level on female flower production and yield. Among the fertigation levels, the coconut yield was significantly higher in 100 per cent NPK fertigation (131 nuts/palm/year) which was on par with 75 and

Table 4. Mean coconut yield of 10 years (nuts / palm / year) as influenced by fertigation

Treatments	Pretreatment yield		10 years mean data	
	Female flowers	Nut yield	Female flowers	Nut yield
No Fertilizer	262	102	226	81
25% NPK (drip)	254	111	280	97
50% NPK (drip)	257	106	306	121
75% NPK (drip)	239	108	294	123
100% NPK (drip)	248	108	326	131
100% NPK (soil)	272	114	276	114
CD (5%)	NS	NS	48	11

50 per cent NPK applied through drip irrigation and significantly differed from 100 per cent NPK through soil application, 25 per cent NPK through fertigation and control. Similar trend was obtained for female flower production also. The higher yield under drip fertigation treatments even under 50 per cent reduction of fertilizer level is mainly due to increased availability of soil nitrogen, phosphorus and potassium, higher annual leaf production and higher photosynthetic activity and more number of female flower production. Bhat *et al.* (2007) reported recording of higher arecanut yield under 75 per cent of the recommended dose through drip irrigation. Silber *et al.* (2003) opined that frequent fertigation improves the uptake of nutrient through continuous replenishments of nutrients in the depletion zone at the vicinity of root surface and enhanced the transport of dissolved nutrients by mass flow in lettuce. This study also confirms better status of soil available nutrients, which lead to higher photosynthetic rate, growth and female flower production. Combined effect of these factors resulted in higher and varied nut yield from 50 to 100 per cent NPK applied through drip fertigation. Thus the study reveals that 50 per cent of the recommended NPK can be saved. Fertilizer savings through fertigation to the tune of 25-50 per cent were reported (Haynes, 1985; Mohammad, 2004). Thakur and Singh (2004) reported that the highest yield was obtained with fertigation at 75 per cent recommended dose followed by 100 per cent fertigation in mango.

Conclusion

The results of the present investigation indicated that the adoption of drip fertigation is a good management technique for improving the coconut productivity. Adoption of fertigation increases the productivity with 50 per cent saving of chemical fertilizers which ensure the higher efficiency of nutrients in crop production. Thus, fertigation technology has many advantages under the present scenario of decreased water availability and escalating fertilizer prices.

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