Indian Journal of Agricultural Sciences **84** (5): 637–42, May 2014/Article

Cost-effective baby corn (*Zea mays*) cultivation under drip fertigation

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Received: 24 October 2013; Revised accepted: 30 December 2013

ABSTRACT

Field experiment was conducted during 2010-2011 at the research farm of Water Technology Centre, Indian Agricultural Research Institute, New Delhi, India to study the economic viability of baby corn (*Zea mays* L.) cultivation round the year (October-February, April-July and August-November) under fertigation system. The present study consisted of nine treatments which includes three fertigation frequencies (biweekly, weekly and fortnightly) and three dripper 0.5, 1.0 and 1.5 kg/cm^2 system operating pressures. Yield attributes of baby corn were significantly ($P<0.05$) affected by fertigation frequencies. Highest yield of cob, corn and fodder were recorded in biweekly fertigation schedule with dripper discharge at system operating pressure of 1.0 kg/cm^2 (132.5, 22.5, 633.3 q/ha) during 2nd season however, lowest yields of cob, corn and fodder (65.8, 11.2 and 454.6 q/ha) were recorded under fortnightly fertigation schedule with dripper discharge at system operating pressure of 1.5 kg/cm2 during 3rd season. High values of benefit cost ratio (3.63) under biweekly fertigation during 2nd season and low values of benefit cost ratio (1.47) were found under fortnightly fertigation during 3rd season.

Key words: Baby corn, BCR, Fertigation, Net Seasonal Income, Yield

Maize (*Zea mays* L.) is one of the important food crops among all cereals in the world. Maize grown for vegetable purpose and consumed in the form of dehusked corn ear, harvested within 2-3 days of silk emergence is known as baby corn. It is a recent introduction in Indian market and primarily grown as a high value vegetable, has huge potential for commercial production. Baby corn production is gaining popularity among the Indian farmers as it gives more returns within a short span of time in comparison to the other cereals. There is a huge demand for high quality baby corn in the national and international market (Thavaprakaash *et al.* 2005). Cultivation of baby corn not only enhance the income of the farmers but also generates employment for the rural poor. The productivity of baby corn largely depends on the proper application and management of water and essential nutrients. The method of fertilizer application and fertigation frequency significantly influence the baby corn yield irrespective of the quantity of fertilizer used (Kumar *et al.* 2012 and Rajput *et al.* 2013).

Water is one of the most important and crucial natural resource for human survival and agriculture. Agriculture consumes more than 80% of available fresh water resources, however, its share is expected to be reduced to 69% by 2025 (Sivannapan 2009) in India as demand from other sectors is increasing due to ever growing population. Fertilizer is another costly input which is essential to increase crop production. But its judicious and proper use is crucial to minimize the adverse effects on soil health and groundwater quality. Thus, it is of paramount importance to utilize available water and nutrients with maximum possible efficiency. Efficient on-farm water management practices have an important role to play in enhancing water as well as nutrient use efficiency. Most of the surface irrigation methods result in poor water application efficiency, ranging only between 30 and 35% (Sivanappan and Padmakumari 1980). However, over 80% application efficiency may be achieved through drip irrigation. Drip irrigation is one of the advance irrigation methods and apply required amount of water directly in the root zone at frequent intervals which may save sufficient quantity of water as compared to surface method of irrigation.

Fertigation refers to the application of fertilizers and chemicals along with irrigation water to the crop through drip irrigation. Fertigation aims at providing optimum nutrients required for the crop to get better and high quality produce. Fertigation enables the application of soluble fertilizers and other chemicals along with irrigation water in the vicinity of the root zone (Patel and Rajput 2000, Narda and Chawla 2002). The application of water and nutrients in small doses at frequent intervals to the crop root zone ensures nutrients availability to the plants at the time of plants need. Muthukumar *et al.* (2005) observed that the application of N in split doses influence the cob yield and

Based on a part of Ph D Thesis of the first author submitted to PG School IARI, New Delhi during 2012

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other plant growth parameters of baby corn. Rajput and Patel (2006) found that yield of onion was not significantly affected in daily, alternate day and weekly fertigation though there was a significant reduction of yields in case of monthly fertigation. The highest yield was recorded in daily fertigation (28.7 tonnes/ha) and lowest onion yield was reported in monthly fertigation (21.4 tonnes/ha). Sampathkumar *et al.* (2010) reported higher corn grain yield at once in 6 days fertigation which was at par with fertigation once in the 9, 12 and 15 days.

Although, the drip fertigation saves water and costly fertilizers but farmers' (small land holdings) concern is its economic viability as initial cost of the drip irrigation system is high. Narayanamoorthy (2003), however, reported that drip fertigation enhanced the crop yield and productivity with reduced cost of cultivation, the net income under drip fertigation is substantially higher than that of crops grown under surface furrow irrigation.

Economics analysis has been carried out by several researchers by taking into consideration the benefit cost ratio under drip irrigation on different vegetable crops while no study have been found on economic viability of baby corn cultivation with drip fertigation in India. The information on drip irrigation along with the fertigation schedule would be very useful to the farmers for profitable cultivation of baby corn. Keeping above facts in view, the present investigation was conducted to study the economic feasibility of growing baby corn under drip fertigation.

MATERIALS AND METHODS

The experiment was conducted at the research farm of Water Technology Centre, Indian Agricultural Research Institute (IARI), New Delhi, India (Latitude 28°37'30"–28°30'0" N, Longitude 77°88'45"–77°81'24" E and AMSL 228.61 m) during 2010–2011 for three consecutive seasons, i.e. October 2010–February 2011, April-July 2011 and August-November 2011. The soil samples were collected at 0.0-15.0, 15.0-30.0, 30.0-45.0, 45.0-60.0 cm soil depths. The soil of the experimental area was deep loam comprising 37.7% sand, 40.7% silt and 21.6% clay. The average bulk density, average field capacity and average saturated hydraulic conductivity of soil were 1.47 g/cm^3, 0.20 and 1.19 cm/h, respectively. The average bulk density and saturated hydraulic conductivity were 1.53 g/cm^3 and 1.17 cm/h, respectively.

The experiment was planned with factorial 3^2 Randomized Complete Block Design with three replications. The first factor was system operating pressures at three levels and second factor was fertigation frequency at three levels. A field plot of 20.2 m × 50 m was selected for the experiments. The field was divided into four equal smaller plots of 5.4 m × 50 m with 1m isolation between two plots. Each plot of 5.4 m × 50 m size was further divided into 9 lines of size of 0.6 m × 50 m. Each line represented a single treatment. Nine treatments were selected including three dripper discharge at three system operating pressures (0.5, 1.0 and 1.5 kg/cm) and three fertigation frequencies (biweekly, weekly and fortnightly). Each treatment was replicated thrice (R_1, R_2 and R_3). The details of different treatments are given as follows: T_1, Fertigation biweekly and dripper discharge 0.94 l/h at 0.5 kg/cm^2 system operating pressure; T_2, Fertigation weekly and dripper discharge 0.94 l/h at 0.5 kg/cm^2 system operating pressure; T_3, Fertigation fortnightly and dripper discharge 0.94 l/h at 0.5 kg/cm^2 system operating pressure; T_4, Fertigation biweekly and dripper discharge 1.41 l/h at 1.0 kg/cm^2 system operating pressure; T_5, Fertigation weekly and dripper discharge 1.41 l/h at 1.0 kg/cm^2 system operating pressure; T_6, Fertigation fortnightly and dripper discharge 1.41 l/h at 1.0 kg/cm^2 system operating pressure; T_7, Fertigation biweekly and dripper discharge 1.71 l/h at 1.5 kg/cm^2 system operating pressure; T_8, Fertigation weekly and dripper discharge 1.71 l/h at 1.5 kg/cm^2 system operating pressure; T_9, Fertigation fortnightly and dripper discharge 1.71 l/h at 1.5 kg/cm^2 system operating pressure.

Drip irrigation system was installed during first season, i e October 2010 and the drip-tape (laterals) were removed after the harvest of 1st and 2nd season crop and again connected to the gate valves during second and third crop season, i e April 2011 and August 2011, respectively. The thin-walled inline drip tape (Azud line, 12 mil (304.8 micron) thickness with 30 cm dripper spacing and dripper discharge 1.4 l/h) was used as drip lateral in each line for the present study. The drip irrigation system was installed with the head work, which includes sand media filter (flow rate 25 m^3/h, 50 mm size, silica sand 0.7 mm), back flush mechanism and a control panel (Model Pro-C, Hunter). Main line (PVC pipes of 60 mm diameter) were connected to sub-mains (PVC pipes of 40 mm diameter) for each 9 rows plot through a valve tree, which include a solenoid valve, ball valve connector and pressure release valve. Hybrid maize (Baby corn-HM 4) was selected for this study as baby corn has immense potential for increasing the income of the farmers.

Reference crop evapotranspiration (ET_o) was computed on a daily basis by using Penman-Monteith's semi-empirical formula (Smith 1991). The actual crop evapotranspiration 'ET_c' was estimated by multiplying reference evapotranspiration with crop coefficient K_C ($ET_c = ET_o \times K_C$) for different months based on crop growth stages. The crop coefficients adopted at initial, crop developmental, mid season and maturity stages were 0.5, 1.2, 1.05 and 0.9, respectively during all three crop seasons (Allen *et al.* 1998). The required amount of water was applied on alternate day through drip irrigation at pre-determined system operating pressures. Total rainfall during the crop seasons, i.e. October 2010- February 2011, April 2011- July 2011 and August- November 2011 were 33.3, 138.4 and 163.6 mm, respectively. Irrigation efficiency of drip irrigation system was assumed as 95% (Rajput and Patel 2001). The water requirements of baby corn ranged from 0.1 to 3.5, 1.2 to 8.7 and 0.6 to 5.8 mm/day from early stage to peak demand period during October 2010-February 2011, April 2011- July 2011 and August-November 2011, respectively.

Soil nutrients status before sowing of crop was determined (123.49, 31.9 and 119.3 kg/ha of nitrogen, phosphorus and potassium, respectively). Manures and fertilizers application included 8 tonnes/ha of farmyard manure, 150 kg N/ha, 60 kg P/ha and 60 kg K/ha, as suggested by Dass *et al.* (2009). Total quantity of fertilizers in all treatments was kept same. Recommended quantity of N, K and P were applied in form of urea, muriate of potash and phosphoric acid, respectively through fertigation in biweekly (12 split doses), weekly (12 split doses) and fortnightly (3 split doses). In sandy loam soils, where potassium may be lost due to leaching, K was applied in split doses. Fertigation started from 15 days after sowing of crop and stopped 15 days before the harvest of crop. Fertilizer solutions of urea, muriate of potash and phosphoric acid were prepared by dissolving the fertilizers and applied through a venturi injector by putting the suction tube in the bucket. During fertigation, the solutions of different fertilizers were applied separately and not mixed, to avoid precipitation due to non-compatibility of two chemicals.

Picking of fresh baby corn was done manually in all seasons. The fresh yield under each treatment was taken as the fresh cob weight (unhusked baby corn), fresh baby corn weight (husked baby corn) at the harvest and fresh weight of fodder. Statistical analysis was done on all data by using standard analysis of variance (ANOVA). Two probability levels, 0.01 and 0.05 were considered for determination of significance.

Benefit cost analysis was carried out to determine the economic feasibility of the baby corn cultivation. Total seasonal cost of the system includes both the seasonal fixed (Drip system) cost and cultivation cost. The gross income from the baby corn production includes market return from baby corn and fodder of the crop. The seasonal cost includes cost of drip-line, fertilizer injector, motor, main and sub mainline, depreciation, prevailing bank interest rate, repair and maintenance cost of the system. The operational cost includes land preparation, seed, inter-cultivation, manure, fertilizer, crop protection and labour charges for sowing of seed, weeding, harvesting, cost of electricity etc. The cost of electricity for running the irrigation system was calculated based on the energy consumed in hours. The interest rate was taken 12% and repair and maintenance cost of the system was taken as 2% per annum of the fixed cost. The Benefit Cost Ratio (BCR) was estimated assuming 1 ha field area, land is flat, water source located at corner and drip-line life will be one year (3 seasons) and useful life of other components of the drip system was considered to be 7 years. Salvage value is assumed as 10% of the capital cost. Depreciation can be calculated using the following equation:

$$D = \frac{C - S}{L}$$

where, D, Depreciation; C, capital cost; S, salvage value; L, useful life, years.

Interest (I) over the capital cost is calculated with 12% interest rate. It is estimated with the equation as under:

$$I = \frac{C + S}{2} \times i$$

Where, *i*, Interest rate, %.

The total income and net profit were calculated based on the prevailing average market price of baby corn and fodder.

Benefit cost ratio

Benefit cost ratio (BCR) was calculated to analyze the returns from the baby corn crop under drip fertigation. The Equation 3 was used to calculate the BCR is as follows:

$$BCR = \frac{\text{Net income}}{\text{Total cost}}$$

Payback period

The payback period was calculated to estimate the time required to get the invested cost. The payback period was calculated with the following Equation:

$$\text{Pay back period} = \frac{\text{Total cost}}{\text{Gross income}} \times \text{Useful life}$$

RESULTS AND DISCUSSION

Yield attributes

The highest yields of baby corn and fodder were recorded during 2nd (April 2011- July 2011) season in all the nine treatments as compared to 1st (October 2010-February 2011) and 3rd (August – November 2011) season (Table 1). The lowest value of cob, baby corn and fodder yields were recorded during 3rd season. It is clear from the statistical analysis that baby corn and fodder yields were significantly ($P<0.01$) affected with fertigation frequency (Table 2). Yield attributes of baby corn were significantly different during different seasons.

The variation in yields component during different seasons could be attributed to the variation of weather parameters. During 2nd season, weather conditions were best suited to the baby corn. Baby corn yield obtained under different treatments is shown in Table 1. Irrigation treatments

Table 1 Cob, baby corn and fodder yield under different treatments

Treat-ment	Season 1		Season 2		Season 3	
	Baby corn yield (t/ha)	Fodder yield (t/ha)	Baby corn yield, (t/ha)	Fodder yield, (t/ha)	Baby corn yield, (q/ha)	Fodder yield, (t/ha)
T_1	1.78	62.2	22.2	62.9	13.2	49.6
T_2	1.69	61.9	21.8	61.2	12.8	48.6
T_3	1.49	59.8	19.9	59.2	11.8	46.2
T_4	1.82	63.1	22.5	63.3	13.5	51.2
T_5	1.76	62.6	22.0	61.9	13.1	50.1
T_6	1.49	60.0	20.5	59.7	12.0	48.8
T_7	1.77	62.0	21.9	62.1	12.9	49.0
T_8	1.64	60.5	21.6	59.2	12.5	48.2
T_9	1.46	57.2	19.8	56.5	11.2	45.5

Table 2 CD values at 5% and 1% significant level for different yield attributes of baby corn

Yield attributes	Season 1		Season 2		Season 3	
	(P<0.01)	(P<0.05)	(P<0.01)	(P<0.05)	(P<0.01)	(P<0.05)
Baby corn yield	12.69	5.14	9.33	3.77	7.68	3.11
Fodder yield	11.68	4.85	6.70	2.71	6.91	2.79

Season 1: October 2010–February 2011, season 2: April 2011-July 2011 and season 3: August 2011-November 2011

at different system operating pressures did not show any significant impact on yield parameters. Yield attributes of baby corn under biweekly and weekly fertigation schedules were at par, however, it was significantly different statistically at 5% and 1% level with fortnightly fertigation frequency schedule (Table 2). Yield parameters with interaction of season and fertigation frequency and irrigation at different system operating pressures were statistically significant.

A trend of lower yields of baby corn attributes was observed in all the treatments during 3rd season as compared to 1st and 2nd seasons. During 1st season, 19.7% less baby corn yield was recorded, whereas, 40.3% less baby corn yield was recorded during 3rd season as compared to 2nd season. During 2nd season (April 2011- July 2011), the average highest yields of baby corn and fodder were recorded in treatment T_4, i e biweekly fertigation schedule with 1.41 l/h dripper discharge at system operating pressure of 1.0 kg/cm^2 (2.25, 63.33 tonnes/ha) followed by treatment T_5, i e weekly fertigation schedule with 1.41 l/h dripper discharge at system operating pressure of 1.0 kg/cm^2 (2.20, 61.94 tonnes/ha), respectively during second season while average lowest yield of baby corn and fodder was recorded in treatment T_9, i e fortnightly fertigation schedule with 1.71 l/h dripper discharge at system operating pressure of 1.5 kg/cm^2 during third season (1.12 and 45.46 tonnes/ha). Higher yields were observed at higher fertigation frequencies it might be due to sufficient amount of nutrients could be available as per plants requirement during peak uptake time result in no nutrients stress in plants.

The fertigation frequency schedules had statistical significant effect on yield attributes of baby corn. Fertilizers applied through fertigation in biweekly and weekly fertigation schedule resulted in higher yield as compared to fortnightly fertigation schedules with same quantity of fertilizers applied. Reasons for lower yield in fortnightly fertigation schedule may be attributed to non-availability of nutrients to the plants at the time of need leading to nutrient stress resulting in subsequent poor plant growth and lower crop yield. In case of frequent nutrient application, the plants were not subjected to nutrient stress and hence higher crop yields were realized.

Similar results were reported in other studies of Binder *et al.* (2000), Rajput and Patel (2006) and Sampathkumar and Pandian (2010). Rajput and Patel (2006) conducted a study on onion with different fertigation frequencies and suggested yield of onion was not affected significantly in daily, alternative day and weekly fertigation frequency. However there was a trend of decrease with monthly fertigation. Sampathkumar and Pandian (2010) investigated the effect of fertigation frequencies and levels on growth and yield of maize and reported that fertigation frequency schedule once in 6 days registered higher grain yield and it was on par with other fertigation frequencies.

Economic analysis

Economic analysis of baby corn under different treatments was conducted and presented in Tables 3 to 5. The net seasonal income was found to be highest (₹ 226 000) for biweekly fertigation with 1.41 l/h dripper discharge at 1.0 kg/cm^2 during April-July (season 2) however, lower net seasonal income (₹ 93 820) was recorded under fortnightly fertigation frequency with 1.71 l/h dripper discharge at system operating pressure of 1.5 kg/cm^2 during August-November (season 3).

The economic analysis indicated that gross cultivation cost in all drip irrigation treatments was higher than that of furrow irrigation. Since seasonal fixed cost (drip system cost) was involved in different drip fertigation treatments whereas in furrow irrigation only cultivation cost was involved.

The benefit cost ratio vary between 3.63 (highest) for biweekly fertigation frequency with 1.41 l/h dripper discharge at system operating pressure 1.0 kg/cm^2 to 3.13 (lowest) for fortnightly fertigation frequency with 1.71 l/h dripper discharge at system operating pressure 1.5 kg/cm^2 under drip irrigation during April-July (season 2) followed 3.05 (highest) biweekly fertigation frequency with 1.41 l/h dripper discharge at system operating pressure 1.0 kg/cm^2 to 2.4 (lowest) fortnightly weekly fertigation frequency with 1.71 l/h dripper discharge at system operating pressure 1.5 kg/cm^2 during October-February (season 1). The lowest range (1.47 to 3.13) of BCR for baby corn cultivation were recorded during August to November (3rd season) under fortnightly weekly fertigation frequency at system operating pressure 1.5 kg/cm^2. The results are corroborated with findings of Sivanappan and Padmakumari (1980) and Tiwari *et al.* (1998).

Drip fertigation is an advance and innovative technology for applying the optimum quantity of water and fertilizer to the crop in small doses in frequent intervals. Frequent fertigation of baby corn crops gives high yield and better quality of produce. Yield attributes of baby corn was not significantly affected in biweekly and weekly fertigation frequency, although, a decreasing trend of yield in weekly and fortnightly fertigation frequency schedule was observed. Highest value of baby corn yield was recorded under biweekly fertigation followed by weekly fertigation frequency however lowest value of baby corn yield was recorded under fortnightly fertigation frequency. Highest yield of baby corn and fodder was recorded in biweekly fertigation schedule with 1.41 l/h dripper discharge at 1.0

Table 3 Economic analysis of baby corn cultivation under different treatments during seasons 1 (October- February)

Treatment	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Baby corn yield (tonnes/ha)	1.78	1.69	1.49	1.82	1.76	1.49	1.77	1.64	1.46
Fodder yield (tonnes/ha)	62.2	61.9	59.8	63.9	62.6	60	62	60.5	57.2
Seasonal fixed cost (₹)	30 099	30 099	30 099	30 099	30 099	30 099	30 099	30 099	30 099
Cost of cultivation (₹)	31 055	31 055	31 055	30 592	30 592	30 592	29 720	29 720	29 720
Total cost of production (₹)	61 154	61 154	61 154	60 691	60 691	60 691	59 819	59 819	59 819
Gross seasonal income (₹)	240 200	230 900	208 800	245 900	238 600	209 000	239 000	224 500	203 200
Net seasonal income (₹)	179 046	169 746	147 646	185 209	177 909	148 309	179 181	164 681	143 381
Benefit cost ratio (BCR)	2.93	2.78	2.41	3.05	2.93	2.44	3.00	2.75	2.40
Pay back period (Years)	1.27	1.32	1.47	1.24	1.27	1.45	1.25	1.33	1.47

Table 4 Economic analysis of baby corn cultivation under different treatments during seasons 2 (April –July)

Treatment	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Baby corn yield (tonnes/ha)	2.22	2.18	1.99	2.25	2.20	2.05	2.19	2.16	1.98
Fodder yield (tonnes/ha)	62.9	61.2	59.2	63.3	61.9	59.7	62.1	59.2	56.5
Seasonal fixed cost (₹)	30 099	30 099	30 099	30 099	30 099	30 099	30 099	30 099	30 099
Cost of cultivation (₹)	32 918	32 918	32 918	32 201	32 201	32 201	31 539	31 539	31 539
Total cost of production (₹)	63 017	63 017	63 017	62 300	62 300	62 300	61 638	61 638	61 638
Gross seasonal income (₹)	284 900	279 200	258 200	288 300	281 900	264 700	281 100	275 200	254 500
Net seasonal income (₹)	221 883	216 183	195 183	226 000	219 600	202 400	219 462	213 562	192 862
Benefit cost ratio (BCR)	3.52	3.43	3.10	3.63	3.52	3.25	3.56	3.46	3.13
Pay back period (Years)	0.62	0.6	0.67	0.58	0.6	0.66	0.59	0.62	0.67

Table 5 Economic analysis of baby corn cultivation under different treatments during seasons 3 (August-November)

Treatment	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
Baby corn yield (tonnes/ha)	1.32	1.28	1.18	1.35	1.31	1.20	1.29	1.25	1.12
Fodder yield (tonnes/ha)	49.6	48.6	46.2	51.2	50.1	48.8	49	48.2	45.5
Seasonal fixed cost (₹)	30 099	30 099	30 099	30 099	30 099	30 099	30 099	30 099	30 099
Cost of cultivation (₹)	36 295	36 295	36 295	35 115	35 115	35 115	33 581	33 581	33 581
Total cost of production (₹)	66 394	66 394	66 394	65 214	65 214	65 214	63 680	63 680	63 680
Gross seasonal income (₹)	181 600	176 600	164 200	186 200	181 100	168 800	178 000	173 200	157 500
Net seasonal income (₹)	115 206	110 206	97 806	120 986	115 886	103 586	114 320	109 520	93 820
Benefit cost ratio (BCR)	1.74	1.66	1.47	1.86	1.78	1.59	1.80	1.72	1.47
Pay back period (Years)	1.83	1.88	2.03	1.75	1.80	1.94	1.79	1.84	2.02

kg/cm^2 operating pressure during second season however, lowest yield of baby corn and fodder was recorded in fortnightly fertigation frequency with 1.71 l/h dripper discharge at 1.5 kg/cm^2 operating pressure during third season**.** The treatment biweekly fertigation with 1.41 l/h dripper discharge at 1.0 kg/cm^2 operating pressure was considered to be appropriate for recommendation. Cultivation of baby corn could be an economic viable option for Indian farmers under drip fertigation.

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