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Impact of fertigation and plastic mulch on pusedostem and physio-chemical characters of tissue cultured grand naine banana (*Musa paradisiaca* L.) grown in high density planting system

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Abstract
Present study is based on one year research trials to evaluate the impact of fertigation and plastic mulch on banana crop to find out the suitable treatments for enhancing physiological & quality attributes of grand naine variety of banana. Result revealed that all the physiological characters like pseudostem height (284.44 cm), girth of pseudostem (77.13 cm) and leaf area index (22.10), stayed recorded highest in treatment combination (T_9 - F_2M_2- Fertigation with 80%PE + 80% RDF + Plastic mulch) which ultimately gave the highest yield. Among quality attributes like total soluble solids (24.25 kg) and ascorbic acid (80.54 tone's), were recorded highest in treatment combination (T_9 - F_2M_2- Fertigation with 80%PE + 80% RDF + Plastic mulch).

Keywords: Banana, Fertigation, Mulching, RDF, Plastic, Growth, Yield and Pseudo-stem

Introduction
Banana (*Musa sp*.) is the second most important fruit crop in India next to mango. Its year round availability, affordability, varietal range, taste, nutritive and medicinal value makes it the favorite fruit among all classes of people. It has also good export potential. Hi-tech cultivation of the crop is an economically viable enterprise leading to increase in productivity, improvement in produce quality and early crop maturity with the produce commanding premium price. Banana and plantains are grown in about 120 countries. Total annual world production is estimated at 86 million tonnes of fruits. India leads the world in banana production with an annual output of about 14.2 million tonnes. Other leading producers are Brazil, Eucador, China, Phillipines, Indonesia, Costarica, Mexico, Thailand and Colombia. In India banana ranks first in production and third in area among fruit crops. It accounts for 13% of the total area and 33% of the production of fruits. Production is highest in Maharashtra (3924.1 thousand tones) followed by Tamil Nadu (3543.8 thousand tones). Within India, Maharashtra has the highest productivity of 65.70 metric t/ha against national average of 30.5 tones/ha, whereas the average yield in Bihar is very less it is about 20 t/ha. This might be due to inappropriate package and practices regarding the irrigation and fertigation. The other major banana producing states are Karnataka, Gujarat, Andhra Pradesh and Assam.
A regulated irrigation technique called drip irrigation uses tubes with emitters. By delivering precise water volumes right to each plant's root zone, it makes water use more efficient (Burt and Styles, 2007) [4]. As a perennial crop, bananas require between 2 and 8 liters of water per plant each day, depending on their age and the climatic conditions. According to Srivanappan *et al*. (1987) [16], the amount of water needed per plant per day varied from 2.3 to 6.7 liters depending on the stage of the crop and the weather.
Fertigation is a technology that continuously applies fertilizer and irrigation water to crops using drip or sprinkler irrigation in a controlled manner to promote steady nutrient uptake by plants and reduce the need for expensive fertilizer and water inputs (Patel and Rajput 2011) [12]. In comparison to a furrow irrigated and conventionally fertigated crop, trickler fertigated potatoes using various fertilizer application rates, frequencies of application, and wetted soil volumes showed significant water and fertilizer savings of 30 and 70%, respectively, with comparable yield levels (Chawla and Narda 2001) [6]. The trickling irrigation method produced the highest yield of fresh tubers, 36.29 t/ha, compared to the furrow irrigation method's 21.5

t/ha. Between 1998 and 2000 at Rahuri, an experiment was carried out to ascertain the impact of water soluble fertilizer using drip irrigation on the development and productivity of bananas (Singh 2000) [15]. The banana output increased dramatically as fertilizer level increased, peaking at 68 t/ha under the 100% recommended dose. In 1997–1998 studies were conducted to determine the effects of drip fertigation on banana growth, yield, and quality. There were twelve treatments totaling two fertilizer sources, three fertilizer levels, and two planting methods. These treatments were also compared with surface irrigation methods using straight fertilizers application (Pawar *et al*. 2001) [13]. The results revealed that the banana fruit yield was significantly higher in normal planting (82.86t/ha) than paired row planting (75.75 t/ha).The fruit yield increased significantly in water soluble fertilizers (81.01 t/ha) as compared to only N through drip (77.59 t/ha).

Mulching generally is advantageous for crop productivity. According to Chakarborthy and Sadhu (1994) [5] and Hooda *et al*. (1999) [8], mulch prevents weed development while also retaining heat and conserving soil moisture. Mulches made of polyethylene are frequently employed in vegetable and horticultural crops, and they have greatly reduced losses brought on by weed competition. According to Brault *et al*. (2002) [3], the film color also influences how well weed seeds beneath plastic germinate, grow, and develop. Considering this situation and looking to the above the fact, the present trial was commenced.

Materials and Methods

Field trial was carried out during the year 2015-16 in *kharif* period at research field of Precision Farming Development Centre, Department of Fruit Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The research was arranged in Factorial Randomized Block Design with 3 replication & twelve treatments combination *viz*., T_1 (F_0M_0) - RDF through conventional + Without mulch (Control), T_2 (F_0M_1) -RDF through conventional + Leaf mulch, T_3 (F_0M_2) - RDF through conventional + Plastic mulch, T_4 (F_1M_0) - Fertigation with 60% PE + 60% RDF + Without mulch, T_5 (F_1M_1) - Fertigation with 60% PE + 60% RDF + Leaf mulch, T_6 (F_1M_2) - Fertigation with 60% PE + 60% RDF + Plastic mulch, T_7 (F_2M_0) Fertigation with 80% PE + 80% RDF + Without mulch, T_8 (F_2M_1) Fertigation with 80% PE + 80% RDF + Leaf mulch, T_9 (F_2M_2) Fertigation with 80% PE + 80% RDF + Plastic mulch, T_{10} (F_3M_0) - Fertigation with 100% PE + 100% RDF + Without mulch, T_{11} (F_3M_1) - Fertigation with 100% PE + 100% RDF + Leaf mulch, T_{12} (F_3M_2) - Fertigation with 100% PE + 100% RDF + Plastic mulch.

Pseudo-stem height (cm)

The pseudo-stem height was measured using a meter scale from the plant's base to the branching of the leaf exil. Three plants were chosen, and for the purpose of recording observations, the actual mean value was used.

Girth pseudo-stem (cm)

The circumference of a pseudo-stem was measured using a measuring tape at a defined location 10 cm above ground level. It was measured in 5 chosen plants, and an average value was calculated.

Leaf area index (m^2)

Three plants were selected and the mean value was calculated by following formula:

$$LAI = \frac{\text{Leaf area } (m^2)}{\text{Ground area } (m^2)}$$

Total soluble solids (%)

Using a hand refract orometer with a 0–30% range and a room temperature of 28 ºC, the TSS of the juice was calculated. % of the total soluble solids in the juice was used to express the mean value.

Ascorbic acid (mg/100gm)

The technique suggested by Rangana (1986) [14] was used to estimate it. After being mixed with 5% meta-phosphoric acid (a stabilizing agent) and 10g of fruit extract from the composite sample, the mixture was filtered to a predetermined volume. A portion of the filtrate was tested against a standardized solution of the 2,6-dichlorophenol indophenol dye until a minimum of 15 seconds of pink color persisted. As mg/100g of pulp, the results have been reported.

Result and Discussion

At 7 MAT, the maximum pseudo-stem height was recorded in F_2M_2 combination (Fertigation with 80% PE + 80% RDF + Plastic mulch) *i.e*. 215.32 cm followed by F_3M_2 combination (Fertigation with 100% PE + 100% RDF + Plastic mulch) *i.e.* 213.81 cm and F_3 M_1 combination (Fertigation with 100 PE + 100% RDF+ Leaf mulch) *i.e*. 207.09 cm. Minimum pseudo-stem height was recorded in F_0M_0 combination (RDF through conventional + Without mulch) *i.e.* 184.75 cm. Outcomes are in accordance by (Navaneethakrishnan *et al.* 2013) [10] appropriate amount of N and P fertilizer needed to provide the highest possible yield of commercially grown Grand Naine bananas. Different concentrations of chemical fertilizers were used, including N (150, 200, 250, and 300 g/tree), P (60 and 90 g/tree), and a non-fertilized control treatment (no N and P administered).

Maximum pseudostem girth was recorded in F_2M_2 combination (Fertigation with 80% PE + 80% RDF + Plastic mulch) *i.e*. 69.10 cm followed by F_3M_2 combination (Fertigation with 100% PE + 100% RDF + Plastic mulch) *i.e.* 68.00 cm and F_3M_1 combination (Fertigation with 100 PE + 100% RDF + Leaf mulch) *i.e*. 67.22 cm. Minimum pseudostem girth was recorded in F_0M_0 combination (RDF through conventional + Without mulch) *i.e.* 57.22 cm followed by F_0M_1 combination (RDF through conventional + Leaf mulch) *i.e*. 58.12 cm. The results are in accordance with Yuvraj and Mahendran (2015) [17] to pseudo stem with higher nitrogen and potassium fertigation levels, girth increased noticeably. The continuous supply of nutrients provided by fertigation may be substantially to blame for the increase in plant height and girth.

Interaction effects of fertigation level and different mulching on leaf area index indicated significant differences. The supreme leaf area index was documented in F_2M_2 combination (Fertigation with 80% PE + 80% RDF + Plastic mulch) *i.e*. 4.35m^2 followed by F_3M_2 combination (Fertigation with 100% PE + 100% RDF + Plastic mulch) *i.e.* 4.31m^2 and F_3M_1 combination (Fertigation with 100 PE + 100% RDF + Leaf mulch) *i.e*. 4.09 m^2, Minimum leaf area index was recorded in F_0M_0 combination (RDF through

conventional + Without mulch) *i.e.* 2.84m^2 followed by F_0M_1 combination (RDF through conventional + Leaf mulch) *i.e.* 3.09 m^2.

The Maximum TSS was documented in F2M2 combination (Fertigation with 80% PE + 80% RDF + Plastic mulch) i.e. 22.94% followed by F2M1 combination (Fertigation with 80% PE + 80% RDF + leaf mulch) i.e. 22.29% and F3M2 combination (Fertigation with 100 PE + 100% RDF + Plastic mulch) i.e. 20.71%, minimum total soluble solids was recorded in F0M0 combination (RDF through conventional + Without mulch) i.e. 17.75% followed by F0M1 combination (RDF through conventional + Leaf mulch) i.e. 18.16% respectively. The findings are in accordance with (Hedge and Srinivas 1991) [7], reported that TSS in the plant increased as N application was increased. The growth, yield, TSS, nutrient uptake, and WUE were all improved with higher levels of K treatments; however the pulp/peel ratio fell.

The interaction effects of fertigation level and different mulching on ascorbic acid indicated significant differences. The Maximum ascorbic acid was recorded in F2M2 combination (Fertigation with 80% PE + 80% RDF + Plastic mulch) i.e. 10.32mg/100gm followed by F2M1 combination (Fertigation with 80% PE + 80% RDF + Leaf mulch) i.e. 9.59 mg/100gm and F3M2 combination (Fertigation with 100 PE + 100% RDF + Plastic mulch) i.e. 8.86 mg/100gm, minimum ascorbic acid was recorded in F0M0 combination (RDF through conventional + Without mulch) i.e. 5.78 mg/100gm followed by F0M1 combination (RDF through conventional + Leaf mulch) i.e. 6.76 mg/100gm respectively. Ali and Gaur (2007) [1] concluded that the Mulching treatments led to an increase in both total sugars and ascorbic acid. Paddy straw and sugarcane garbage produced the best results, respectively. Alike results in guava were too recorded by Panigrahi *et al.* (2018) [11].

The treatment combination T_9- F_2M_2 (Fertigation with 80PE + 80% RDF + Plastic mulch) found best in all other treatments like pseudo-stem height (at 7 months after transplanting *i.e.* 215.32 cm), pseudo-stem girth (69.10 cm), LAI (4.35 m$^{2)}$ and post-harvest quality observation like TSS (22.94%) and ascorbic acid (10.32 mg/100gm) were found superior from other treatments. Because of WUE, FUE 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 and thus the benefit: cost (2.39) ratio were higher.

Table 1: Effect of fertigation level and mulching on pseudo-stem height and fruit physio-chemical characteristics

Treatment		Pseudo-stem height (cm)			Pseudo-stem girth(cm)	Leaf area index	Total soluble solid (%)	Ascorbic acid (mg/100gm)
		3 MAT	5 MAT	7 MAT				
Factor A : Fertigation level								
F0	RDF through conventional	33.6	93.97	191.47	58.85	3.01	18.04	6.38
F1	Fertigation with 60% PE + 60% RDF	38.29	99.23	202.53	62.53	3.37	19.27	8.41
F2	Fertigation with 80% PE + 80% RDF	41.7	101.75	207.61	66.7	4.09	22.33	9.67
F3	Fertigation with 100% PE + 100% RDF	38.92	99.65	203.4	66.81	4.12	20.17	8.51
	SEm±	0.82	0.65	2.81	0.59	0.05	0.35	0.07
	CD (5%)	2.43	1.92	8.28	NS	0.4	1.48	0.21
Factor B : Mulching								
M_0	Without mulch (Control)	35.47	96.49	194.39	61.75	3.44	19.38	7.61
M_1	Leaf mulch	38.09	98.31	201.79	65.59	3.59	20.11	8.4
M_2	Plastic mulch	40.83	101.16	207.57	65.83	3.91	20.38	8.72
	SEm±	0.71	0.56	2.43	0.51	0.04	0.3	0.06
	CD (5%)	2.1	1.66	7.17	NS	0.12	NS	0.19

Table 2: Interaction effect of fertigation level and mulching on pseudo-stem height (cm) of banana Cv. (G-9)

Fertigation level x mulching		Pseudo-stem height (cm)			Pusedostem girth (cm)	Leaf area index	Total soluble solid (%)	Ascorbic acid (mg/100gm)
		3 MAT	5 MAT	7 MAT				
F_0M_0	RDF through conventional + Without mulch (Control)	31.02	91.49	184.75	57.22	2.84	17.75	5.78
F_0M_1	RDF through conventional + Leaf mulch	33.46	93.35	193.37	58.12	3.09	18.16	6.76
F_0M_2	RDF through conventional + Plastic mulch	36.32	97.08	196.29	61.22	3.12	18.23	6.6
F_1M_0	Fertigation with 60% PE + 60% RDF + Without mulch	36.69	97.72	201.06	60.33	3.1	18.72	7.58
F_1M_1	Fertigation with 60% PE + 60 % RDF + Leaf mulch	38.3	100.44	201.68	62.26	3.13	19.39	8.39
F_1M_2	Fertigation with 60% PE + 60 % RDF + Plastic mulch	39.88	99.51	204.86	65.00	3.87	19.73	9.27
F_2M_0	Fertigation with 80% PE + 80 % RDF + Without mulch	40.12	101.18	202.46	64.24	3.86	21.77	9.11
F_2M_1	Fertigation with 80% PE + 80 % RDF + Leaf mulch	41.46	100.36	205.04	66.77	4.06	22.29	9.59
F_2M_2	Fertigation with 80% PE + 80 % RDF + Plastic mulch	43.5	104.32	215.32	69.10	4.35	22.94	10.32
F_3M_0	Fertigation with 100% PE + 100% RDF + Without mulch	34.04	95.56	189.3	65.22	3.95	19.3	7.96
F_3M_1	Fertigation with 100% PE + 100% RDF + Leaf	39.13	99.08	207.09	67.22	4.09	20.53	8.7

	mulch							
F_3M_2	Fertigation with 100% PE + 100% RDF + Plastic mulch	43.6	103.71	213.81	68	4.31	20.71	8.86
	SE(m) ±	1.42	1.13	4.86	1.03	0.08	0.61	0.29
	C.D. at 5%	NS	NS	NS	NS	0.24	NS	0.38

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