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Microtube Irrigation For Banana Cultivation in South Bihar: Participatory Assessement and Refinement

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ABSTRACT*

To evaluate the efficacy of drip irrigation to improve production and quality of horticultural crops in humid region of eastern India, a participatory study was carried out at four locations in Patna district (Bihar, India) with banana as target crop. Initially, the system was laid out as per conventional design having TABE (take apart button emitter) with 12mm lateral which gave 7.2 l/h discharge with coefficient of variation of 54%. The system was refined to improve its performance and reduce the cost as per need and perception of the farmers. Farmers expressed one TABE per plant insufficient and hence, TABE were replaced with newly designed star microtube emitters, which delivered water at four points in a circle of 25 cm diameter around a plant. A decreasing trend in the discharge along lateral was observed which was rectified by replacing the lateral with 16mm lateral. The system had better performance with less discharge variations and cheap as compared to conventional system. The system was tested with two varieties of banana: *Alpan* and *dwarf Cavendish*. Farmers were satisfied with the refinements and realized advantages of drip irrigation in early shooting and bunch emergence, better finger size and bunch size, and better returns. Considering annualised cost of the drip system and benefits due to improved production only, the B-C ratio was 1.01 to 1.87 for var. *Alpan* and 1.61 to 1.75 for var. *dwarf Cavendish*.

Drip irrigation yields better production and improved quality of produce with less cost, and can play an important role in diversification of agriculture from the present rice-wheat system to horticulture based cropping system, for which immense opportunity exists in Bihar. In eastern region, farmers are mostly resource poor and have low risk bearing capacity. To popularize the drip irrigation among small farmers (Postel et al., 2001), it is essential that the technology is assessed and refined to suit the local conditions and involve low initial and operational cost (Polak et al., 1997). Keeping this in view, drip irrigation was undertaken as an intervention in the National Agricultural Technology Project (NATP), sub-project "Technology Assessment and Refinement (TAR) through Institute Village Linkage Programme (IVLP) under Irrigated Agro Eco Region in the Command of Sone Canal System, Bihar". Based on the experience, need and farmers' perception, the drip irrigation design was assessed in farmers' field conditions in participatory mode and refinements were carried out to improve performance of the system with satisfaction of the farmers.

Banana is quite a remunerative horticultural crop which is mostly grown in northern Bihar. In southern Bihar (south of Ganges), commercial cultivation of banana is generally not in practice. Drip irrigation in banana has also been reported to be economical (Behra and Sahoo, 1998; Desale et al., 2003). Hence, Banana (Musa sp., AAA group) was selected as target crop for introduction and assessment of drip irrigation. Success of such intervention can open new vistas not only for crop diversification but also for improvement in livelihood of the farmers.

MATERIALS AND METHODS

The project area of IVLP consisted of four villages viz. Beeranchak (F1), Beerpur (F2), Bhelura Rampur (F3), and Doshia tola (F4) in Naubatpur block of Patna district. One suitable field was selected in each village and two varieties of the banana, viz. Alpan (tall) variety and dwarf Cavendish (dwarf) were planted during 1-5 August 2003 at a spacing of 3.0 x 3.0 m and 1.5 x 1.5 m, respectively. The study was taken up in participatory mode with knowledge and input sharing. Drip system, diesel for operation, sucker seeds, and partial cost of chemical fertilizers were provided by the Project, while land, labour, organic fertilizers (compost and poultry manure), pump and well, part of chemical fertilizers and pesticides, etc were contributed by the farmers.

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Layout of the Drip System

Drip irrigation system was laid in the four villages. The fields had a tube well adjacent to or in the field fitted with 5 hp pump. One filter to each of the system was connected with provision for connecting fertilizer tank. Main line (50 mm PVC pipe) was laid along one of the boundary of the field and laterals (12 mm) were laid across the field. TABE (take apart button emitters) were attached to laterals with one emitter per plant. After 3 months of operation of the system when plants grew bigger, it was realized that one emitter was insufficient to distribute the water-front to entire root zone. Lopaz and Abreu (1985) also reported similar experience and used more than two emitters per plant. Farmers had shown their apprehension that such water application will not meet the water requirement all around the plant and plant may suffer due to water deficit. This would require 3-4 emitters to apply water around the plants. But, this would have increased the cost of the system substantially. Keeping this in view, following refinements were carried out in emitters.

Refinements in Emitters

Star microtube emitters developed by Bhatnagar and Srivastava (2003) for gravity fed irrigation system for vegetables, was introduced for the banana with one star emitter for each plant for applying water at four locations around the plant (Fig. 1). Farmers were quite satisfied with this refinement. However, in due course, it was realized that water application was less for the plants located at the end of the lateral, especially for dwarf plants having more number of emitters per lateral as compared to tall plants. It was due to increased friction losses as the discharge with the star emitter was more as compared to TABE. Varying the length of microtubes to compensate the head losses in lateral is one of the solutions as suggested by Bhatnagar and Srivastava (2003) and increasing the size of lateral is another solution. Convincing the farmers with second solution was easier and therefore, replacement of 12 mm lateral with 16 mm lateral for dwarf plants was carried out as second refinement.

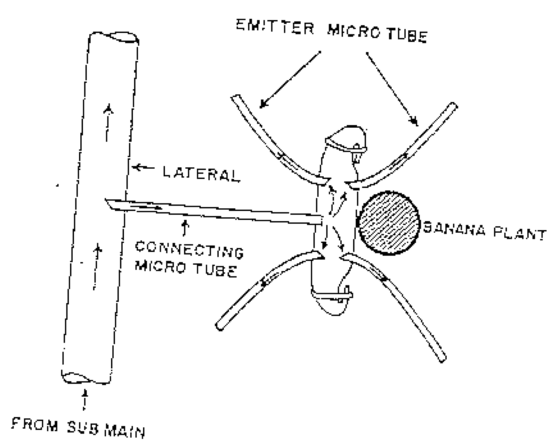

Fig. 1: Star microtube emitters for banana

Irrigation Scheduling and Fertigation

The banana was scheduled for irrigation at 60% of pan evaporation. From practical point of view, a rough calculation was made and then as a thumb rule, water was applied for one hour twice a week during summer season, and half an hour twice a week during winter season. Under farmer's practice (no-drip), farmers apply water (100 mm or more) through flooding in the check basins once in 20 days during winters and once in 10-15 days during summer. However, based on rainfall occurrence, the water application was delayed as per common judgment of the farmers under both the methods. Fertiliser in the form of Urea, SSP, and MOP was applied as per recommendation. Basal dose of 25% of Urea and MOP, 50% of SSP was applied and rest was applied in 4-5 splits as fertigation through drips using fertilizer tank.

RESULTS AND DISCUSSION

Comparison of Water Emission Systems

Three types of water emission systems were tested i.e. TABE with 12 mm laterals, star emitters with 12 mm laterals and star emitters with 16 mm laterals. Cost comparison was also made if two emitters were provided on the same lateral and four emitters provided with a piece of lateral surrounding the plant. The non-pressure compensating TABE had average discharge was 7.2 l/hr with coefficient of variation of 54% (Fig. 2). The discharge obtained with star emitter (with 12mm lateral) was 15.1 l/h, with a uniform decrease in the discharge with increasing length of the lateral (Fig. 3). The discharge decreased from 35 l/hr near main line to < 5 l/h near end of the lateral for 36 m of lateral length with coefficient of variation as 52%. The second refinement was carried out for another field having 25 m of lateral. When the lateral was changed to 16 mm size, the average discharge increased to 26.7 l/hr and the coefficient of variation in discharge reduced to just 17%. Farmers were very happy to observe the uniformity and showed their appreciation.

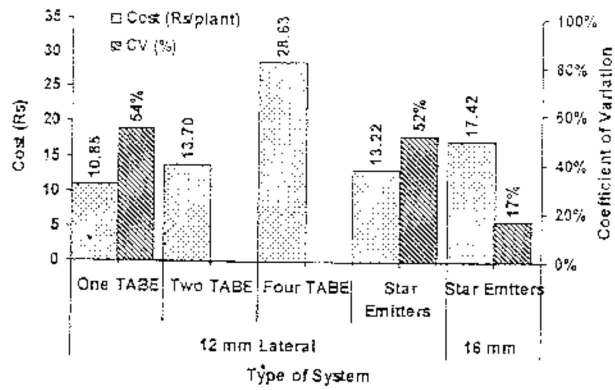

Fig. 2 : Comparison of cost and coefficient of variatioin discharge for different water emission systems

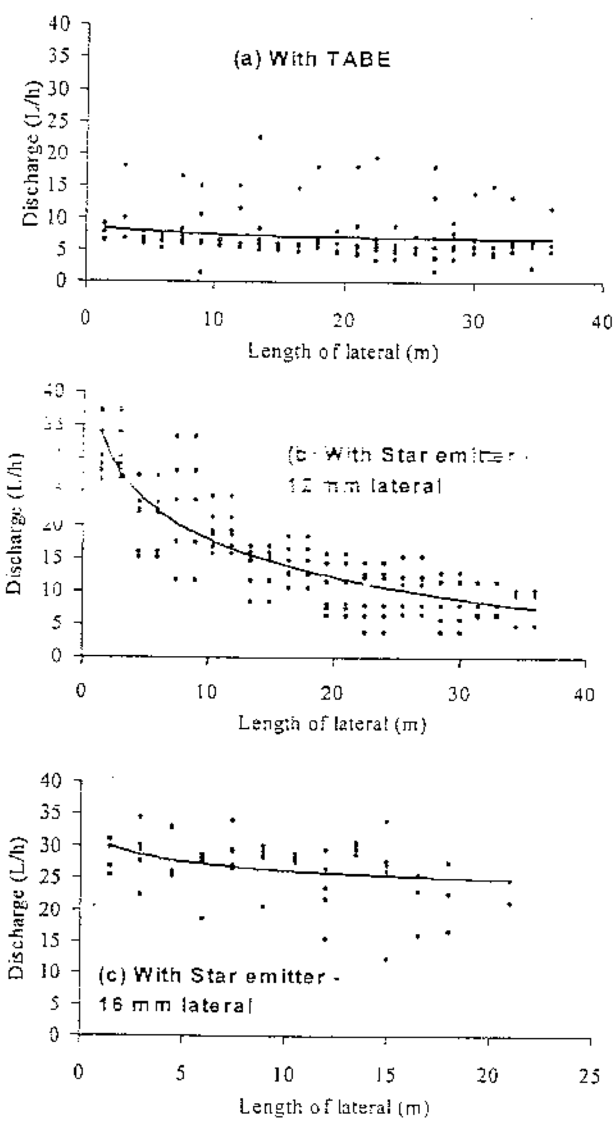

Fig. 3 : Variation in discharge along the length of lateral for different water emission system

The cost of lateral and emitters with one TABE/plant was Rs 10.85, which is expected to increase to Rs 28.63 for four TABE plant, an increase by 164%. This was too high from farmer's point of view. The star emitter cost Rs 4.67 as compared to Rs 2.80 for TABE. Including the cost of lateral the total cost works out to Rs 13.22/plant for one star/plant, an increase by 22% over TABE (Fig.2). But it delivered water at four points around the plant instead of one point. Even by replacing the lateral by 16 mm tubings, the cost was Rs 17.42/plant.

Irrigation Water Saving

During monsoon period (July – October), no irrigation is required, except during the longer dry spells. The details of irrigation water application along with rainfall and class A pan evaporation is given in Table 1. Drip irrigation met below 50% of cumulative pan evaporation (CPE) during summer months, while during November and winter months, it was between 70-85%. In farmer's practice, irrigation of around 200% CPE was estimated to be applied during winters and 80-100% in other periods. It showed a saving of water around 370 mm during the 20 months of study, which saved diesel of more than Rs 6000/ha.

Banana Yield

Drip irrigation coupled with fertigation improved the quality and yield of banana in both the varieties (Table 2). It accelerated the flowering and harvesting of banana by about 3 months (i.e. flowering in May 2003) under drip irrigation plots while it started by the end of July 2003 for no-drip plants. The size of fingers was bigger for drip irrigation (35-45 mm diameter for dwarf Cavendish variety) as compared to no-drip irrigated fingers (28-37 mm). However, number of fingers per bunch had no trend. At locations F2 and F4, the number of fingers per bunch was more for no-drip treatment. However, as the finger size was small and of poor quality, the market value of banana with no-drip fingers was lesser than drip irrigated ones. However, at location F4, adverse soil conditions (hard soil along with water stagnation during monsoon and poor fertility), and failure of pumps for longer period caused lesser production under drip irrigation. Whereas, the plants received sufficient water from canal irrigation under farmers practice condition. Hence, the benefits from drip irrigation could not be realized at F4. At field location F1, no-drip treatment could not be undertaken due to constraint of land availability near pump. Farmer at F1 location cooperated nicely and provided all inputs to the plants as per recommendations and therefore, maximum benefit was realized as compared to other locations.

Proper irrigation scheduling is very important in realizing maximum benefits from an irrigation system. The irrigation scheduling with 80 to 100% of CPE is reported in the literature for drip in banana (Tiwari and Reddy, 1997; Goenaga and Irizarry, 1998, etc.). But, the irrigation applied through drip was less (Table 1) as compared to recommended amount. It indicates the potential for better production, however, it will increase the cost of production and economic viability has to be worked out.

Economics

Banana is mostly sold by number of fingers or bunch (at field level) rather than by weight in the region, and its price depends on quality (size and freshness) of the fingers and its timing of harvesting. Farmers' perception indicates that the banana produced under drip irrigation had better liking and was sold at relatively higher price. Farmers sold banana of both varieties grown with drip for Rs 40 to 120 per bunch, while it was Rs 30 to 60 per bunch for no-drip treatment. However, as expressed by the farmers, an average price of Rs 65 per bunch for drip irrigated and Rs 40 per bunch for non-drip banana was used in the economic calculations.

Economic analysis is given in Table 3. Average cost of the system was estimated as Rs 63,500/ha with star emitters and 12 mm laterals, while it was about Rs 73,600/ha with 16 mm lateral for 3.0 x 3.0 m spacing excluding the cost of filter and fertilizer tank. The cost for 1.5 x 1.5 m spacing was Rs 1,37,000 and Rs 1,66,000 /ha, respectively, for the two systems. However, the cost of drip system largely depends upon size and shape of the field. For relatively bigger field in F4, the cost of the system was 15% and 37% less than the above values, respectively for the two spacing, which was mainly because cost of mainline did not increase with size of field. Since cost of filtration and fertigation unit depends largely on size of field and its value becomes insignificant for larger field sizes, it was excluded in the analysis.

Except for location F4 with var. Alpan, the drip system had B-C ratio of around 1.55 for tall variety and 2.03 to 2.47 for dwarf variety. After recovering the annualised cost of the system, a net benefit of Rs 17,000 to 19,000 and Rs 97,000 to 99,000 per ha was realised (Table 3). The cost of cultivation excluding irrigation was worked out to be around Rs 30,000/ha for var. Alpan and Rs 89,000/ha for var. dwarf Cavendish. As a diversification of agriculture, banana cultivation with drip irrigation was found to be remunerative as well as economically viable. Because of adverse soil conditions and faulty pumping unit, the response at F4 was poor.

The above analysis indicated economic viability of the system considering banana production only. However, as the farmers obtained more price due to better quality and realised saving in inputs including labour, etc. are other benefits which further improve the economics.

Table 1. Water application under drip and farmer's practice and saving in diesel

Item	Nov'03	Dec'03-Feb'04	Mar-Jun'03	Jul-Oct'03	Nov'03	Dec'04-Feb'04	Mar'04	Total / Average
Rainfall (mm)	0	72.2	189.3	967.9	0	26.1	0	1256
Evaporation (mm)	104.49	171.19	681.56	449.12	67.52	140.35	143.80	1758
Drip Irrigation (mm)	73.82	80.53	194.62	13.42	57.04	83.89	60.40	564
EIFP*	88.89	222.22	311.11	0.00	44.44	222.22	44.44	933
Irrigation as % of CPE Drip	70.65	81.36	39.54	-2.59	84.49	73.43	42.00	53.88
EIFP	85.07	224.49	63.20	0.00	65.82	194.51	30.91	91.39
Saving in water (mm)	15.07	141.69	116.49	-13.42	-12.60	138.33	-15.96	370
Saving in Diesel$ (l/ha)	8.37	78.72	64.72	-7.46	-7.00	76.85	-8.86	205
Saving in Diesel (Rs/ha)#	251.11	2361.48	1941.48	-223.70	-210.00	2305.56	-265.93	6160

CPE-Cumulative pan evaporation; EIFP-Estimated irrigation by farmer's practice; $For 5 HP pump: 5 l/s discharge and 1 litre/hr diesel consumption; # Diesel cost Rs 30/l

Table 3. Economic analysis for drip system for banana production

Item	Location of the field				Wt. Av. (per ha)'
	F1	F2	F3	F4	
A - Variety - Alpan at 3.0 x 3.0 m spacing					
Cost of the drip system					
1) Filter and fertigation unit	7,500	7,500	7,500	7,500	7,500
2) Main line	1,536	1,536	1,536	1,536	34,362
3)a. Emitters (star) & Lateral (12 mm)	1,142	981	1,165	1,154	24,673
b. Emitters (star) & lateral (16 mm) ' 1,618	1,373	1,641	1,625	34,766	
Installation cost (Rs)	200	200	200	200	4,474
Annual cost of system (Rs)*	884	835	891	888	19,503
System cost for 20 months (Rs/ha)	32,728	35,123	29,994	29,352	32,426
Additional Income due to drip system (Rs/ha)	-	54,545	46,827	11,964	
Net Benefit (Rs/ha)	-	19,423	16,833	-17,387	
B-C ratio	-	1.55	1.56	0.41	
B - Variety - Dwarf Cavendish at 1.5 x 1.5 m spacing					
Cost of the drip system					
1) Filter and fertigation unit	7,500	7,500	7,500	7,500	7,500
2) Main line	1,536	1,536	1,536	1,536	59,305
3) a. Emitters (star) & Lateral (12 mm)	2,110	1,648	833	3,008	66,266
b. Emitters (star) & lateral (16 mm)	2,816	2,208	1,110	4,016	88,533
Installation cost (Rs)	300	300	300	300	11,583
Annual cost of system (Rs)*	1,212	1,0[illegible]	820	1,488	42,119
System cost for 20 months (Rs/ha)	55,411	66,[illegible]	96,371	47,089	72,611
Additional Income due to drip system (Rs/ha)	-	[illegible]	195,31[illegible]	[illegible]	
Net Benefit (Rs/ha)	-	96,895	98,942	[illegible],572	
B-C ratio	-	2.47	2.03	1.27	
Economics of Banaua Production with Drip irrigation$					
B-C ratio of var. Alpan	1.87	1.01	1.14	0.59	1.34
B-C ratio for var. Dwarf Cavendish	1.69	1.75	1.61	0.83	1.63

9% interest and 5 yr life + 5% annual maintenance (with 12 mm lateral, excluding filter and fertigation unit); $ Considering cost o[f] production (excluding irrigation) for banana Rs 30,000/ha for var.Alpan and Rs 89,000 for var. dwarf Cavendish; 'Area weighted averag[e] per ha (excluding F4)

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REFERENCES

Behra B P; Sahoo N. 1998. Economic evaluation [of] drip irrigation systems in Orissa. Environ. Ecol., 16(2 297-299.

Bhatnagar P R; Srivastava R C. 2003. Gravity-f[ed] drip irrigation system for hilly terraces of the northw[est] Himalayas. Irrigation Sci., 21, 151-157.

Table 2. Banana production under drip and no-drip (farmer's practice) treatments.

Item\Field location		Village F1	F2	F3	F4	Wt.Av. (per ha)*
Variety - Alpan at 3.0 x 3.0 m spacing						
Area (m²)	Drip	450	396	495	504	447
	No Drip	-	540	261	315	401
No.banana planted	Drip	50	44	55	56	1,120
	No Drip	-	60	29	35	1,188
No. bunches harvested up to March'2004	Drip	81	40	52	27	1,302
	No Drip	-	15	14	18	401
Av. No. of fingers/bunch	Drip	180 (28)	94 (20)	105 (30)	86 (22)	127 (26)
	No drip	-	97 (29)	64 (17)	86 (23)	88 (25)
Income (Rs/ha)	Drip	108,000	60,606	63,030	32,143	77,405
	Non-drip	-	16,667	32,184	34,286	28,129
Variety - Dwarf Cavendish at 1.5 x 1.5 m spacing						
Area (m²)	Drip	365	270	142	527	259
	No Drip	-	11	90	223	51
No.banana planted	Drip	162	120	63	234	17,758
	No Drip	-	5	40	99	7,166
No. of bunches harvested up to March'2004	Drip	137	113	65	92	15,861
	No Drip	-	3	23	30	4,123
Av. No. of fingers/bunch	Drip	118 (28)	96 (20)	75 (32)	42 (13)	102 (26)
	No Drip	-	110 (13)	60 (23)	50 (12)	93 (16)
Income (Rs/ha)	Drip	225,205	251,111	274,648	104,744	243,243
	Non-drip	-	163,6[illegible]	153,333	80,71[illegible]	16[illegible],385

* Area Weighted average per ha (excluding F1), Value in parenthesis are standard deviation in no. of fingers per bunch

Farmer's Response

The demonstrations carried out at four locations created awareness about the drip irrigation system in the eastern region. Initially, the farmers were reluctant in accepting the drip irrigation as they thought, it was a costly system and required skill to operate. Moreover, as the site was in canal command area, farmers thought that the drip irrigation is only water saving technology and is irrelevant in their case. But, through success of the interventions, thinking has been initiated about relevance and usefulness of the drip irrigation especially for diversification of their agriculture to more remunerative horticulture production. Early shooting and bunch emergence, good quality, better production, ease in water application and handling of the system are some of the advantages felt by the farmers in using drip irrigation with star emitters. They also felt that there is saving in irrigation water as well which will benefit to the farmers who use ground water for irrigation.

CONCLUSIONS

The benefits of drip irrigation have been demonstrated in the farmer's field in participatory mode. Besides savings in diesel and other inputs, the drip irrigation was shown to be economically viable only from the benefits accrued from improved production. As the farmers were actively involved in the process implementation and evaluation, refinement of the technology, a good response has been obtained from the farming community. Drip irrigation with star microtube arrangement was found convincing due to better performance, water delivery around plant and easy handling that require less skill to operate and maintain. But, still low investment capacity of the farmers and lack of infrastructure to support the system, are the bottlenecks in wider adoption of the technology in eastern region.

Desale P G; Pawar P P; Patil R P 2003. Economic analysis of drip irrigation for banana. Indian J. Agri. Economics, 58(3), 506

Goenaga R; Irizarry H. 1998. Yield of banana grown with supplemental drip-irrigation on an ultisol. Experimental Agriculture, 34, 439-448.

Lopaz J R; Abreu J M H 1985. Localised banana irrigation systems evaluation in the Canary Islands. In: Drip/Trickle Irrigation in Action. Proc third International Drip/Trickle Irrigation Congress, Fresno, California, USA (18-21 November, 1985), 281-287.

Polak P; Nanes B; Adhikari D 1997. A low cost drip irrigation system for small farmers in developing countries. J. Am. Water Resour. Assoc, 33, 119-124.

Postel S; Polak P; Gonzales F; Keller J 2001. Drip irrigation for small farmers, a new initiative to alleviate hunger and poverty. Water International, 26(1), 3-13.

Tiwari K N; Reddy, K Y. 1997. Economic analysis of trickle irrigation system considering geometry. Agricultural Water Management.