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# Productivity and profitability of taro (*Colocasia esculenta* (L.) Schott) under drip and furrow irrigation

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## Abstract

Productivity and profitability of taro under drip irrigation and furrow irrigation was worked out based on the data collected from field experiments carried out at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, for three years (2016-17 to 2018-19). The experiment was conducted in RBD, with upland taro variety, Muktakeshi, during summer, with seven treatments which included five levels of drip irrigation, furrow irrigation and a rainfed crop and three replications. The mean data over a period of three years indicated that drip irrigation @ 100% CPE resulted in the highest cormel yield, gross and net income and B:C ratio in taro. In addition to saving of irrigation water (30%), drip irrigation resulted in 45% increase in cormel yield, 57% increase in net income and 20% increase in B:C ratio, compared to furrow irrigation.

**Keywords:** B:C ratio, Taro, Drip irrigation, Productivity, Profitability

## Introduction

Taro (*Colocasia esculenta* (L.) Schott is aherbaceous perennial root crop, widely cultivated in tropical and subtropical regions of the world. It is now grown in almost every area of the humid tropics. The corms and cormels are the major economic part of the crop. Depending on the cultivars and culture, the leaves, flowers, and petioles are also occasionally utilized as food (Fred and Makeati, 2001).

Taro is adapted to tropical lowlands with evenly distributed annual rainfall of 2000 mm, high temperatures of 20-35ºC and shaded conditions. It grows best in well drained loamy soils but can be grown in a wide range of soils including sandy, clay and loamy soils with pH ranging from 5.5 to 6.5 (Onwueme, 1999). Two main production systems exist in taro cultivation, the flooded or low land taro production, where water is available throughout, and the water level can be controlled and the dry land taro or upland taro, which is rain-fed and often has to be supplemented with irrigation to realise the expected yield. Taro is reported to be one of the least water efficient crops and upland varieties may be adapted to water limited conditions (Uyeda et al., 2011). Li Meiling et al., (2019) reported that sandy soil has greater potential to improve the water use efficiency (WUE) of taro under limited water availability conditions. The average productivity of taro is the highest in Asia (16.5 t ha$^{-1}$) and the lowest in Africa (4.3 t ha$^{-1}$) and the world average productivity is reported as 5.39 t ha$^{-1}$(http://www.fao.org/faostat).

In India, taro is mainly cultivated in the states of Uttar Pradesh, Madhya Pradesh, Andhra Pradesh, Odisha, Telengana, and the Northeastern hilly areas. In other places, it is cultivated on a limited scale as intercrop or

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homestead crop but consumed as a routine vegetable or food crop by all sections of people. The crop is mostly cultivated with monsoon rains, quite often needs supplemental irrigation, using furrow system. Most of the varieties and land races are season insensitive and can be grown in any part of the year, provided sufficient soil moisture is assured. Being a moisture sensitive crop, taro responds well to irrigation and drip irrigation is established to be a successful practice in enhancing irrigation water use efficiency and water productivity in many crops. In the present study, a comparison is made betweenfurrow irrigation and drip irrigation in upland taro cultivation in terms of productivity and profitability.

## Materials and Methods

The data were collected from the field experiments carried out in taro, during the three consecutive summer seasons of 2016-2017, 2017-2018 and 2018-2019 at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India. In all the seasons, the crop was planted in November and harvested in May. Based on the USDA taxonomic system, the soil was classified as sandy clay loam having 62% sand, 10% silt and 28% clay content. The soil of the experimental area was medium in available nitrogen (252 kg $ha^{-1}$), high in available phosphorus (121 kg $ha^{-1}$) and medium in available potassium (188 kg $ha^{-1}$).

During the first season, minimum and maximum temperature varied from 21.9 to 24.3ºC and 31.5 to 33.9ºC respectively with a total rainfall of 180 mm and relative humidity ranging between 70.1 to 80.9%. Second season received a rainfall of 352 mm, minimum and maximum temperature 21.5 to 24.9ºC and 30.1 to 34.2ºC respectively, relative humidity from 52 to 76.6% were recorded. Minimum and maximum temperature varied from 20.8 to 25.3ºC and 31.2 to 34.4ºC respectively, relative humidity from 68.1 to 83.4%, during the third season, receiving a rainfall of 251 mm.

The experiment was conducted in Randomized Block Design, with five levels of drip irrigation, and two controls, furrow irrigation and rainfed crop replicated thrice. The five levels of dripirrigation were 50% ($I_1$), 75% ($I_2$), 100% ($I_3$), 125% ($I_4$) and 150 % ($I_5$) of cumulative pan evaporation (CPE), based on the daily evaporation data collected from a Class B open pan evaporimeter, placed near the site. Taro variety 'Muktakeshi' was used for the study. This variety was released during 2002 by the Regional Station of ICAR-Central Tuber Crops Research Institute, Bhubhaneswar, Odisha. It is a clonal selection from Bhatpara, a collection from Cuttack, Odisha. The variety is resistant to *Phytophthora* leaf blight disease and is suitable for cultivation both in uplands as well as in lowlands. It is comparatively a short duration variety having 6-7 months duration with an average yield of 17-20 $tha^{-1}$ under good management conditions.

Small pits were taken in rows at a spacing of 60 cm and cormels of uniform size (25 to 30 g) were planted at a spacing of 45 cm. As per the package of practices recommended by ICAR-CTCRI, 80 kg N, 25 kg P and 100 kg K were applied in three spilt doses. One third dose of N and K, and full dose of P were applied two weeks after initiation of sprouting, remaining N and K at one month interval in equal splits. Agronomic practices were the same in all the seasons.

Drip system was laid out and drippers were placed so as to coincide with the spacing of the plants. Each plot had 36 plants with a net plot size of 16 plants. Irrigation was given through drip system, and the flow of water was controlled using a drip meter. Furrow irrigation was given twice a week @ 5 mm per day. For rainfed crop, only life-saving irrigation was given, whenever there was no rain continuously for a week.The crop was harvested after seven months, corm yield and cormel yield were recorded from different treatments from the net plot during the three growing seasons and based on the yield data from net plots, per hectare yield was estimated in t $ha^{-1}$. Economic indices *viz.*, cost of cultivation, gross income, net income and benefit: cost ratio were worked out based on various inputs and labour costs at the end of three years. The data over the three years were pooled and analyzed statistically following Indian NARS Statistical computing portal (SSCNARS) by applying the technique of Analysis of Variance (ANOVA) for RBD and multiple comparison of treatment means was done by least significant difference.

## Results and Discussion

**Corm and cormel yield**

Pooled analysis of data of three seasons showed significantvariation among treatments for yield. Seasons did not impart significant effect on yield. The cormel yield and total yield varied significantly among different drip irrigation levels. There was no significant variation in corm yield among the treatments. The cormelyield increased from 13.18 to 21.08 t $ha^{-1}$ under drip irrigation levels from 50% to 100% CPE and thereafter declined. There was 45% increase in cormel yield under drip irrigation at 100% CPE, compared to furrow irrigation. Rainfed crop resulted incormel yield of 3.47 t $ha^{-1}$. Corm yield was the highest with irrigation at 125% CPE and the total yield (corm + cormel) was the highest at 75% CPE. Cormel to corm ratio did not show any definite trend with increase in drip irrigation from 50% to 150% CPE, however, the value was the highest at $ET_c$ 100% (Table 1).

Table 1. Cormel yield, corm yield and total yield of taro (t $ha^{-1}$) under different irrigation treatments (Pooled mean of three seasons)

| Treatment | Cormel | Corm | Total | Cormel/ Corm ratio |
|---|---|---|---|---|
| T1 | 13.18 | 8.52 | 20.58 | 1.32 |
| T2 | 17.71 | 13.12 | 34.39 | 1.35 |
| T3 | 21.08 | 12.88 | 31.06 | 1.64 |
| T4 | 18.8 | 13.92 | 29.49 | 1.42 |
| T5 | 18.26 | 12.18 | 32 | 1.50 |
| T6 | 14.47 | 10.39 | 24.86 | 1.39 |
| T7 | 3.47 | 3.28 | 7.43 | 1.06 |
| CD | 6.563 | NS | 13.612 | 0.252 |

Corm yield was more under lower levels of irrigation, but cormel yield was more with higher levels of drip irrigation, though the values were not statistically different under different irrigation levels. More number of tillers produced under lower levels of irrigation might have resulted in more corm yield. It is also evident from the values of cormel to corm ratio, which was the highest for 100% CPE (1.64) but was comparable to125% CPE and 150% CPE. Low land production systems and the upland production supplemented with irrigation is a must for realising good yield in taro. Irrigation would be beneficial for taro production in drier months as well as low rainfall areas (Sunitha et al., 2022). In field experiment in taro with different irrigation water levels of 50, 75 and 100% $ET_c$, $ET_c$ at 50% resulted in the highest reduction in terms of vegetative growth, yield characteristics, yield and bio constituents compared to 75% of $ET_c$ level and unstressed plant (100% of $ET_c$) (El Aal et al., 2019). In yet another study, *in-situ* moisture conservation methods influenced soil water availability and subsequent vegetative growth and yield of taro under upland conditions (Manyatsi et al., 2011). Increased cormel yield in taro (Mabhaudhi et al., 2013) and tuber yield in potato (Badr et al*.,* 2012) is reported with increase in amount of water applied. In the present study also, the highest cormel yield was observed for irrigation at 100% CPE, beyond which the yield showed a declining trend. In potato, Camargo et al., (2015) found 80% of irrigation requirements showed statistically similar yields to 100 and 120% of irrigation requirements.

**Cost of installation of drip irrigation unit**

The cost of irrigation materials depends mainly on the distance of the field from the water source. Since taro is planted at a closer spacing of 60×45 cm, a greater number of drippers are required. The total cost of installation in one ha of area comes to be about ₹2.25 lakhs (Table 2) including accessories and installation charges. After considering the depreciation, maintenance cost etc. during subsequent years, the cost of fertigation unit comes to about ₹60,250 per year.

Table 2. Cost of installation of drip irrigation (Area: 1 ha) (Fixed cost) (₹ $ha^{-1}$)

| No. | Particulars | Cost of laterals, drippers etc. | Cost of pipes, valve, motor, filters etc. |
|---|---|---|---|
| 1 | Fixed cost ($\times 10^3$) | 1.50 | 0.75 |
| 2 | Life year | 6 | 20 |
| 3 | Depreciation ($\times 10^3$) | 25.0 | 3.75 |
| 4 | Interest (12%) ($\times 10^3$) | 18 | 9 |
| 5 | Repair and maintenance (2%) ($\times 10^3$) | 3.0 | 1.5 |
| | Total | 46 | 14.25 |
| | Grand total | 60.25 | |

**Cost of cultivation**

The cost of cultivation of taro under different levels of drip irrigation was worked out and it ranged from ₹227400 to ₹292450. The variation was mainly due to the difference in irrigation water applied (Table 3). Under the rainfed conditions, the cost of cultivation was only ₹160200 $ha^{-1}$.

Table 3. Cormel yield and economics of tarocultivation under drip and furrow irrigation

| Treat-ment | Cormel Yield (t $ha^{-1}$) | Cost of cultiva-tion (₹ $ha^{-1}$) | *Gross income (₹ $ha^{-1}$) | Net income (₹ $ha^{-1}$) | B:C Ratio |
|---|---|---|---|---|---|
| T1 | 13.18 | 267450 | 659000 | 391550 | 2.46 |
| T2 | 17.71 | 271450 | 885500 | 614050 | 3.26 |
| T3 | 21.08 | 275950 | 1054000 | 778050 | 3.82 |
| T4 | 18.8 | 279950 | 940000 | 660050 | 3.36 |
| T5 | 18.26 | 292450 | 913000 | 620550 | 3.12 |
| T6 | 14.47 | 227400 | 723500 | 496100 | 3.18 |
| T7 | 3.47 | 160200 | 173500 | 13300 | 1.08 |
| CD | 6.563 | | | | 0.48 |

*Price of taro@ ₹50000 per tonne

**Gross income and Net income**

The gross income ranged from ₹659000 to 1054000 under drip irrigation treatments and net income from ₹391550 to 778050 per ha. The gross and net income from rainfed crop was ₹1,73,500 and 13,300, respectively. The highest net income was obtained from T3, *i.e.*, irrigation at 100% CPE. The minimum was for T1, *i.e.*, drip irrigation at 50% CPE. Positive response from drip irrigation was evident upto irrigation at 100% CPE, from more yield, which consecutively resulted in more gross and net income. Drip irrigation resulted in

45.68% increase in cormel yield compared to furrow irrigation and hence it was more profitable, though the initial investment for installation of drip irrigation facility was incurred.

**B:C Ratio**

B:C ratio also followed a similar trend as in gross and net income. The ratio ranged from 2.46 to 3.82 under drip irrigation, whereasfurrow irrigation and rainfed control resulted in B:C ratio of 3.18 and 1.08 respectively. Similar increase in yield, gross and net income, and B:C ratio under drip irrigation over flood irrigation due to increased water and nutrient use efficiencies in tuber crops, have been reported (Nedunchezhiyan, 2017; Sunitha et al., 2018).

**Productivity, profitability and relative economic efficiency**

The crop was of seven months duration and productivity in terms of cormel yield and profitability in terms of profit/day were worked out. Based on pooled means, the productivity per day was 1.4 times and profitability $ha^{-1}$ $day^{-1}$ was 1.6 times higher under drip irrigation compared to furrow irrigation. Relative economic efficiency (which is a measure of increase in net income over control) was worked out to be 56.8% over furrow irrigation. Maximum productivity per day and profitability $ha^{-1}$ $day^{-1}$ were recorded by drip irrigation at 100% CPE (Fig.1). In this experiment, taro yielded 45% more yield under T3, compared to furrow irrigation, which resulted in more gross and net income and B:C ratio, productivity and profitability, in addition to saving of almost 30% irrigation water.

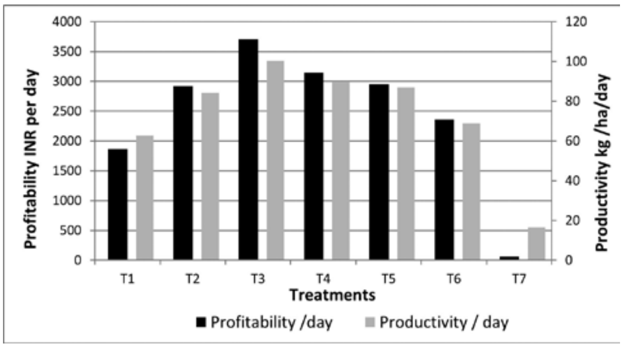


Fig. 1. Productivity and Profitability of taro cultivation under different irrigation regimes

## Conclusion

The above findings clearly revealed thattaro cultivation under drip irrigation was economical compared to that under furrow irrigation. The pooled mean of data over three years indicated that drip irrigation @ 100% cumulative pan evaporation resulted in highest cormel yield, gross and net income, B:C ratio and profitability per ha per day in upland taro during summer months.

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