Piovarci. (1975). Genetic analysis and combining ability of grain yield components of Maize inbred lines. *Pl. Breed. Abst.* **46** : 330.

Sanghi, A.K., Agarwal, K.N. and Qadri. (1983). Combining ability for yield and maturity in early maturing maize under high plant population densities. *Indian J. Genet.* **43** : 123-128.

Singh, A.K., Dixit, R.K. and Singh, H.G. 1979. Combining ability analysis for yield and its attributes in Mazie (*Zea mays* L.). *Indian J. Agric. Res.* **13** : 27-30.

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Hydraulic design and performance evaluation of subsurface drip irrigation for coconut in Coimbatore district

I. MUTHUCHAMY, K. SUBRAMANIAN, BALAJI KANNAN AND S. SENTHILVEL
Dept. of Soil and Water Conservation Engineering, Tamil Nadu Agricultural University, Coimbatore - 641 003

Abstract : Field experiments, conducted during 1993 to 1996 with subsurface drip irrigation (drippers are placed on the surface) for coconut in a farmer's field in Coimbatore showed that application of 112 lit/day/tree registered 133 nuts/tree/year. The water saving was 63 per cent in the drip over the conventional basin method. The yield increase was 7.25 per cent over the conventional method. In subsurface drip irrigation system, a labour saving of 75 per cent was recorded over the conventional method for irrigation work alone.
(***Key Words** : Subsurface drip system, Sand filter, Mesh filter, Lateral, Micro tube and Drippers)*

The traditional coconut cultivation regions in the southern peninsular India spread over Kerala, Tamil Nadu, Karnataka and Andra Pradesh. Tamil Nadu ranks second in coconut production in the country with an area of 2,70,000 hectares and a production of 3282 million nuts. Coimbatore district pioneers coconut production in the state with the largest area of 57,384 hectares under the crop and production of 5224 lakh / nuts / year.

The present extent of area and the productivity of nuts should be increased with the help of improved conservation water management techniques as we have already utilized 95 per cent of the surface and 80 per cent of the ground water. Hence the only option to increase the extent of area and productivity are by adopting drip irrigation. Besides, the once abundantly available human labour force is slowly but steadily migrating to the industrial sector. So, the farming community in Tamil Nadu is facing not only the water scarcity problem but also agricultural labour force shortage problem in the agricultural sector.

Indian National Committee on Irrigation and Drainage (Sivanappan, 1994) reported that the water requirement in the drip irrigation was 100 lit/day/tree in Coimbatore district when compared to 300 lit/day/tree in conventional method for 15 year old tall variety of coconut.Yusuf (1988) reported that trip irrigation at the rate of 32 lit/day/tree registered 61 nuts/tree/year when compared to 43 nuts/tree/year under basin irrigation of 50 lit/day/tree for 8 year old coconut palm.

Only limited studies have been conducted in Tamil Nadu to find out the effect of subsurface drip irrigation system and its impact on water saving, labour and yield etc. Hence, a study was taken up by the Water Technology Center during 1993-96 to find out the effect of subsurface drip irrigation system and its impact on yield of coconut in Coimbatore.

Materials and Methods

A progressive farmer's field was selected in Coimbatore to conduct the study. The area consist of one hectare subsurface drip irrigation field and another one hectare conventional basin irrigation field. The soil type of experimented sites is Red loamy soil with average depth of 90 cm. The test crop in the test sites was 25 years old tall coconut variety. The irrigation water was pumped from a bore well with the help of 12.5 HP submergible pump.

Surface drip system

This entire field of one hectare coconut trees is provided with subsurface drip system. The irrigation water is pumped from a bore well with the help of 12.5 HP motor. The irrigation water is first filtered through the 0.75m x 0.6m size cylindrical sand filter. Once the coarse particles are separated with the sand filter, the water is then passed trough the 0.6 x 0.15m size cylindrical mesh filter with 120 size mesh for separation of fine particles of clay and decayed matters. The sand filter and mesh filter are provided with backwash mechanism for periodical cleaning. From the mesh filter, the irrigation water enters the main HDPE pipe of 110mm OD which is buried 80 cm below the surface with 10 cm sand cushioning. Sub main of 63 mm OD HDPE pipe are branched from main line at the same depth of 80 cm below the soil surface to irrigate 16 numbers of coconut trees. From the sub main, lateral of 16 mm OD HDPE pipes are laid 80 cm below soil surface along the row of coconut trees. Laterals are laid on both sides of the submain. A lateral of length 52.5m supplies irrigation water for eight coconut trees on one side, while only seven trees are supplied on the other side. 10mm OD micro tubes are used to connect the laterals laid below the soil surface and the emitter. Irrigation water is brought to the surface of the soil through the micro tubes and is emitted through the drippers, located 0.75m away from the trunk of the tree. Each tree is provided with 4 numbers of PC drippers of 8 lit/hr at 90° geometry with the help of four-way out let distributor. Control valves and pressure gauges are provided in the main line and sub - main line to regulate the designed discharge and required operating pressure.

Experimental details

The inrow and inter row espacement of coconut trees were 7.5 m x 7.5 m. Eighteen plots of size 30 m x 7.5 m were selected in the field. Different treatments were achieved in the field by regulating control valve for required flow rate. The following six irrigation treatments were tested with three replications

T_1 – (Irrigation through drip) – 48 lit/day/tree

T_2 – (Irrigation through drip) – 64 lit/day/tree

T_3 – (Irrigation through drip) – 80 lit/day/tree

T_4 – (Irrigation through drip) – 96 lit/day/tree

T_5 – (Irrigation through drip) – 112 lit/day/tree

T_6 – (Control Basin Method, adopted by farmers) – 300 lit/day/tree

Ten cm depth of irrigation water was applied once in 7 days in the control plot of size $21m^3$ consisting of one coconut tree. This worked out to 300 lit/day/tree. The yield details, uniformlity distribution, declogging details, labour employed and subsurface drip system were observed for the period from 1993-1996.

Estimation of water requirement for Coconut

The daily crop water requirement is estimated with the following formula.

$$V = E_p K_c K_p A$$

Where,

V = Volume of water required per tree per day in litres

E_p = Pan evaporation of the day in mm

K_c = Crop factor

K_p = Pan coefficient

A = Wetted area for one coconut tree in m^2

Depth of water to be applied, in mm = V/A

Hours of operation required = V/(No. of drippers x dripper discharge)

Hydraulic design

The head loss computation for subsurface drip system was done with the following model.

$$H_f = \frac{K'LQ^m}{D^{n_1}} \frac{\sum_{N}^{N} i^m}{N^{m+1}}$$

$$H_f = \frac{K'LQ^m}{D^{n_1}} \frac{1}{m+1}$$

Where,

Hf = Head loss in multi outlet pipe due to friction, in m

Table 1. The yield details of Coconut in drip and conventional irrigation during 1993-96

Treatment	Water requirement lit/day/tree	Number of nuts/tree/year			Mean
		1993-94	1994-95	1995-96	
T_1 (Drip)	48	83	84	83	83
T_2 (Drip)	64	92	90	90	91
T_3 (Drip)	80	102	104	101	102
T_4 (Drip)	96	114	116	113	114
T_5 (Drip)	112	133	135	132	133
T_6 (Conventional)	300	123	125	124	124
				SE	0.8213
				SED	1.1615
				CD (5 %)	2.4229

Table 2. The mean uniformity percentage of various drippers during the period 1993-96

S. No.	Types of Dripers	Emission uniformity (%)			Mean
		1993-94	1994-95	1995-96	
1	Micro tube (6mm OD)	74	72	70	72
2	Tape type (50lit/sec)	68	65	62	65
3	Button type	85	82	79	82
4	HPC type	96	95	94	95
5	LPC type	92	91	93	92
6	HD type	92	91	87	90
7	OD type	92	91	87	90
				SE	0.8116
				SED	1.1478
				CD (5%)	2.5137

Table 3. Declogging operation details of different types of drippers

S. No.	Types of Dripers	Frequency of declogging (in days)		
		10	15	20
1	Micro tube (6mm OD)	—	—	✓
2	Tape type (50lit/sec)	—	—	✓
3	Button type	✓	—	—
4	HPC type	—	✓	—
5	LPC type	✓	—	—
6	HD type	✓	—	—
7	OD type	✓	—	—

Table 4. Comparison of labour requirement for coconut through drip and conventional system

S. No.	System of Irrigation	Labour requirement (numbers/day/hectare)		
		1994	1995	1996
1.	Subsurface drip	½	½	½
2.	Conventional basin irrigation system	1	1	1

Table 5. Cost of subsurface drip system for coconut in Coimbatore district

S. No.	Description	Dimension of cross section (LxBxH)m	Volume of earth work, m^3	Unit cost Rs. / m^3	Total cost Rs. / acre
1	Earthwork excavation for main	100x0.15x0.8	12	56	672
2	Earthwork excavation for lateral	600x0.15x0.8	72	56	4,032
3	Installation (Common for both)	—	—	—	12,000
4	Unforeseen	—	—	—	500
				Total	17,204

m and n are the constants whose values are 1.852, 1.167 respectively

n1 = 2m + n

$$K = \left(\frac{2.8196}{C}\right)^{1.852}$$

Q = Total discharge in m^3/sec

L = Length in m

D = Internal diameter of the lateral in m

C = Constant (120 to 160), taken as 150 for plastic materials

Computation of maximum length and lateral

The maximum length of lateral was designed using the following model

$$L = \frac{H\ \{H_{var}\}}{ZL^m + S_e}$$

where,

H = Operating pressure head in m

H_{var} = Variable operating head in m is given by

$$H_{var} = \frac{H_f + H_e}{H}$$

H_f = Head loss in m

H_e = Head loss/gain due to field elevation in m

$$Z = \frac{K'q^m}{1^m D^n}\left[\frac{1}{m+1}\right]$$

q = individual dripper discharge in lph

l = spacing of drippers in m

S_e = slope of the field = H_e/L

Estimation of Emission Uniformity in percentage

Discharge of the drippers were measured and the following formula was used to compute the emission uniformity

$$E_u = 100\left[1.27\frac{C_v}{n}\right]\left(\frac{q_{min}}{q_{ave}}\right)$$

Where,

Eu = Emission uniformity in percentage

Cv = Coefficient of variation = (S_q / q_{av}) 100

n = numbers of drippers per plant

q_{min} = minimum average discharge of last 4 drippers

q_{av} = average discharge of all sample drippers

S_q = Standard deviation of emission rates

Results and Discussion

The yield details are given in Table 1 and Fig 1. From the table, it is clearly noticed that irrigation of 112 lit/day/tree through drip irrigation recorded the highest nut yield of 133 nuts/tree/year (7.25% higher than control) as compared to 124 nuts/tree/year in conventional basin irrigation, which works out to 300 lit/day/tree. Adoption of the above drip treatment also resulted in the water saving to the tune of 163 per cent.

The dripper uniformity percentage is given in Table 2 and Fig 2. The results depict clearly that the high - pressure compensating drippers record the highest uniformity percentage of 95 per cent among all other drippers.

The declogging operation details of different modes of drippers are given in Table 3. The high pressure compensating drippers should be declogged manually once in 10 days for effective utilizaiton.

From the Table 4, it is known very clearly that for drip irrigated coconut field only half labour was engaged per day ha^{-1} where as in basin method, it was worked out one labour per day ha^{-1}.

From the Table 5, it is clear that for subsurface drip system an amount of Rs. 5200/- is

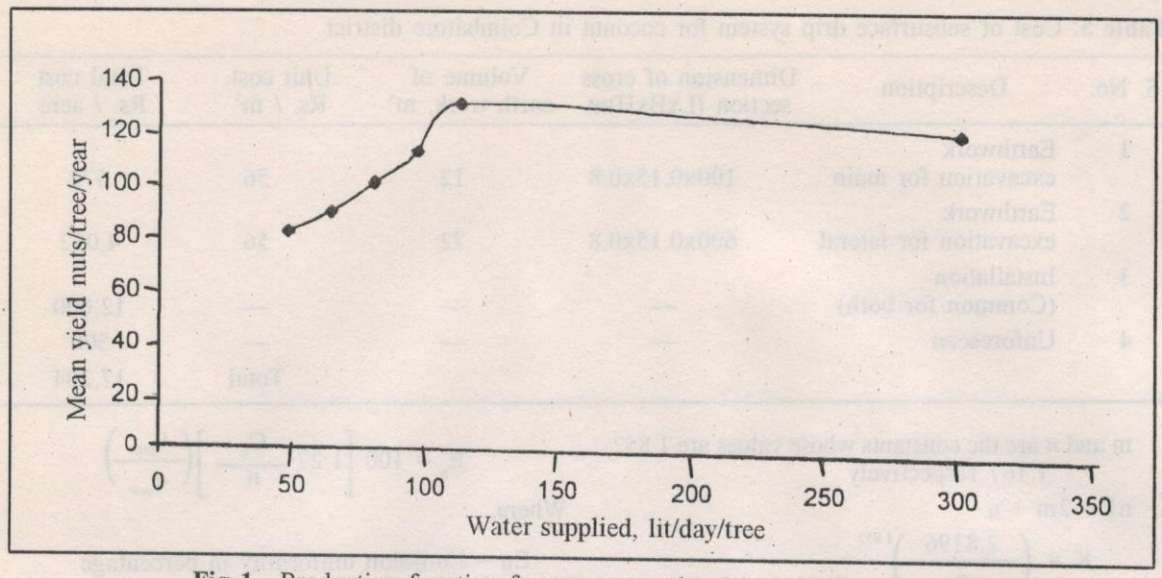

Fig 1. Production function for coconut under drip irrigation system

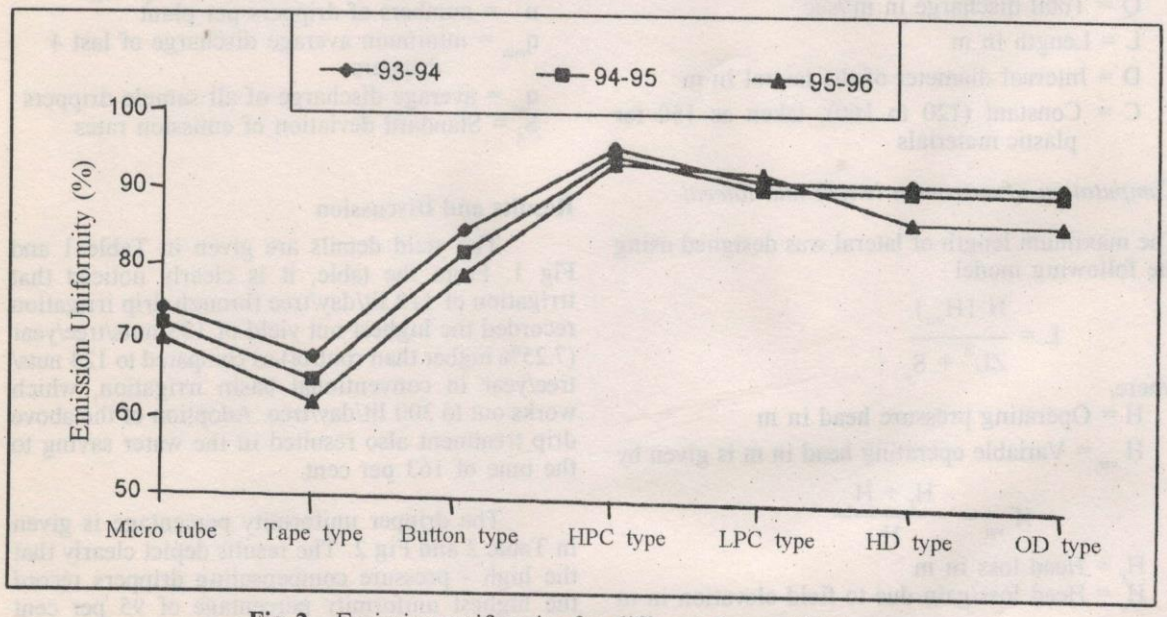

Fig 2. Emission uniformity for different types of drippers

to be incurred extra cost over and above the normal surface cost of Rs. 12,000 to install subsurface drip irrigation for coconut in Coimbatore condition.

References

Sivanappan, R.K. 1994. Drip Irrigation in India. Indian National Committee on Irrigation and Drainage, New Delhi.

Yusuf, M. 1988. Studies on drip irrigation for coconut. Annual report, CPCRI, Kasaragod. p. 4-6.

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