Current Horticulture **11**(1): 57–60, January–April 2023

Analysis of benefit: cost ratio in drip irrigation and fertigation in greater yam *(Dioscorea alata)* + maize *(Zea mays)* intercropping system

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https://doi.org/10.5958/2455-7560.2023.00013.4

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Received: 8 September 2021; **Accepted:** 15 May 2022

ABSTRACT

A field experiment was conducted at Regional Centre, ICAR-Central Tuber Crops Research Institute, Bhubaneswar, Odisha, India, during 2015-16 and 2016-17 to study drip irrigation and fertigation in greater yam (*Dioscorea alata* L.) + maize (*Zea mays* L.) intercropping system. The treatments I_2F_4 and I_2F_3 resulted in 31.8 and 29.9% higher tuber equivalent yield, respectively than the control. Drip irrigation increased fertilizer responsiveness in greater yam + maize intercropping system. However, response to fertilizer was higher under partial deficit irrigation. Thus 20% more fertilizers can be recommended under drip fertigation than surface irrigation with soil application. Drip irrigation reduced cost on weeding and irrigation. The total cost reduction (excluding capital cost, harvesting and threshing) was about 8.3% (₹ 11,500/ha) and 7.1% (₹ 9,900/ha) due to drip irrigation at I_1F_2 and I_2F_2, respectively compared to surface flood irrigation at the same level of fertilizer application (control). The gross and net returns in treatment I_1F_2 were 5.2 and 3.1% higher, respectively than the control, saving 21.2% irrigation water. The treatment I_3F_2 resulted in 21.1 and 24.7% higher gross and net returns, respectively than the control. Thus, drip fertigation increased water- and fertilizer-use efficiency (20%).

Key Words: Tuber equivalent yield, Gross return, Net return, Intercropping, Fertigation, Drip irrigation

Greater yam (*Dioscorea alata* L.) + maize (*Zea mays* L.) intercropping system is getting popular in irrigated areas due to its higher productivity and returns. However, providing surface flood irrigation and top dressing of fertilizer to greater yam + maize intercropping system at later stage of crop growth period (after 4 months) is difficult due to drying and lodging of maize and coverage of ground by greater yam crop (Nedunchezhiyan *et al.*, 2021a). Irrigation efficiency in drip irrigation is as high as 90% compared to 30-50% in surface irrigation. However, when irrigation water priced, surface flood irrigation become is costlier. Also, additional costs are incurred for weeding and frequent irrigations (Gangaiah *et al.*, 2019). Drip fertigation results in 25-50% savings in fertilizer dose and increase in productivity of 50-75% in coconut (Maheswarappa and Krishnakumar, 2019). Nedunchezhiyan *et al.* (2018) and Bhargavi *et al.* (2019) also reported similar report. Hence, keeping in view, an experiment was conducted to evaluate the benefit: cost ratio of drip irrigation and fertigation in greater yam + maize intercropping system.

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MATERIALS AND METHODS

A field experiment was conducted at Regional Centre, ICAR-Central Tuber Crops Research Institute, Bhubaneswar, Odisha, India, during 2015-16 and 2016-17 on alfisols. The location is characterized by a hot and humid summer, and a cool and dry winter. The soil (top 0.30 m) was having pH 6.8, organic carbon 0.39%, and available N (196 kg/ha), P (21.4 kg/ha) and K (265 kg/ha). The experiment was conducted in split plot design with three replications. The main and sub-plots treatment consisted of three drip irrigation [I_1- at 80% of cumulative pan evaporation (CPE) during 1-270 days after planting (DAP), I_2-at 100% of CPE during 1-90 DAP + at 80% of CPE during 91-270 DAP and I_3-at 100% of CPE during 1-270 DAP] and four fertigation [F1- N-P_2O_5-K_2O 100-90-100 kg/ha, F_2- N-P_2O_5-K_2O 120-90-120 kg/ha, F_3- N-P_2O_5-K_2O 140-90-140 kg/ha and F_4- N-P_2O_5-K_2O 160-90-160 kg/ha], respectively.

A control (surface irrigation at 100% of CPE; soil application of N-P_2O_5-K_2O 120-90-120 kg/ha) was also included to compare drip irrigation and fertigation treatments. Water soluble N, P and K fertilizers (urea, urea phosphate and potassium sulphate) applied in five equal splits (basal, 30, 60, 90 and 120 DAP) through drip irrigation. In control, full dose of P_2O_5 (single superphosphate) was applied as basal. The N (urea) and K (muriate of potash) were applied in three split applications, basal (40%), 45 DAP (30%) and 90 DAP (30%). Drip irrigation on alternate days and surface irrigation once every seven days were given as per treatment based on CPE considering pan factor 0.7.

Ridges were formed at 90 cm distance and 200 g cut tubers of greater yam variety 'Da 293 (Sree Nidhi)' were planted at 90 cm spacing on ridges. On the same day hybrid maize 'MRM 3777' seeds were sown at 30 cm spacing in between two greater yam plants in the intra-rows. Maize cobs were harvested 3 months after planting (MAP) and left the haulms in the field. Prior to harvesting of greater yam (290 DAP), irrigation was withheld 20 days before.

The tuber equivalent yield (TEY) data was computed taking into the consideration of selling price of maize seeds and greater yam tubers along with their yield. The effective rainfall was calculated as per Reddy and Reddi (2010). During cropping season 2015-16, it was 439, 396 and 396 mm at I_1, I_2 and I_3, respectively. During 2016-17, it was 470, 448 and 441 mm at I_1, I_2 and I_3, respectively. The amount of water applied through drip irrigation was 383, 432 and 451 mm at I_1, I_2 and I_3, respectively during first season. The amount of water applied through drip irrigation was 274, 301 and 345 mm at I_1, I_2 and I_3, respectively during second season. During first and second cropping season, 451 and 345 mm of water, respectively was applied in the control treatment.

The data were analyzed in a randomized block design using SAS statistical software (SAS, 2010). The homogeneity of error variance was tested using Bartlett's χ^2-test. As the error variance was homogeneous, pooled analysis of two years data was done. Comparison of treatment means for significance at 5% level of probability was done using the critical differences (CD) as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The tuber equivalent yield was increased with increasing level of drip irrigation and fertilizers but decreased at highest level of drip irrigation (I_3) (Fig. 1). The treatment I_2F_4 resulted in maximum tuber equivalent yield and it was followed by I_2F_3. This was due to higher maize and greater yam yield (Fig. 1). The treatments I_2F_4 and I_2F_3 resulted in 31.8 and 29.9% higher tuber equivalent yield, respectively than the control. Similarly, the treatments I_3F_4 and I_3F_3 resulted in 24.7 and 21.1% higher tuber equivalent yield, respectively than the control. The marginal decline in tuber equivalent yield at higher drip irrigation level might be due to more vegetative growth.

Higher tuber equivalent yields at higher level of fertilizer application indicated that with drip irrigation, fertilizer responsive-ness of the greater yam + maize intercropping system can be increased. Increasing 16.6% N and K_2O fertilizers increased 21.1-29.9% tuber equivalent yield, whereas 33.3% increasing N and K_2O fertilizers increased 24.7-31.8% tuber equivalent yield under drip irrigation than the recommended soil application. This also indicated that response to fertilizer was higher under partial deficit irrigation. Sunitha *et al.* (2016) also observed similar results in cassava. Drip fertigation is considered to be most efficient in improving the yield (Behera *et al.*, 2013).

Cost of cultivation was calculated for various treatments. Cost of irrigation (both labour and other costs) was substantially less under drip irrigation because of the requirement of labour was less and water saving was high, and it substantially reduced the working hours of pump-set which extensively reduced the cost on electricity. The cost of irrigation (excluding capital cost) to the cost of cultivation was 2.9 and 3.1% under I_1F_2 and I_2F_2, respectively compared to 9.2% under the control. The operation-wise cost of cultivation clearly pointing out that cost reduction was high in operations like weeding and irrigation under drip irrigation.

The total cost reduction (excluding capital cost, harvesting and threshing) was about 8.3% (Rs. 11,500/ha) and 7.1% (Rs. 9,900/ha) due to drip irrigation at I_1F_2 and I_2F_2, respectively when compared to surface flood irrigation at same level of fertilizer application (control). The harvesting and threshing cost excluded

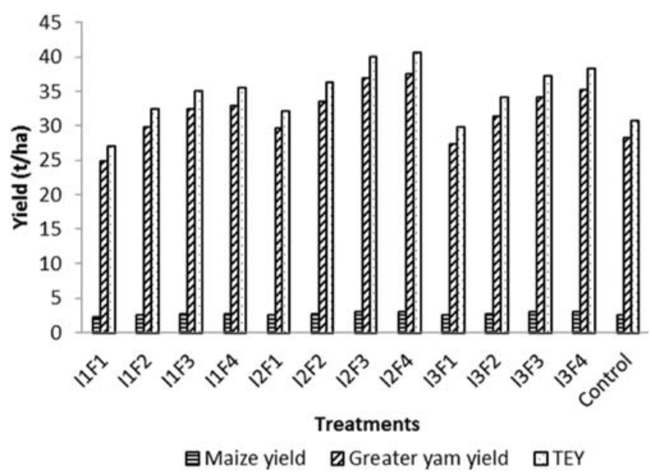

Fig. 1: Yield of greater yam + maize intercropping system under drip irrigation and fertigation [CD (0.05): maize 0.1; greater yam 2.4; TEY 2.4]

because it was influenced by system productivity. Bhargavi *et al.* (2019), Gangaiah *et al.* (2019) and Nedunchezhiyan *et al.* (2021 b) also reported that weeding and frequent irrigation was expensive under surface flood irrigation.

The gross and net returns were increased with increasing level of drip irrigation and fertilizers but decreased at highest level of drip irrigation (I_3) (Fig. 2). The treatment I_2F_4 and I_2F_3 resulted in higher gross and net returns. This was due to higher yields in these treatments (Fig. 1). The treatments I_2F_4 and I_2F_3 resulted in 31.8 and 29.9% higher gross return, and 40.2 and 38.2% higher net return, respectively than the control. This higher gross and net income is purely because of yield effect though cost of cultivation was higher due to capital cost of drip irrigation. Similar result in sugarcane was reported by Narayanamoorthy (2005). Similarly, the treatments I_3F_4 and I_3F_3 resulted in 24.7 and 21.1% higher gross return, and 29.1 and 24.7% higher net return, respectively than the control. The marginal decline in gross and net return at higher drip irrigation level was might be due to lower yield (Fig. 1).

The tuber equivalent yield in treatment I_1F_2 was found near to the control among all the treatments (Table 1). Irrigation water applied in this treatment was 69.5 mm lesser than the control (Table 1) which saved 21.2% water, *i.e.* 0.21 ha additional area of greater

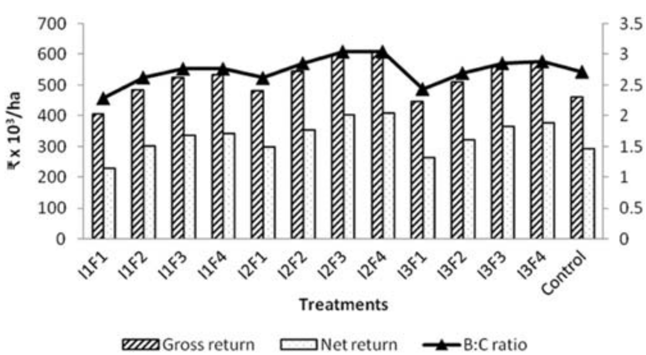

Fig. 2: Economics of greater yam + maize intercropping system under drip irrigation and fertigation[CD (0.05): gross return 21.2; net return 19.5; B:C ratio 0.14]

yam + maize intercropping can be irrigated. The fertilizers applied in both the treatments were equal (N-P_2O_5-K_2O 120-90-120 kg/ha). The gross and net returns in the treatment I_1F_2 were 5.2 and 3.1% higher respectively than the control (Table 1).

The benefit: cost (B:C) ratio was marginally declined due to higher cost of cultivation owing to capital cost of drip system. Maheswarappa and Krishnakumar (2019) reported that among the irrigation methods, drip irrigation is the best, which ensures water saving without affecting productivity. Further, application of fertilizer through drip system (fertigation) resulted in increased fertilizer-use efficiency and savings in fertilizer dose 25 to 50%. Nedunchezhiyan *et al.* (2016) also reported similar report in elephant-foot yam.

In treatments I_3F_2 and control, same level of water (398 mm) and fertilizer (N-P_2O_5-K_2O 120-90-120 kg/ha) were applied (Table 2). The former was through drip and fertigation, and the latter was on surface and soil. In treatment I_3F_2 resulted in 21.1% higher tuber equivalent yield than the control (Table 2). Singh and Singh (2021) reported that 57.1% higher yield in soybean under drip fertigation over conventional furrow-irrigated crop with soil application of fertilizers. Nedunchezhiyan *et al.* (2022) also reported higher yield in tuber crops under drip fertigation than surface irrigation with soil application of fertilizers. The gross and net returns in the treatment I_3F_2 were 21.1 and 24.7% higher respectively than the control. The cost of cultivation was higher in treatment I_3F_2 than the control (Table 2) owing to high capital cost of drip system and harvesting and threshing cost. The B:C ratio of the treatment I_3F_2 was 5.1% higher than the control in-spite of higher cost of cultivation (Table 2). Nedunchezhiyan (2017) and Sunitha *et al.* (2018) also reported higher B:C ratio under drip fertigation than soil application in elephant-foot yam.

CONCLUSION

When same quantity of water and fertilizer was applied through drip, it increased 21.1% higher tuber equivalent yield, 21.1 and 24.7% higher gross and net

Table 1. Comparison of drip fertigation vs control at same level of greater yam+maize intercropping system yield

Particulars	Treatment (I_1F_2)	Control
Tuber equivalent yield (t/ha)	32.4	30.8
Irrigation water application (mm)	328.5	398.0
Fertilizer application (N-P_2O_5-K_2O kg/ha)	120-90-120	120-90-120
Cost of cultivation (₹ × 10^3/ha)	184.9	170.0
Gross return (₹ × 10^3/ha)	486	462
Net return (₹ × 10^3/ha)	301.1	292
B:C ratio	2.63	2.72

Table 2. Comparison of drip fertigation vs control at same level of water and fertilizer application in greater yam+maize intercropping system

Particulars	Treatment (I_3F_2)	Control
Tuber equivalent yield (t/ha)	37.3	30.8
Irrigation water application (mm)	398.0	398.0
Fertilizer application (kg/ha)	120-90-120	120-90-120
Cost of cultivation (₹/ha)	195.4	170.0
Gross return (₹/ha)	559.5	462
Net return (₹/ha)	364.1	292
B:C ratio	2.86	2.72

returns, respectively than soil application. When same quantity of fertilizer was drip fertigated, it saved 21.2% water and resulted in 5.2 and 3.1% higher gross and net returns, respectively. Thus, drip fertigation increased water and fertilizer-use efficiency 20%.

REFERENCES

Bhargavi B, Behera U K, Rana K S, Singh R, Prasad S, Pandey R N and Singh G. 2019. Crop diversification with high-value crops for higher productivity and profitability under irrigated ecosystem. *Indian Journal of Agronomy* **64**(4): 440-4.

Dhawan B D. 2002. Technological change in Indian irrigated agriculture: A study of water saving methods. Commonwealth Publishers, New Delhi, India.

Gangaiah B, Prasadbabu M B B, Latha P C, Singh T V and Rao P R. 2019. Plastic mulch cultivation of rice *(Oryza sativa)* in India in light of dwindling water resources. *Indian Journal of Agronomy* 64(4): 458-63.

Gomez K A and Gomez A A. 1984. *Statistical Procedures for Agricultural Research.* John Wiley & Sons, New York.

Maheswarappa H P and Krishnakumar V. 2019. An overview on water management in coconut *(Cocos nucifera). Indian Journal of Agronomy* **64**(4): 431-9.

Narayanamoorthy A. 2005. Economics of drip irrigation in sugar-cane cultivation: Case study of a farmer from Tamil Nadu. *Indian Journal of Agricultural Economics* **60**(2): 235-48.

Nedunchezhiyan M, Byju G and Jata S K. 2021a. Drip fertigation for greater yam *(Dioscorea alata)* and maize *(Zea mays)* intercropping. *Indian Journal of Agricultural Sciences* **91**(9): 1302-6.

Nedunchezhiyan M, Byju G, Ravi V and James George. 2018. Effect of fertigation schedule on production potential, quality and nutrient uptake of elephant-foot yam *(Amorphophallus paeoniifolius). Current Horticulture* **6**(1): 19-26.

Nedunchezhiyan M, Mukherjee A, Byju G, Ravi V and James George. 2016. Growth, dry matter production and nutrient uptake of elephant foot yam *(Amorphophallus paeoniifolius (Dennst.) Nicolson)* as influenced by drip irrigation and fertigation levels. *Journal of Root Crops* **42**(1): 22-32.

Nedunchezhiyan M, Suja G and Ravi V. 2022. Tropical root and tuber crops-based cropping systems-a review. *Current Horticulture* **10**(1): 14-22. http://doi.org/10.5958/2455-7560.2022.00003.6

Nedunchezhiyan M, Suresh Kumar J and Biswanath Sahoo. 2021b. Effect of weed control on growth, dry-matter production and partitioning in elephant-foot yam [*Amorphophallus paeoniifolius (Dennst.) Nicolson*]. *Current Horticulture* **9**(1): 40-4.

Nedunchezhiyan M. 2017. Drip irrigation and fertigation effects on corm yield, water and fertilizer use efficiency and economics in elephant foot yam *(Amorphophallus paeoniifolius). Indian Journal of Agronomy* **62**(4): 519-24.

Reddy T Y and Reddi G H S. 2010. Principles of agronomy, 4th edn., Kalyani Publishers, Ludhiana, India.

SAS. 2010. SAS Institute Inc., Cary, NC, USA.

Singh A and Singh K G. 2021. Effect of drip irrigation, fertigation and plastic mulching on growth and yield of soybean *(Glycine max). Indian Journal of Agronomy* **66**(1): 56-60.

Sunitha S, George J and Sreekumar J. 2016. Productivity of cassava as affected by precision management under humid tropical environment in India. *Acta Horticulturae* **1118**(3): 17-23.

Sunitha S, George J, Suja G, Ravi V, Haripriya S and Sreekumar J. 2018. Irrigation schedule for maximum corm yield and water productivity in elephant foot yam *(Amorphophallus paeoniifolius). Indian Journal of Agricultural Sciences* 88(7): 1013-7.