Journal of Biological Control, 34(3): 185-192, 2020, DOI: 10.18311/jbc/2020/25206

Research Article

Application of bioagents/organic preparations for the management of Eumusae leaf spot disease of French plantain cultivar Nendran (*Musa* AAB) in Kerala

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ABSTRACT: The efficacy of bioagents/organic preparations *viz.,* cow dung extract + *Pseudomonas fluorescens* (1%), PGPR mix II (2%), *P. fluorescens* (2%), turmeric powder + baking soda mixture (5:1 per litre of water), salicylic acid (25ppm), KAU micronutrient multimix (Sampoorna) (1%), petroleum based mineral oil (0.1%) along with chemical check Bordeaux mixture (1%) and control were tested for the management of Eumusae leaf spot disease of French plantain cultivar Nendran (*Musa* AAB). A field experiment was laid in the hotspot area of this disease at Banana Research Station, Kannara, Kerala during May 2016-2017 in Randomized Block Design (RBD) with nine treatments replicated thrice with nine plants per replication. The observations like Per cent Disease Severity (PDS), Youngest Leaf Spotted (YLS), Disease Development Time (DDT), vegetative and yield parameters were recorded. The results of the field experiments revealed that all the bioagents/organic preparations were equally effective in suppressing the disease when compared to the chemical check (Bordeaux mixture, 1%). Among the bioagents/ organic preparations evaluated, the lowest per cent disease severity (PDS) of 20.93 per cent was recorded in plants sprayed with PGPR mix II (2%). While the maximum Disease Development Time (DDT) of 43 days and the highest (6.69) youngest leaf spotted were recorded in plants treated with turmeric powder + baking soda mixture (5:1) and *Pseudomonas fluorescens* (2%) respectively. The yield in terms of bunch weight was recorded highest (8.47 kg) in plants applied with *P. fluorescens* (2%) which was closely followed by PGPR mix II having a bunch weight of (7.93 kg). The study revealed that foliar spraying of PGPR mix II (20g/l) and *P. fluorescens* (20g/l) four times starting from the initial appearance of the disease on the lowest leaves of 75 per cent plants was safe and effective for the management of Eumusae leaf spot disease of banana.

KEY WORDS: Disease development time, Eumusae leaf spot, per cent disease severity, PGPR mix II

(Article chronicle: Received: 21-04-2020; Revised: 19-09-2020; Accepted: 21-09-2020)

INTRODUCTION

Banana and plantains are one of the most important fruit crops grown under all types of tropical and subtropical agricultural systems from small, mixed subsistence gardens to very large company owned monocultures. The multifaceted uses of banana as a source of food, fibre, fuel, therapeutic purposes and a source of vitamins has made it a crop of wide popularity and these aspects clearly place banana as one among the healthiest of fruits. However, the crop is highly vulnerable to the incidence of fungal, bacterial and viral diseases which considerably reduces the crop yield especially in French plantain cultivar Nendran (Musa AAB).

Among the various fungal diseases, Sigatoka leaf spot disease caused by three species of related ascomycetous fungi *viz., Mycosphaerella musicola, M. fijiensis* and *M. eumuase* is a destructive disease of banana in the tropics and sub tropics (Arzanlou *et al.,* 2007). The studies on characterization of the *Mycosphaerella* spp. associated with Sigatoka leaf spot disease in Kerala revealed that the predominant leaf spot disease occurring in Kerala was Eumusae leaf spot disease caused by *Mycosphaerella eumusae* (George *et al.*, 2018). This disease incites necrotic lesions on leaves and severe infestations can lead to considerable reduction in photosynthetic area of leaves which in turn cause yield loss (Arzanlou *et al.*, 2007; Chillet *et al.,* 2009). Apart from yield loss, the disease also causes delayed flowering, reduction in number of hands and fingers, premature ripening of the fingers and peel splitting of the fruits affecting the export potential of banana. Among the different cultivars, the commercially grown Cavendish cultivar (AAA) and French plantain cultivar (Nendran, (AAB) are highly susceptible to Eumusae leaf spot disease driving the popular cultivars out of cultivation and thereby making banana production a less profitable enterprise (Estelitta *et al.,* 1991 and Selvarajan *et al.,* 2001). In India,

this foliar disease is more prevalent in states of Kerala, Tamil Nadu, Karnataka, Maharashtra, Gujarat, West Bengal and Tripura where the maximum disease severity of 11–80 per cent was reported on different cultivars (Shanthiyaa *et al.*, 2013). Therefore, effective and timely management of the disease is very much essential.

During 1970s there occurred tremendous shift towards chemical based agriculture from the traditional farming. Indiscriminate use of pesticides and agrochemicals have led to irreparable problems to environment and public health. Over the last few decades, due to increased awareness on pesticide residues and their hazardous effects on human and environment more ecofriendly approaches of crop protection are being popularized. Also, recently the agriculture sector of our country is giving more thrust on organic farming, hence, it is necessary to develop an effective management package comprising of organic preparations/bioagents against leaf spot diseases of banana. Therefore, the present study was undertaken to develop an effective ecofriendly management package using bioagents/organic chemicals against Eumusae leaf spot disease of banana.

MATERIALS AND METHODS

A field experiment was laid out in the hotspot area with high inoculum pressure at Banana Research Station, Kannara, Kerala to evaluate the efficiency of seven bioagents/ organic and inorganic preparations *viz.,* cow dung extract + *Pseudomonas fluorescens* (1%) (PN026), PGPR mix II (2%) (Talc formulation produced by Kerala Agricultural University), *P. fluorescens* (2%) (PN026), turmeric powder + baking soda mixture (5:1 per litre of water), salicylic acid (25ppm), KAU micronutrient multimix (Sampoorna) (1%) (Kerala Agricultural University), petroleum based mineral oil (0.1%) along with a chemical check (Bordeaux mixture, 1%) against Eumusae leaf spot of banana. The warm humid climate prevailing in the state was highly favourable for the natural incidence of the disease. The statistical design followed was Randomized Block Design (RBD) with nine treatments replicated thrice with nine plants per replication. The susceptible French plantain variety Nendran (*Musa* AAB) was used in the experiment. Pits of size 50 cm x 50 cm x 50 cm were taken and applied with lime. Healthy suckers were planted with a spacing of 2 x 2 m. The organic manures and the fertilizer application were done as per Package of Practices (POP) recommendations of KAU (KAU, 2011). The details of the treatments are given in Table 1.

The first spray was given when ten leaf spot appeared on the lowest leaves of seventy-five per cent of the plants in the field followed by three subsequent spraying at fortnightly intervals. Observations on PDS, YLS, DDT, vegetative (six months after planting), agronomic and yield parameters were recorded.

Per cent disease severity (PDS)

The disease severity was assessed at six months after planting and at flowering stage using Gauhl's modification of Stover's severity scoring system score chart (Meredith and Lawrence, 1969) using the 0–6 scale as mentioned:

Score	Symptoms
0	no symptom
1	< 1% of lamina with symptoms
2	1 to 5% of lamina with symptoms
3	6 to 15% of lamina with symptoms
4	16 to 33% of lamina with symptoms
5	34 to 50% of lamina with symptoms
6	51 to 100% of lamina with symptoms

The per cent disease severity was calculated using the formula:

$$\text{Per cent disease severity (PDS)} = \frac{\sum nb \times 100}{(N-1)T}$$

where,

n= number of leaves in each grade,

b= grade

N=Number of grade used in the scale

T= total number of leaves

Youngest leaf spotted (YLS)

Counting from the top of the plant, the youngest leaf spotted was calculated by counting the position of the first fully unfurled leaf showing at least ten leaf spots of stage 6. The observations on YLS were recorded both at six months after planting and at shooting stage.

Disease development time (DDT)

DDT is the parameter which indicates the time or number of days taken by the leaves to reach ten leaf spots of stage 6. The cigar leaves of banana plants in each treatments were selected and tagged with the date at which it was emerged. These leaves were observed once in a week until the appearance of ten mature (stage 6) leaf lesions and the date was recorded. The DDT was calculated by counting the number of days between the tagging of leaves and the appearance of ten leaf spot.

Per cent reduction of disease over control

Per cent reduction of disease over control was calculated as

$$= \frac{\text{PDS in control plants} - \text{PDS in treatments}}{\text{PDS in control plants}}$$

Vegetative characters

Vegetative characters such as plant height, girth and number of green leaves at the time of flowering was noticed.

Yield parameters

The yield characters such as bunch weight, number of hands, number of fingers, length and circumference of fingers, fresh and ripe weight of fingers, peel to pulp ratio and Total Soluble Solids (TSS) were recorded.

Economic analysis

The economic analysis was carried out by calculating benefit: cost ratio

Statistical analysis

The data obtained from the field experiment was subjected to two-way analysis of variance using the statistical package MSTAT.

RESULTS AND DISCUSSION

Effect of treatments on per cent disease severity (PDS)

The statistical analysis of data on PDS revealed that all the treatments were significantly superior to the untreated control both at vegetative (six months after planting) and shooting stage (Table 2). The severity of the disease was assessed during vegetative and shooting stage because the reduction in green leaf area during these stages would in turn reduce the crop yield.

During vegetative stage, the lowest PDS (18.01%) was recorded in plants sprayed with T8 (Bordeaux mixture 1%) which served as a chemical check. However, this treatment was found to be on par with other bioagents/organic treatments such as T3 (*Pseudomonas fluorescens* 2%), T5 (salicyclic acid 25 ppm), T2 (PGPR mix II 2%) and T7 (petroleum based mineral oil 0.1%) having PDS of 18.59, 19.17, 19.82 and 20.04 per cent respectively. The highest PDS (31.33%) was noticed in plants without any treatments T9 (untreated control).

At shooting stage, the lowest PDS (18.75%) was observed in plants sprayed with T8 (Bordeaux mixture 1%) which served as a chemical check. This treatment was on par with T2 (PGPR mix II 2%), T1 (cow dung + *P. fluorescens* 1%), T3 (*P. fluorescens* 2%) and T4 (turmeric powder + baking soda, 5:1) with PDS of 22.21, 23.19, 24.86 and 25.34 per cent respectively. While the highest PDS (34.03%) was recorded in plants without any treatments (T9). Though salicyclic acid (25 ppm) was effective in management of the disease at vegetative stage no effect was observed during the shooting stage.

Comparing the mean PDS at vegetative and shooting stage revealed that the lowest PDS (20.84 %) was recorded in plants sprayed with T8 (Bordeaux mixture 1%) which served as a chemical check. Five to six sprays of Bordeaux mixture (1%) at fortnightly intervals soon after the appearance of the initial symptom were observed effective in reducing the disease severity of leaf spot disease of banana (KAU, 2011). This was followed by T2 (PGPR mix II, 2%), T3 (*P. fluorescens* 2%), T1 (cow dung extract + *P. fluorescens* (1%), T5 (salicylic acid 25 ppm), T7 (petroleum based mineral oil 0.1%), T4 (turmeric powder + baking soda mixture, 5:1), T6 (KAU micronutrient mix, 1%) with PDS of 20.93, 21.72, 22.74, 22.76, 23.44, 23.79 and 24.53 per cent respectively. The highest PDS (32.70%) was recorded in plants without any treatment (T9). The observation on effect PRPR mix II on Eumusae leaf spot disease were in tune with the findings of Hedge and Mesta (2014), who reported that *P. fluorescens* and *B. subtilis* were effective in reducing the disease pressure caused by *M. musicola* which in turn increases the yield of the plant. Latha *et al.* (2009) reported that foliar application of PGPR mix on tomato leaves produced induced systemic resistance and plant growth promotion which enhanced disease resistance in tomato plants against *Alternaria solani.* The induced systemic resistance elicited by PGPR were every much effective in managing a wide spectrum of fungal, bacterial and viral diseases including virus in several plant species under green-house and field environments (Murphy *et al.*, 2003; Kloepper *et al.*, 2004; Kavino *et al.*, 2008). The PGPR is a group of rhizosphere colonizing bacteria, which produce substances that increase the growth of plants and/or protect them against pathogens (Harish *et al.*, 2009). Application of *P. fluorescens* along with the substrates (sugarcane filter press or coffee husks) to the rhizosphere increased the growth of the plants and were also effective in reducing the disease caused by *M. fijiensis* when compared with the control (water and substrates) (Riveros and coworkers, 2002). The assessment of inhibitory effect of salicylic acid on *M. fijiensis* revealed that the application of salicylic acid inhibited the mycelial growth and spore germination of the pathogen thereby effectively used in the management of the disease (Elisee *et al.,* 2014). Similarly, Thammaiah and Shirol (2008) and Ruth and Nagalakshmi (2017) noted that petroleum based mineral oil was effective in the management of Sigatoka leaf spot disease by inhibiting the spore germination of the pathogen.

The highest per cent disease reduction over control (36.26%) was noticed in plants sprayed with T8 (Bordeaux mixture) followed by T2 (PGPR mix II), T3 (*P. fluorescens*), T1 (cow dung extract + *P. fluorescens*), T5 (salicyclic acid), T7 (petroleum based mineral oil) and T4 (turmeric powder + baking soda) having per cent disease reduction of 35.99, 33.57, 30.45, 30.39, 28.31 and 27.24 per cent respectively. Although, the highest per cent disease reduction was recorded in plants sprayed with Bordeaux mixture (1%) which served as a chemical check, the other biagents/organic/inorganic treatments used in the study were equally effective in the

management of Eumusae leaf spot of banana. While the lowest per cent reduction over control (24.98%) was noticed in plants sprayed with KAU micronutrient mix (1%).

Effect of treatments on youngest leaf spotted (YLS)

Youngest leaf spotted (YLS) denotes the leaf number of the fully unfurled leaf with at least ten necrotic leaf spots. Higher value of YLS reflects the effectiveness of the treatment. Statistically significant differences in YLS were noticed among treatments both at vegetative and shooting stage (Table 3).

At vegetative stage, the highest YLS was recorded in plants sprayed with T3 (*P. fluorescens*) and T8 (Bordeaux mixture) with YLS of 7.33. These treatments were followed by T7 (petroleum based mineral oil), T2 (PGPR mix II) and T5 (salicylic acid) with YLS of 7.16, 6.83 and 6.83 respectively. While the lowest YLS (6.38) was recorded in T9 (untreated control).

At shooting stage, the highest YLS (6.50) was noticed in plants sprayed with T2 (PGPR mix II) followed by T8 (Bordeaux mixture) and T3 (*P. fluorescens*) with YLS of 6.41 for both the treatments. While the lowest YLS (5.12) was observed in T9 (untreated control).

Comparing the mean value of YLS at vegetative and shooting stage, results revealed that the highest YLS (6.87) was recorded in T3 (*P. fluorescens* 2%) as well as in T8 (Bordeaux mixture, chemical check). These treatments were followed by T2 (PGPR mix II 2%), T7 (petroleum based mineral oil 0.1%), T5 (salicylic acid 25 ppm), T4 (turmeric powder + baking soda mixture, 5:1), T6 (KAU micronutrient mix, 1%) and T1 (cow dung extract + *P. fluorescens*, 1%) with YLS of 6.69, 6.67, 6.41, 6.37, 6.15 and 6.12 respectively. While the lowest YLS (5.16) was recorded in T9 (untreated control). Kavino *et al.* (2007) and Saravanakumar and Samiyappan (2007) reported that among the various PGPRs studied, *P. fluorescens* could exhibit antagonistic action against plant pathogens which in turn reduces the inoculums level of the pathogen.

Table 1. List of organic/ inorganic preparations

Treatment no.	Treatments
T1	Foliar spraying with cow dung extract + *Pseudomonas fluorescens* (PN026) (1%)
T2	Foliar spraying PGPR mix II (20g/l) (Talc formulation by Kerala Agricultural University)
T3	Foliar spraying of *Pseudomonas fluorescens* (PN026) (20g/l)
T4	Foliar spraying of turmeric powder + baking soda mixture (5:1 per litre of water)
T5	Foliar spraying of salicylic acid (25mg/l)
T6	Foliar spraying of KAU micronutrient multimix (Sampoorna) (10g/l) (Kerala Agricultural University)
T7	Foliar spraying of petroleum based mineral oil (1ml/l) (POP)
T8	Foliar spraying of Bordeaux mixture (1%) (Chemical check)
T9	Untreated control

Table 2. Effect of bioagents/organic/inorganic treatments for PDS of Eumusae leaf spot disease (PDS)

Treatment details	*PDS at 6 MAP**	PDS at shooting	Mean PDS	Per cent disease reduction over control
T1:Cow dung extract + *Pseudomonas fluorescens* (1%)	22.29^{b}	23.19^{de}	22.74	30.45
T2:PGPR mix II (2%)	19.82^{bcde}	22.21^{e}	20.93	35.99
T3:*P. fluorescens* (2%)	18.59^{be}	24.86^{bcde}	21.72	33.57
T4:Turmeric powder + baking soda mixture (5:1)	22.25^{bc}	25.34^{bcde}	23.79	27.24
T5:Salicylic acid (25 ppm)	19.17^{cde}	26.35^{bcd}	22.76	30.39
T6:KAU micronutrient multimix (Sampoorna) (1 %)	21.24^{bcd}	27.82^{b}	24.53	24.98
T7:Petroleum based mineral oil (0.1%) (POP)	20.04^{bcde}	26.83^{bc}	23.44	28.31
T8:Bordeaux mixture (1%) (Chemical check)	18.01^{e}	18.75^{cde}	**20.84**	**36.26**
T9:Untreated control	31.33^{a}	34.03^{a}	32.70	-
CD(0.05)	**03.10**	**03.53**	-	-

*Per cent disease severity, ** Months after planting

Table 3. Effect of bioagents/organic/inorganic treatments on Youngest leaf spotted (YLS) and Disease development time (DDT) on Eumusae leaf spot

Treatment details	*YLS at 6 MAP**	YLS at flowering	Mean YLS	DDT***
T1:Cow dung extract + *Pseudomonas fluorescens* (1%)	06.58^{b}	05.66^{cd}	06.12	37.33^{cd}
T2:PGPR mix II (2%)	06.83^{ab}	06.50^{a}	06.69	40.00^{abc}
T3:*P. fluorescens* (2%)	07.33^{a}	06.41^{ab}	06.87	38.66^{bcd}
T4:Turmeric powder + baking soda mixture (5:1)	06.41^{b}	06.33^{abc}	06.37	43.00^{ab}
T5:Salicylic acid (25 ppm)	06.83^{ab}	06.00^{abc}	06.41	38.00^{cd}
T6:KAU micronutrient multimix (Sampoorna) (1 %)	06.50^{b}	05.81^{bcd}	06.15	39.66^{abcd}
T7:Petroleum based mineral oil (0.1%) (POP)	07.16^{a}	06.25^{abc}	06.67	35.33^{de}
T8:Bordeaux mixture (1%) (Chemical check)	07.33^{a}	06.41^{ab}	06.87	44.00^{a}
T9:Untreated control	06.38^{c}	05.12^{d}	05.16	32.66^{e}
CD(0.05)	**00.57**	**00.67**	**-**	**04.52**

*Youngest leaf spotted, ** Months after planting, ***Disease development time

Table 4. Effect of bioagents/organic/inorganic treatment on agronomic characters

Treatment details	Plant height (cm)	Plant girth (cm)	No: of green leaves
T1:Cow dung extract + *Pseudomonas fluorescens* (1%)	213.33	058.63^{a}	004.91
T2:PGPR mix II (2%)	216.16	059.16^{a}	005.58
T3:*P. fluorescens* (2%)	195.00	050.58^{bc}	005.66
T4:Turmeric powder + baking soda mixture (5:1)	212.50	048.66^{c}	005.42
T5:Salicylic acid (25 ppm)	204.16	052.87^{bc}	005.16
T6:KAU micronutrient multimix (Sampoorna) (1 %)	225.83	058.58^{a}	005.50
T7:Petroleum based mineral oil (0.1%) (POP)	225.08	058.68^{a}	005.42
T8:Bordeaux mixture (1%) (Chemical check)	221.66	057.08^{ab}	006.16
T9:Untreated control	158.00	055.21^{ab}	004.42
CD (0.05)	**NS**	**001.32**	**NS**

Effect of treatments on Disease development time (DDT)

The maximum days (44 days) for disease development was recorded in plants sprayed with T8 (Bordeaux mixture 1%). This was followed by T4 (turmeric powder + baking soda mixture (5:1)), T2 (PGPR mix II), T6 (KAU micronutrient mix), T3 (*P. fluorescens*), T5 (salicylic acid), T1(cow dung extract + *P. fluorescens*) and T7 (petroleum based mineral oil) having DDT of 43, 40, 39.66, 38.66, 38, 37.33 and 35.33 days respectively. The lowest DDT (32.66 days) was noticed in plants without any treatment (T9) (Table 3).

Effect of treatments on agronomic characters

The statistical analysis on agronomic characters such as plant height, plant girth and number of functional leaves revealed that no statistically significant difference were recorded among the treatments in terms of plant height and number of functional leaves while statistically significant difference were recorded in plant girth among the treatments (Table 4).

Although no significant differences were recorded in plant height the highest plant height (225.83 cm) was recorded in plants sprayed with T6 (KAU micronutrient mix) followed by T7 (petroleum based mineral oil) (225.08 cm). While the lowest plant height was registered in T9 (untreated control) with plant height of 158.16 cm. Foliar application of micronutrients such as boron, copper, iron and zinc along or in combination at 3, 5 and 7 months after planting were effect in increasing the plant height of banana cv. Robusta (AAA) (Nalina *et al.,* 2009). Also, Hazarika and Raghavan (2018) reported that foliar application of micronutrients increased both growth and yield of banana cv. Grand Naine (AAA).

The highest plant girth (59.16 cm) was recorded in plants sprayed with T2 (PGPR mix II) followed by T7 (petroleum based mineral oil) and T1 (cow dung extract +*P. fluorescens*) and T6 (KAU micronutrient mix) having plant girth of 58.68 cm, 58.63 cm and 58.58 cm respectively. While the lowest

plant girth (48.66cm) was recorded in plants sprayed with T4 (turmeric powder + baking soda mixture).

The highest number of green leaves (6.16) was recorded in plants sprayed with T8 (Bordeaux mixture) followed by T3 (*P. fluorescens*) with 5.66 leaves. The lowest number of green leaves (4.42) was noticed in T9 (untreated control).

Effect of treatments on yield characters

Statistical analysis of the yield attributes such as bunch weight, number of hands, number of fingers, length of fingers, circumference of fingers, fresh weight of fingers, ripe weight of fingers and peel to pulp ratio revealed that there was no statistically significant difference between treatments except in circumference of fingers (Table 5).

Table 5. Effect of bioagents / organic / inorganic treatments on yield characters of banana var. Nendran

Treatment details	Weight of bunch (kg)	No: of hands	No: of fingers	Per cent increase in yield over control	B: C ratio
T1:Cow dung extract + *Pseudomonas fluorescens* (1%)	07.37	05.91	60.33	12.17	01.21
T2:PGPR mix II (2%)	07.93	06.50	61.91	20.70	01.37
T3:*P. fluorescens* (2%)	08.47	06.50	63.66	28.91	01.37
T4:Turmeric powder + baking soda mixture (5:1)	07.62	05.75	65.83	15.98	01.35
T5: Salicylic acid (25 ppm)	07.86	06.08	57.58	19.63	01.32
T6:KAU micronutrient multimix (Sampoorna) (1 %)	07.67	06.16	63.58	16.74	01.37
T7:Petroleum based mineral oil (0.1%) (POP)	07.78	05.91	62.66	18.41	01.35
T8:Bordeaux mixture (1%) (Chemical check)	08.82	06.50	65.83	34.24	01.60
T9:Untreated control	06.57	05.75	55.25	-	01.14
CD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**

Table 5 (contd…). Effect of bioagents / organic / inorganic treatments on yield characters of banana var. Nendran

Treatment details	Length of fingers (cm)	Circumference of fingers (cm)	Fresh weight of fingers (g)	Dry weight of fingers (g)	Peel to pulp ratio	TSS (0brix)
T1:Cow dung extract + *Pseudomonas fluorescens* (1%)	022.96	012.33^{ab}	127.33	109.04	000.14	027.33
T2:PGPR mix II (2%)	023.51	012.93^{a}	133.46	110.17	000.17	026.00
T3:*P. fluorescens* (2%)	024.32	013.11^{a}	153.06	136.03	000.13	027.66
T4:Turmeric powder + baking soda mixture (5:1)	022.56	012.44^{ab}	125.01	089.67	000.14	027.00
T5: Salicylic acid (25 ppm)	024.88	012.44^{ab}	136.46	102.25	000.18	028.67
T6:KAU micronutrient multimix (Sampoorna) (1 %)	021.18	011.92^{c}	124.33	090.78	000.18	029.33
T7:Petroleum based mineral oil (0.1%) (POP)	023.48	012.43^{ab}	123.01	102.86	000.16	027.60
T8:Bordeaux mixture (1%) (Chemical check)	023.05	012.55^{ab}	140.75	129.10	000.12	028.00
T9:Untreated control	020.27	012.26^{c}	120.11	102.71	000.19	026.66
CD(0.05)	NS	4.302	NS	NS	NS	NS

The yield in terms of bunch weight was recorded highest (8.82 kg) in plants sprayed with T8 (Bordeaux mixture, Chemical check) followed by T3 (*P. fluorescens*) and T2 (PGPR mix II) having bunch weight of 8.47 kg and 7.93 kg respectively. The lowest bunch weight of 6.57 kg was noticed in plants without any treatments (T9). Kavino *et al.,* 2010 application of *P. fluorescens* on plants improved the plant height, girth, bunch weight, number of hands and chlorophyll content when compared to untreated plants. The inoculation of PGPR on plants resulted in increase in the photosynthetic rate which in turn increases the yield of the crop (Mia *et al.*, 2000). Significant increases in crop yields following application of PGPR have been documented under diverse field conditions (Bashan, 1998).

The highest peel to pulp ratio (0.19) was recorded in plants without any treatments (T9) which was followed by T5 (salicyclic acid) and T6 (KAU micronutrient mix) with a ratio of 0.18. The lowest (0.13) peel to pulp ratio was recorded in T3 (*P. fluorescens*). The TSS of fruits obtained from all the treatments had TSS ranged from 26–29^0 brix which was found to be in the normal range of TSS of banana var. Nendran. The highest TSS (29.33^0 brix) was recorded in T6 (KAU micronutrient mix (1%). While the lowest value (26^0 brix) was noticed in fingers of plants sprayed with PGPR mix II.

Economic analysis

The benefit to cost ratio of different treatments was calculated and data are presented in Table 5. The highest B: C ratio was observed in T8 (Bordeaux mixture) with a ratio of 1.60 followed by T3 (*P. fluorescens*), T2 (PGPR mix II) and T6 (KAU micronutrient multimix (Sampoorna)) having B:C ratio of 1.37 while the lowest B: C ratio (1.14) was observed in T9 (control).

The results of the present study revealed the foliar application of Bordeaux mixture (1%) were recorded to be the most effective among the treatments, however foliar application of bioagents/organic/inorganic preparations were equally effective in the management of Eumusae leaf spot disease of banana. Considering the efficiency, safety and economic benefit of bioagents/organic/inorganic treatments, the foliar application of bioagents such as PGPR mix II (20g/l) and *P. fluorescens* (20g/l) starting from the appearance of ten leaf spots on the lowest leaves of 75 per cent plants and subsequently three sprays at fortnightly intervals could bring down the disease severity of Eumusae leaf spot disease to significantly lower levels assuring effective management of the disease with increase in crop yield and without leaving any chemicals residues on banana fruit and in the ecosystem.

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