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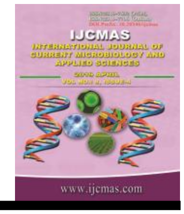

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Cost Benefit Analysis of Drip Fertigation and Flower Induction in Pineapple (*Ananas comosus* L. Merr.) Variety 'Giant Kew' in Goa, India

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ABSTRACT

The economics of drip fertigation and flower induction in pineapple variety 'Giant Kew' in Goa state, India was estimated in the present study. The field experiment was conducted in split plot design with six main plot treatments *viz.*, F0- Surface irrigation + Conventional application of 100 % RDN (12:4:12 g NPK/ plant/ cycle), F1-Drip irrigation + Conventional application of 100% RDN (12:4:12 g NPK/ plant/ cycle), F2- Fertigation with 125% RDN (15: 5:15 g NPK/ plant/ cycle), F3- Fertigation with 100 % RDN (12:4:12 g NPK/ plant/ cycle), F4-Fertigation with 75 % RDN (9:3:9 g NPK/ plant/ cycle) and F5- Fertigation with 50 % RDN (6:2:6 g NPK/ plant/ cycle) and two flower induction treatments (T1:Ethephon 25 ppm+ Urea (2%) + Sodium Carbonate (0.04%), T2: NAA 25 ppm) along with a control (T0) as the sub plot treatments. The establishment cost of drip was calculated and a depreciation of 4 %, 10 % interest on cost and 2 % repair and maintenance cost were considered for the calculation of the fixed costs and operating costs. The total cost of cultivation was estimated by adding the fixed costs and operating costs along with the main plot and subplot treatment costs. The highest total cost of cultivation of ₹ 421295.05 was recorded in F2T2 followed by F2T1 (₹ 420860.04). The net returns were calculated by deducting the total cost of cultivation from the gross returns. Among all the treatments, the net returns were the highest in F2T1 (₹ 1383500.47) followed by F3T1 (₹ 1396412.28). The highest B: C ratio of 3.34 was obtained in F3T1 followed by F2T1 (3.32). Fertigation with 100 % or 75 % RDN by straight fertilizers and flower induction by Ethephon 25ppm+ Urea (2%) + Sodium carbonate (0.04%) can give maximum returns in 'Giant Kew' pineapple production in Goa.

Introduction

Input costs and labour charges constitute the major share of cost of agricultural production. Efficient utilization of these resources is required to reduce the cost of cultivation and increase the benefit of the farmers. Surface irrigation and conventional soil application of fertilizers reduces the water and fertilizer use efficiency of the crop plants. It also causes leaching of chemical fertilizers to the nearby water bodies and ground water pollution.

Dosage, time and method of application of fertilizers play an important role in the effective utilization of mineral nutrients by the plants. Conventionally, straight fertilizers are applied in split doses at the time of planting and at critical growth stages. But the fertilizer use efficiency of straight fertilizers is low in conventional method of application. Water soluble solid fertilizers (conventional straight fertilizers) or liquid fertilizers can be effectively used in the drip fertigation to save the nutrients. Fertigation through drip irrigation can save the fertilizers up to 50 % and since the water and nutrients are readily available at root zone, the plants can utilize completely. According to Pawar and Dingre (2013), in banana, the drip method of irrigation resulted in lowest water requirement (1192.60 mm) as compared to surface method of irrigation (2170.93 mm) and resulted in 45.3 % water saving. According to More *et al.* (2005), a large portion of the labour force is utilized for irrigation in banana. Drip irrigation method can save human labour imparted for irritation.

Fruit crops are avid feeders of mineral nutrients and the heavy doses of nutrients recommended for these crops are more subjected to losses. Fertigation of fruit crops in low doses for a long period of time had proven its effectiveness in plant growth, yield and quality of many fruits and vegetable crops and enhanced the income of the farmers. Pramanik *et al.* (2016) reported that, drip irrigation at 60% of CPE with 80% of recommended NPK fertigation can provide maximum fruit yield and water use efficiency in banana. Drip can save water up to 40-60 % along with enhancing fertilizer use efficiency in Guava (Ramniwas *et al.,* 2013). Pramanik *et al.,* (2014) had also reported 90 % water use efficiency and 41.7 % water saving in drip irrigation system over 30-40 % water use efficiency in conventional flood irrigation in banana. But this technique is rarely practiced by the farmers even in the water scarce area due to the high initial establishment cost and the difficulties in maintenance due to clogging.

Pineapple (*Ananas comosus* (L.) Merr.) is an important fruit crop of Goa., as inter crop under partial shade of coconut, areca nut or forest trees. The crop is commonly cultivated as a rainfed crop without nutrients and irrigation and maintained perennially in most of the farms. Planting is done usually in May-June in order to exploit the monsoon. Since it is a hardy crop and thrives under low moisture situations, the crop survives, but with irregular flowering. Almeida *et al.* (2002) reported that, high dose of N and K at equal intervals of time or in equal amounts of N and K at decreasing intervals of time can be used for fertigation in pineapple. According to Carr, (2012), drip irrigation, micro-jets or over head sprinklers can be used in pineapple production when the water supply is restricted and the cost of labour is high.The drip irrigation depths that provided the maximum N, P, K and Ca accumulation in ‘Perola’ pineapple were 53.6, 61.6, 54.5 and 60.2% of ECA(Class A pan evaporation) respectively (Amaral *et al.,* 2014). According to Patra *et al.* (2015), in pineapple, drip irrigation was superior to micro sprinklers and sub-surface irrigation under gangetic alluvial plains of West Bengal. According to them, individual fruit weight without crown varied from 1.4 to 1.6 kg regardless of irrigation levels under drip system; and irrigation at 0.6 E0 recorded the higher yield (56.86 t/ ha), maximum water use efficiency (59.6-70.2 kg/ ha/ mm), water saving and benefit-cost ratio (3.15-3.32) with an average increase of 8.6, 10.9 and 15.4% in yield in drip irrigation scheduled at 0.6, 0.8 and 1.0 of E0, respectively.

As natural flowering in pineapple is not uniform, it leads to multiple and staggered harvest and thus increases the cost of production. Flower induction (forcing) at right maturity stage results in uniform flowering. Maximum yield (129.96 t/ha in main season and 123.73 t/ha in main season of main crop, and 111.92 t/ha in off-season and 108.60 t/ha in off-season of ratoon crop) was recorded under ethrel 100 ppm (Singh *et al.*,1999). Highest fruit weight, fruit length, fruit pulp: peel ratio were recorded with NAA 10 ppm application (Pal *et al.*, 2010). According to Suresh *et al*. (2010), NAA 10 ppm produced maximum yield per hectare (without crown) of 62.46 t. In this present study, the cost economics of fertigation and flower induction in 'Giant Kew' pineapple cultivation was analyzed.

Materials and Methods

The experiment was conducted at ICAR-CCARI, Old Goa (15° 48'58" N; Longitude, 73°92'29" E; Latitude, Altitude: 18.60 MSL) during 2016-2019. The experimental site had red lateritic soil with acidic pH (6.34) and EC (0.34 dSm^{-1}). The soil was virgin and organic carbon content was high (1.22 %) with high organic matter content (2.10%). The soil had 143.17 kg/ ha available Nitrogen, 33.43 kg/ ha available Phosphorus and 244.79 kg/ ha available Potassium at the time of initiation of the experiment.

A popular pineapple cultivar, 'Giant Kew' locally known as 'Raja' was used for the experiment. Uniform sized suckers were planted in trenches (90x60x45 cm) with population density of 41152 plants/ ha. The study was conducted in split plot design with six main plot treatments *viz.,* F0- Surface irrigation + Conventional application of 100 % RDN (12:4:12 g NPK/ plant/ cycle), F1- Drip irrigation + Conventional application of 100% RDN (12:4:12 g NPK/ plant/ cycle), F2- Fertigation with 125% RDN (15: 5:15 g NPK/ plant/ cycle), F3- Fertigation with 100 % RDN (12:4:12 g NPK/ plant/ cycle), F4- Fertigation with 75 % RDN (9:3:9 g NPK/ plant/ cycle) and F5- Fertigation with 50 % RDN (6:2:6 g NPK/ plant/ cycle) and two flower induction treatments (T1: Ethephon 25 ppm+ Urea 2%+ Sodium Carbonate (0.04%), T2: NAA 25 ppm and a control (T0). Irrigation water requirement of pineapple at different stages was calculated for the particular experimental location from 14 years (2003-2016) consolidated weather data obtained from the meteorological observatory of ICAR- CCARI, Ela, Old Goa. In F0 and F1 treatments, $1/4^{th}$ quantity of N and K were given as basal and remaining were given in three equal splits at three months interval. Full dose of phosphorus was applied as basal at the time of planting in all treatments. Weekly fertigation with Urea (46% N) and Muriate of Potash (60 % K_2O) were given at different crop growth stages as described by Malezieux and Bartholomew (2003). During the monsoon season (June- September), fertigation was stopped due to heavy rainfall and the missed dosages were compensated in the following months.

Flower induction treatments were applied when the crop reached 40 leaf stages. The treatment solutions (50 ml/ plant) were poured in the centre of the core during evening hours, since the stomata of pineapple opens during that time (CAM photosynthetic adaptation). The plants started flowering after 45 days of treatment application and harvesting was done when the fruits attained $1/3^{rd}$ yellow in the bottom region. Per hectare yield was calculated by multiplying mean fruit weight with total number of plant per hectare.

Cost of establishment of the drip system

Land tax was negligible for the experimental area and was not considered for calculation. The irrigation water source was a well in the plot with a motor. A depreciation of 2% was applied to it in calculating the fixed cost of both fertigation treatments and the surface irrigation treatments. Cost of establishment of the drip system included the cost of pipe network system, emitting system, fitting and accessories and installation charges with 12 % GST. The life span of the drip system was considered as 10 years. A depreciation of 4 % and 10 % interest on cost was applied to the establishment cost to calculate the fixed cost.

Cost of cultivation of pineapple except the treatments

Cost of cultivation was same for all treatments except the treatment costs (main plot treatments + sub plot treatments). It included cost of planting material, farm yard manure, plant protection chemicals, and transportation and electricity charges. The man power utilized for the land preparation, weeding and other cultural operations were considered uniform for all treatments. Labour charges @ ₹ 600/ man/ day for a total of 180 man days were required for pineapple production per cycle.

Cost of the treatments

The cost of main plot treatments was calculated by considering the cost of fertilizers and application charges. F0 and F1 treatment had manual application of fertilizers and irrigation water. Surface irrigation was provided to F0 treatment in weekly interval with hose pipe. Fertilizers were applied in four months interval in split doses in F0 treatment. Treatment application cost of F0 treatment was considered as 4 man days/ crop cycle. The subplot treatments were applied once in a crop cycle and application cost was considered for a single man day with 20 laborers.

Total cost of cultivation

Total cost of cultivation included the fixed costs, operational costs and the cost of main plot and subplot treatments.

Total cost of cultivation (Rs.) = Cost of establishment + Cost of cultivation except the treatments + Cost of the main plot treatment + Cost of subplot treatment.

Gross returns (₹) = Yield (Kg/ ha) x Price of pineapple (₹ / kg)

Net returns (₹) = Gross returns – Total cost of cultivation

Benefit: Cost ratio (B: C ratio) = Net returns/ Total cost of cultivation

Results and Discussion

The fixed cost involved in drip system was land tax (which is very low and considered as negligible). Cost of water source (well) and the motor was ₹ 75000.00 (with 2% depreciation), cost of establishment (₹ 311373.00) with 4% depreciation and 10 % interest cost. The drip fertigation system had components like pipe network system, emitting system including venturi and fitting and accessories. The details of the cost of establishment are mentioned in Table 1.

The operating costs were the repair and maintenance cost of the drip system (2% of the establishment cost), cost of panting materials, cost of farm yard manure, land preparation charges, transportation charges and labour charges. The details of fixed and operation costs involved were described in Table 2.

F0 recorded ₹ 328350.00 as the cost cultivation except the treatment; and for all other treatments, it was ₹ 378169.68. Among the main plot treatments, F2 recorded the highest cost (₹ 34797.25) followed by F0 (₹ 29756.10) (Table 3). In F0, F1 and F3 treatments, the amount of fertilizers used were same; but the application cost was higher in the F0 treatment. According to Pramanik *et* *al.* (2014) high cost of liquid fertilizers has increased the total cost on fertilization in banana, but drip fertigation system reduced the labour costs by 15-20 per cent and allowed mechanized and easy cultivation. In this experiment, the use of straight fertilizers (Urea 46% and MOP 60 % K_2O) had considerably reduced the cost of the treatments. Among the flower induction treatments, Ethephon treatment was cheaper compared to NAA. The total cost of T1 treatment was ₹ 12493.11 and T2 was ₹ 12928.12. The cost of flower induction chemical application was ₹ 12000.00 in both treatments. Flower induction chemicals were manually poured to the central rosette cup of the plant and mechanization is not possible for this operation. In this experiment, flower induction was given only once when more than 90 % of the plant population attained 40 leaves.

Table.1 Cost of establishment of the fertigation system for one ha pineapple

Sl. No.	Particulars	Unit	Qty.	Rate (₹)	Amount (₹)
A	**Pipe Network**				
1	PVC Pipe 50mm	M	216	53.00	11448.00
2	PVC Pipe 75mm	M	144	62.00	8928.00
	Sub Total A				20376.00
B	**Emitting System**				
1	Drip Lateral 16mm	M	800	10.00	8000.00
2	Inline 16-4-40cm	M	14400	10.60	152640.00
3	Joiner 16 Mm	Nos.	520	3.00	1560.00
4	Line end 16 mm	Nos.	2800	3.30	9240.00
5	GTO 16 mm	Nos.	520	4.70	2444.00
6	Sand Filter (2.5’’)	Nos.	1	24500.00	24500.00
7	Disc Filter (2.5’’)	Nos.	1	5000.00	5000.00
8	Venturi	Nos.	1	2200.00	2200.00
9	PVC Ball Valve 50 mm	Nos.	2	410.00	3280.00
10	Flush Assembly 50 mm	Nos.	2	66.00	528.00
	Sub Total B				229768.00
	Sub Total Rs.(A+B)				250144.00
	Fitting and accessories cost				16243.40.00
	Sub Total Rs.(A+B+C)				246011.40
D	Installation Charges				32000.00
	Sub Total (Material+ Installation Charges)				278011.00
	GST @12%				33361.37
	TOTAL				**311373.00**

Table.2 Fixed costs and operating costs of fertigated pineapple cultivation except treatments in drip and surface irrigation

Sl. No.	Particulars	Cost of cultivation except treatment in drip irrigation treatments (₹)	Cost of cultivation except treatment in surface irrigation treatment (₹)
Fixed costs			
A.	Water source (well)+ motor charges (₹ 75000) with 2% depreciation	1500.00	1500.00
B.	Cost of establishment of drip system (₹ 311373.00) with 4% depreciation	12454.92	0.00
C.	Interest cost (10 %) of establishment cost	31137.30	0.00
D.	Fixed cost total (A+B+C)	45092.22	1500.00
Operating costs			
E.	Cost of repair and maintenance of drip (2%) of establishment cost	6227.46	0.00
F.	Cost of panting material @ Rs. 5/- 41152 plants/ ha (90x 60x 45 cm)	205760.00	205760.00
G.	Farm Yard manure @ 999/m^3 -10 t/ ha	9990.00	9990.00
H.	Plant protection chemicals	100.00	100.00
I.	Transportation	2000.00	2000.00
J.	Miscellaneous	1000.00	1000.00
K.	Man power (180 man days/ crop cycle) @ ₹ 600/- person including all cultural operations including harvest)	108000.00	108000.00
L.	Operating cost total (E+F+G+H+I+J+K)	333077.46	326850.00
	TOTAL (D+L)	378169.68	328350.00

Table.3 Cost of main plot and subplot treatments in the fertigated pineapple production

Main plot treatments	Quantity of fertilizers (kg/ ha)			Cost of fertilizers (Rs.)			Cost of application (Rs.)	Total (Rs.)
	Urea	Rock Phosphate	Muriate of potash	Urea @Rs. 6/ kg	Rock Phosphate @ Rs.9/ kg	Muriate of potash @ Rs. 12/ kg		
F0	1073.24	914.39	823.04	6439.44	8229.51	9876.48	2400.00	29756.10
F1	1073.24	914.39	823.04	6439.44	8229.51	9876.48	600.00	27956.10
F2	1341.55	1143.20	1028.80	8049.30	10288.80	12345.60	600.00	34797.25
F3	1073.24	914.39	823.04	6439.44	8229.51	9876.48	600.00	27956.10
F4	805.34	686.00	617.28	4832.04	6174.00	7407.36	600.00	21122.02
F5	536.62	457.20	411.52	3219.72	4114.80	4938.24	600.00	14278.10
Subplot treatments						**Cost of chemical (Rs.)**	**Cost of application (Rs.)**	**Total (Rs.)**
T0: Control						0.00	0.00	0.00
T1: Ethephon 25 ppm (131.90 ml @ Rs.1450.00/ l)+ 2 % Urea (41.152 kg @ Rs. / kg+ 0.04% Sodium Carbonate (0.82 kg @ Rs.67.00/ kg						493.11	12000.00	12493.11
T2: NAA 25 ppm (1.143 l Planofix (4.5 %SL) @ Rs. 812.00/ l						928.12	12000.00	12928.12
Quantity of flower induction chemical applied =2057.6 L/ ha treatment solution @ 50 ml/ plant Treatments are applied on the same day with 20 labourers@ 2000 plants/ person Application cost @ Rs. 600/ person = 20 x 600= 12000.00								

Table.4 Cost economics analysis of fertigated and flower induced 'Giant Kew' pineapple main crop

Treatments	Cost of cultivation except treatment (A) (Rs.)	Cost of main plot treatment (B) (Rs.)	Cost of subplot treatment (C) (Rs.)	Total cost of cultivation (Rs.) A+B+C	Yield (kg/ ha)	Gross returns @ Rs. 18/ kg	Net returns (Rs.)	B: C Ratio
F0T0	328350.00	32356.10	0.00	360706.10	73662.08	1325917.44	965211.34	2.68
F0T1	328350.00	32356.10	493.11	361199.21	78463.15	1412336.64	1051137.43	2.91
F0T2	328350.00	32356.10	928.12	361634.22	77228.59	1390114.56	1028480.34	2.84
F1T0	378169.68	35356.10	0.00	413525.78	89574.19	1612335.36	1198809.58	2.90
F1T1	378169.68	35356.10	493.11	414018.89	92729.17	1669125.12	1255106.23	3.03
F1T2	378169.68	35356.10	928.12	414453.90	90671.57	1632088.32	1217634.42	2.94
F2T0	378169.68	42197.25	0.00	420366.93	95472.64	1718507.52	1298140.59	3.09
F2T1	378169.68	42197.25	493.11	420860.04	100959.57	1817272.32	1396412.28	3.32
F2T2	378169.68	42197.25	928.12	421295.05	97255.89	1750606.08	1329311.03	3.16
F3T0	378169.68	35356.10	0.00	413525.78	94100.91	1693816.32	1280290.54	3.10
F3T1	378169.68	35356.10	493.11	414018.89	99862.19	1797519.36	1383500.47	3.34
F3T2	378169.68	35356.10	928.12	414453.90	96432.85	1735791.36	1321337.46	3.19
F4T0	378169.68	28522.02	0.00	406691.70	90989.82	1637816.68	1231124.98	3.03
F4T1	378169.68	28522.02	493.11	407184.81	93552.21	1683939.84	1276755.03	3.13
F4T2	378169.68	28522.02	928.12	407619.82	91906.13	1654310.40	1246690.58	3.06
F5T0	378169.68	21678.10	0.00	399847.78	84635.95	1523447.04	1123599.26	2.81
F5T1	378169.68	21678.10	493.11	400340.89	86556.37	1558014.72	1157673.83	2.89
F5T2	378169.68	21678.10	928.12	400775.90	85458.99	1538261.76	1137485.86	2.84

Total cost of cultivation was the highest in F2T2 (₹ 421295.05) followed by F2T1 (₹ 420860.04) and F2T0 (₹ 420366.93) (Table 4). The lowest cost of cultivation was recorded in F0T0 (₹ 360706.10). The yield was the highest in F2T1 (100959.57 kg/ha) followed by F3T1 (99862.19 kg/ha). The gross return @ ₹ 18/ kg fruits and the net returns were also highest in F2T1 (₹ 1817272.32 and ₹ 1396412.28 respectively). Among all the treatments, the highest benefit cost ratio was recorded in F3T1 (3.34) followed by F2T1 (3.32). Patra *et al.,* 2015 had reported BC ratio of 3.15-3.32 in drip irrigated pineapple cv. 'Kew' in gangetic plains of India. The cost of cultivation of F2 treatments was higher than the F3 treatments. Hence even though the yield was higher in F2T1, the highest BC ratio was obtained in F3T1.

The study proved that the cultivation of Pineapple in the Goa state has great potential. The soil and climate is suitable for exploiting the yield potential of the crop. Initial establishment cost of the drip system was high, but the additional benefit obtained by the increased yield will compensate the higher cost of production with drip fertigation. Application of flower induction hormones can induce flowers uniformly and can reduce the cost of production. Drip fertigation and flower induction can influence the yield of the crop and enhance the productivity. The crop can be continued for at least two ratoons. Drip fertigation with 100% RDN or 75 % RDN and the flower induction with Ethephon were found to be highly economical for pineapple production in Goa.

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