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# Water requirement and nutrient management of guava (cv. Arka amulya) using drip under high density plantation in coastal Odisha

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**Abstract**
In the experimental farm, the vegetative characteristics and yield characteristics of the 3-year-old guava were observed at various fertigation doses. Four levels of fertigation i. e. 100%, 80% and 60% of the recommended dose of fertilizer (RDF) by drip irrigation and 100% of the recommended dose of fertilizer by soil application were studied in a Randomized block design (RBD). The results showed a significant effect on the plant height, girth of trunk & number of primary branches in vegetative parameters. Canopy spread has shown insignificant effect on various fertigation levels. Yield characteristics *viz*., number of fruits per plant, weight of the fruit, equatorial and polar diameter of the fruit and yield per hectare affected significantly across various fertigation levels and higher doses resulted in better values. Water use efficiency (WUE) & Fertilizer use efficiency (FUE) were varied with fertigation levels. The results revealed that drip-fertigation can play a positive role in increasing yield, WUE of guava plants with additional benefit of saving in fertilizer cost and fruit quality improvement.

**Keywords:** Recommended dose of fertilizers, nutrient management, evapotranspiration, high density, water use efficiency, water requirement

## 1. Introduction
Water is an essential input for agricultural production. It not only increases agricultural production but contributes to the nation's economy. Water is a scarce resource in the current situation and there exists a large gap in terms of available water and its requirement for irrigation of crops. It is becoming increasingly scarce due to various reasons *viz.* population growth, expansion in industrial area, skewed rainfall pattern etc. The present level of irrigation efficiency in conventional systems of irrigation is low due to water loss through conveyance, leaching and evaporation. In this context, micro-irrigation has greater potential for increasing irrigation efficiency, bringing additional area under irrigation and thus helps in reducing the water demand in agriculture. Adoption of innovative irrigation techniques can increase the water use efficiency. Drip irrigation is the most efficient way to supply water and nutrients to the plants, which not only saves water but also increases the yield of fruits and vegetables (Tiwari *et al*., 1998) [28]. This water saving is due to the maximum amount of water accumulated in the root zone and deep percolation losses are reduced when a drip irrigation system used (Rajasekhar *et al*., 2017).
At present the government is emphasizing more on production of horticultural crops to meet the nutritional requirement of people and to export. Guava (*Psidium guajava*) is considered to be one of the most exquisite and nutritionally valuable and profitable crop. It is rich in vitamin C. This crop is generally grown under rain fed conditions. In India, Guava occupies 5th position with respect to the amount of cultivated area among all horticultural crops (NHB, 2017).
Cv. Arka amulya is a guava variety that is a progeny of Allahabad Safeda and Triploid. The vigor of the plants is medium and spreading type. Fruits have a round shape. The skin of the fruits is smooth and yellow in color. Fruits on an average weigh between 180 - 200g and the flesh is white and firm. TSS is around 12 Brix, soft seeded, weights 1.80 g per 100 seeds.
Due to the difficulties of achieving precise field measurements, crop water requirements (CWR) are used. The irrigation methods often need to be applied based on climatic and agronomic conditions. Testing the accuracy of the different methods under a new set of

Conditions is laborious, time-consuming and expensive, and yet crop water requirement data is often required on short notice for project planning. Among the different variables affecting guava production and productivity, much more depends on nutrients and water. Essentially, these two inputs need to be handled in a manner that provides optimal performance. The inadequacy of one or other nutrients at the critical stage of fruit production has a negative impact on productivity and product quality. It is also important that these inputs are managed effectively. In order to meet this need, and due to lack of knowledge on fertigation management in guava plantation an effort was made to read about the crop water requirements and water use efficiencies of Guava at different stages of growth under drip irrigation and to study the effect of fertigation on guava under different levels.

## 2. Materials and Methods

The research was carried out in Precision Farming Development Centre (PFDC), OUAT, Bhubaneswar. The climate of the experimental farm is hot humid tropical which receives on an average 1408 mm annual rainfall with 68 rainy days. The area is located in Odisha's east and south- east coastal agro-climate zone. Maximum average monthly temperature of 32°C is observed in the month of May and minimum average monthly temperature is observed 24°C in the month of January. Similarly, the maximum and minimum relative humidity 73% and 84% observed during the month of May and January respectively. The distribution of rainfall of Bhubaneswar is uneven and erratic and nearly 85% of total annual rainfall falling between June to October. April and May are relatively dry.

The experimental site's soil was categorized as loamy sand, having a pH of 4.32, Electrical Conductivity of 0.07dS $m^{-1}$ and organic content of 0.37%. On volume basis, the field capacity and permanent wilting point of soil at the experimental site were 18.9 and 3%, respectively. The bulk density of the soil was 1.18g/$cm^3$. The control head of the drip irrigation system consisted of submersible pumps, sand filter, screen filter, control valves, regulating valves. 16mm laterals with emitters of 4Lph discharge are used. The distance between the plants is 2.5m×3m. Venture is connected to the mainline for applying the liquid fertilizers uniformly. Fertilizer is applied monthly through venturi injector. Each plant is provided with 4 drippers of 4Lph capacity. The type of emitters used in the system is online. The RDF 375:150:375 g/plant/year based on soil test for 3rd year guava plants. The study was designed in Randomized block design with three repetitions of four treatments. The treatments used were 100%, 80%, 60% of RDF & 100% RDF in soil application and denoted as $T_1$, $T_2$, $T_3$ & $T_4$ respectively. The water soluble fertilizers used in this experiment were MAP (Mono Ammonium Phosphate), SOP (Sulphate of Potash) & Urea. The uniformity of the system was checked on every month of the drip system. The layout of the field shown in Fig. 1. The treatments of the experiment were

T1: 100% RDF through fertigation
T2: 80% RDF through fertigation
T3: 60% RDF through fertigation
T4: Drip irrigation with 100% RDF in soil application

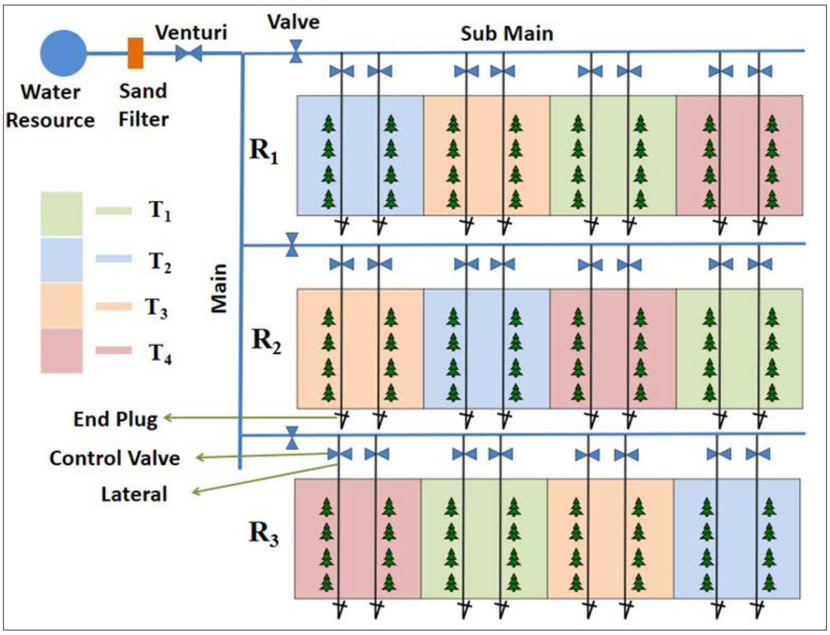


**Fig 1:** Layout of the drip system in experimental plot

### 2.1 Cultural practices

Weeds are cut prior to flowering. Intercultural operations were held timely. In the months of February and September plants were pruned. During flowering stage spraying of micronutrients *viz*., 4g Zinc Sulphate ($ZnSO_4$) + 2g Boric acid ($BH_3O_3$) per liter of water and urea 2 percent during fruit development was applied.

Irrigation scheduling is based on crop water requirement. Reference crop evapotranspiration ($ET_O$) was computed by using CROPWAT 8.0. Crop coefficients for various growth stages of Guava plants were selected from Singh *et al*., 2007 [11], based on growth stage of plants. The crop water requirement was obtained by multiplying the reference evapotranspiration with crop coefficient. The crop water requirement of the crop was calculated on a monthly basis. Following equation was used to measure the volume of water needed by plant per day was calculated (Pawar *et al*., 2013) [5].

$$V = \frac{ET_O \times K_C \times LS \times ES \times W_a}{\eta}$$

Where,
V = volume/amount of water applied (Lpd/plant)
$ET_O$ = reference evapotranspiration (mm)
$K_C$ = crop coefficient
LS = lateral spacing, m
ES = emitter spacing, m
$W_a$ = wetted area factor
η = application efficiency

Irrigation time (h) calculated by using the following equation.

$$\text{Irrigation time (in hours)} = \frac{\text{water requirement (litres)}}{\text{rate of application (litres)}}$$

For each month, the daily crop water requirement for guava was calculated. On a daily basis, drip irrigation system running time also computed. Quantity of total water required was computed on the basis of daily crop water requirement and effective rainfall. Total volume of water supplied was the cumulative water requirement of two days' minus effective rainfall (if rainfall occurred).

The specifications for crop water requirements and the duration of the irrigation system as set out in Table 1. Height of the plant, spread of the canopy, girth, number of primary branches and yield parameters, *viz*., number of fruits per plant, fruit diameter, average weight of the fruit, yield per plant and yield per hectare were calculated.

The water use efficiency was computed as following (Ramniwas *et al*., 2013).

$$\text{WUE}\left(\frac{\text{kg}}{\text{m}^3}\right) = \frac{\text{yield (water kg)}}{\text{total amount of used (cubic meters)}}$$

The fertigation was provided to the plants on a monthly basis through the drip. 100% of RDF through soil application was provided in the month of July. The nitrogen dose was split into two and one is applied in the month of July and the second dose was applied during the fruit setting stage i.e., in the mid of October. The following formula is used to calculate fertigation efficiency.

$$\text{FUE} = \frac{\text{yield (kg/ha)}}{\text{total amount of nutrients applied (kg of NPK/ha)}}$$

The biometric observations *viz*., plant height, canopy spread, girth were measured by using tape and yield parameters *viz*., equatorial and polar diameter of the fruits were measured by using the vernier caliper. Weights of the fruits were measured by using an electronic table top weighing balance. Yield per hectare was get by calculating the number of trees per hectare and multiplied by number of fruits per plant. The variance of analysis was done by using SAS Software for different parameters. Multiple comparison tests were done by using DMRT (Duncan's Multiple Range Test).

## 3. Results and Discussions

The crop water requirement of the crop was calculated on a monthly basis and time of operation is provided in the following Table 1. The daily water requirement of the Guava crop was obtained highest in the month of May as 69. 98 l/day/plant followed by in April month as 66. 82 l/day/plant. The highest $K_C$ value was obtained in the month of April because $K_C$ value will be more in the mid-season state of the crop. The maximum volume of water is needed during the flowering and fruit setting stage and comparatively less amount of water needed in initial and maturity stage. The daily running time of the drip system ranged from 85.44 to 262.43 minutes in different months due to variation of irrigation requirements. Findings are conformity with Sharma *et al*., 2014 that requirement of the water for crop obtained maximum in the month of May.

**Table 1:** Crop water requirement of 3-year-old guava (cv Arka amulya) in coastal Odisha

| Month | $ET_O$ (mm/day) | $ET_O$ (month) | $K_C$ | Water per plant (l/day) | Duration (min) | Water required ($m^3$/ha) |
|---|---|---|---|---|---|---|
| January | 2. 7 | 83. 7 | 0. 65 | 27. 20 | 102. 00 | 1124. 08 |
| February | 3. 81 | 106. 7 | 0. 6 | 32. 00 | 120. 01 | 1322. 50 |
| March | 4. 69 | 145. 4 | 0. 6 | 43. 61 | 163. 56 | 1802. 38 |
| April | 5. 94 | 178. 2 | 0. 75 | 66. 82 | 250. 59 | 2761. 40 |
| May | 6. 45 | 200. 0 | 0. 7 | 69. 98 | 262. 43 | 2891. 88 |
| June | 4. 28 | 128. 4 | 0. 7 | 44. 94 | 168. 52 | 1857. 05 |
| July | 5. 13 | 159. 0 | 0. 55 | 43. 73 | 163. 99 | 1807. 18 |
| August | 3. 68 | 114. 1 | 0. 55 | 31. 37 | 117. 64 | 1296. 38 |
| September | 3. 61 | 108. 3 | 0. 55 | 29. 78 | 111. 68 | 1230. 70 |
| October | 3. 32 | 102. 9 | 0. 55 | 28. 30 | 106. 13 | 1169. 56 |
| November | 2. 95 | 88. 5 | 0. 6 | 26. 55 | 99. 56 | 1097. 12 |
| December | 2. 45 | 76. 0 | 0. 6 | 22. 78 | 85. 44 | 941. 54 |
| Total | | | | | | 19301. 83 |

### 3.1 Effect of growth parameters on different fertigation levels

The highest plant height was recorded in 100% RDF through fertigation ($T_1$) as 2.79 m, as compared to 100% RDF through soil application ($T_4$) as 2.47 m in the harvesting stage. The difference in plant height between the different treatment levels during the different stages of crop growth has shown a significant effect and the parameters are shown in the Table 1. The results are confirmed with Kumar *et al*., 2013 [4] that vegetative growth of the plant showed positive effect under different fertigation levels.

Plant spread was maximum as 2.20 $m^2$ in $T_1$ and minimum as 2.04 $m^2$ in $T_4$. Under different fertigation levels $T_3$ showing minimum spread 2.05 $m^2$. Canopy spread is effecting insignificantly under different fertigation treatments at various stages of the plant growth. The number of primary branches of 3-year-old Guava were maximum in $T_1$ (5) i.e., 100% RDF through fertigation followed by $T_2$ (4) i.e., 80% of RDF through fertigation. Results obtained same as Khan *et al*., 2013 [3] that canopy spread shows non-significant effect across different fertigation levels when comparing means by multiple comparison tests. The lowest number of branches obtained in 100% RDF through soil application is 3. At different stages of crop growth under various levels of fertigation the number of primary branches varied significantly. The girth of the trunk shows significant difference under different levels of fertigation levels at various crop growth stages. The girth of trunk was highest in $T_1$ as 19.08 cm and lowest in $T_4$ as 15.09 cm i.e., in 100% RDF through soil application. The girth of the trunk differed significantly across various stages of crop growth under various levels of fertigation. The results were found similar to Selvamurugan *et al*., 2017 in coconut crop that plant growth parameters were higher in 100% RDF.

**Table 2:** Effect of fertigation on growth parameters of 3-year-old guava in different crop stages

| Treatment | Plant stage | Plant height (m) | Canopy spread (m$^2$) | Girth (cm) | No of primary branches |
|---|---|---|---|---|---|
| $T_1$ | Initial stage | 1. 77$^a$ | 2. 10$^a$ | 16. 76$^a$ | 3$^a$ |
| $T_2$ | | 1. 71$^b$ | 2. 02$^a$ | 15. 96$^a$ | 3$^a$ |
| $T_3$ | | 1. 71$^b$ | 2. 02$^a$ | 15. 73$^a$ | 3$^a$ |
| $T_4$ | | 1. 70$^b$ | 1. 95$^a$ | 15. 21$^b$ | 2$^a$ |
| $T_1$ | Flowering stage | 2. 03$^a$ | 2. 11$^a$ | 17. 33$^a$ | 4$^a$ |
| $T_2$ | | 1. 95$^b$ | 2. 04$^a$ | 16. 36$^a$ | 3$^a$ |
| $T_3$ | | 1. 89$^c$ | 2. 03$^a$ | 16. 10$^a$ | 3$^a$ |
| $T_4$ | | 1. 88$^c$ | 1. 97$^a$ | 15. 38$^b$ | 3$^a$ |
| $T_1$ | Mid-season stage | 2. 36$^a$ | 2. 13$^a$ | 18. 18$^a$ | 4$^a$ |
| $T_2$ | | 2. 37$^a$ | 2. 05$^a$ | 17. 05$^b$ | 4$^a$ |
| $T_3$ | | 2. 16$^b$ | 2. 03$^a$ | 16. 50$^c$ | 4$^a$ |
| $T_4$ | | 2. 12$^b$ | 1. 98$^a$ | 15. 65$^c$ | 3$^b$ |
| $T_1$ | Harvesting stage | 2. 79$^a$ | 2. 20$^a$ | 19. 08$^a$ | 5$^a$ |
| $T_2$ | | 2. 74$^a$ | 2. 14$^a$ | 17. 78$^b$ | 4$^b$ |
| $T_3$ | | 2. 55$^b$ | 2. 05$^a$ | 16. 95$^b$ | 4$^b$ |
| $T_4$ | | 2. 47$^b$ | 2. 04$^a$ | 15. 91$^c$ | 3$^c$ |

Means with the same letter are not significantly different

### 3.2 Yield parameters
Different Fertigation levels shows significant effect across yield characters *viz*., equatorial diameter and polar diameter of the fruit, weight of the fruit, number of fruits & yield per hectare. The equatorial and polar diameter of the fruit affected significantly under different treatments. The effect of fertigation treatment on yield parameters shown in Table 3.

The number of fruits per plant obtained maximum in $T_1$ (85) followed by $T_2$ (70) & lowest obtained in $T_4$ (45) i.e., 100% RDF through fertigation. The weight of the fruits also affected significantly among various levels of treatments. $T_2$ obtained maximum fruit weight as 188.75g and minimum fruit weight observed in $T_4$ i.e., 100% RDF through soil application. $T_1$ and $T_2$ treatments are at par with each other in weight of the fruit. Yield per plant was obtained maximum in 100% RDF through fertigation as 15.15 kg/tree and lowest in 100% RDF through soil application as 7.55 kg/tree. Yield per hectare obtained highest as 20.64 t/ha in $T_1$ followed by $T_2$ (17.36 t/ha) and lowest as 10.02 t/ha in $T_4$. Results are same as Suman *et al*., (2011) [12] that he observed highest yield in guava for 100% RDF application.

**Table 3:** Effect of fertigation on yield characteristics of 3-year-old guava

| Treatment | Number of fruits | Yield/plant (kg) | Yield/ha (t) | Fruit weight (g) | Polar diameter (cm) | Equatorial diameter (cm) |
|---|---|---|---|---|---|---|
| $T_1$ | 85$^a$ | 15.15$^a$ | 20.64$^a$ | 178.93$^a$ | 7.41$^a$ | 7.21$^a$ |
| $T_2$ | 69$^b$ | 13.04$^b$ | 17.36$^b$ | 188.75$^a$ | 7.07$^b$ | 7.00$^b$ |
| $T_3$ | 57$^c$ | 10.64$^c$ | 14.05$^c$ | 185.00$^a$ | 6.69$^c$ | 6.65$^c$ |
| $T_4$ | 45$^d$ | 7.55$^d$ | 10.02$^d$ | 166.60$^b$ | 6.28$^d$ | 6.29$^d$ |

Means with the same letter are not significantly different.

### 3.3 Water and fertilizer use efficiency
The water and fertilizer use efficiencies of 3-year old guava varied significantly among different levels of treatments and shown in table 4. The water use efficiency (WUE) obtained maximum in 100% RDF through fertigation ($T_1$) as 1.07 kg/m$^3$ followed by $T_2$ as 0.90 kg/m$^3$ and lowest was obtained in 100% RDF through soil application as 0.52 kg/m$^3$. Shirgure *et al*., (2001) [10] have observed maximum water use efficiency with drip irrigation in Nagpur mandarin mainly due to saving in water and higher fruit yield. The fertilizer use efficiency (FUE) showed significant difference across different levels of treatments. FUE observed maximum in $T_3$ (19.52kg/ha) followed by $T_2$ (18.08 kg/ha) and minimum efficiency observed in $T_4$ as 8.36 kg/ha. The results were more or less similar to the Ramniwas *et al*., 2013. The increase in FUE is due to reduction in the amount of fertilizer applied. The lowest FUE was observed in soil application due to low efficient use fertiliser by plant which leads to lower yield.

**Table 4:** Water and fertilizer use efficiencies of 3-year guava under different levels of fertigation

| Treatment | WUE (kg/m$^3$) | FUE (kg/ha) |
|---|---|---|
| $T_1$ | 1.07$^a$ | 17.20$^a$ |
| $T_2$ | 0.90$^b$ | 18.08$^b$ |
| $T_3$ | 0.73$^c$ | 19.52$^c$ |
| $T_4$ | 0.52$^d$ | 8.36$^d$ |

Means having the same letter are not significantly different

## 4. Conclusions
The study clearly revealed that high density planting is superior over normal planting. Drip application of water soluble fertilizers increased yield positively and improved produce quality. The yielding of guava was found to be dependent on the fertilizer doses. 100% recommended dose of

fertilizers by drip fertigation at one-month interval appeared to be an ideal practice for improving the growth, yield attributes, fruit quality, and yield of guava (Cv Arka amulya). Owing to water saving, drip irrigation may also allow to bring additional area under cultivation. Evapotranspiration being the dominant governing factor in estimation of crop water requirement. Guava crop water requirement varies from 22.78 to 69.98l/plant/day for the fully growing season. Results revealed that drip fertigation with 100% RDF showed positive results on growth and yield parameters than the 100% RDF through soil application.

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