

Effect of Fertigation and Mulching on Growth and Yield of Guava under High Density at Various Stages of Growth in Coastal Odisha

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Authors' contributions

This work was carried out in collaboration among all authors. Author LPC designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author BPB managed the analyses of the study. Author PCP managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted on Guava with four treatments and viz., three levels of fertigation i.e., 100%, 80%, 60% of Recommended Dose of Fertilizer (RDF) with mulching and the control refers to drip irrigation with 100% RDF in soil application. The variety used in experiment is Cv Arka Amulya with a spacing of 3 m × 2.5 m. For fertigation purpose, water-soluble fertilizer of Nitrogen, Phosphorous and Potassium is used. The results showed that vegetative growth parameters viz., plant height, girth, number of primary branches were significantly affected and canopy spread was non-significantly affected at various stages of the plant growth. The maximum plant height (2.89 m), canopy area (2.16 m²), girth (19.78cm), number of branches (6) found in 100% RDF through fertigation with mulching at the harvesting stage of the crop. The interaction effect of mulching and fertigation showed significant effect on both the vegetative and yield parameters.

Keywords: RDF; fertigation; high density planting; canopy; girth.

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1. INTRODUCTION

Guava (*Psidium guajava* L.) is one of the important fruits of the tropics and sub-tropics parts of the world. It belongs to the family 'Myrtaceae'. Guava is under cultivation in India since early 17th century introduced by Portuguese. Its origin is considered from tropical South America stretching from Mexico to Peru. In tropical and subtropical conditions of northern India, guavas mainly have two flowering seasons i.e., summer (April- May) and rainy (July – August). The summer (April-May) flowering produces crops for the rainy season and the rainy season (July-August) flowering produces crops in the winter season.

In north India, guava trees produce about 90% crops in rainy season, 8-10% in winter season and very few in spring season. This feature in guava cultivation is a major source of concern. Rainy season fruits are rough, insipid, poor in quality, less nutritive, easily affected by insect pests and have very short shelf life. Due to these characteristics of the guava fruits do not fetch remunerative prices. Whereas, the winter season fruits are superior in quality, free from diseases and pests and fetches more prices in the market. Winter season crop have better storage life than the rainy season crop and thus can be transported to destination offering remunerative prices [1].

Guava is a pruning responsive crop. High-density planting of guava is one of the important techniques where higher numbers of plants per unit area are accommodated as compared to the conventional planting density. Normally high-density planting (HDP) is done at a spacing of 3 x 6m (555 trees/ha) whereas conventional planting followed at a spacing of 6 x 6m (277 trees/ha). Mandal et al. [2] found the highest yield with less spacing under drip whereas lowest yield was observed under more spacing. Shoot pruning in high density orchards is prerequisite to maintain the desired canopy of this fast growing guava plant. Efficient training and pruning can maintain the proper canopy size of the guava tree and improve fruit quality and quantity.

National productivity of guava is 15.7 t/ha whereas, Odisha state productivity of guava is 7.3t/ha. Guava cultivated in an area of 14,230 ha in Odisha, which is 4.3% of total fruit crop area of the state [3]. Hence there should be the promotion of guava cultivation in the state in

large scale. The irrigated area of Odisha is 50% and 22% of cultivated area during kharif and rabi seasons, respectively. The rainfall pattern in the state is not uniform throughout the year. About 80% of total annual rainfall occurs during June to September and rest 20% rainfall spreads over 8 months. The advanced method of irrigation like drip irrigation has become popular in horticultural crops viz. fruit crops, plantation crops, vegetable crops and flowers due to water-saving and increase of productivity.

Mulching is used to control weed, temperature moderation and salinity reduction. The notable advantage of the use of plastic mulch is its impermeability which prevents direct evaporation of moisture from the soil and thus reduces the water losses. Plastic like HDPE, LDPE and LLDPE materials has been used as plastic mulch.

Drip fertigation is a method of fertilizer application in which fertilizer is incorporated within the irrigation water by the drip system. In this system fertilizer solution is distributed evenly in irrigation. The availability of nutrients is very high therefore the efficiency is more. In this method liquid fertilizer, as well as water soluble fertilizers are used. This approach would achieve an efficiency of fertilizer usage of up to 90%. In Odisha about 20,000 ha area is under drip irrigation in horticultural crops but the adoption of fertigation by the farmers is limited. Hence the benefit of drip irrigation is not fully utilized. This may be due to lack of knowledge regarding fertigation schedule of different crops, availability of water soluble fertilizer and lack of awareness. The cost of fertilizers are high and most of the major fertilizers like N, P, K are imported to meet the domestic requirement for which huge investment is required in foreign exchange. Hence an effort has been made to study the effect of fertigation on Guava using drip irrigation technology and polyethylene mulching. Thus, the investigation was carried out to examine the effect of fertigation and mulching on vegetative and yield parameters of guava and to suggest the most efficient level of fertigation that would attain maximum growth and yield of the crop under high density planting.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was carried out in the Precision farming development center, OUAT,

Bhubaneswar, Odisha during July-2018 to February-2019. The experimental site lies at 20° 31' 15" N latitude to 85° 47' 24" E longitude and 25.5 m above mean sea level. The experimental site comes under East and south eastern coastal plain of Odisha.

2.2 Treatment Application

The field experiment consists of drip irrigation system. The experiment is laid out in Random block design (RBD) with three replications comprising four treatments shown in Fig. 1. The four treatments are 100%, 80%, 60% RDF under mulching and no mulching conditions and fourth treatment is drip irrigation with 100% RDF in soil application without mulch. The plantation with a spacing of 3 m × 2.5 m. The variety used in the experiment was *Cv Arka Amulya*. The soil of the experimental plot is loamy sand. Irrespective of treatments the recommended dose of N:P;K fertilisers (RDF) is 500:200:500 kg/ha, the soil was characterized with low in available nitrogen (164 kg/ha), medium in available phosphorus (30 kg/ha) and low in available potassium (100 kg/ha). The water soluble fertilizers are applied through drip system. The experiment uses venture injector with manifold as fertigation unit. The variation in the recommended dose of fertilizer in response to different trials may be associated with soil factor, plant age and the crop growth. Different treatments of N, P and K were applied to Guava trees. The LDPE (100 µ) mulch film was put over the soil around the respective girth of each plant with 30% surface coverage for irrigation. The control head of drip irrigation system consisted of submersible pumps, sand filter, screen filter, control valves, regulating valves. 16 mm laterals with emitter of 4 Lph discharge are used. Venture is connected to the mainline for applying the liquid fertilizers uniformly. Fertilizer is applied monthly through venture injector. Each plant is provided with 4 drippers of 4Lph capacity. Irrigation is provided to the plants on daily basis through drip. Treatments in the trail were:

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

The amount of fertilizer used for various treatments on monthly basis per plant was

estimated. The Fertilizer Use Efficiency (FUE) was computed by using following expression [4].

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

R1	T2	T3	T4	T1
R2	T3	T4	T1	T2
R3	T1	T2	T3	T4

Fig. 1. Layout of field

2.3 Mulching

Mulching leads to change the micro-environment of the top soil. So temperature at 8:30 A.M., 12:30 P.M. and 4:30 P.M. at the surface in mulch and subsurface (5cm below the soil surface) were taken by using soil thermometer.

Parameters of vegetative growth characteristics such as plant height, canopy spread (EW and NS), girth of the trunk and number of primary branches had taken. Plant height, canopy spread and girth of the plants were measured by using measuring tape. The equatorial and polar diameters of the fruit were measured by using vernier caliper. The analysis of variance was done by using SAS Software.

3. RESULTS AND DISCUSSION

The performance of different fertigation treatments under mulching conditions in guava for different stages of the crop were analyzed based on the vegetative growth and yield.

3.1 Vegetative Growth Parameters

Parameters viz., height of the plant, girth, number of primary branches and canopy spread are the indicators of plant growth. The effect of fertigation and mulching of crop at different stages of the crop were evaluated for three year old guava plants. Plants after pruning have almost similar height. Therefore, at initial stage of plants, height of the plants is equal which means there is no significant difference of height among the plants during initial stage. In other stages of plant i.e., flowering stage, mid-season stage and

harvesting period the plant height varied with treatment. The effect of different treatments on vegetative growth of guava was tabulated in Table 1. The maximum (2.89 m) and minimum (2.47m) height was observed in T₁ and T₄ treatments, respectively. There is a significant difference in height between the different levels of treatments. Results are conformity with Barman et al. [5], Pramanik and Patra, [6].

Canopy spread was non-significant during the season. Different treatments at different crop periods had a non-significant effect on canopy spread. The maximum plant spread was noticed in 100 % fertigation with mulching (2.16 m²) during the winter season whereas minimum in soil application (2.04 m²). The results are verified with Khan et al. [7] that canopy spread and canopy volume showed non-significant effect under interaction effect of fertigation and mulching.

Application of various levels of fertigation showed significant influence on girth of the trunk. The maximum (24.68 cm) girth of trunk was noticed in T₂ (80 % fertigation with mulch). Fertigation levels indicates the maximum girth of trunk was in T₁ (19.78 cm) as highest and at par with T₂ (18.84 cm) and minimum in drip irrigation with 100% RDF in soil application T₄ (15.91 cm). Results are verified with Sukla et al, [8]. Different fertigation levels had significant influence on

number of primary branches during the crop period. However, it was observed that maximum number of branches in T₁ was followed by T₂. Minimum number of branches obtained in drip irrigation with 100 % RDF in soil application. The mulching and non-mulching treatments are varied significantly. The effect of fertigation and mulching on vegetative growth of Guava plants under different treatments shown in Table 1.

3.2 Yield Parameters

3.2.1 Physical characteristics of the fruit

Results show that the fruit diameter differed significantly in various fertigation levels. Different fertigation levels and mulching had significant influence on polar fruit diameter during the seasons. The highest polar diameter of fruit (7.82 cm) was observed in 100 % fertigation and minimum (6.28 cm) in 100% RDF through soil application. However, the polar diameters in all treatments are significantly varied at 0.01% of level of significance. Polar diameters (7.40, 7.14 and 6.96 cm) were recorded in different treatments i.e., 100, 80, and 60 % fertigation respectively. Different treatments had significant influence on fruit weight. From the observations found that maximum fruit weight (201.43 g) was recorded in 80% fertigation with mulch treatment and minimum (166.60 g) in soil application. The results are in agreement with Barman et al. [5].

Table 1. Effect of fertigation and mulching on 3 year old guava on vegetative growth parameters

Treatment	Plant stage	Plant height (m)	Canopy spread (m ²)	Girth (cm)	No of primary branches
T ₁	Initial stage	1.74 ^a	2.11 ^a	16.83 ^a	3 ^a
T ₂		1.71 ^a	2.05 ^a	17.00 ^a	3 ^a
T ₃		1.70 ^a	2.04 ^a	15.91 ^b	2 ^a
T ₄		1.71 ^a	2.02 ^a	15.21 ^c	2 ^a
T ₁	Flowering stage	2.11 ^a	2.13 ^a	17.73 ^a	4 ^a
T ₂		1.94 ^b	2.08 ^a	17.51 ^a	4 ^a
T ₃		1.92 ^b	2.06 ^a	16.21 ^b	3 ^b
T ₄		1.88 ^b	2.03 ^a	15.38 ^c	3 ^b
T ₁	Mid-season stage	2.46 ^a	2.15 ^a	18.61 ^a	5 ^a
T ₂		2.27 ^b	2.09 ^a	18.15 ^a	4 ^b
T ₃		2.25 ^b	2.07 ^a	16.51 ^b	3 ^c
T ₄		2.12 ^c	2.03 ^a	15.65 ^b	3 ^c
T ₁	Harvesting stage	2.89 ^a	2.16 ^a	19.78 ^a	6 ^a
T ₂		2.65 ^b	2.09 ^a	18.84 ^b	5 ^b
T ₃		2.55 ^b	2.07 ^b	16.85 ^c	4 ^b
T ₄		2.47 ^c	2.04 ^b	15.91 ^d	3 ^c

Means with the same letter are not significantly different

3.2.2 Yield characters

It is clear from the data that various treatments had significant effect on the number of fruits per plant during season. On average value basis maximum (95) number of fruits per plant was recorded in T₁ whereas, minimum (45) number of fruits per plant in T₄ under mulching conditions. However, T₁ was at par with T₂ (71). Results revealed that maximum estimated fruit yield (23.22 t ha⁻¹) was observed in mulch with 100% fertigation followed by (18.65 t ha⁻¹) in 80% fertigation with mulch conditions. It shows that there is significant difference between the treatment levels on yield characters. Fertigation and mulching effect on guava yield shown in Table 2. The results are in conformity with the findings of Singh et al. [9] obtained higher yields from drip-irrigated plots with mulching compared with those only having drip system. Results also are in accordance with Pramanik and Patra [6] who found the 100% of irrigation and fertigation recommended for higher yield. Kumar et al [10] revealed the yield attributes are significantly influenced by fertigation levels.

3.2.3 Effect of mulching on soil temperature

Mulched surface temperature was more than that of non-mulched treatments after 8:30 A.M. However, the mulched sub surface temperature was higher in the morning and gradually decreased afterwards than that of the no mulched treatments. This leads to good environment for root growth and affects the temperature moderation process due to mulching. The LDPE mulch shows that the maximum temperature difference of 7.8 °C occurred between the surface and sub-surface (5 cm below the soil surface) temperatures shown in Fig. 2. Results are similar to Selvamuragan et al. [11], he observed that drip fertigation and mulching affected the root zone temperature (°C) and plastic mulches significantly increased the soil temperature than un-mulched control treatments.

3.2.4 Fertilizer use efficiency

The data on fertilizer use efficiency as influenced by mulching, levels of fertilizer and their combination are shown in Table 3.

Table 2. Effect of fertigation and mulching on 3 year old Guava on yield parameters

Treatment	Number of fruits	Yield/plant (kg)	Yield/ha (t/ha)	Fruit weight(g)	Polar diameter	Equatorial diameter
T ₁	95 ^a	17.413 ^a	23.217 ^a	183.193 ^b	7.82 ^a	7.40 ^a
T ₂	71 ^b	14.395 ^b	18.650 ^b	201.430 ^a	7.18 ^b	7.14 ^b
T ₃	66 ^b	12.256 ^b	16.240 ^b	185.800 ^b	6.76 ^c	6.96 ^c
T ₄	45 ^c	7.552 ^c	10.027 ^c	166.600 ^c	6.28 ^d	6.29 ^d

Means with the same letter are not significantly different

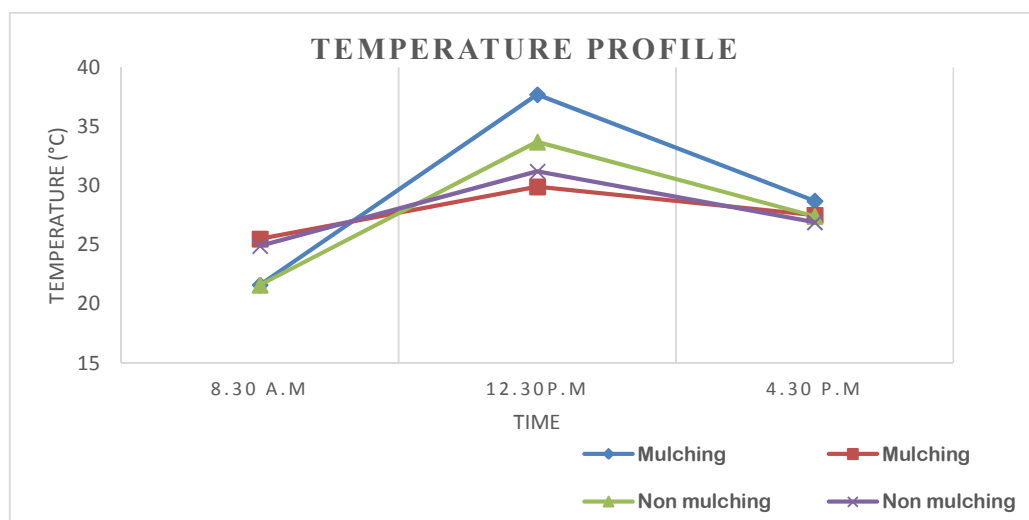


Fig. 2. Effect of LDPE mulch on soil temperature

Fertilizer use efficiency differed non-significantly among the treatments in fertigation levels. Maximum FUE (22.56 kg/ha) was observed in T with treatment T3 (60% fertigation with mulch) and minimum FUE found in 100% RDF through soil application as 8.36 kg/ha. The data reveals that the combination of mulching and fertigation levels had influenced on FUE under various treatments. WUE of guava plants also varied significantly with various treatments and results are consistent with Pramanik and Patra [6] the highest WUE obtained in 100% irrigation through drip.

Table 3. FUE and WUE of Guava plants under various treatment

Treatment	FUE	WUE
T ₁	19.35 ^a	1.20 ^a
T ₂	19.43 ^a	0.97 ^b
T ₃	22.56 ^a	0.84 ^b
T ₄	8.36 ^b	0.52 ^c

Means with the same letter are not significantly different

Ramniwas et al. [12], Samanth et al. [13] reported that the interaction effect of irrigation and fertigation effect was giving significant result on both vegetative and yield parameters. Ramniwas et al. [14] stated that interaction effect of 100 % fertigation with 100% irrigation giving higher yield. Ramanarao et al. [15] observed that maximum plant height, periphery of root stock, yield per plant and yield per hectare was highest in 100% irrigation with 100% fertigation.

4. CONCLUSIONS

The performance of Guava (Cv. Arka Amulya) under different fertigation levels was verified for growth, yield parameters and yield characteristics. The vegetative parameters such as plant height (2.89 m), canopy spread (2.16 m²), girth of trunk (19.78cm), number of branches (6), maximum in T₁ (100% RDF through fertigation with LDPE mulching) followed by T₂ (80% RDF through fertigation with mulching). All the treatments are differed significantly at various stages of crop. The average fruits per plant (95), yield per hectare (23.22 t), polar diameter (7.82cm) and equatorial diameter(7.37cm) were recorded highest in 100% RDF through drip fertigation along with mulching (T₁), while weight of the fruits was maximum in 80% RDF through fertigation with mulching(T₂). The Fertilizer use efficiency (22.56 kg/ha) observed maximum in 60% RDF through

fertigation with mulching followed by 80% RDF through fertigation and lowest (8.36 kg/ha) recorded in 100% RDF through soil application. The results of the present investigation revealed that among different fertigation levels T1 was statistically superior over higher level. RDF through fertigation was superior over RDF through soil application. The interaction effect of fertigation and mulching revealed good result in both vegetative and yield parameters. Therefore, 100% RDF through fertigation with mulching is recommended for sustainable guava production for coastal Odisha conditions.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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