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Economics of Okra Cultivation (*Abelmoschus esculentus* (L.) Moench] Under Trickle Fertigation

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ABSTRACT

An experiment was conducted to compare the effect of conventional fertilisers and water soluble fertilisers at varying frequency of application on yield and its economic feasibility on hybrid okra [*Abelmoschus esculentus* (L.) Moench]. The experiment was laid out in a randomised block design with two controls involving ten treatments in a factorial way and was replicated thrice. The plot receiving daily fertigation of water soluble fertilisers had recorded the highest fruit yield (23.25 t ha^{-1}), which was about 51.67 per cent higher over soil application of recommended dose of fertilisers and 219.81 per cent higher over absolute control (7.2 t ha^{-1}). The yield recorded under daily fertigation of conventional fertiliser was found comparable to daily fertigation of water soluble fertilisers. The maximum benefit cost ratio of 2.66 was registered under daily fertigation of conventional fertiliser, followed by fertigation of conventional fertilisers at 3 days interval (2.42). Such a high benefit cost ratio is attributable to the reduced cost of cultivation, resulting from lower fertiliser cost compared to water soluble fertilisers. Fertigation daily with conventional fertiliser gave an additional benefit of ₹ 1,01,188.32 ha^{-1} as against control, followed by daily fertigation using water soluble fertilisers (91,552.24 ha^{-1}).

Key words *Abelmoschus esculentus (L.) Moench, conventional fertilisers, drip irrigation, frequency, okra, water soluble fertilisers*

Vegetables play an important role in providing a balanced diet by supplying nutrients, vitamins, minerals and antioxidants. India is the second largest producer of vegetables in the world accounting for 14 per cent of the global vegetable production. However, the vegetable consumption of an average Indian is (183 g) far less than the recommended dietary allowance of 300 g (Singh *et al.,* 2011a) and this demand supply gap is likely to widen further with the growing population and shrinking resources. Efficient management of water and nutrients are the two key factors needed to be managed efficiently for increasing the yield as well for sustaining the environmental quality. Drip fertigation has been well recognised as an efficient and precise method of applying water and fertiliser directly in the root zone for maximising productivity as well as net returns in horticultural crops (Meenakshi, 2002).

Hence, the present investigation was taken up to study the economic feasibility of using solid water soluble fertilisers and conventional fertilisers for yield enhancement in okra under drip fertigation.

MATERIALS AND METHODS

The experiment was conducted in the horticulture farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, U.T. of Puducherry, India. Okra hybrid 'Shakti' was used for the study. The experiment was laid out in a Randomized Block Design (RBD) with two controls involving ten treatments as detailed below in a factorial way and was replicated thrice.

Treatments	Details
S_1F_1	Daily fertigation with water soluble fertilisers
S_1F_2	Fertigation at 3 days interval with water soluble fertilisers
S_1F_3	Fertigation at 5 days interval with water soluble fertilisers
S_1F_4	Fertigation at 7 days interval with water soluble fertilisers
S_2F_1	Daily fertigation with conventional fertilisers
S_2F_2	Fertigation at 3 days interval with conventional fertilisers
S_2F_3	Fertigation at 5 days interval with conventional fertilisers
S_2F_4	Fertigation at 7 days interval with conventional fertilisers
RDF	Soil application of recommended dose of fertilisers
Control	No fertiliser

Table 1. Effect of fertigation on fruit yield hectare^{-1} (tonnes) in okra

Source → / Frequency ↓	Fruit yield hectare^{-1} (tonnes)		
	S_1	S_2	Mean
F_1	23.25	22.67	22.96
F_2	21.88	20.59	21.24
F_3	20.40	17.72	19.06
F_4	18.44	17.20	17.82
Mean	20.99	19.55	-
RDF	.		15.33
Control			7.27
Factor		SEd	CD (p = 0.05)
Fertiliser source		1.828	NS
Fertigation frequency		1.530	3.21
Source x Frequency		1.140	NS
Control Vs RDF Vs Rest		0.855	1.80

Source : S_1 – Fertigation with water soluble fertilisers; S_2 – Fertigation with conventional fertilisers
Frequency : F_1 – Daily; F_2 – Three days interval; F_3 – Five days interval; F_4 – Weekly interval
RDF : Soil application of recommended dose of fertilisers
Control : No fertilizer

A plot size of 22.50 m^2 was maintained for each treatment. The crop was irrigated daily considering the E_{pan} value and the crop co-efficient value (Kc). The entire quantity of water lost through evapo transpiration was replenished every day through drip system (Rekha *et al.,* 2006). The ET value was worked out as suggested by Kisekka *et al*. (2010). A fertiliser dose of 200:100:100 kg NPK ha^{-1} along with 15 t ha^{-1} of FYM was uniformly applied to all the treatment plots (Crop production techniques of horticultural crops, 2004) except in absolute control. The FYM and full dose of NPK were applied through soil in RDF, while FYM along with 75 per cent of recommended P_2O_5 as Super Phosphate were applied as basal in all the fertigation treatments. Full 'N' and K_2O along with the remaining 25 per cent of P_2O_5 were applied through fertigation. The treatments that were not fertigated on a particular day were given drip irrigation alone for a similar duration. Urea, Polyfeed (19-19-19), Potassium Nitrate (13-0-45) and Mono Ammonium Phosphate (12-61-0) were used as water soluble fertilisers (S_1), while Urea, Diammonium Phosphate and Muriate of Potash were used as conventional fertilisers (S_2). The solution of Diammonium Phosphate and Muriate of Potash were filtered before injecting into the system to avoid clogging of emitters. Fertigation scheduling was done by dividing the entire crop period into 4 different growth stages as recommended by Vadivel (2006). The total quantity of fertilisers recommended during each stage was split according to the frequency interval and was supplied through the fertigation system. The seeds were raised on beds in a paired row system with a spacing of 90x60x30 cm. Other cultural practices as recommended (Crop production techniques of horticultural crops, 2004) were followed uniformly for all the plots. The cost benefit ratio was worked out by taking into account the prevailing rate of labour and all the inputs.

Table 2. Cost of manures and fertilisers

Sl. No.	Treatments	Particulars	Quantity (kg ha^{-1})	Rate unit^{-1} (₹)	Amount (₹)	Total amount (₹)
1.	S_1F_1 S_1F_2 S_1F_3 S_1F_4	Farm yard manure	25000.00	0.50	12500.00	34955.76
		Poly feed	52.60	53.00	2787.80	
		Potassium Nitrate	200.00	63.00	12600.00	
		Mono Ammonium Phosphate	24.59	64.00	1573.76	
		Urea	350.13	5.41	1894.20	
		Single Super Phosphate	468.75	7.68	3600.00	
2.	S_2F_1 S_2F_2 S_2F_3 S_2F_4	Farm yard manure	25000.00	0.50	12500.00	20679.68
		Urea	432.00	5.41	2337.12	
		Di Ammonium Phosphate	56.84	26.00	1477.84	
		Muriate of Potash	166.97	4.58	764.72	
		Single Super Phosphate	468.75	7.68	3600.00	
3.	RDF	Farm yard manure	25000.00	0.50	12500.00	20411.29
		Urea	434.00	5.41	2347.94	
		Single Super Phosphate	625.00	7.68	4800.00	
		Muriate of Potash	166.67	4.58	763.35	
4.	Control	-	0	0	0	0

RESULTS AND DISCUSSION

Fruit yield hectare^{-1} (tonnes)

The study revealed the significance of varying frequency interval of fertigation on yield (Table 1) with the maximum yield recorded in F_1 (22.96 t ha^{-1}), which was found to be on par with F_2 (21.24 t ha^{-1}). The highest yield recorded in S_1F_1 (23.25 t ha^{-1}) was about 52.00 per cent more than RDF (15.33 t ha^{-1}) and about 220.00 per cent more than control (7.27 t ha^{-1}). Increased yield under fertigation over RDF had been reported earlier by Sasani *et al.* (2006). The superiority of drip fertigation over soil application with regard to yield is the result of better availability and uptake of nutrients leading to increased metabolite activities in the plant system as reported earlier by Tumbare and Nikam (2004), Muralikrishnasamy *et al.* (2004), Shedeed *et al.* (2009), Akanda *et al.* (2012) and Sasani *et al.* (2006). The yield recorded in S_1F_1 was also found to be on par with S_2F_1 (22.67 t ha^{-1}) and S_1F_2 (21.88 t ha^{-1}) and such a trend had already been reported by Al-Jaloud *et al.* (1999), Patel and Rajput (2005), Badr and El-Yazied (2007) and Singh *et al.* (2011b).

Economic analysis

The data on the cost of manures and fertilisers, cost of cultivation, cost and returns with respect to fertigation in okra hybrid 'Shakti' is presented in Table 2, 3 and 4 respectively. The cost of cultivation and gross return varied markedly among the treatments and ranged from 46,287.00 ha^{-1} (control) to 82,574.76 ha^{-1} (S_1F_1) and 58,160.00 ha^{-1} (control) to 1,86,000.00 ha^{-1} (S_1F_1) respectively. The highest gross return of 1,86,000.00 ha^{-1} recorded in S_1F_1 was followed by S_2F_1 (1,81,360.00 ha^{-1}).

The net profit also varied considerably between the treatments. The highest net profit of 1,13,061.32 ha^{-1} was obtained in S_2F_1, followed by S_1F_1 (1,03,425.24 ha^{-1}) and S_2F_2 (96,569.32 ha^{-1}). The lowest net profit (11,873.00 ha^{-1}) was noticed in control followed by soil application of fertilisers (55,201.71 ha^{-1}).

The analysis of benefit cost ratio showed that S_2F_1 (daily fertigation using conventional fertilisers) recorded the highest benefit cost ratio (2.66), followed by S_2F_2 (2.42) and S_1F_1 (2.25), whereas, the lowest benefit cost ratio was recorded in control

Table 3. Details on cost of cultivation

Sl. No.	Description of work	Amount (₹)									
		S_1F_1	S_1F_2	S_1F_3	S_1F_4	S_2F_1	S_2F_2	S_2F_3	S_2F_4	RDF	Control
A.	Preparatory cultivation										
(i).	Tractor ploughing thrice @ ₹ 156 hr^{-1} @ 7.5 hrs ha^{-1}	1170.00	1170.00	1170.00	1170.00	1170.00	1170.00	1170.00	1170.00	1170.00	1170.00
(ii).	Cost of labour for formation of ridges and furrows (16 labourers @ ₹ 148)	2368.00	2368.00	2368.00	2368.00	2368.00	2368.00	2368.00	2368.00	2368.00	2368.00
	Total	3538.00	3538.00	3538.00	3538.00	3538.00	3538.00	3538.00	3538.00	3538.00	3538.00
B.	Cost of drip system										
(i).	Cost of drip system for a 3.7 months crop ha^{-1}	2621.00	2621.00	2621.00	2621.00	2621.00	2621.00	2621.00	2621.00	2621.00	2621.00
	Total	2621.00	2621.00	2621.00	2621.00	2621.00	2621.00	2621.00	2621.00	2621.00	2621.00
C.	Seeds and sowing										
(i).	Seeds @ 3.5 kg ha^{-1} and ₹ 3000 kg^{-1}	10500.00	10500.00	10500.00	10500.00	10500.00	10500.00	10500.00	10500.00	10500.00	10500.00
(ii).	Cost of labour for sowing (10 labourers @ ₹ 148)	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00	1480.00
	Total	11980.00	11980.00	11980.00	11980.00	11980.00	11980.00	11980.00	11980.00	11980.00	11980.00
D.	Manures and fertilizers										
(i).	Cost of manures and fertilisers	34955.76	34955.76	34955.76	34955.76	20679.68	20679.68	20679.68	20679.68	20411.29	0
(ii).	Cost of labour for application of farm yard manure (5 labourers @ ₹ 148)	740.00	740.00	740.00	740.00	740.00	740.00	740.00	740.00	740.00	0
	Total	35695.76	35695.76	35695.76	35695.76	21419.68	21419.68	21419.68	21419.68	21151.29	0
E.	Labours for irrigation and fertigation										
(i).	Labourers for irrigation (13 labourers @ ₹ 148)	1924.00	1924.00	1924.00	1924.00	1924.00	1924.00	1924.00	1924.00	1924.00	1924.00

Sl. No.	Description of work	Amount (₹)									
		S_1F_1	S_1F_2	S_1F_3	S_1F_4	S_2F_1	S_2F_2	S_2F_3	S_2F_4	RDF	Control
(ii).	Labours for fertigating the field (Daily – 4; 3days interval – 3; 5 days interval – 2; 7 days interval – 1)	592.00	444.00	296.00	148.00	592.00	444.00	296.00	148.00	0	0
	Total	2516.00	2368.00	2220.00	2072.00	2516.00	2368.00	2220.00	2072.00	1924.00	1924.00
F.	Intercultural operations										
(i).	Thinning and gap filling (3 labourers @ ₹ 148)	444.00	444.00	444.00	444.00	444.00	444.00	444.00	444.00	444.00	444.00
(ii).	Hand weeding twice @ 12 labourers weeding^{-1}	1776.00	1776.00	1776.00	1776.00	1776.00	1776.00	1776.00	1776.00	1776.00	1776.00
(iii).	Cost of plant protection chemicals	5060.00	5060.00	5060.00	5060.00	5060.00	5060.00	5060.00	5060.00	5060.00	5060.00
(iv).	Cost of labour for application of chemicals (8 labourers @ ₹ 148)	1184.00	1184.00	1184.00	1184.00	1184.00	1184.00	1184.00	1184.00	1184.00	1184.00
	Total	8464.00	8464.00	8464.00	8464.00	8464.00	8464.00	8464.00	8464.00	8464.00	8464.00
G.	Harvest										
(i).	Cost of labour for 40 harvest (3 labourers for each harvest)	17760.00	17760.00	17760.00	17760.00	17760.00	17760.00	17760.00	17760.00	17760.00	17760.00
	Total	17760.00	17760.00	17760.00	17760.00	17760.00	17760.00	17760.00	17760.00	17760.00	17760.00
Total cost of cultivation		82574.76	82426.76	82278.76	82130.76	68298.68	68150.68	68002.68	67854.68	67438.29	46287.00

(1.26) followed by S_1F_4 and RDF (1.80 and 1.82 respectively).

The benefit cost ratio worked out based on the present rates of inputs and the prevailing labour charges revealed that the daily fertigation of conventional fertiliser (S_2F_1) had recorded the highest benefit cost ratio than other treatments. This is mainly attributable to the better growth and dry matter production recorded with fertigation at closer intervals resulting from increased nutrient availability and nutrient use efficiency, leading to higher yield. Further, compared to water soluble fertilisers the conventional fertilisers are very cheap reducing the cost of cultivation to a greater extent. The yield of okra under conventional fertiliser was comparable to water soluble fertiliser, especially at frequent intervals as the quantity of nutrients supplied was the same irrespective of the source and frequencies.

Partial budgeting

The result of partial budgeting analysis is presented in Table 5. Partial budgeting technique was imposed to compare the economic viability of the fertigation treatments. Partial budgeting was done comparing the absolute control with rest of the treatments, considering the added cost and

Table 4. Influence of fertigation on cost and returns in okra

Treatments	Cost of cultivation (₹ ha^{-1})	Marketable yield (t ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C
S_1F_1	82574.76	23.25	186000.00	103425.24	2.25
S_1F_2	82426.76	21.88	175040.00	92613.24	2.12
S_1F_3	82278.76	20.40	163200.00	80921.24	1.98
S_1F_4	82130.76	18.44	147520.00	65389.24	1.80
S_2F_1	68298.68	22.67	181360.00	113061.32	2.66
S_2F_2	68150.68	20.59	164720.00	96569.32	2.42
S_2F_3	68002.68	17.72	141760.00	73757.32	2.08
S_2F_4	67854.68	17.20	137600.00	69745.32	2.03
RDF	67438.29	15.33	122640.00	55201.71	1.82
Control	46287.00	7.27	58160.00	11873.00	1.26

added returns. There was an additional benefit of 1,01,188.32 ha^{-1} for S_2F_1 (daily fertigation using conventional fertilisers) and 91,552.24 ha^{-1} for S_1F_1 (daily fertigation using water soluble fertilisers) compared to control.

From partial budgeting, it is understood that the daily fertigation of conventional fertiliser (S_2F_1) has recorded an additional yield of 15.40 t ha^{-1} over control. An additional cost of 22,011.68 ha^{-1} was incurred in this treatment giving an additional return of 1,23,200 ha^{-1}. Though fertigation of water soluble fertiliser on daily basis (S_1F_1) had recorded an additional yield of 15.98 t ha^{-1} over control considering the additional cost incurred on water soluble fertilisers, the use of conventional fertilisers on daily basis was found to be the best for adoption by the farmers.

Daily fertigation of conventional fertilisers could be considered the best as it had recorded a benefit cost ratio of 2.66 even though it had registered an yield of 22.67 t ha^{-1}, which was just 2.56 per cent lower than the yield recorded under daily fertigation of water soluble fertilisers.

Table 5. Partial budgeting between treatments and control in okra

Treatments	Added cost (₹ ha^{-1})	Additional yield (t ha^{-1})	Added return (₹ ha^{-1})	Estimated change (₹ ha^{-1})
S_1F_1	36287.76	15.98	127840.00	91552.24
S_1F_2	36139.76	14.61	116880.00	80740.24
S_1F_3	35991.76	13.13	105040.00	69048.24
S_1F_4	35843.76	11.17	89360.00	53516.24
S_2F_1	22011.68	15.40	123200.00	101188.32
S_2F_2	21863.68	13.32	106560.00	84696.32
S_2F_3	21715.68	10.45	83600.00	61884.32
S_2F_4	21567.68	9.93	79440.00	57872.32
RDF	21151.29	8.06	64480.00	43328.71
Control	-	-*	-	-

*Yield of control plot - 7.27 t ha^{-1}

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