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Economic Viability of Drip Fertigation in Maize (*Zea mays* L.) Based Cropping System

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Field experiments were conducted at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, from July 2006 to August 2007 to study the effect of varying irrigation regimes and fertilizer levels in maize based cropping system. The experiment was laid out in split plot design with three replications. The experiment consisted of three irrigation regimes in main plots *viz.,* I_1 - Drip irrigation at 75 % WRc (computed water requirement of crop), I_2 - Drip irrigation at 100 % WRc, I_3 - Drip irrigation at 125 % WRc and four fertilizer levels in sub plots *viz.*, F_1 - 75 % RDF, F_2 - 100 % RDF, F_3 - 125 % RDF and F_4 - Drip irrigation + 100 % RDF by soil application. The expenditure incurred from field preparation to harvest was worked out and used for calculating the economics of drip system. The gross income (Rs. 3,09,554) was higher in the treatment with 100 per cent WRc with 125 per cent RDF whereas, higher benefit cost ratio of 4.07 was recorded by drip irrigation at 100 per cent WRc with soil application of RDF. Drip irrigation at 75 per cent WRc with 125 per cent RDF (I_1F_3) recorded higher net profit per mm of water used (Rs. 274), which was followed by same irrigation regime with 100 per cent RDF.

Key words: Drip fertigation, maize, economics

Improper management of water has contributed extensively to the current water scarcity and pollution problems in many parts of the world, and is also a serious challenge to future food security and environmental safety. Addressing these issues require an integrated approach to soil-water-plant-nutrient management at the plant-rooting zone. One of these technologies is fertigation, which is the direct application of water and nutrients to plants through a drip irrigation system. The introduction of simultaneous micro-irrigation and fertilizer application (fertigation) opens new possibilities for controlling water and nutrient supplies to crops besides maintaining the desired concentration and distribution of nutrients and water into the soil (Bar-Yosef, 1999). Adoption of micro irrigation, may help in saving significant amount of water and increase the quality and quantity of produce. All these emphasize the need for water conservation and improvement in water-use efficiency to achieve 'more crop per drop'. Fertigation provides the essential nutrients directly to the active root zone, thus minimizing the loss of expensive nutrients which ultimately helps in improving the productivity and quality of farm produce. There was an increase in the use efficiency of nitrogen, phosphorus and potassium to 95, 45 and 80 per cent, respectively (Satisha, 1997). By introducing drip fertigation, it is possible to increase the yield of crops by 3 times from the same quantity of water. When fertilizer is applied through drip, yield increase, there is 30 per cent saving of fertilizer (Sivanappan and Ranghaswami, 2005).

Materials and Methods

Field experiments were conducted at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, from July 2006 to August 2007 to study the effect of varying irrigation regimes and fertilizer levels in maize based cropping system. The experimental soil was sandy clay loam. The nutrient status of the soil was low in nitrogen medium in phosphorus and high in potassium. The experiment was laid out in split plot design with three replications. The experiment consisted of three irrigation regimes in main plots *viz.,* I_1 - Drip irrigation at 75 % WRc (computed water requirement of crop), I_2 - Drip irrigation at 100 % WRc, I_3 - Drip irrigation at 125 % WRc and 4 fertilizer levels in sub plots *viz.,* F_1 - 75 % RDF, F_2 - 100 % RDF, F_3 - 125 % RDF and F_4 - Drip irrigation + 100 % RDF by soil application. One control treatment with conventional furrow irrigation and soil application of 100 per cent recommended dose of fertilizer was also included for comparison.

The drip irrigation and fertigation was scheduled once in three days as per the treatment schedule for each crop in the cropping system. The test crops chosen for the cropping system were "Maize (CoHM(5))", "Sunflower (Co4)" and "Beetroot (Ruby

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Table 1. Economics (Rs. ha^{-1}) of Maize - Sunflower – Beetroot cropping system under drip fertigation system

Treatment	Gross income (Rs. ha^{-1})	Cost of cultivation under drip system: Cost of cultivation (Rs. ha^{-1})	Cost of drip system ** (Rs. ha^{-1})	Total cost (Rs. ha^{-1})	Net income (Rs. ha^{-1})	B:C ratio
I_1F_1	2,45,261	51,850	19,869	71,719	1,73,542	3.42
I_1F_2	2,81,619	58,130	19,869	77,999	2,03,620	3.61
I_1F_3	3,08,382	64,411	19,869	84,280	2,24,102	3.66
I_1F_4	2,40,771	44,658	19,869	64,527	1,76,244	3.73
I_2F_1	2,73,040	52,450	19,869	72,319	2,00,721	3.78
I_2F_2	2,92,578	58,730	19,869	78,599	2,13,979	3.72
I_2F_3	3,09,554	65,011	19,869	84,880	2,24,674	3.65
I_2F_4	2,65,154	45,258	19,869	65,127	2,00,027	4.07
I_3F_1	2,41,504	53,050	19,869	72,919	1,68,585	3.31
I_3F_2	2,58,446	59,330	19,869	79,199	1,79,247	3.26
I_3F_3	2,67,408	65,611	19,869	85,480	1,81,928	3.13
I_3F_4	2,32,965	45,858	19,869	65,727	1,67,238	3.54
Surf. Irrgn.	2,12,623	56,740	0	56,740	1,55,883	3.75

** Cost due to depreciation cost, interest and repair and maintenance cost of drip system

Queen)". During July to October 2006, hybrid maize was grown as test crop with a spacing of 75 / 45 x 20 cm in paired row technique. During January to March 2007, the test crop was sunflower grown in the same field with a spacing of 75 / 45 x 30 cm followed by beetroot during June to August 2007 with a spacing of 20 x 15 cm (four rows), so as to maintain the recommended population. In the farmer's method (furrow irrigation), spacing of 60 x 20 cm, 60 x 30 cm and 30 x 10 cm were followed in ridges and furrow system for maize, sunflower and beetroot respectively. The fertilizer sources for supplying NPK through drip irrigation were urea, mono ammonium phosphate (12:61:0 NPK) and muriate of potash,

Table 2. Economic viability of Maize – Sunflower – Beetroot cropping system under drip fertigation at 75 per cent WRc

	Details of economics	I_1F_1	I_1F_2	I_1F_3	I_1F_4	Control
1	Fixed cost	82,041	82,041	82,041	82,041	-
a	Life (7 years)	7	7	7	7	-
b	Depreciation @ 15 per cent	12,306	12,306	12,306	12,306	-
c	Interest @ 8 per cent	6,563	6,563	6,563	6,563	-
d	Repairs and maintenance	1,000	1,000	1,000	1,000	-
e	Total (b+c+d)	19,869	19,869	19,869	19,869	-
2	Total cost of cultivation (Rs/ha) from Maize-sunflower-beetroot	51,850	58,130	64,411	44,658	56,740
3	Seasonal total cost (Rs/ha) (2+e)	71,719	77,999	84,280	64,527	56,740
4	Total water used (mm) in cropping system	819	819	819	819	1,489
5	Total income from Maize-sunflower-beetroot (Rs/ha)	2,45,261	2,81,619	3,08,382	2,40,771	2,12,623
6	Net seasonal income (Rs) (5-3)	1,73,542	2,03,620	2,24,102	1,76,244	1,55,883
7	Additional area cultivated due to saving of water (ha)	0.82	0.82	0.82	0.82	-
8	Additional expenditure due to additional area (Rs) (3x7)	58,671	63,809	68,947	52,788	-
9	Additional income due to additional area cultivated (Rs) (6x7)	1,41,970	1,66,576	1,83,331	1,44,180	-
10	Additional net income (Rs) (9-8)	83,298	1,02,767	114,384	91,392	-
11	Gross cost of production (3+8)	1,30,390	1,41,808	1,53,227	1,17,315	56,740
12	Gross income (5+9)	3,87,231	4,48,195	4,91,713	3,84,951	2,12,623
13	Gross net income (12-11)	2,56,840	3,06,387	3,38,486	2,67,636	1,55,883
14	Gross benefit -cost ratio (12/11)	2.97	3.16	3.21	3.28	3.75
15	Net profit per mm of water used (Rs) (6/4)	212	249	274	215	105
16	Marginal benefit cost ratio	2.37	2.77	2.89	2.84	-

respectively. Fertigation was done through ventury, once in three days starting from 12 DAS to 71 DAS for maize, 12 DAS to 62 DAS for sunflower and 12 DAS to 49 DAS for beetroot which was regulated by taps provided near the off take points of the sub main.

Table 3. Economic viability of Maize – Sunflower – Beetroot cropping system under drip fertigation at 100 per cent WRc

	Details of economics	I_2F_1	I_2F_2	I_2F_3	I_2F_4	Control
1	Fixed cost	82,041	82,041	82,041	82,041	-
a	Life (7 years)	7	7	7	7	-
b	Depreciation @ 15 per cent	12,306	12,306	12,306	12,306	-
c	Interest @ 8 per cent	6,563	6,563	6,563	6,563	-
d	Repairs and maintenance	1,000	1,000	1,000	1,000	-
e	Total (b+c+d)	19,869	19,869	19,869	19,869	-
2	Total cost of cultivation (Rs/ha) from Maize-sunflower-beetroot	52,450	58,730	65,011	45,258	56,740
3	Seasonal total cost (Rs/ha) (2+e)	72,319	78,599	84,880	65,127	56,740
4	Total water used (mm) in cropping system	1,043	1043	1,043	1,043	1,489
5	Total income from Maize-sunflower -beetroot (Rs/ha)	2,73,040	2,92,578	3,09,554	2,65,154	2,12,623
6	Net seasonal income (Rs) (5-3)	2,00,721	2,13,979	2,24,674	2,00,027	1,55,883
7	Additional area cultivated due to saving of water (ha)	0.43	0.43	0.43	0.43	-
8	Additional expenditure due to additional area (Rs) (3x7)	30,925	33,610	36,296	27,849	-
9	Additional income due to additional area cultivated (Rs) (6x7)	85,831	91,500	96,073	85,534	-
10	Additional net income (Rs) (9-8)	54,906	57,890	59,778	57,685	-
11	Gross cost of production (3+8)	1,03,244	1,12,209	1,21,176	92,976	56,740
12	Gross income (5+9)	3,58,871	3,84,078	4,05,627	3,50,688	2,12,623
13	Gross net income (12-11)	2,55,627	2,71,869	2,84,452	2,57,712	1,55,883
14	Gross benefit -cost ratio (12/11)	3.48	3.42	3.35	3.77	3.75
15	Net profit per mm of water used (Rs) (6/4)	192	205	215	192	105
16	Marginal benefit cost ratio	3.14	3.09	3.00	3.81	-

The expenditure incurred from field preparation to harvest was worked out and used for calculating the economics of drip system. The crop yield was computed per hectare and the total income was worked out based on the minimum market rate which was prevalent during the time of this study. Net returns were obtained by subtracting the cost of cultivation from gross return for each treatment. The benefit cost ratio (BCR) was worked out by using the formula suggested by Palaniappan (1985).

$$BCR = \frac{\text{Gross Return (Rs.ha}^{-1}\text{)}}{\text{Total Cost of Cultivation (Rs.ha}^{-1}\text{)}}$$

The cost of drip system for one hectare was worked out based on current market rates. The life of the drip system was assumed to be 7 years. Prevailing market price of drip components from a standard firm was used for various components of drip system. Interest on capital investment was taken as 8.0 per cent per annum. To assess the economics of drip irrigation system, the following aspects were considered for computation.

Discount Factor

The factor that translates expected benefits or costs in any given future year into present value terms is called discount factor. The discount factor is equal to 1/(1 + i)n where 'i' is the interest rate and 'n' is the number of years from the date of initiation for the program or policy until the given future year.

Discounted benefit cost ratio

$$DBCR = \frac{\text{Total discounted benefit}}{\text{Total discounted cost}}$$

Discounted benefit was arrived by multiplying the net additional income by the corresponding factor (1/(1+i)n) for each year. It is summed up for all the 7 years to arrive at total discounted benefits. Because of longer life period, the discounted benefit cost analysis was employed to have real time cost benefit appraisal of the drip system.

Payback period

Payback period refers to the period of time required for the return on an investment to "repay" the sum of the original investment.

Results and Discussion

The economics of the drip irrigation system was computed considering the longer life span of the

Table 4. Economic viability of Maize – Sunflower – Beetroot cropping system under drip fertigation at 125 per cent WRc

	Details of economics	I_3F_1	I_3F_2	I_3F_3	I_3F_4	Control
1	Fixed cost	82,041	82,041	82,041	82,041	-
a	Life (7 years)	7	7	7	7	-
b	Depreciation @ 15 per cent	12,306	12,306	12,306	12,306	-
c	Interest @ 8 per cent	6,563	6,563	6,563	6,563	-
d	Repairs and maintenance	1,000	1,000	1,000	1,000	-
e	Total (b+c+d)	19,869	19,869	19,869	19,869	-
2	Total cost of cultivation (Rs/ha) from Maize-sunflower-beetroot	53,050	59,330	65,611	45,858	56,740
3	Seasonal total cost (Rs/ha) (2+e)	72,919	79,199	85,480	65,727	56,740
4	Total water used (mm) in cropping system	1,267	1,267	1,267	1,267	1,489
5	Total income from Maize-sunflower -beetroot (Rs/ha)	2,41,504	2,58,446	2,67,408	2,32,965	2,12,623
6	Net seasonal income (Rs) (5-3)	1,68,585	1,79,247	1,81,928	1,67,238	1,55,883
7	Additional area cultivated due to saving of water (ha)	0.18	0.18	0.18	0.18	-
8	Additional expenditure due to additional area (Rs) (3x7)	12,777	13,877	14,978	11,516	-
9	Additional income due to additional area cultivated (Rs) (6x7)	29,539	31,407	31,877	29,303	-
10	Additional net income (Rs) (9-8)	16,762	17,530	16,899	17,786	-
11	Gross cost of production (3+8)	85,696	93,076	1,00,458	77,243	56,740
12	Gross income (5+9)	2,71,043	2,89,853	2,99,285	2,62,268	2,12,623
13	Gross net income (12-11)	1,85,347	1,96,777	1,98,827	1,85,024	1,55,883
14	Gross benefit -cost ratio (12/11)	3.16	3.11	2.98	3.40	3.75
15	Net profit per mm of water used (Rs) (6/4)	133	141	144	132	105
16	Marginal benefit cost ratio	2.02	2.13	1.98	2.42	-

system, increased productivity, additional area coverage and net additional income over surface irrigation method. Though the initial capital investment was high (Rs. 82,041) towards drip fertigation system, the benefits obtained would be greater considering the longer life of the system. An annualized cost of Rs. 19,869 (Table 2 - 4) was included in the cost of cultivation for the annual maintenance and repairs including interest rate and depreciation of the drip system. The additional expenditure and additional income due to additional area cultivated was included in the computation of the economics. Among the three crops in the cropping system, the vegetable crop gave higher net return and B:C ratio when compared to maize and sunflower due to its high value and high yield potential within short duration. So in any cropping system under drip fertigation a vegetable crop could be included, to fetch higher return and repay the investment cost of drip system in a single year itself. Also the duration of vegetable crop such as beetroot was 60 to 70 days only, which could be easily accommodated in any cropping system.

Among the treatments, though the highest yield and gross income was obtained in the treatment combination of I_2F_3 (Table 1), the B:C ratio was higher from the crops treated with drip irrigation with soil application of conventional fertilizers (I_2F_4). The reason might be that the costs of the water soluble fertilizer like mono ammonium phosphate is high when compared to conventional fertilizers. The cost of the specialty fertilizers alone accounted for Rs. 18,840, Rs. 25,120 and Rs. 31,401 ha^{-1} under 75, 100 and 125 per cent RDF, respectively for the entire cropping system, as compared to conventional fertilizers which accounted for Rs. 9,678 ha^{-1} only. Kavitha *et al.* (2007) also reported that though the yield was highest with water soluble fertilizer, the benefit cost ratio was less mainly due to high cost of special fertilizer in drip fertigated tomato. However, the yield and gross income was high in the fertigated plots, due to higher uptake and nutrient use efficiencies from the costly fertilizers, which obtained a very meager difference of B:C ratio when compared to conventional fertilizers (soil applied plots). Thus the additional expenditure towards the drip fertigation system and water soluble fertilizers was well compensated through greater additional income.

Drip irrigation at 100 per cent WRc with 125 per cent RDF recorded higher net income of Rs. 2,24,674 and was closely followed by drip irrigation at 75 per cent WRc with 125 per cent RDF (Rs. 2,24,102). The reason might be due to higher yield obtained

Table 5. Evaluation of Pay back period of maize - sunflower - beetroot cropping system under drip fertigation

Treatment	Cost (Rs. ha^{-1})	Additional benefit (Rs. ha^{-1})	Discounted factor	Discounted benefit (Rs. ha^{-1})	Payback period (months)
I_1F_1	82041	1,00,957	0.93	93,479	10.53
I_1F_2	82041	1,50,504	0.93	1,39,355	7.06
I_1F_3	82041	1,82,603	0.93	1,69,077	5.82
I_1F_4	82041	1,11,753	0.93	1,03,475	9.51
I_2F_1	82041	99,744	0.93	92,356	10.66
I_2F_2	82041	1,15,986	0.93	1,07,395	9.17
I_2F_3	82041	1,28,569	0.93	1,19,045	8.27
I_2F_4	82041	1,01,829	0.93	94,286	10.44
I_3F_1	82041	29,464	0.93	27,282	36.09
I_3F_2	82041	40,894	0.93	37,865	26.00
I_3F_3	82041	42,944	0.93	39,763	24.76
I_3F_4	82041	29,141	0.93	26,983	36.49

from the treatment with 100 and 75 per cent WRc with 125 per cent RDF. Under drip irrigation method, irrigation water could be saved up to 50 per cent when compared to surface irrigation method. By utilizing the saved water from drip irrigation regime at 75 per cent WRc, an additional area of 0.82 ha could be cultivated. As a result of additional area covered under drip irrigation, the gross net income (Rs. 3,38,486) was higher in the treatment with 75 per cent WRc with 125 per cent RDF(I_1F_3), which might be due to additional income from additional area of 98, 88 and 57 per cent more than surface irrigation for maize, sunflower and beetroot, respectively (Tables 2 - 4). Similarly higher B:C ratio was realized in tomato under drip irrigation when the water so saved was assumed to be utilized to cover additional area of the same crop than conventional irrigation (Hugar, 1996).

The additional income (Rs. 29,303) due to additional area cultivated was lower in the drip irrigation treatment at 125 per cent WRc with soil application of RDF. The additional area cultivated due to saving of irrigation from 125 per cent WRc was 0.18 ha only which might be the reason for low additional income. Drip irrigation at 75 per cent WRc with 125 per cent RDF realized higher net profit per mm of water used (Rs. 274), which was followed by same irrigation regime with 100 per cent RDF, due to high additional area (0.82 ha) cultivated by saving about 50 per cent of irrigation water which earned higher additional income also. Surface irrigation method obtained Rs. 105 as net profit per mm of water used, which might be due to the fact that there was no additional area cultivated due to saving of water under this treatment.

The shortest pay back period of 5.82 months was registered in the drip irrigation regime at 75 per cent WRc with 125 per cent RDF, which was followed by the same irrigation regime with 100 per cent RDF with 7.06 months as pay back period. Since the additional area cultivated and additional income are high under 75 per cent WRc and also the yield and gross income are high from 125 per cent RDF, which might have resulted in highest net income and increased the repaying capacity within 6 months. The longest period of 36.49 months was obtained by drip irrigation at 125 per cent WRc with soil application of RDF. Lower the B:C ratio longer the pay back period, higher the B:C ratio shorter the pay back period. Similar results were observed by Senthilkumar (2000), Ramaprabha Nalini (1999) in groundnut and Sharma (1998) in garlic under microsprinkler and Suresh Kumar (2000) in capsicum under drip.

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