Research Article

Journal of Plantation Crops, 2007, 35 (3) : 166-170

Influence of drip irrigation on growth and yield of bush pepper (*Piper nigrum* L.) intercropped in coconut garden in laterite soil

C.K. Thankamani* and P.K. Ashokan**

*Indian Institute of Spices Research, Marikunnu, Calicut-673012.

**Kerala Agricultural University, Trichur, Kerala, India

(Manuscript Received: 02-11-05, Revised: 14-02-06, Accepted: 12-09-07)

Abstract

An experiment was conducted to study the influence of drip irrigation on yield and quality parameters of bush pepper grown in coconut garden. The treatments included were pot watering (Control) and six levels of drip irrigation 2,4,8,12,16 liters per plant from Oct-May and 16 liters (Oct-March). The highest average dry berry yield per plant for five year's was recorded in the treatment where 8 liters was provided by drip irrigation (196 g) followed by the treatment 16 liters from October to May (165 g) and the lowest yield was recorded in the treatment 2-litre drip (66 g). Among the different years studied, maximum yield was obtained during 4th year. The benefit cost ratio was high for the treatment 8 l(2.0), followed by 16 l October-May (1.7) and 12 liters (1.1). The drip irrigation provided at the rate of 2 litres, 4 litres, 16 litres from Oct-March and 10 liters pot watering recorded a benefit cost ratio of <1. The pooled means showed higher Oleoresin content in the treatments 8 liters, 12 liters and 16 liters (October-May) drip irrigation treatments and pot watering. The data for four years indicated that maximum Piperine content was recorded in the drip irrigation treatment 16 litres (October-March) and least in 2 litres drip. Of the different drip irrigation levels, 8 liters daily proved to be the most efficient for obtaining maximum profit from bush pepper intercropped in coconut garden.

Keywords: Bush pepper, drip irrigation, yield, piperine, oleoresin, benefit cost ratio.

Introduction

Black pepper (*Piper nigrum* L.) is the most valued spice crop of India. Regeneration by planting laterals (plagiotropic branches) results in bush pepper. It needs no supports, and can be harvested without climbing. The other advantages of bush pepper are early yielding (within one year) and yielding round the year. Bush pepper may be ideal as an under-storey crop in coconut plantations. Inspite of high rainfall (3000 mm per year) in Kerala the crop is subjected to moisture stress from December to May, because of the uneven distribution of rainfall (an average of 126 rainy days per year). Periodic water stress during the above period is regarded as the major constraint in increasing the productivity of black pepper in the State (Vasantha *et al.*, 1989). Drip irrigation is one of the efficient methods of irrigation suggested for perennial crops (Dhanapal *et al.*, 1995; Sivanappan, 1998). There are a few studies on the response of vine pepper to irrigation (IISR, 1998), but none on bush pepper. The present investigation was carried out to study the response of field grown bush pepper to drip irrigation.

Materials and Methods

A field experiment on drip irrigation was conducted at Peruvannamuzhi farm of Indian Institute of Spices Research (IISR), Kozhikode, Kerala, latitude11^{0}34-35′N, longitude 75^{0}48-49′E, altitude 60 m during 1997-2002. The soil was clay loam, having pH 5.2, available nitrogen 400 kg ha^{-1}, available phosphorous 24 kg ha^{-1} and available potash 72 kg ha^{-1}. The experimental site has a typical tropical humid climate with bimodal monsoon rains, aggregating into three thousand mm per year. Majority of precipitation occurrs between June to October.

Six-month-old bush pepper was planted in twenty-year-old coconut garden at a spacing of 2 x 1.80 m, during June 1997. The distance between two coconut trees was 7.5 x 7.5 m. The plants were maintained by providing supplementary irrigation system. NPK fertilizer was applied at the rate of 10:5:20 g/plant at tri monthly intervals. There were seven treatments including control (Pot watering @ 10 litres / plant). Different levels of drip irrigations were 2 litres, 4 litres, 8 litres, 12 litres

and 16 litres per day (Oct-May), and 16 litres drip (October-March). Whole plot had 14 bush pepper plants and net plot had 3 bush pepper plants. All the plants except control were irrigated for one hour daily from October to May. To provide irrigation, drip- emitters were placed 10 cm away from the planting point. In the case of 2 litres drip per day, single emitter of 2 litres capacity was used, 10 cm away from the planting point in western direction. For 4 litres drip per day, single emitter of 4 litres capacity was placed in western direction. For 8 litres drip, two 4 litres emitters were placed at eastern as well as western direction. For 12 litres drip per day, one emitter of 8 litres capacity was placed on western direction and 4 litres capacity emitter on eastern direction. For 16 litres drip per day, two emitters of 8 litres capacity each were placed on both sides of the plant. In control, pot watering at the rate of 10 litres per plant was given daily. Periodic observations on growth, yield and quality of berries were recorded. During the 6th year only yield data was recorded. The data were statistically analyzed as per the procedure given by Panse and Sukhatme (1985).

The cost and returns were arrived based on the cost of cultivation at the labour wages prevailing in the locality and the average price of dry pepper during the experimental period. The interest on the capital cost of establishing drip irrigation was included in the cost of cultivation.

Results and Discussion

Higher number of leaves (Table 1) was observed in plants irrigated with 16 litres drip (October-March) after first year's growth. Drip irrigation @ 4, 8 and 12 litres per plant were on par with pot watering (10 litres per plant) when the number of leaves per plant were compared, but they were significantly superior to drip irrigation at the rate of 2 litres per plant. The total leaf area was the highest in plants irrigated with 16 litres (October-March) followed by 16 litres drip (October-May) and least in plants irrigated with 2 litres drip (Table1). Maximum number of branches was observed on plants irrigated with 16 litres drip (October–March) compared to other drip irrigation levels, except 16 litres drip (October–May), which was on par. The number of branches per plant was very low, where 2 litres of water per day was applied through drip.

Table 1. Effect of drip irrigation on growth of bush pepper intercropped in coconut garden (First year)

Quantity of drip irrigation (litres plant^{-1})	Number of leaves	Leaf area (cm^2)	Number of branches
2	25	1832	17.7
4	69	2422	22.2
8	72	3952	31.3
12	66	2752	26.3
16(Oct. - May)	92	4663	38.9
16 (Oct. - March)	102	5066	41.2
Control (Pot watering (10 litres)	69	3545	31.9
CD (0.05)	11.6	1841	4.3

The number of spikes per plant showed highly significant variations between the years and drip irrigation levels (Table 2). During the first two years the number of spikes per plant was considerably low. However, during third year sharp increase in the spikes production was observed which continued during subsequent years. The number of spikes production was less in the case of 2 litres and 4 litres of drip irrigation. The highest number of spikes was recorded in 16 litres drip given during Oct. - May. There was no significant difference between the 16 litre drip irrigation(Oct. - May) and pot watering (10 litres) during fourth year.

Table 2. Effect of drip irrigation levels on number and length of spikes of bush pepper during four years

Quantity of drip irrigation (litres plant^{-1})	Number of spikes per plant					Length of spike (cm)				
	1998	1999	2000	2001	Mean	1998	1999	2000	2001	Mean
2	5.0	11.9	94.6	114.3	56.4	5.4	7.0	7.4	9.0	7.2
4	11.7	40.2	89.8	105.4	61.8	8.3	8.4	8.2	9.0	8.5
8	16.	57.9	74.0	101.4	62.3	9.3	7.4	7.7	8.5	8.3
12	5.7	47.2	57.0	59.7	42.6	5.7	7.4	7.4	8.6	7.3
16	7.7	33.7.	121.4	145.2	77.7	7.7	4.0	6.9	8.5	6.8
16(Oct. –Mar.)	11	37.8	60.0	73.2	45.51	8.0	8.3	6.9	7.8	7.8
Pot watering (10 litres)	18.3	25.3	44.2	137.9	56.5	7.0	7.1	7.6	8.5	7.6
CD(0.05)	6.6	NS	26.5	27.7	23.1	1.7	2	NS	NS	1.9

The length of spike, observed during the first year was significantly superior in the plants irrigated with 8 litres drip. It was on par with 4 and 16 litres of drip irrigation. During the fourth year, spike length was comparatively higher in all the drip irrigation levels except 8 and 16 litres of drip (Oct. - March). During second and fourth year, the length of spikes was not significantly influenced by the drip irrigation levels. The pooled mean indicated the superiority of 4 and 8 litres of drip, which was on par with 16 litres drip (Oct. - March). The number of berries per spike (Table 3) varied with years and levels of drip irrigation. The number of berries was relatively high during third and fourth years. During the first two years the number of berries per spike was considerably low with 2 litres drip irrigation. Pooled

mean showed maximum number of berries in the plants given 8 litres drip irrigation, which was on par with all other levels except 2 litres drip irrigation.

Table 3. Effect of drip irrigation levels on number of berries per spike during four years

Quantity of drip irrigation (litres plant^{-1})		Number of berries per plant				
		1998	1999	2000	2001	Mean
2	(Oct.-May)	23.0	22.7	40.0	44.0	32.4.
4		43.7	36.9	40.4	42.7	40.9
8		45.7	41.9	48.6	50.0	46.5
12		35.0	41.2	45.4	42.0	38.7
16		43.0	34.0	44.0	48.3	42.3
16 (Oct. –Mar.)		45.0	29.2	39.0	44.7	39.5
Pot watering (10 litres)		42.7	37.2	40.0	41.7	38.6
CD (0.05)		12.9	NS	5.1	2.0	10.2

During the first year, the dry berry yield was considerably low and there were no significant differences between the levels of drip irrigations (Table 4). The second year yield data showed that the 12 litres drip irrigation was on par with 8 litres, 16 litres (Oct. - March) and 16 litres (Oct. - May). During the third year maximum berry yield was obtained from the plants with 16 litres drip. However, this was on par with 8 litres drip. During the fourth and fifth year maximum yield was from the plants irrigated with 8 litres drip, but it was on par with 16 litres (Oct. - May) drip. When the pooled means were considered, the maximum yield was from the plants given 8 litres of drip followed by 16 litres (Oct. - May) and 12 litres drip. The plants drip-irrigated with two and 4 litres per plant per day resulted in very low yield. Similarly, 16 litres drip with a break in irrigation during April - May resulted in significantly low yield.

Table 4. Effect of drip irrigation levels on dry berry yield for five years

Quantity of drip irrigation (litres plant^{-1})		Dry berry yield per plant (g)					
		1998	1999	2000	2001	2002	Mean
2	(Oct. – May)	22.2	40.2	88.0	98.5	81.3	66.2
4		33.5	51.7	127.0	131.4	91.7	87.2
8		95.0	173.3	230.0	322.1	159.0	195.9
12		61.7	118.3	162.2	186.7	80.0	121.8
16		65.0	119.7	263.4	295.1	83.9	165.4
16 (Oct. – March)		72.2	122.7	71.7	101.1	60.0	85.5
Pot watering (10 Litres)		28.3	47.7	112.6	117.1	91.1	79.4
CD (0.05)		6.7	66.0	75.8	54.2	40.8	41.8

Overall, the yield was high for the plants irrigated with 8 litres drip during the dry season from Oct. - May. This is accomplished from the higher number of spikes per plant, increased length of spikes, number of berries per spike etc. observed in plants given 8 litres drip irrigation. Preliminary irrigation experiments conducted on vine pepper from Indian Institute of Spices Research (IISR) showed that drip- irrigation at the rate of 7 litres per day during Oct. - May was better than Oct. - March (IISR, 1998). For three-year-old bush pepper, yield was high if drip-irrigation was given at the rate of 8 litres during Oct. - May (Thankamani and Ashokan, 2002). In black pepper vines the recommended quantity of irrigation under conventional method is 100 litres per vine at an interval of 8-10 days from Oct. - March (Satheesan *et al.*, 1998). That means, irrigation of 10-12 litres per plant per day is required. However, there is no recommendation on the quantity of water required for bush pepper under conventional irrigation practices. Compared to the 10–12 litres of water required for vine pepper, under conventional irrigation, only 8 liters is required by adopting drip irrigation. This accounts to a saving of 25 per cent irrigation water. By providing drip irrigation, saving of water to the extent of 70, 62, 50, 70, 75, 66 and 60 per cent was obtained for coconut, arecanut, rubber, oil palm, tea, coffee and cardamom respectively (Satheesan *et al* ., 1994) . In the present experiment, the yield obtained was less in 16 litres drip (Oct. - May), probably because of the partitioning of more photosynthates to vegetative parts as is evident from the leaf area and number of leaves. Leaf area and dry matter are the two plant characters that determine the total biological production, but partitioning of total biological yield is the most important factor that determines the economic yield (Donald and Hamblin, 1976). The yield was least from the plants irrigated with 2 litres drip. This was mainly due to less vegetative growth, less number of spikes and other yield contributing characters. Lower availability of soil moisture might have reduced the uptake of mineral nutrients also.

Quality parameters

Oleoresin

The oleoresin content of the berries (Fig.1) varied with the years and drip irrigation levels. During the first three years maximum oleoresin content was observed with 8 litres of drip irrigation. The third year and fourth year data showed wide variations and different trends.

The pooled means showed higher oleoresin content with 8, 12, 16 litres of drip and 10 litres pot irrigation per day. Other levels of drip irrigation resulted in low oleoresin content. The oleoresin content decreased when a break in irrigation was given during April - May.

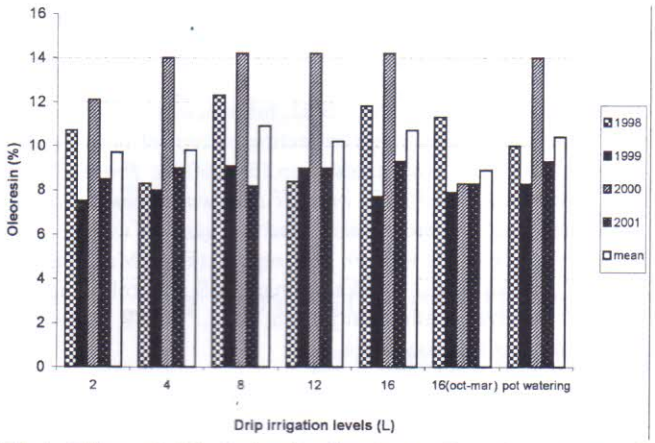

Fig.1. Effect of drip irrigation levels on oleoresin content of berries of bush pepper

These results indicate that the water stress probably due to lower levels of irrigation or a break in irrigation may not be conducive for the biosynthesis of oleoresin.

Piperine

The piperine content (Fig. 2) showed significant variations with years and drip irrigation levels. More piperine content was observed during the second year followed by third year. During the first year, higher piperine content was observed with 8 litres of drip irrigation. During second and third years, the highest piperine content was observed with 16 litres of drip irrigation (Oct. - March).

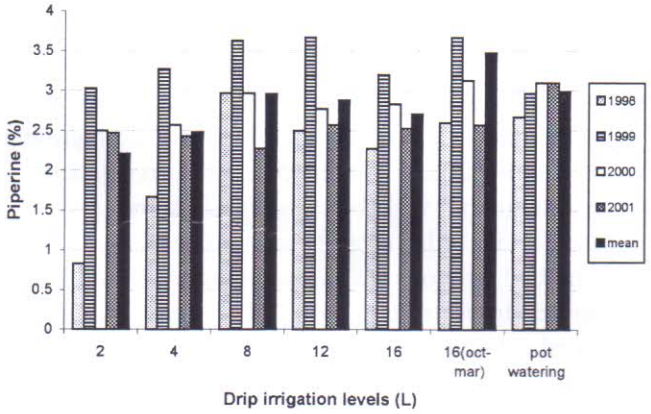

Fig.2. Effect of drip irrigation levels on piperine content of berries of bush pepper

In pooled mean the maximum piperine content was recorded with 16 litres (Oct. - March) drip followed by pot watering with 10 litres, drip irrigation 8 litres and 12 litres per plant per day. As in the case of oleoresin, here also the water stress from the lower levels of irrigation may have adversely affected the biosynthesis of piperine.

Economics of cultivation

The benefit- cost ratios were high with drip irrigations of 8 litres, 12 litres and 16 litres (Oct. - May). Sixteen litres (Oct. - March), 2 litres and 4 litres drip and pot watering were relatively poor when the benefit - cost ratios were considered (Table 5). The highest benefit-cost ratio was recorded with 8 litres of drip irrigation followed by 16 and 12 litres of drip. The 2 litres, 4 litres, 16 litres (Oct. - March) drip irrigation and 10 litres pot watering recorded a benefit cost ratio of < 1.

Table 5. Benefit-Cost analysis of field grown bush pepper.

Quantity of drip irrigation (Litres plant^{-1})		Yield of pepper (kg/ha)	Total cost (Rs.)	Return (Rs.)	Benefit:cost ratio
2	(Oct. - May)	811	154045	105430	0.7
4		1069	154045	138970	0.9
8		2404	154045	312520	2.0
12		1342	154045	174460	1.1
16		2027	154045	263510	1.7
16 (Oct. - March)		1050	153545	136500	0.9
Pot watering (10 litres)		974	172595	126620	0.7

Considering the yield for five years, benefit cost ratio and berry-quality, irrigating the bush pepper plants with 8 litres drip is the best for getting maximum profit from bush pepper intercropped in coconut garden.

References

Dhanapal, R., Yusuf, M. and Bopaiah, M.G. 1995. Moisture movement studies under drip irrigation in coconut basins. *J. Plantn. Crops*, **23** (1): 28-34

Donald, C.M. and Hamblin, J. 1976. The biological yield and harvest index of cereals as agronomic and plant breeding criteria. *Adv. Agron.*, **28**: 261-405

Panse, V.G. and Sukhatme, P.V. 1985. *Statistical methods for Agricultural Workers* 4th ed. ICAR, New Delhi. 347 p.

Indian Institute of Spices Research (IISR), 1998. Annual report 1998. Indian Institute of Spices Research. Kozhikode. 126 p

Satheesan, K.V., Varadan, K.M. and Madhavachandran, K.M 1994. Micro irrigation for plantation crops. Problems and prospects pp. 27-29. In : *Proc. Nat. Seminar* on water management for plantation crops (Ed.) Satheesan, K.V. Centre for Water Resources Development and Management, Calicut, Kerala.

Satheesan, K.N., Rajagopalan, A. Kumar, J., Mammootty, K.P. and Nair, P.K.V. 1998. Influence of irrigation levels on yield, quality and incidence of pests and diseases in black pepper. pp. 107-110. In: Water and nutrient management for

sustainable production and quality of spices. (Eds.) Sadanandan, A.K., Krishnamurthy, K.S., Kandiannan, K. and Korikanthimath, V.S. Indian Spices Society , Calicut, Kerala, India.

Sivanappan, R.K. 1998.Water management of spice crops. pp.103-106 In: *Proc.Nat.Sem.water and nutrient management for sustainable production and quality of spices*. (Eds). Sadanandan, A.K.,Krishnamurthy, K.S., Kandiannan, K. and Korikanthimath V.S. Indian Spices Society, Calicut, Kerala, India.

Vasantha,S.,Thomas T.V. Ramadasan, A. and Zachariah,T.J.1989. Plastid pigments of black pepper cultivars, an evaluation of physiological parameters. *Indian J.Plant Physiol.*, **33** (4) : 363-366.

Thankamani and Ashokan P.K. 2002. Influence of drip irrigation on yield and moisture extraction pattern of bush pepper grown in coconut garden. pp.157-160 In: *Proceedings, National symposium on soil and water conservation measures and sustainable land use systems with special reference to the western ghat region* .(Eds.) Manivannan, S., Sikka A.K., Korikanthimath V.S., Askokkumar,J., Priyadevi,S. and Manjunath, B.C. ICAR Research Complex for Goa, India.