



# Productivity of Cassava (*Manihot esculenta*) as Affected by Drip Fertigation in the Humid Tropics

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## Abstract

Field experiments were carried out at Central Tuber Crops Research Institute, Kerala, India, during three seasons (2009-2012) to investigate the response of cassava to precision approaches in irrigation and fertigation. The experiments were laid out in split plot design with three replications. The main plots included three levels of drip irrigation viz., ( $I_1$  - irrigation at 100% pan evaporation (PE);  $I_2$  - 80% PE and  $I_3$  - 60% PE). The sub plots comprised three fertigation schedules viz., three ratios of recommended N and K fertiliser doses (100:100 kg ha<sup>-1</sup>) applied at growth stages of 1-40 days, 40-80 days and 80-120 days ( $F_1$  - 50,30,20;  $F_2$  - 30,50,20 and  $F_3$  - 50,40,10). Minisetts of cassava variety Sree Vijaya were planted at a distance of 60 x 45 cm during the dry spell (December-May) in all the years. Results indicated that irrigation at 100% PE yielded maximum tuber yield in all the seasons (43.9 t ha<sup>-1</sup>). There was no significant difference in yield among the fertigation schedules. However, interaction effects showed that  $I_1F_1$  resulted in better growth characters, yield attributes and yield followed by  $I_1F_3$ . On an average, 280 mm, 224 mm and 168 mm of water were applied in  $I_1$ ,  $I_2$  and  $I_3$  irrigation levels respectively during the growing season. Water use efficiency was also higher for irrigation at  $I_1$  level of irrigation.

**Key words:** Cassava, drip irrigation, fertigation, tuber yield, tuber bulking rate, water use efficiency

## Introduction

Cassava, often called as 'poor man's food' is considered as the most important crop among the tropical tuber crops. The crop is widely cultivated due to its adaptation to small and marginal lands, drought tolerance and comparatively affordable cost of cultivation. Apart from its role as a staple/subsidiary food, during the past few decades there has been growing recognition of the value of cassava roots as a low cost energy source for livestock and as a raw material for industrial starch and fuel alcohol. It has a built in mechanism to avoid drought by dropping its leaves temporarily. Drought stress can also be managed by giving supplementary irrigation during the drought periods. Dry matter production, crop growth rate (CGR), tuber weight and yield were significantly greater in cassava, when supplementary

irrigation was provided at 75% of CPE or 20 mm water per week during the drought period (7-10<sup>th</sup> month of crop growth) than the rainfed crop (Nayar et al., 1993).

Moreover, being a photo insensitive crop, cassava can be grown throughout the year irrespective of the season, provided sufficient moisture is assured. Development of short duration varieties made it possible to raise more than a crop in a year. Because of the increasing demand of the crop, cultivation has been extended to nonconventional areas also with less rainfall, where the crop is mostly grown under conventional surface method of irrigation, in which major portion of irrigation water is lost by evaporation and deep percolation resulted in lower efficiencies. Cassava needs adequate moisture for sprouting and subsequent establishment of setts. Earlier studies at CTCRI revealed that cassava requires about

18 irrigations given to a depth of 5 cm which amounts to a total water requirement of 90 cm ha<sup>-1</sup> for a 10 month crop (Ramanujam, 1994). Sushamma et al. (1982) reported that cassava requires 5 to 6 irrigations during summer from January to May when planted in September.

Water being a critical input in modern agriculture, efforts should be made to reduce the wastage of water and to increase the efficiency in crop production. Drip irrigation in combination with fertigation has proved to be successful in terms of water productivity and increased yield in a wide range of crops. Edoga and Edoga (2006) reported that with drip irrigation, the soil is maintained continuously in a condition which is highly favourable for crop growth. So an attempt has been made to study the response of cassava to supplementary irrigation, to work out the water requirement of cassava through drip irrigation and to arrive at an optimum fertigation schedule through precision approaches to enhance the tuber yield when the crop is planted during summer months under tropical conditions.

## Materials and Methods

Field experiments were conducted consecutively for three years 2009-2010, 2010-2011 and 2011-2012 at Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala. The location falls in the humid tropical climatic zones of India. The study was conducted during December to June in all the years to make use of the dry spell of almost five months from December to May. Short duration variety (7 months) of cassava, Sree Vijaya was used for the study. The experiment was laid out in split plot design with drip irrigation in main plots and three fertigation schedules in sub plots.

Irrigation levels:

I<sub>1</sub>: Irrigation at 100% of pan evaporation (PE)

I<sub>2</sub>: Irrigation at 80% PE

I<sub>3</sub>: Irrigation at 60% PE

Fertigation schedules:

F<sub>1</sub>: Application of N and K fertilizers as 50% of N and K during 1-40 days, 30% of N and K during 40-80 days and 20% during 80-120 days after planting (50, 30, 20)

F<sub>2</sub>: N and K as 30% during 1-40 days, 50% during 40-80 days and 20% during 80-120 days (30, 50, 20)

F<sub>3</sub>: N and K as 50% during 1-40 days, 40% during 40-80 days and 10% during 80-120 days (50, 40, 10)

To arrive at optimum schedule, Urea and Muriate of potash were used as the source of N and K respectively.

A rainfed crop with NPK as soil application as per recommended practices was included as control to work out the water use efficiency under irrigation. Minisetts were initially raised in a nursery during November and transplanted to the main field after one month. Transplanting was done on ridges made at a distance of 60 cm and planting was done on ridges at a distance of 45 cm. After ridge formation, drip system was laid out in the field and drips were placed at a distance of 45 cm so as to coincide with the spacing of the minisetts. At the time of land preparation, FYM @ 12.5 t ha<sup>-1</sup> and full dose of P @ 50 kg ha<sup>-1</sup> were applied as basal. Daily irrigation water was calculated based on daily pan evaporation and pan factor, in mm. Crop factor was taken into account at different stages of growth as suggested by Allen and Pruitt (1991). During initial and final stages, crop factor was taken as 0.3 and during middle stage, the factor was taken as 0.8.

At the time of harvest, biomass production, yield and yield attributes were recorded. Effective rainfall and irrigation water given during each month were recorded and the total water used by the crop was assessed. From these data, water use efficiency was calculated. The data over the years were pooled and analysed statistically following SAS procedure and the results are briefed here.

## Results and Discussion

### Yield attributes and yield

The yield and yield attributes were significantly affected by irrigation levels. However, the different fertigation schedules did not significantly affect these attributes. Tuber bulking rate was found to differ significantly due to irrigation levels. The fertigation schedules as well as interaction effects were not significant. The rate of tuber bulking was maximum for I<sub>2</sub> during the initial period up to 4 months, however, during later stages, rate of increase was higher for I<sub>1</sub> level of irrigation (Fig.1). A steady increase was noted in I<sub>3</sub>, which was the lowest during the entire period.

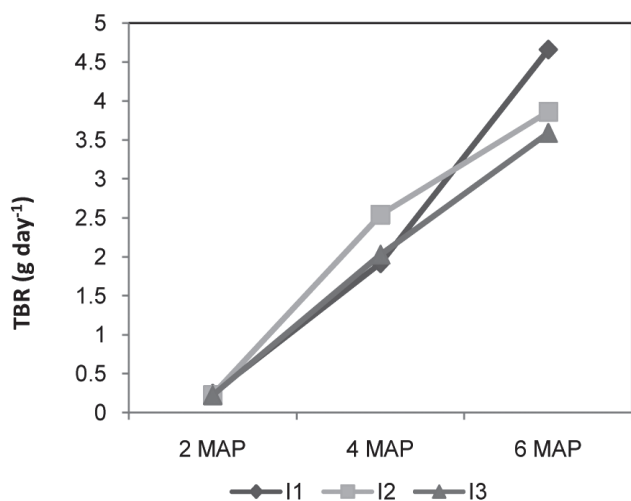


Fig. 1. Tuber bulking rate of cassava as influenced by irrigation levels

In the earlier studies of Khatib et al. (2007) and Mogaji Kehinde (2011), tuber length and tuber girth showed positive response to drip irrigation treatments resulting in highest values in full irrigation compared with the other treatments in cassava.

Different levels of irrigation as well as the interaction effects of irrigation and fertigation schedules significantly

affected the tuber yield of cassava in all the years. Yield performance of cassava over the years and the mean yield are presented in Table 1.

During 2009-2010, drip irrigation at 100% pan evaporation resulted in superior yield over 80 and 60% levels. Irrigation at 60% PE resulted in significantly lowest yield compared to higher levels of irrigation. During the second year also, drip irrigation at 100% pan evaporation ( $I_1$ ) produced the highest tuber yield, but was on par with irrigation at 80% PE ( $I_2$ ). During 2011-2012,  $I_1$  resulted in highest tuber yield and was superior over 80% and 60% irrigation levels. Pooled data also revealed that tuber yield showed a declining trend with decreasing level of irrigation. Irrigation at 100% and 80% pan evaporation were on par with maximum yield at 100% irrigation. The data clearly showed that when cassava is planted during summer months, it responded positively to irrigation.

Fertigation treatments did not significantly affect the yield of cassava in different years, however, pooled data showed that fertilizer application of 50% NPK during the first 40 days, 30% during 40-80 days and the rest 20% during 80-120 days resulted in higher yield. This may be because

Table 1. Tuber yield of cassava ( $t\ ha^{-1}$ ) as affected by drip irrigation levels, fertigation schedules and their interaction effects

Irrigation levels	2009-2010	2010-2011	2011-2012	Mean
$I_1$	44.41	50.99	36.43	43.94
$I_2$	39.66	47.25	29.19	38.70
$I_3$	33.62	35.79	26.53	31.98
CD (0.05)	5.26	10.36	3.85	6.89
Fertigation schedules	2009-2010	2010-2011	2011-2012	Mean
$F_1$	41.84	44.39	31.30	39.18
$F_2$	38.13	44.23	32.83	38.40
$F_3$	37.73	45.40	30.26	37.78
CD (0.05)	NS	NS	NS	NS
Interaction (I x F)	2009-2010	2010-2011	2011-2012	Pooled Mean
$I_1F_1$	48.86	44.89	40.07	44.61
$I_1F_2$	43.38	47.44	32.88	41.23
$I_1F_3$	41.00	55.63	36.33	44.32
$I_2F_1$	42.44	52.36	28.17	40.99
$I_2F_2$	38.11	46.83	31.84	38.93
$I_2F_3$	38.44	42.55	27.56	36.18
$I_3F_1$	34.22	35.94	25.65	31.94
$I_3F_2$	32.89	38.42	27.75	33.02
$I_3F_3$	33.75	33.02	26.18	30.98
CD (0.05)	NS	15.85	2.231	3.386

$I_1$  - Irrigation at 100% PE;  $I_2$  - 80% PE;  $I_3$  - 60% PE;  $F_1$  - N and K fertilizers in 50, 30, 20;  $F_2$  - 30, 50, 20;  $F_3$  - 50, 40, 10

most of the nutrient requirement would be during the early stages of vegetative growth and tuber bulking up to 5 months rather than tuber maturity phase when the plant will be less photosynthetically active.

The interaction effects of irrigation and fertigation did not significantly affect the yield of cassava during 2009-2010. However, drip irrigation at 100% pan evaporation and fertilizer application of 50% N and K during the first 40 days, 30% during 40-80 days and the rest 20% during 80-120 days resulted in higher yield ( $I_1F_1$ ). During 2010-2011,  $I_1F_3$  i.e., a combination of 100% irrigation along with fertigation at the rate of 50% during the first 40 days, 40% during the next 40 days and the rest 10% during 80-120 days resulted in maximum tuber yield followed by  $I_2F_1$ . During 2011-2012,  $I_1F_1$  produced the maximum yield which was significantly superior over the other combinations. Pooled analysis indicated that irrigation at 100% PE in combination with fertigation at the rate of 50% fertilizers during 0-40 days and 40% fertigation during 40-80 days and 10% during 80-120 days resulted in maximum yield, which was on par with fertigation at 50, 40, 10.

Amanulla et al. (2006a) reported that in cassava, maximum tuber yield of 36 t ha<sup>-1</sup> was obtained with drip irrigation at 100% of surface irrigation followed by 75% of the surface irrigation, which were on par. In another irrigation experiment conducted in Nigeria, maximum dry matter yield as well as tuber yield were obtained when cassava was irrigated at a water regime of 100% available water (Odubanjo et al., 2011).

In the present experiment different doses of fertilizers were not tried, but only the schedule of application. A higher application during early stages showed positive response, however, significant difference could not be obtained.

#### Water use efficiency

Water use efficiency (WUE) was worked out based on both total biomass yield and fresh tuber yield under different irrigation levels (Table 2). On an average the crop consumed 540 mm of water for the whole period under 100% PE followed by 484 mm under 80% PE and 428 mm under 60% PE. The data indicated a gradual reduction in WUE with decreasing quantity of irrigation.

Percentage increase in WUE was maximum in  $I_1$  (92.6) and minimum in  $I_3$  (76.8) compared to rainfed crop.

Table 2. Water use efficiency estimated under different irrigation levels

Item	$I_1$	$I_2$	$I_3$	Rainfed
In terms of dry matter yield (kg ha <sup>-1</sup> mm <sup>-1</sup> )	56.2	51.5	35.8	25.4
In terms of fresh tuber yield (kg ha <sup>-1</sup> mm <sup>-1</sup> )	81.5	80.6	74.8	42.3
Increase in WUE (%)	92.6	90.5	76.8	—

This clearly reveals that supplementary irrigation during summer months increases cassava tuber yield, though the crop is reported to be drought tolerant. The values were almost the same under  $I_1$  and  $I_2$  irrigation levels. So it can be inferred that the additional water supplied in  $I_1$  level over  $I_2$  level could not result in significant increment in terms of productivity. Increase in water use efficiency in cassava with drip irrigation has been reported by Amanullah et al. (2006a and 2006b) in Tamil Nadu and the water use efficiency was 22 to 51% higher in drip irrigation compared to that of surface method. They further reported a WUE of 38.9 kg ha<sup>-1</sup> mm<sup>-1</sup> in cassava under surface irrigation at IW/CPE ratio of 0.6. Odubanjo et al. (2011) also reported similar findings, where the water use efficiency was 14.83 to 61.72% higher under drip irrigation for the two seasons.

#### Conclusion

In order to cope up with the increasing demand of cassava for variable uses, productivity needs to be enhanced by judicious use of inputs. The possibility of increasing the production per unit cropped area using supplemental irrigation is little exploited. The above findings clearly revealed that cassava responds well to supplementary irrigation during summer months. Drip irrigation at 100% of pan evaporation along with application of 50% N and K fertilizers during the first 40 days, 30% during 40-80 days and the rest 20% during 80-120 days after planting through drip system resulted in three fold increase in the tuber yield of cassava.

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