



ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(7): 3297-3300
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www.thepharmajournal.com
Received: 07-04-2023
Accepted: 22-06-2023

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Effect of fertigation and mulching on growth and yield of tissue cultured grand naine banana (*Musa paradisiaca* L.) under high-density planting system

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Abstract

An experiment was conducted in Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya Raipur (C.G.) during 2015-16 to enhance growth and yield of banana (*Musa paradisiaca* L.) fruit. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replication and twelve treatments combination namely T₁ (F₀M₀) - RDF through conventional + Without mulch (Control), T₂ (F₀M₁) -RDF through conventional + Leaf mulch, T₃ (F₀M₂) - RDF through conventional + Plastic mulch, T₄ (F₁M₀) - Fertigation with 60% PE + 60% RDF + Without mulch, T₅ (F₁M₁) - Fertigation with 60% PE + 60% RDF + Leaf mulch, T₆ (F₁M₂) - Fertigation with 60% PE + 60% RDF + Plastic mulch, T₇ (F₂M₀) Fertigation with 80% PE + 80% RDF + Without mulch, T₈ (F₂M₁) Fertigation with 80% PE + 80% RDF + Leaf mulch, T₉ (F₂M₂) Fertigation with 80% PE + 80% RDF + Plastic mulch, T₁₀ (F₃M₀) - Fertigation with 100% PE + 100% RDF + Without mulch, T₁₁ (F₃M₁) - Fertigation with 100% PE + 100% RDF + Leaf mulch, T₁₂ (F₃M₂) - Fertigation with 100% PE + 100% RDF + Plastic mulch. Result revealed that all the growth parameters like plant height (284.44 cm), girth of plant (77.13 cm) and number of leaves per plant (22.10), were recorded highest in treatment combination (T₉ - F₂M₂- Fertigation with 80% PE + 80% RDF + Plastic mulch) which ultimately gave the highest yield. Among yield parameters like weight of bunch per plant (24.25 kg), bunch yield per hectare (80.54 tone's) and Marketable bunch yield per hectare (78.20 tone's), were recorded highest in treatment combination (T₉ - F₂M₂- Fertigation with 80% PE + 80% RDF + Plastic mulch).

Keywords: Banana, fertigation, mulching, RDF, plastic, growth, yield and FRBD

Introduction

Banana (*Musa paradisiaca* L.) belongs to the family musaceae is a large perennial herb with leaf sheaths that form trunk like pseudo stem. In recent years, considering the adverse impact of indiscriminate use of chemicals, new trend for organic production of banana is increasing in the country. A new name, i.e., "Green Foods" for this has been coined. India is the leading producer of banana in the world, contributing 25% to the global production with a total area of 0.920 million ha and production 33.73 million tons (Anon, 2020) [1]. The total area under banana in the Chhattisgarh is 0.24 million ha which producing 5.94 million tons of banana (Anon, 2020) [1]. The major banana growing states are Tamil Nadu, Maharashtra, Karnataka, Gujarat, Andhra Pradesh, Assam, Madhya Pradesh, Orissa and West Bengal. Tamil Nadu has the largest area followed by Maharashtra and Karnataka. Tamil Nadu also ranks first in production, followed by Maharashtra. However, the highest productivity is recorded in Maharashtra followed by Gujarat, Tamil Nadu and Madhya Pradesh. Maharashtra excels in productivity owing to monoculture of high-yielding Cavendish clones coupled with adoption of improved technologies like high density planting, fertigation and growing tissue culture plants (Mustaffa, 2011) [8].

Drip irrigation (trickle or micro irrigation) is a promising system for economizing the available irrigation water. It is also necessary to manage the available water efficiently for maximum crop production. Drip irrigation can apply water both precisely and uniformly at a high irrigation frequency compared with furrow and sprinkler irrigation (Hanson and May, 2007) [3]. Banana crop under drip irrigation resulted in increased yield, higher number of hands with more length and girth of fruits. Weekly fertigation with proportionate quantities of 200:30:300g NPK/plant/year starting with 9th week after planting, effectively increased yield of banana cv. Robusta (Mahalakshmi *et al.*, 2000) [6]. Fertigation, a technique of application of both water and fertilizers through drip irrigation system during the recent years was shown to

be very effective in achieving higher water and fertilizer use efficiencies. In this method, both water and fertilizer are delivered precisely in the effective crop root zone as per the crop needs and crop developmental phases. Increased growth and yield with drip fertigation has been reported in several crops and the yield increase ranged between 7-112% depending on the crops, varieties, and method of irrigation. The water and fertilizer saving through drip fertigation system have been reported to be 40-70 and 30-50% respectively (Rekha *et al.*, 2008) [11]. The aim of this Investigation was to study the effect of Sub-surface drip fertigation on growth, yield and economics of banana.

Mulching plays an important role in soil moisture conservation, improving soil structure, regulate soil temperature and reduces weed growth (Reddy and Khan, 2000) [10]. Mulch conserves soil moisture retained heat as well as it suppresses weed growth. The greatest benefit from plastic mulch is that the soil temperature in the planting bed is raised, promoting faster crop development and earlier harvest. The growth and productivity of banana is influenced by soil moisture. Banana being a shallow-rooted crops, it is highly sensitive to soil moisture stress. Nutrients and conserve the soil moisture and to increase the productivity. It is necessary to adopt proved package of practices, particularly, in situ moisture conservation by mulching. Traditionally, the farmers use paddy straw, sunflower waste, sugarcane trash for mulching the banana crop.

Materials and Methods

Field experiment was carried out during the year 2015-16 in *kharif* season at research field of Precision Farming Development Centre (PFDC), Department of Fruit Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replication and twelve treatments combination. With the objectives of to find out the effect of fertigation and mulching on growth and yield of banana. The various growth and yield parameters were recorded using following methods:

Height of plant (cm)

Plant height was measured in centimeter from ground level up to the first newly emerged leaf of growing shoot with the help of measuring tape.

Girth of plant (cm)

Trunk girth of plant was measured ten cm above the ground level with the help of measuring tape and it was averaged.

Average no. of leaves

The total number of leaves including green leaves except the scale and sword leaves were counted at one month interval and at flowering stage of plant.

Weight of bunch per plant (kg)

Total yield per plant was calculated by weighting the bunch after harvesting and mean was calculated.

Bunch yield per hectare (tonnes)

The bunch were weighted separately from each plant and the total yield was worked out by multiplying the number of plants and then per hectare yield of fruit was calculated in tonnes/hactare.

Marketable bunch yield per hectare (tonnes)

Marketable yield = Gross yield - Non marketable yield

Result and Discussion

At 7 MAT, the maximum height of plant was recorded in F2M2 combination (Fertigation with 80% PE + 80% RDF + Plastic mulch) *i.e.*, 284.44 cm followed by F3M2 combination (Fertigation with 100% PE + 100% RDF + Plastic mulch) *i.e.* 282.32 cm and F3M1 combination (Fertigation with 100 PE + 100% RDF + Leaf mulch) *i.e.* 280.55 cm, minimum height of plant was recorded in F0M0 combination (RDF through conventional + Without mulch) *i.e.* 235.01 cm. The results are in accordance with (Mahalakshmi *et al.*, 2000) [6] Robusta banana grown under sandy-loam conditions of Coimbatore, irrigation @ 25 litre/day and fertigation with 100% RDF of 200:300g N& K recorded the most vigorous plant growth and height of plant (289.40 cm to 239.23 cm)) and yield (111.33 t/ha) under the normal planting system. HDP population of 5000 pl/ha + 40 litres of water/day + 75% RDF fertigation (450:675g N & K plant- 1) recorded yield increase of 209.7%. The interaction effects of fertigation level and different mulching on girth of plant indicated non-significant differences. The maximum girth of plant was recorded in F2M2 combination (Fertigation with 80% PE + 80% RDF + Plastic mulch) *i.e.*, 77.13 cm followed by F3M2 combination (Fertigation with 100% PE + 100% RDF + Plastic mulch) *i.e.* 76.49 cm and F3M1 combination (Fertigation with 100 PE + 100% RDF + Leaf mulch) *i.e.* 73.41, Minimum girth of plant was recorded in F0M0 combination (RDF through conventional + Without mulch) *i.e.* 66.45 followed by F0M1 combination (RDF through conventional + Leaf mulch) *i.e.* 67.26. These findings are in conformity with the results obtained by Kumar *et al.* (2009) [9]. However, in banana that treatment 100% of recommended dose of fertilizer (RDF), NPK under drip fertigation gave highest values of plant height, plant girth and average number of leaves followed by treatment 80% of RDF.

At 7 MAT, The Maximum number of leaves per plant was recorded in F2M2 combination (Fertigation with 80% PE + 80% RDF + Plastic mulch) *i.e.* 22.10 followed by F3M2 combination (Fertigation with 100% PE + 100% RDF + Plastic mulch) *i.e.* 21.22 and F3M1 combination (Fertigation with 100 PE + 100% RDF + Leaf mulch) *i.e.* 20.12, minimum number of leaves per plant was recorded in F0M0 combination (RDF through conventional + Without mulch) *i.e.* 18.33 followed by F0M1 combination (RDF through conventional + Leaf mulch) *i.e.* 18.86. Mahalakshmi *et al.* (2001) [7] observed that fertigation was effective in increasing the vigour of the banana plants as measured by the plant girth, numbers of leaves and phyllocron. Crop duration was significantly earlier in fertigation than the control plants.

The Maximum weight of bunch per plant was recorded in F2M2 combination (Fertigation with 80% PE + 80% RDF + Plastic mulch) *i.e.* 24.25 kg followed by F3M2 combination (Fertigation with 100% PE + 100% RDF + Plastic mulch) *i.e.* 23.12 kg and F3M1 combination (Fertigation with 100 PE + 100% RDF + Leaf mulch) *i.e.* 21.68 kg, minimum bunch weight per plant was recorded in F0M0 combination (RDF through conventional + Without mulch) *i.e.* 16.40 kg followed by F0M1 combination (RDF through conventional + Leaf mulch) *i.e.* 17.26 kg respectively after harvest. The results are accordance with Mahalakshmi *et al.* (2001) [7] that fertigation treatment registered the maximum bunch weight of 44.53 kg

with corresponding highest number of hands (10.52) and fingers (203.73). Similar trend of results was obtained by Panigrahi *et al.* (2018)^[9] in guava under fertigation system.

The interaction effects of fertigation level and different mulching on bunch yield per hectare indicated significant differences. The Maximum bunch yield per hectare was recorded in F2M2 combination (Fertigation with 80% PE + 80% RDF + Plastic mulch) i.e. 80.54 followed by F3M2 combination (Fertigation with 100% PE + 100% RDF + Plastic mulch) i.e. 74.61 and F3M1 combination (Fertigation with 100% PE + 100% RDF + Leaf mulch) i.e. 71.77, minimum bunch yield per hectare was recorded in F0M0 combination (RDF through conventional + Without mulch) i.e. 64.75 followed by F0M1 combination (RDF through conventional + Leaf mulch) i.e. 67.56 tonnes per hectare. These results were obtained by (Kumar *et al.* 2008) that fertigation with 75% RDF through surface drip-irrigation increased fruit yield in both the main and ratoon crops of banana by 9.12 and 12.85%, respectively.

The Maximum marketable bunch yield per hectare was recorded in F2M2 combination (Fertigation with 80% PE + 80% RDF + Plastic mulch) i.e. 78.20 followed by F3M2 combination (Fertigation with 100% PE + 100% RDF + Plastic mulch) i.e. 72.11 and F3M1 combination (Fertigation

with 100 PE + 100% RDF + Leaf mulch) i.e. 68.70, minimum marketable bunch yield per hectare was recorded in F0M0 combination (RDF through conventional + Without mulch) i.e. 61.85 followed by F0M1 combination (RDF through conventional + Leaf mulch) i.e. 64.17 respectively. The results are in accordance with (Geonaga and Irizarry, 1995), marketable yield was higher 86.3 kg/ha from the R2 crop with irrigation at a pan factor of 1.25.

The treatment combination T₉- F₂M₂ (Fertigation with 80PE + 80% RDF + Plastic mulch) found best in all other treatments like plant height (284.44 cm at seven month after transplanting), girth of plant (77.13 cm), number of leaves per plant (22.10), bunch weight per plant (24.25 kg), bunch yield per hectare (80.54 tonnes per hectare) and marketable bunch yield (78.20 tonnes per hec.) were found superior from other treatments.

Because of water use efficiency, fertilizer use efficiency and response of mulching effect extremely higher as compared to non-mulch condition. Uptake of soluble fertilizers and silver on black polythene mulch provide best environment during root growth, crop growth stage as well as all critical stages of whole life cycle of banana and this treatment combination also resulted quality bunches which contributed to higher yield.

Table 1: Effect of fertigation level and mulching on growth characteristics of banana

Treatment	Height of plant (cm)			Girth of plant (cm)	Average number of leaves			
	3 MAT	5 MAT	7 MAT		3 MAT	5 MAT	7 MAT	
Factor A: Fertigation level								
F0	RDF through conventional	48.14	127.81	244.6	67.71	13.33	16.33	18.17
F1	Fertigation with 60% PE + 60% RDF	52.24	134.19	263.07	71.93	14.66	17	19.46
F2	Fertigation with 80% PE + 80% RDF	55.99	139.66	278.43	75.31	14.76	17.92	20.52
F3	Fertigation with 100% PE + 100% RDF	53.48	138.37	275.41	74.07	14.46	17.57	20.2
	SEm±	0.51	1.21	2.49	0.65	0.11	0.15	0.17
	CD (5%)	1.51	3.56	7.3	1.92		NS	0.45
Factor B: Mulching								
M ₀	Without mulch (Control)	49.71	133.04	257.82	70.82	13.86	16.83	19.1
M ₁	Leaf mulch	52.63	134.68	265.84	71.86	14.25	17.06	19.58
M ₂	Plastic mulch	55.06	137.22	272.48	74.09	14.66	17.72	20.54
	SEm±	0.44	1.05	2.15	0.56	0.11	0.13	0.15
	CD (5%)	1.3	3.08	6.32	1.66	0.34	0.39	0.45

Table 2: Interaction effect of fertigation level and mulching on growth characteristics of banana

	Fertigation level x mulching	Height of plant (cm)			Girth of plant (cm)	Average number of leaves		
		3 MAT	5 MAT	7 MAT		3 MAT	5 MAT	7 MAT
F ₀ M ₀	RDF through conventional + Without mulch (Control)	46.02	123.34	235.01	66.45	12.93	15.93	18.33
F ₀ M ₁	RDF through conventional + Leaf mulch	48.45	128.19	246.2	67.26	13.53	16.46	18.86
F ₀ M ₂	RDF through conventional + Plastic mulch	49.97	131.91	252.61	69.44	13.53	16.6	19.13
F ₁ M ₀	Fertigation with 60% PE + 60% RDF + Without mulch	50.34	132.81	257.38	70.81	13.86	16.8	19.2
F ₁ M ₁	Fertigation with 60% PE + 60% RDF + Leaf mulch	51.94	133.46	261.29	71.69	14.06	17.13	19.46
F ₁ M ₂	Fertigation with 60% PE + 60% RDF + Plastic mulch	52.90	136.31	270.55	73.30	14.26	17.06	19.73
F ₂ M ₀	Fertigation with 80% PE + 80% RDF + Without mulch	54.70	136.4	266.46	73.70	14.4	17.4	19.6
F ₂ M ₁	Fertigation with 80% PE + 80% RDF + Leaf mulch	55.12	138.07	275.33	75.10	14.2	17.26	19.86
F ₂ M ₂	Fertigation with 80% PE + 80% RDF + Plastic mulch	58.66	140.66	284.44	77.13	14.8	19.12	22.1
F ₃ M ₀	Fertigation with 100% PE + 100% RDF + Without mulch	54.00	140	272.44	72.33	14.26	17.2	19.26
F ₃ M ₁	Fertigation with 100% PE + 100% RDF + Leaf mulch	56.12	139	280.55	73.41	14.4	17.4	20.12
F ₃ M ₂	Fertigation with 100% PE + 100% RDF + Plastic mulch	57.24	140	282.32	76.49	14.46	18.12	21.22
	SE(m) ±	1.89	2.1	4.31	1.13	0.22	0.27	0.31
	C.D. at 5%	NS	NS	NS	NS	0.64	0.79	0.91

Table 3: Effect of fertigation level and mulching on bunch yield of banana cv. (G-9) per hectare (tonnes)

Treatments		Bunch weight of per plant (kg)	Bunch yield per hectare (tonnes)	Marketable bunch yield per hectare (tonnes)
Factor A: Fertigation level				
F0	RDF through conventional	17.08	66.6	63.97
F1	Fertigation with 60% PE + 60% RDF	18.9	68.98	66.58
F2	Fertigation with 80% PE + 80% RDF	23.02	75.64	73.24
F3	Fertigation with 100% PE + 100% RDF	20.09	70.35	67.71
SEm±		0.14	0.56	0.54
CD (5%)		0.42	1.65	1.59
Factor B: Mulching				
M ₀	Without mulch (Control)	18.93	68.43	65.84
M ₁	Leaf mulch	19.93	70.52	67.72
M ₂	Plastic mulch	20.46	72.22	70.07
SEm±		0.12	0.49	0.47
CD (5%)		0.36	1.43	1.30

Table 4: Interaction effect of fertigation level and mulching on bunch yield of banana cv. (G-9) per hectare (tonnes)

Fertigation level x mulching		Bunch weight of per plant (kg)	Bunch yield per hectare (tonnes)	Marketable bunch yield per hectare (tonnes)
F ₀ M ₀	RDF through conventional + Without mulch (Control)	16.4	64.75	61.85
F ₀ M ₁	RDF through conventional + Leaf mulch	17.26	67.56	64.17
F ₀ M ₂	RDF through conventional + Plastic mulch	17.57	67.49	65.89
F ₁ M ₀	Fertigation with 60% PE + 60% RDF + Without mulch	18.03	67.91	65.39
F ₁ M ₁	Fertigation with 60% PE + 60% RDF + Leaf mulch	19.31	69.39	66.86
F ₁ M ₂	Fertigation with 60% PE + 60% RDF + Plastic mulch	19.37	69.63	67.5
F ₂ M ₀	Fertigation with 80% PE + 80% RDF + Without mulch	21.68	70.53	69.42
F ₂ M ₁	Fertigation with 80% PE + 80% RDF + Leaf mulch	20.66	71.23	67.73
F ₂ M ₂	Fertigation with 80% PE + 80% RDF + Plastic mulch	24.25	80.54	78.2
F ₃ M ₀	Fertigation with 100% PE + 100% RDF + Without mulch	20.00	69.3	66.69
F ₃ M ₁	Fertigation with 100% PE + 100% RDF + Leaf mulch	21.68	71.77	68.7
F ₃ M ₂	Fertigation with 100% PE + 100% RDF + Plastic mulch	23.12	74.61	72.11
SE(m) ±		0.14	0.97	0.93
C.D. at 5%		0.42	2.86	2.97

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