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Effect of vermicompost on seed quality and salicylic acid against spot blotch pathogen of wheat

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Abstract
The prepared vermicompost had used alone or in combination with bio-agents, bio-fertilzer, and foliar application of fungicide in pot culture experiment at Glass house complex at Department of Plant Pathology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during 2018-19 and 2019-20. The maximum germination (%) was recorded in T_{10} treatment as soil application with PGPR + Vermicompost (6gm+300gm) and two foliar spray with propiconazole (vegetative stage and booting stage) representing 95.57% and 99.58%, respectively. The maximum seed viability as 88.20% and 91.66% also was recorded in T_{10} treatment (Soil application with PGPR + Vermicompost (6gm+300gm) and two foliar sprays with propiconazole at vegetative stage and booting stage). Seedling emergence (%) highest was recorded in T_{10} treatment as 97.67% and 98.18%. respectively. The highest level of vigor index was found in T_{10} treatment as soil application of PGPR + Vermicompost (6gm+300 gm), two foliar spray with propiconazole (vegetative stage and booting stage) representing 6500.67 and 7061.21 against 1811.75 and 1830.89 in case of Control-1 and Control-2 respectively. The maximum activity of salicylic acid was found in T_{10} treatment as soil application with PGPR + Vermicompost (6gm+300gm) and two foliar spray with propiconazole (vegetative stage and booting stage) indicating 0.72, 0.88, 1.12 and 0.85 (mg/g) of fresh leaves against 0.26, 0.31, 0.38 and 0.28 mg/g in case of control-1 and 0.28, 0.35, 0.42 and 0.33 mg/g in case of control-2 at 10, 20, 30 and 40 days of pathogen inoculation, respectively during 2018-19. The similar trend of increase activity of salicylic acid was noticed during 2019-20. The increased activity of salicylic acid in plants might be responsible for defense response in plant against *B. sorokiniana.*

Keywords: Wheat, vermicompost, growth, pathogen, salicylic acid

Introduction
Wheat (*Triticum aestivum* L.) is a widely grown cereal crop and considered as staple food in most of parts in the world. It ranked first among cereals in the word both in term of area and production. In India, wheat is the second most important food crop, after rice and so called as "King of cereals". The cultivation of wheat is prehistoric in Old World and ancient Egyptian monuments showed the establishment of it cultivation (de Candolle, 1888) [6]. Wheat is belong to family Poaceae (Graminae) and generally, self-pollinated, C_3 and hexaploid plant. It is widely grown in different climates varying from temperate, irrigated dry, high rainfall, warm humid to dry and cold. The common bread wheat, *T. aestivum*, is the most important species, occupying more than 90% of the wheat growing area and 87% of the total wheat production in the country. In world, wheat is grown over 215.44 million hectare areas with production of 730.90 million metric tons and yield of 3.39 metric tons per hectare. In India, wheat is grown over 29.65 million hectare area with production of 99.87 million metric tons and yield of 3.37 metric tons per hectare (Anonymous, 2019) [1]. The crop is attacked by number of pathogens such as parasitic fungi, viruses, bacteria and nematodes and all are capable of reducing yield significantly. In India, foliar blights of wheat are considered as complex disease, which includes leaf blight caused by *Alternaria triticina* Prasada and Prabhu and spot blotch caused by *Bipolaris sorokiniana* (Sacc.) Shoemaker (Syn. *Helminthosprium sativum* Pammel, King and Bakke). *Bipolaris sorokiniana* (Sacc.) (Wiese, 1998) [31]. Spot blotch has been considered as a major constraint to wheat yields in South Asia due to reduction in 1000-grain weight and grain yield (Singh *et al.*, 2007) [28]. Annual yield loss of wheat due to this disease in south Asia is estimated at 15-20% (Duvieller and Sharma, 2009) [10]. The management of the disease can be done through cultural, physical, mechanical, biological use of resistant varieties, nutrient management and foliar spray of fungicides. The cultural practices like tillage operation,

intercropping, mulching, irrigation, roughing, soil amendment, fertilizer application and crop nutrition are easy, eco-friendly, pollution free and beneficial for human and animals. Moreover, cultural practices cannot manage the disease in standing crop where disease has already stable. Use of resistant variety is an alternative method for management of disease which is also cheapest and most economical method. The most commonly used resistant varieties are HS652, PBW550, HD2733, PBW781, DBW39, HD2967 etc. (Dibya *et al*., 2020) [8]. But resistant can be break down due to development of virulent strain of the pathogen. Biological control on the other hand is important alternative for management of plant disease. Vermicompost is a suitable alternate technology for conversion of different types of organic wastes (domestic as well as industrial) into value added material; vermicompost (Garg *et al.*, 2006) [12]. Vermicompost is the non-thermophilic biodegradation of organic material through the interaction between earthworms and microorganisms, whereby organic material residuals are fragmented rapidly into much finer particles by passing them through a grinding gizzard while maintaining nutrients. Use of earthworms for waste management, organic matter stabilization, soil detoxification and vermicompost production has been well documented (Kaviraj and Sharma, 2003; Loh *et al*., 2005; Suthar, 2006) [17, 19, 30]. Applications of vermicompost singly or in combination with either other organic fertilizers or chemical fertilizers have been proved effective to enhance growth and yield of various plants like Urad and Soyabean (Javed and Panwar, 2013) [15], Setaria grass (Sabrina *et al*. 2013), Marigold (Paul and Bhattacharya, 2012) [27, 25]. However, a single management practices are not possible to keep pathogens out so integrated disease management (IDM) to application for management of the spot blotch disease of wheat. Despite this risk, good hygiene will significantly reduce losses caused by disease. The integrated application of vermicompost and NPK fertilizer significantly improved the growth, yield attributes and yield of wheat (Devi *et al*., 2011) [7].

Material and Methods

A glasshouse experiments were conducted at Department of Plant Pathology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during 2018-2020. The procedures and techniques applied during the course of investigation were elucidated as below:-

Preparation of vermicompost from spent mushroom substrate (SMS)

Spent Mushroom Substrate (SMS) is being rich in organic matter adds nutrients to the soil, help in neutralizing acidic soils, it improves water quality along with bioremediation of contaminated soils. In order to improve the physico-chemical characteristics of soil, Spent Mushroom Substrate (SMS) is used in preparation of vermicompost and used as manure. It enhances nutrient content for better yield production. Earthworm feed the organic waste materials pass through the digestive system of earthworm and used as granular form like coccun is called vermicompost. The chemical secretion in the earth worm digestive system tract which help breakdown of soil and organic matter, enhance hormones and directly make available to plant.

Collection of Spent Mushroom Substrate (SMS)

Spent Mushroom Substrate (SMS) of Oyster and Button mushroom was collected from Mushroom Research and Development Centre, Department of Plant Pathology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur for preparation of vermicompost. After harvesting of mushroom old rotten spent mushroom substrate from white button and oyster mushrooms are used for the worms to multiply and to convert it into manure for field crops. Normally, minimum twelve month are required to prepared good quality vermicompost.

Isolation, purification, identification and maintenance of *Bipolaris sorokiniana*

Collection of diseased leaf samples

Wheat leaves showing characteristic blight symptoms were collected from Nawabganj Farm, C S Azad University of Agriculture and Technology, Kanpur. The samples were kept dry paper envelopes and brought to laboratory for isolation of pathogen. Each envelope was marked clearly to show details of the location, variety, crop growth stage, reaction type and date of collection etc. excess surface moisture from the samples was dried by blotter paper and preserved at 6 to 8^0C for further study.

Preparation of medium

Potato dextrose agar (PDA) medium consisting following composition was prepared and sterilized using method described by Johnston and Booth (1983) [16]. The peeled potato was cut in 12 mm cubes. Two hundred grams of potato cubes were rinsed in water and boiled for 20 minutes in 500 ml water. Potato broth was filtered through cheese cloth and kept in measuring cylinder. Agar was dissolved in 200 ml of water by slight heating and added to potato broth. Dextrose was added in it. The final volume was made up to 1000 ml by adding distilled water. The pH was adjusted to 7.0. The PDA was poured in test tube for preparation of PDA slant and also in flask. Then, prepared PDA media was sterilized at 15 psi for 20 minutes in an autoclave.

Isolation of *B. sorokiniana*

The diseased leaf samples, showing distinct symptoms were selected for isolation of the pathogen. The selected leaves were washed with fresh sterilized water in order to remove the dust particles and surface contaminants. The washed diseased leaves were cut into small bits, with some healthy portions, with the help of sterilized scalpel and forceps. The cut leaf pieces were surface sterilized with 0.1 per cent mercuric chloride solution under aseptic conditions inside a Laminar flow and washed thoroughly 3 to 4 times with sterilized water to remove the traces of Mercuric Chloride. Excess moisture was removed by placing these in the folds of sterilized blotting papers. The pieces, thus sterilized were transferred in Petri dishes with the help of sterilized inoculation needle. Petri dishes used in the experiment, were previously sterilized at 160 ^{0}C for two hours in an electric oven and poured with 20 per cent Potato Dextrose Agar medium. The medium was previously autoclaved at 15 pounds per square inch for 15 minutes. Three to four pieces of diseased leaves were placed per Petri dish at equal distance from each other. Petri dishes were properly marked with glass marking pencil indicating date of isolation. The Petri dishes were then transferred at 24-30 ^{0}C in an incubator. The plates were inoculated for 24 hours at 25^0 C under light and then for 24 hours at 18 ^{0}C in dark.

After continuous light and dark period, the fungal growth was observed and then identified (Barnett, 1960) [2]. A small bit of culture of *B. sorokiniana* was taken from the margin and transferred in petri-plate containing PDA (potato dextrose agar), then inoculated for 5-6 days at 25^0C.Upon the completion of fungal growth, the culture were transferred to refrigerator for further use.

Experimental details

Application of vermicompost in Soil

The application of vermicompost in soil along with FYM, *Azotobacter*, *Trichoderma harzianum* and PGPR were used in different doses. The doses in FYM with vermicompost (200gm +200gm, 400gm +200gm, 200gm +400gm), *Azotobacter* with vermicompost (6gm +300gm, 4gm +200gm, 2gm +100gm), *T. harzianum* with vermicompost (6gm +300gm, 4gm +200gm, 2gm +100gm), PGPR with Vermicompost (6gm +300gm, 4gm +200gm, 2gm +100gm) and alone vermicompost as control (control-2) were used to conduct the experiment.

Application of A*zotobactor* in Soil

In soil, *Azotobactor* with vermicompost were used in 3 treatments in different doses as 6gm+300gm, 4gm+200gm and 2gm+100gm in three replications and foliar spray of propiconazole at vegetative stage and booting stage.

Soil application with *T. harzianum*

Bioformulation of *T. viride* was applied @ 4gm applies in the soil. The sterilized soil was filled up in earthen pots having 30cm diameter. The soil was treated with the bioformulation of *T. viride* @ 4gm before filling the pots. The treated seeds were then sown in earthen pots and after 40 days of sowing, seedlings were inoculated with conidial suspension of *B. sorokiniana*.

Soil application of PGPR

In soil, bioformulation of PGPR was applied @ 6gm, 4gm and 2gm with vermicompost @ 300gm, 200gm and 100gm respectively. The sterilized soil was filled up the earthen pots having 30cm diameter. The soil was treated with the bioformulation of PGPR @ 6gm, 4gm and 2gm were used in 3 replications respectively and two foliar spray of propiconazole at vegetative stage and booting stage.
The treatments details were given as below:

Treatments detail

- **T_1** Soil application with FYM + Vermicompost (200gm+200gm) and two foliar spray with propiconazole at vegetative stage and booting stage.
- **T_2** Soil application with FYM + Vermicompost (400gm+200gm) and two foliar spray with propiconazole at vegetative stage and booting stage.
- **T_3** Soil application with FYM + Vermicompost (200gm+400gm) and two foliar spray with propiconazole at vegetative stage and booting stage.
- **T_4** Soil application with Azotobacter + Vermicompost (6gm +300gm) and two foliar spray with propiconazole at vegetative stage and booting stage.
- **T_5** Soil application with Azotobacter + Vermicompost (4gm+200gm) and two foliar spray with propiconazole at vegetative stage and booting stage.
- **T_6** Soil application with Azotobacter + Vermicompost (2gm +100gm) and two foliar spray with propiconazole at vegetative stage and booting stage.
- **T_7** Soil application with Trichoderma harzianum + Vermicompost (6gm+300 gm) and two foliar spray with propiconazole at vegetative stage and booting stage.
- **T_8** Soil application with T. harzianum + Vermicompost (4gm+200 gm) and two foliar spray with propiconazole at vegetative stage and booting stage.
- **T_9** Soil application with T. harzianum + Vermicompost (2gm+100 gm) and two foliar spray with propiconazole at vegetative stage and booting stage.
- **T_{10}** Soil application with PGPR + Vermicompost (6gm+300 gm) and two foliar spray with propiconazole at vegetative stage and booting stage.
- **T_{11}** Soil application with PGPR + Vermicompost (4gm+ 200gm) and two foliar spray with propiconazole at vegetative stage and booting stage.
- **T_{12}** Soil application with PGPR + Vermicompost (2gm+100gm) and two foliar spray with propiconazole at vegetative stage and booting stage.
- **T_{13}** Without vermicompost (control-1)
- **T_{14}** Soil application with Vermicompost alone (control-2)

The observation pertaining the effect of different treatments was recorded as per following parameters.

Germination test

Soil application of vermicompost alone or in combination with FYM, *Azotobactor, T. harzianum* and PGPR was used to find out the effect of germination percentage of wheat seeds and growth parameters. The treated seeds were planted in 22.5x10 cm in pots which were previously filled up with a mixture of different treatments. The germination of seeds by counting and growth of seedling were measured by measuring scale every at 24 hour interval up to 7 days. Germination percentage was calculated by use of following formula:

$$\text{Germination\%} = \frac{\text{Number of germinated seed}}{\text{Total number of seeds}} \times 100$$

Vigor index = (mean shoot length + mean root length) ×% germination

Estimation of salicylic acid

The accumulation of salicylic acid in wheat leaves after treatment of vermicompost alone or in combination with FYM, biocontrol agents (Azotobactor, *T. Harzianum* and PGPR) at different dose and foliar spray fungicides as followed by inoculation of pathogen was estimated following procedure developed by Malamy (1990) [21]. In this method, the salicylic acid estimation was carried out with spectrophotometer was measured at 306 nm wave length calorimetrically.

Reagents Needed

Ethanol 80%, Folin reagent, Ethyl acetate and Sodium sulphate standard (100 mg catechol in 100 ml of water, which was diluted 10 times for a working standard).

Procedure

Salicylic acid of the treated leaves of each treatment were cut into small pieces of size 0.5-1.0 cm, soaked in water for overnight, than filtered through the Watman filter paper No.1.

The ethyl acetate fraction was taken and sodium sulphate added to remove the moisture and filtrate was evaporated to dryness in water bath. The stock solution was prepared by the addition of 10 ml methanol. The stock solution was used for recording the absorbance in a spectrophotometer (SHIMADZU, 2450 PC, Japan) at 306 nm. The absorbance was fixed at 306 nm and the readings were recorded at different ppm of SA and standard curve was prepared for the estimation of SA concentration in the leaf sample (Pankaj *et al.*, 2005). [24] The readings were taken at 306 nm absorbance. The standard curve was plotted to get a best fit line passing through the origin. From the standard curve the concentration of SA in the sample was calculated according to the formula y = mx ± c (Lowery *et al*., 1951) [20].

Correlation coefficient

The biochemical analysis of wheat leaves at different days of pathogen inoculation with disease severity of spot blotch of wheat show negative correlation were calculated by Pearson's correlation (also called Pearson's *R*) and the correlation coefficient was used in linear regression equation by the following formula:-

$$pxy = \frac{Cov(x,y)}{\sigma x \sigma y}$$

Where: pxy = Pearson product moment correlation coefficient
Cov (x,y)= covariance of variables x and y
σx = Standard deviation of x
σy= Standard deviation of y

Experimental Design

The data were analyzed by following the procedure of Randomized Block Design (RBD) and Completely Block Design (CRD). Data recorded in percentage were first transformed at Arc sin value (Fisher and Yates, 1963) $\sqrt{sin^{-1}}$ before statistical analysis. Treatments were compared by means of critical difference (CD) at 5 per cent level of significant.

Experimental plan of work

Experimental Design	:	**Complete randomized design (CRD)**
Season	:	Rabi (2018-19 and 2019-20)
Crop	:	Wheat
Replication (pot experiment)	:	Three
Seedling/pot	:	20 seedling/pot
Variety	:	HD 2329
Treatment	:	14

Result and discussion

A critical scanning of data revealed that the germination (%) significantly increased in all the treatments over control. The data presented in the Table 1, the maximum germination (%) was recorded in T_{10} treatment as soil application with PGPR + Vermicompost (6gm+300gm) and two foliar spray with propiconazole (vegetative stage and booting stage) representing 95.57% and 99.58% followed by T_7 treatment (soil application with *T. harzianum* + Vermicompost (6gm+300 gm) and two foliar spray with propiconazole at vegetative stage and booting stage) representing 94.56% and 98.10%, T_{11} treatment (soil application with PGPR + Vermicompost (4gm+ 200gm) and two foliar spray with propiconazole at vegetative stage and booting stage) representing 91.17% and 95.57% were recorded. The maximum seed viability as 88.20% and 91.66% was recorded in T_{10} treatment (Soil application with PGPR + Vermicompost (6gm+300gm) and two foliar spray with propiconazole at vegetative stage and booting stage). It is also cleared from the table that all the different management approaches were statistically significant with respect to seed viability of wheat. The Table 1, showed that the among all the treatment maximum seedling emergence (%) was recorded in T_{10} treatment (Soil application with PGPR + Vermicompost (6gm+300 gm) and two foliar spray with propiconazole at vegetative stage and booting stage) representing as 97.67% and 98.18%. respectively. The maximum vigor index was found in T_{10} treatment as soil application of PGPR + Vermicompost (6gm+300 gm), two foliar spray with propiconazole (vegetative stage and booting stage) representing 6500.67 and 7061.21 against 1811.75 and 1830.89 in case of Control-1 and Control-2 respectively. The rest of the treatments were also showing better vigor index as compare to control-1 and control-2. It is also cleared that all the IDM approaches were statistically significant with respect to vigor index. Among the treatments, the maximum activity of salicylic acid was found in T_{10} treatment as soil application with PGPR + Vermicompost (6gm+300gm) and two foliar spray with propiconazole (vegetative stage and booting stage) indicating 0.72, 0.88, 1.12 and 0.85 (mg/g) of fresh leaves against 0.26, 0.31, 0.38 and 0.28 mg/g in case of control-1 and 0.28, 0.35, 0.42 and 0.33 mg/g in case of control-2 at 10, 20, 30 and 40 days of pathogen inoculation, respectively during 2018-19. The treatment T_{10} (soil application with PGPR + Vermicompost (6gm+300gm) and two foliar spray with propiconazole at vegetative stage and booting stage) possess increased per cent activity of salicylic acid as 194.73% over control-1 and 166.66 over control-2 at 30 days of pathogen inoculation. The similar trend of increase activity of salicylic acid was noticed during 2019-20 as highest in T_{10} treatment (soil application with PGPR + Vermicompost (6gm+300gm) and two foliar spray with propiconazole (vegetative stage and booting stage) showing 0.74, 0.90, 1.14 and 0.87 against 0.29, 0.32, 0.40 and 0.30 in case of control-1 and 0.31, 0.38, 0.45 and 0.35 in case of control-2 at 10, 20, 30 and 40 days of inoculation, respectively. It is evident from the Table 2 that among the different days of interval, maximum salicylic acid activity was noticed at 30 days of pathogen inoculation during both the years i.e. 2018-19 and 2019-20, thereafter, it was decreased. The increased activity of salicylic acid in plants might be responsible for defense response in plant against *B. sorokiniana*. Biswas *et al*., (2015) [5] also found that seed treatment with bio-fertilizers *viz*., *Azotobacter chroococum*, PGPR, *T. harzianum*, *T. viride*, PSB, *Rhizobium*, significantly increased germination of wheat seed, seedling emergence and increased number of tiller per plant. PGPR helps in root expansion, improve uptake of plant nutrients, protects plants from root diseases and most important improves biomass production in the rhizosphere are found in almost all the crops (Kloepper *et al*., 1989; Okon *et al*., 1994; Glick *et al*., 1995) [23, 18, 13]. Singh *et al*. (2017) [28] revealed that the different bio-fertilizers alone or in combination with others as seed, soil and foliar spray have stimulatory effect on germination, sprouting behaviour and growth parameter with the best as soil application FYM @ 150gm/pot + Mustard cake @ 150 gram/pot + tuber treatment with *T. viride* + foliar spray with bio- formulation of *T. viride*. Morajdhwaj *et al*.,

(2016) [22] also found that the IDM practices found best in stimulating germination, increase plant height of potato at different days after sowing. Prasad *et al.* (2017) [26] the high vigour index in wheat was observed after PGPR inoculation and the percent seed germination of wheat got augmented by two fold and vigour index observed was much higher. The increased activity of salicylic acid in plants might be responsible for defense response in plant against *B. sorokiniana*. Domiciano *et al.* (2010) [9] evaluated that the total salicylic in the increased resistance to spot blotch of plants. Bisen *et al.* (2015) [4] found that the higher amount of total phenol and salicylic acid in rice leaves resulted lower disease incidence. Husain, (2022) [14] biochemical analysis of the treated leaves revealed that increased content of salicylic acid are produced due to adaptation of IDM practices in case of both the diseases which might be responsible for defense response in wheat.

Table 1: Effect of vermicompost alone or in combination of FYM, bio-agent and bio-fertilizers on germination, seed viability and seedling emergence.

Treatment	2018-19				2019-20			
	Seed Germination (%)	Seed Viability (%)	Seed Emergence (%)	Vigor index	Seed Germination (%)	Seed Viability (%)	Seed Emergence (%)	Vigor index
T_1	78.36	63.62	68.14	4044.94	81.73	69.17	76.44	4486.97
T_2	89.15	78.67	90.92	5176.04	92.71	84.26	91.30	5808.28
T_3	47.47	41.32	40.68	2162.25	50.17	47.18	44.11	2390.60
T_4	52.98	46.16	45.72	2603.96	54.47	50.67	48.76	2739.18
T_5	88.69	78.20	87.68	4925.84	90.88	80.62	89.14	5526.41
T_6	74.71	57.84	51.68	3776.59	77.67	62.71	70.61	4159.22
T_7	94.56	86.56	95.18	6109.52	98.10	90.12	96.56	6672.76
T_8	83.11	68.61	79.61	4390.70	86.57	72.54	82.65	4853.11
T_9	65.15	52.93	47.50	3267.92	74.31	54.65	54.89	3851.48
T_{10}	95.57	88.20	97.67	6500.67	99.58	91.66	98.18	7061.21
T_{11}	91.17	81.64	92.24	5692.65	95.57	87.64	94.62	6428.99
T_{12}	85.41	75.35	84.40	4548.08	87.65	78.11	86.71	5121.38
T_{13} (Control-1)	35.71	34.58	32.15	1421.61	35.26	40.16	33.21	1502.78
T_{14} (Control-2)	42.71	38.19	38.86	1811.75	41.19	44.58	39.76	1830.89
SE (m)	1.799	1.234	1.389	-	1.916	1.388	1.542	-
SE (d)	2.544	1.745	1.965	-	2.710	1.963	2.181	-
CD	5.214	3.577	4.023	-	5.554	4.024	4.471	-

Table 2: Effect of vermicompost on Salicylic acid content in wheat leaves at different days of intervals in Wire house condition.

Treatment	2018-19						2019-20					
	Salicylic acid (mg/g of fresh leaves)						Salicylic acid (mg/g of fresh leaves)					
	Days interval				Per cent Increase Over control-1 (at 30 days)	Per cent Increase Over control-2 (at 30 days)	Days interval				Per cent Increase Over control-1 (at 30 days)	Per cent Increase Over control-2 (at 30 days)
	10 Days	20 Days	30 Days	40 Days			10 Days	20 Days	30 Days	40 Days		
T_1	0.46	0.58	0.72	0.55	89.47	71.42	0.49	0.65	0.74	0.62	85.00	64.44
T_2	0.65	0.76	0.91	0.71	139.47	116.66	0.70	0.82	0.95	0.80	137.50	111.11
T_3	0.31	0.42	0.55	0.38	44.73	30.95	0.34	0.45	0.56	0.42	40.00	24.44
T_4	0.32	0.47	0.63	0.43	65.78	50.00	0.36	0.52	0.65	0.48	62.50	44.44
T_5	0.62	0.73	0.86	0.70	126.31	104.76	0.69	0.79	0.88	0.75	120.00	95.55
T_6	0.38	0.55	0.67	0.52	76.31	59.52	0.42	0.60	0.70	0.58	75.00	55.55
T_7	0.70	0.85	1.05	0.82	176.31	150.00	0.72	0.87	1.11	0.85	177.50	146.66
T_8	0.53	0.62	0.76	0.60	100.00	80.95	0.58	0.71	0.79	0.69	97.50	75.55
T_9	0.35	0.51	0.64	0.49	68.42	52.38	0.37	0.59	0.68	0.55	70.00	51.12
T_{10}	0.72	0.88	1.12	0.85	194.73	166.66	0.74	0.90	1.14	0.87	185.00	153.34
T_{11}	0.68	0.81	0.97	0.78	155.26	130.95	0.71	0.84	1.06	0.81	165.00	135.56
T_{12}	0.59	0.68	0.81	0.65	113.15	92.85	0.64	0.75	0.82	0.73	105.00	82.22
T_{13} (Control-1)	0.26	0.31	0.38	0.28	-	-	0.29	0.32	0.40	0.30	-	-
T_{14} (Control-2)	0.28	0.35	0.42	0.33	10.52	-	0.31	0.38	0.45	0.35	12.50	-
SE (m)	0.039	0.012	0.015	0.013	-	-	0.015	0.036	0.046	0.038	-	-
SE (d)	0.055	0.017	0.021	0.019	-	-	0.021	0.051	0.065	0.054	-	-
CD	0.035	0.035	0.044	0.040	-	-	0.044	0.104	0.134	0.111	-	-

T1 = Soil application with FYM + Vermicompost (200gm+200gm) and two foliar spray with propiconazole at vegetative stage and booting stage.T2= Soil application with FYM + Vermicompost (400gm+200gm) and two foliar spray with propiconazole at vegetative stage and booting stage. T3= Soil application with FYM + Vermicompost (200gm+400gm) and two foliar spray with propiconazole at vegetative stage and booting stage. T4= Soil application with Azotobacter + Vermicompost (6gm +300gm) and two foliar spray with propiconazole at vegetative stage and booting stage. T5= Soil application with Azotobacter + Vermicompost (4gm+200gm) and two foliar spray with propiconazole at vegetative stage

and booting stage. T6= Soil application with Azotobacter + Vermicompost (2gm +100gm) and two foliar spray with propiconazole at vegetative stage and booting stage. T7= Soil application with *T. harzianum* + Vermicompost (6gm+300 gm) and two foliar spray with propiconazole at vegetative stage and booting stage. T8= Soil application with *T. harzianum* + Vermicompost (4gm+200 gm) and two foliar spray with propiconazole at vegetative stage and booting stage. T9= Soil application with *T. harzianum* + Vermicompost (2gm+100 gm) and two foliar spray with propiconazole at vegetative stage and booting stage. T10= Soil application with PGPR + Vermicompost (6gm+300 gm) and two foliar spray with propiconazole at vegetative stage and booting stage. T11= Soil application with PGPR + Vermicompost (4gm+ 200gm) and two foliar spray with propiconazole at vegetative stage and booting stage. T12= Soil application with PGPR + Vermicompost (2gm+100gm) and two foliar spray with propiconazole at vegetative stage and booting stage. T13= Without vermicompost (control-1). T14= Soil application with Vermicompost alone (control-2).

Conclusion

The present finding of study concluded that integration of soil application with PGPR+vermicompost (6gm+300gm) and two foliar spray with propiconazole at vegetative stage and booting stage have good ability to increase growth and yield parameters and increase level of plant defense molecule like salicylic acid.

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