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Effect of drip irrigation and fertigation on yield, water-and fertilizer-use efficiency and economics of greater yam *(Dioscorea alata)* in eastern India

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Abstract

An experiment was conducted to see the effect of drip irrigation and fertigation on greater yam (*Dioscorea alata* L.) during 2020-21, 2021-22 and 2022-23 at the Regional Centre of ICAR-Central Tuber Crops Research Institute, Bhubaneswar, Odisha, in split plot design with drip irrigation levels in main plots (I_1-60% CPE, I_2-80% CPE and I_3-100% CPE) and in sub-plots fertigation levels (F_1- N- P_2O_5-K_2O 60-60-60 kg ha^{-1}, F_2- N- P_2O_5-K_2O 80-60-80 kg ha^{-1} and F_3- N- P_2O_5-K_2O 100-60-100 kg ha^{-1}). Check: (surface irrigation IW/CPE: 1.0; P_2O_5 60 kg ha^{-1} basal application; N-K_2O 80-80 kg ha^{-1} soil application at basal (40%), 30 (30%) and 60 (30%) days after planting) and control: (surface irrigation IW/CPE: 1.0; no fertilizer) also included to compare the treatments. The treatment I_3 resulted in higher tuber yield, cost of cultivation, gross return, net return and B:C ratio, however, it was statistically on a par with I_2. Among fertigation, treatment F_3 resulted in significantly higher tuber yield, cost of cultivation, gross return, net return and B:C ratio. The interaction treatment I_3F_3 resulted in higher tuber yield, gross and net returns as well as B:C ratio and it was statistically on a par with I_2F_3 and I_3F_2. The treatment I_2F_3 resulted in higher water-use efficiency (WUE) and fertilizer-use efficiency (FUE). Hence, treatment I_2F_3 can be recommended for optimum tuber yield, higher WUE and FUE and better returns.

Key words: Greater yam, Drip irrigation, Fertigation, Water-use efficiency, Eastern India

Greater yam (*Dioscorea alata* L.) serves as a staple food in many countries in Africa, Asia and South as well as Latin America. In India, yams are grown in an area of about 30,000 hectares, producing 8.10 lakh tonnes annually with a yield of 28 tonnes/ha. It is mostly cultivated in Kerala, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Odisha, Gujarat and in North-eastern states (Nedunchezhiyan *et al.*, 2023a). Greater yam is a subsistence food crop in tribal, hilly areas and in other parts, it is a vegetable cash crop (Nedunchezhiyan and Sahoo, 2019; Nedunchezhiyan *et al.*, 2022). Greater yam is rich in starch, various minerals and dietary fibre which confers many health attributes to it (Vashi *et al.*, 2018; Adomeniene and Venskutonis, 2022; Sinnadorai *et al.*, 2022).

Greater yam, being a long duration (10 months) crop, can suffer from insufficient moisture during post monsoon. The most common method of irrigation is surface irrigation to cope up with the deficiency of rains. Although it ensures uniform spreading which causes high evaporation and seepage losses. Water is a scarce resource which needs to be preserved and the ultimate goal should be to ensure more crop per drop. Drip irrigation is an efficient method of providing water directly in to the root zone of the plants. The available research results revealed that the productivity gain due to drip method of irrigation was estimated to be in the range of 20 to 90% for different crops besides substantial saving of water to the extent of 40-80% (Sivanappan, 2004; Nedunchezhiyan *et al.*, 2017). The greater crop yields with considerable saving of water and higher water use efficiency in vegetables was reported in drip irrigation systems (Manjunath *et al.*, 2001; Tiwari *et al.*, 2003). Schedule of irrigation by pan evaporation is an easy and inexpensive method and most widely adopted (Ertek *et al.*, 2007). Further, surface irrigation becomes cumbersome at later stages [6 months after planting (MAP)] due to trailing of greater yam on the ground or stake. Under such situations, drip irrigation could be a better option for greater yam. In greater yam+maize (*Zea mays* L.) intercropping system drip irrigation at 100% of cumulative pan evaporation (CPE) during 1-90 DAP + at 80% of CPE during 91-270 DAP was found optimum for higher greater yam tuber yield (Nedunchezhiyan *et al.*, 2020; Nedunchezhiyan *et al.*, 2021).

The method of nutrient application is also important in improving the nutrient-use efficiency. Fertilizers applied directly to soil are generally not utilized efficiently by the crops. In fertigation, nutrients are applied through drip emitters directly into the zone of maximum root activity so as to achieve maximum yield (Patel and Rajput, 2000; Chawla and Narda, 2002). Intercultural operations such as surface irrigation and top dressing of fertilizers are very difficult due to huge canopy development after third month. Hence, drip irrigation and fertigation are right option for water and nutrient management for greater yam. Drip fertigation is considered to be most efficient in improving the yield (Behera *et al.*, 2013). Nedunchezhiyan *et al.* (2018) reported higher fertilizer-use efficiency under drip fertigation in elephant-foot

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yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson). Fertigation of 140-90-140 kg $ha^{-1}$of N-P_2O_5-K_2O was considered optimum for greater yam+maize intercropping system (Nedunchezhiyan *et al.*, 2021). Keeping in view, the study was carried out to find the effect of drip irrigation and fertigation on tuber yield, water-and fertilizer-use efficiency and economics of greater yam.

MATERIALS AND METHODS

A field experiment was conducted during 2020-21, 2021-22 and 2022-23 at the Regional Centre of ICAR-Central Tuber Crops Research Institute, Bhubaneswar, Odisha (20°14′53.25″ N, 85°47′25.85″ E; 33 M above MSL). The soil of experimental site (0-30 cm depth) had a pH of 6.4, soil organic carbon 0.39%, available nitrogen 218 kg ha^{-1}, available phosphorus 42.6 kg ha^{-1} and available potassium 358 kg ha^{-1}.

The climate of the experimental location is characterized by hot and humid summers and cool, dry winters. The mean weather data over the three experimental years showed that the average maximum and minimum temperatures during crop growing season were 32.4°C and 22.8°C, respectively. The average relative humidity was 79.8%. The total rainfall received during the crop growing period was 1288.4 mm with 82 rainy days. The total evaporation was 957.7 mm.

The experiment was laid out in split plot design with drip irrigation levels in main plots (I_1-60% CPE, I_2-80% CPE and I_3-100% CPE) and in sub-plots fertigation levels (F_1- N- P_2O_5-K_2O 60-60-60 kg ha^{-1}, F_2- N- P_2O_5-K_2O 80-60-80 kg ha^{-1} and F_3- N- P_2O_5-K_2O 100-60-100 kg ha^{-1}). Check: (surface irrigation IW/CPE: 1.0; P_2O_5 60 kg ha^{-1} basal application; N-K_2O 80-80 kg ha^{-1} soil application at basal (40%), 30 (30%) and 60 (30%) days after planting) and control: (surface irrigation IW/CPE: 1.0; no fertilizer) also included to compare the treatments. The treatments were replicated thrice. In fertigation treatments, water-soluble fertilizer N-P_2O_5-K_2O through fertigation as per treatment at basal (40%), 30 (30%) and 60 (30%) days after planting (DAP). In control/check, P_2O_5 was applied during last plough. N and K were applied in 3 splits at basal (40%), 30 DAP (30%) and 60 DAP (30%). Farmyard manure 10 t/ha was incorporated at last plough in all treatments except control/check. The cut tubers weighing 200 g were planted on ridge formed at 90 cm spacing. The plant- to -plant distance of 90 cm was maintained. The crop was harvested 300 days after planting.

The data were subjected to analysis of variance (ANOVA) appropriate for a randomized block design. Since the experiment was conducted over three consecutive years, a pooled analysis across years was performed. Treatment means were compared using the critical difference (CD) test at the 5% probability level following the procedures described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The results revealed that increasing irrigation level increased greater yam tuber yield (Fig. 1). The treatment I_3 resulted in higher tuber yield however, it was statistically on par with I_2. This showed that for drought resistant greater yam drip irrigation at 80% CPE was enough for getting optimum tuber yield. Nedunchezhiyan *et al.* (2021) reported that drip irrigation at 80% of CPE during 91-270 DAP (later part of crop growth stage) was found optimum for higher greater yam tuber yield in greater yam+maize intercropping system. When maize is intercropped with greater yam, during that period only required drip irrigation at 100% CPE (Nedunchezhiyan *et al.*, 2020). Among fertigation, the treatment F_3 resulted in significantly higher tuber yield (Fig. 2). The treatment F_3 recorded 20.5 and 6.6 % higher tuber yield that F1 and F_2, respectively. This showed that greater yam being a long duration and high yield potential crop requires higher nutrients. The lowest yield was found with the treatment F_1 (Fig. 2). The interaction between

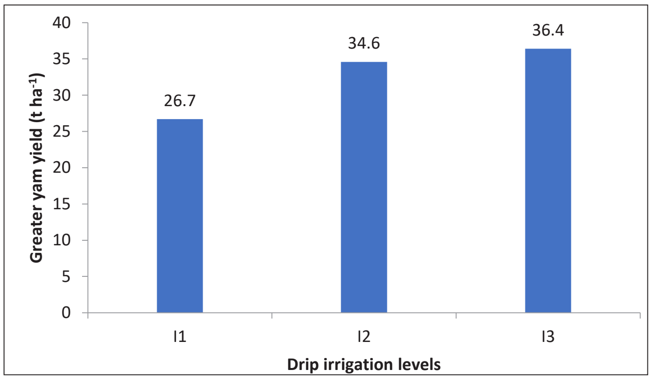

Fig. 1. Effect of drip irrigation levels on tuber yield (CD 0.05=2.0)

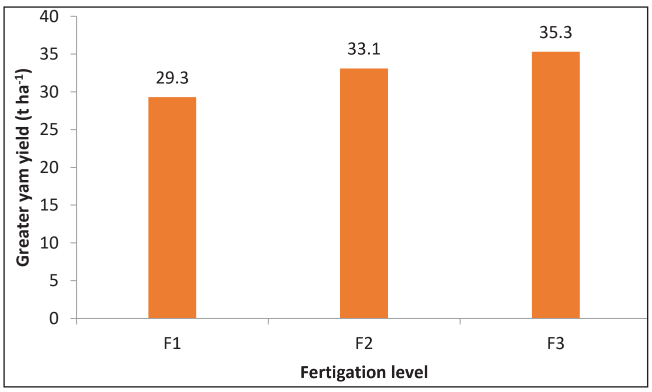

Fig. 2. Effect of fertigation levels on tuber yield (CD 0.05=0.9)

Table 1: Tuber yield, water- and fertilize-use efficiency as influenced by drip irrigation and fertigation levels

Treatment	Tuber yield (t ha-1)	Water-use efficiency (kg ha-mm-1)	Fertilizer-use efficiency (kg kg-1)
I1F1	22.9	35.2	127
I1F2	27.0	41.5	150
I1F3	30.1	46.3	167
I2F1	31.0	45.8	141
I2F2	35.3	52.1	160
I2F3	37.6	55.5	171
I3F1	33.9	48.2	131
I3F2	37.0	52.6	142
I3F3	38.1	54.1	146
C (NPK)	25.7	36.5	117
C	14.0	19.8	-
CD (0.05)	2.6	3.3	11

Table 2: Consumptive use/water requirement of greater yam

Consumptive use/ water requirement	Drip irrigation			Surface/ flood irrigation 100% CPE
	I1: 60% CPE	I2: 80% CPE	I3: 100% CPE	
Irrigation water (mm)	66.8	89.1	111.2	111.2
Effective rainfall (mm)	547.3	547.3	547.3	547.3
Soil profile contribution (mm)	15.4	14.2	12.6	14.8
Total (mm)	629.5	650.6	671.1	673.3

Table 3. Economics of greater yam cultivation as influenced by drip irrigation and fertigation levels

Treatment	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
Drip irrigation levels				
I1	186100	399900	213800	2.14
I2	194800	519800	325000	2.67
I3	197300	545700	348400	2.76
CD (0.05)	2700	30200	27600	0.12
Fertigation levels				
F1	186800	439200	252400	2.34
F2	193200	496800	303500	2.56
F3	198200	529400	331200	2.64
CD (0.05)	1300	14000	12800	0.06
Interaction				
I1F1	179800	343100	163300	1.91
I1F2	186400	405200	218800	2.17
I1F3	192000	451400	259400	2.35
I2F1	188500	465400	276800	2.47
I2F2	195000	529400	334400	2.72
I2F3	200800	564600	363700	2.81
I3F1	192000	509200	317200	2.65
I3F2	198300	555700	357400	2.80
I3F3	201700	572200	370500	2.83
C (NPK)	171300	385100	213800	2.25
C	135100	209300	74200	1.55
CD (0.05)	3200	38700	35700	0.17

irrigation and fertigation levels was found significant (Table 1). The treatment I_3F_3 resulted in higher tuber yield and it was statistically on par with I_2F_3 and I_3F_2 (Table 1). The treatments I_3F_3, I_2F_3 and I_3F_2 resulted in 48.2, 31.6 and 30.5% higher tuber yield than check (Table 1). These treatments further indicated that if equal quantity of fertilizers and water applied through soil with surface irrigation (check) and drip irrigation (I_3F_2), drip fertigation increased 30.5% tuber yield. This also indicated that drip fertigation increased water and fertilizer use efficiency. Nedunchezhiyan (2017) also reported similar information in elephant foot yam.

The treatment I_2F_3 resulted in higher water use efficiency (WUE) and it was followed by I_3F_3 and I_3F_2 (Table 1). The lower WUE was recorded drip irrigation at 60% CPE (I_1) in combination with any levels of fertilizer (I_1F_1, I_1F_2 and I_1F_3). Lower level of fertilizer application in higher level of drip irrigation at 80 and 100% CPE also recorded lower WUE (I_2F_1 and I_3F_1) (Table 1). The check registered higher WUE than control (Table 1). This indicated that WUE can also be increase by fertilizer application. The treatment I_2F_3 resulted in higher fertilizer use efficiency (FUE) (Table 1). The higher level of drip irrigation (I_3) with any quantity of fertilizer resulted in lower FUE (I_3F_1, I_3F_2 and I_3F_3) (Table 1). The lower fertilizer levels with any level of drip irrigation resulted in lower FUE (I_1F_1, I_1F_2, I_2F_1, I_2F_2, I_3F_1 and I_3F_2) (Table 1). Nedunchezhiyan *et al.* (2018) also observed similar result in elephant foot yam.

Eastern India receives high rainfall (1200 mm) during South-West monsoon. Long duration crops are planted/sown before monsoon with protective irrigation. In case of greater yam cultivation pre-monsoon irrigation is given for uniform sprouting and growth, whereas post-monsoon irrigation is given for rapid tuber bulking. In the present investigation higher amount of irrigation water was applied (pre and post monsoon) to the treatment I_3 followed by I_2 (Table 2). The consumptive use of water was ranged from 629.5-673.3 mm (Table 2). Effective rain fall is major contributor of consumptive use of water by the greater yam crop (Table 2). The irrigation water required during pre and post monsoon period was 66.8-111.2 mm (Table 2). Among drip irrigation, the consumptive use of water in the treatment I_3 was higher followed by I_2 (Table 2). Nedunchezhiyan *et al.* (2024) reported that about 900 mm was found optimum for greater yam+maize intercropping system.

Marked variation in cost of cultivation, gross return, net return and benefit:cost (B:C) ratio was noticed due to drip irrigation and fertigation levels (Table 3). The treatment I_3 resulted in higher cost of cultivation, gross return, net return and B:C ratio (Table 3). However, it was statistically on par with I_2. This was due to higher tuber yield in these treatments (Fig. 1). Among fertigation, the treatment F_3 resulted in significantly higher cost of cultivation, gross return, net return and B:C ratio (Table 3). This was due to higher tuber yield in this treatment (Fig. 2). The interaction between irrigation and fertigation levels was found significant (Table 3). The treatment I_3F_3 resulted in higher cost of cultivation and it was statistically on par with I_2F_3 (Table 3). This was due to higher tuber yield in this treatment (Table 1). The treatment I_3F_3 resulted in higher gross and net returns as well as B:C ratio and it was statistically on par with I_2F_3 and I_3F_2 (Table 3). Nedunchezhiyan *et al.* (2023b) also reported similar report in greater yam+maize intercropping system.

CONCLUSION

In greater yam, drip irrigation at 100%CPE along with fertigation of N- P_2O_5-K_2O 100-60-100 kg ha^{-1} (I_3F_3) and drip irrigation at 80%CPE along with fertigation of N- P_2O_5-K_2O 100-60-100 kg ha^{-1} (I_2F_3) were comparable in terms of tuber yield and returns. However, the treatment drip irrigation at 80%CPE along with fertigation of N- P_2O_5-K_2O 100-60-100 kg ha^{-1} (I_2F_3) saved 221000 litres (22.1 mm) of water per ha with higher WUE and FUE. Hence, in greater yam drip irrigation at 80% CPE along with fertigation of N- P_2O_5-K_2O 100-60-100 kg ha^{-1} (I_2F_3) can be recommended for optimum tuber yield, higher WUE and FUE and better returns.

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REFERENCES

Adomeniene A and Venskutonis P R. 2022. *Dioscorea* spp.: comprehensive review of antioxidant properties and their relation to phytochemicals and health benefits. *Molecules* **27**(8):2530.

Behera M S, Verma O P, Mahapatra P K, Singandhupe R B and Kumar A. 2013. Effect of irrigation and fertility levels on yield, quality and economics of Japanese mint (*Mentha arvensis*) under drip irrigation system. *Indian Journal of Agronomy* **58**(1): 109-13.

Chawla J K and Narda N K. 2002. Growth parameters of trickle fertigated potato. *Indian Journal of Agricultural Sciences* **70**(11): 747-52.

Ertek A, Sensoy S, Geddik I and Kuciikyumuk C. 2007. Irrigation scheduling for green capsicum (*Capsicum annum* L.) grown by field condition by using class A pan evaporation value. *American-Eurasian Journal of*

Agricultural and Environmental Science **2**(4): 349-58.

Manjunath M V, Shukla K N, Chauhan, H S, Singh P K and Singh R. 2001. Response of micro irrigation on various vegetables. *In*: *Proceedings of International Conference on Micro and Sprinkler Irrigation Systems*, 8-10 February 2000, Jalgoan Maharashtra, India, p 84.

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.

Nedunchezhiyan M and Sahoo B. 2019. Root and Tuber Crops. Kalyani Publishers, Ludhiana, India.

Nedunchezhiyan M, Byju G, Ravi V and James George. 2017. Spacio-temporal fertigation effects on growth, yield and nutrient use efficiency of elephant foot yam (*Amorphophallus paeoniifolius*). *American-Eurasian Journal of Agriculture & Environmental Science* **17**(1): 63-77.

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, Kalidas Pati, Chauhan, V B S and Arutselvan R. 2023b. Analysis of benefit: cost ratio in drip irrigation and fertigation in greater yam *(Dioscorea alata)* + maize *(Zea mays)* intercropping system. *Current Horticulture* **11**(1): 57-60. https://doi.org/10.5958/2455-7560.2023.00013.4

Nedunchezhiyan M, Kalidas Pati, Chauhan V B S and Jata S K. 2021. Enhancing factor productivity of a greater yam+maize intercropping system under drip fertigation. *Journal of Root Crops* **47**(1&2): 9-15.

Nedunchezhiyan M, Pati K, Chauhan V B S, Gowda K H, Arutselvan R., Laxminarayana K and Jata S K. (2024). Drip fertigation in greater yam+maize inter cropping system. *TF-5/2024/TSP* pp-1-4.

Nedunchezhiyan M, Pati K, Chauhan V B S, Arutselvan R, Laxminarayana, K, Byju G and Veena S S. 2020. Growth, dry matter production and yield characteristics of greater yam+maize intercropping system under varied drip irrigation and fertigation levels. *Journal of Root Crops* **46**(2): 14-22.

Nedunchezhiyan M, Sheela Immanuel, Jeeva ML, Kesava Kumar H, Visalakshi Chandra C and Chintha Pradeepika. 2023a. Yams, Technical Bulletin No.101, ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, India, 32 p.

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

Panse V G and Sukhatme P V.1967. *Statistical Methods for Agricultural Workers*. ICAR, New Delhi, India.

Patel N and Rajput T B S. 2000. Effect of fertigation on growth and yield of onion. In: *Proceedings of International Conference on Micro and Sprinkler Irrigation system*, 8-10 February 2000, Jalgaon, Maharashtra, pp. 77.

Sinnadorai N, Kumar M, Bidyalakshmi D M, Jayashri Y J, Sweta M and Sanjeet K. 2022. Food, medicinal and ecological significance of Dioscorea bulbifera (Dioscoreaceae). In: Manjula BL, et al., editors. Yam. India, APRF p. 29-40

Sivanappan R K. 2004. Irrigation and rain water management for improving water use efficiency and production cotton crop. In: *Proceedings of International Symposium on Strategies for Sustainable Crop Production – A Global Vision*, November 23-25, UAS, Dharwad.

Tiwari K N, Singh A and Mal P K. 2003. Effect of drip irrigation on yield of cabbage (*Brassica oleracea* L var. *capitata*) under mulch and non-mulch conditions. *Agricultural Water Management* **58**: 19-28.

Vashi J M, Saravaiya S N, Desai K D, Patel A I, Patel H B and Sravani V. 2018. Effect of planting distance on growth and tuber yield of greater yam (*Dioscorea alata* L.) Under different growing conditions. *International Journal of Chemical Studies* **6**(4): 1475-81.