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Research Article

Yield and Quality of *Panchagavya* and *Trichoderma viride* Applied Cotton

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Abstract

Background and Objective: Bio-fertilizer application has become one of the best alternates to chemical fertilizers, as an effective and sustainable soil management practice. Specific agronomy practices have been evolved in the cultivation of cotton, ultimately gained with improved yield and lint quality. An investigation was done to test the treatment effects over the growth, biochemical contents and cotton fibre yield and lint quality of a cotton cultivar, applied with *Panchagavya* and *Trichoderma viride*. **Materials and Methods:** *Panchagavya* and *Trichoderma viride* were applied to SVPR2 cotton cultivar, grown in containers under experimental conditions, using a randomized block design. Biochemical contents, yield response and lint quality were determined and the data were analyzed using biostatistical methods. **Results:** The biochemical contents analyzed in the cotton plants were found to have an influential role in the yield response and the physical quality of lint fibre, raised in the experimental SVPR2 cotton variety. **Conclusion:** The novelty in this research work, using the organic fertilizers treatment regime adapted has been found with an improved yield in cotton, combined with its better lint quality. This study result could be recommended to adopt organic farming for the benefit of cotton growers and industries and further contributing to the Cleaner Production Mechanism.

Key words: Cotton lint quality, cleaner production mechanism, *Panchagavya*, *Trichoderma viride*, sustainable soil quality, nitrogenous fertilizer

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

India generates about 30% of the agricultural gross domestic product¹ and 4.5 million Indian farming communities, who have cotton production, as their livelihood². This quantum of cotton production facilitates India to reach the second largest cotton producer country in the world. Improved cotton production and lint quality have been practiced through selection procedures and breeding methods³, molecular level studies through the regulation of gibberellic acid synthesis was demonstrated to bring out cotton fibre with the desired length⁴. From the agronomy point of view, a sizable number of cotton growers prefer the application of chemical fertilizers^{5,6} or the want of enhanced cotton production and fibre quality. Since the land and soil quality is importantly considered, the modified land-use practice through nitrogenous fertilizer application negatively impacts the poor microbial diversity in the rhizosphere region of the crop. This situation allows the soil to hamper its physical conditions⁷ by the chemical fertilizer application in the agronomy practice.

Sustainable organic farming has become the preferred alternative to the heavy use of chemical fertilizer to plantation crops, including cotton. The multiple benefits of using bio-wastes including the safety land-filling of waste materials, thereby providing the possible reduction in the emission of greenhouse gases⁸ and to produce quality crops, eventually leading to the Cleaner Development Mechanism. Maintenance of organic standards is specifically required, as this important social responsibility in the fair trade standards of cotton growers and industries.

The practice of the organic farming system significantly supports the sustainable cotton lint production system⁹. Several reports confirm the application with *Panchagavya*, *Trichoderma* sps. exhibited beneficial over the pest resistance of crops¹⁰⁻¹². Baggs *et al.*¹³ and Rezaei *et al.*¹⁴ used crop residues as an alternative to chemical fertilizer since the latter one causes the immobilization of soil nitrogen. Crop residue application improves soil potassium thereby improved cotton production¹⁵. He *et al.*¹⁶ explored the higher root biomass in the cotton plant by the soil-applied straw biochar, further found with significantly improved soil nutrients. However, the yield component of the cotton plant on the improved soil quality has been well documented, there is the existence of a dearth of knowledge on the biochemical contents of the cotton plant and its relationship with the lint quality.

In this context, research question-posing on the treatment effects of bio-fertilizers-*Panchagavya* and

Trichoderma viride, over the growth, biochemical substances which could be related to the yield potential and lint quality in native cotton variety. Therefore, the research work was done using the application of *Trichoderma viride* and *Panchagavya* to SVPR2 cotton cultivar, to determine the growth, biochemical contents, cotton fibre yield and lint quality. Application of bio-fertilizer has become the better choice to chemical fertilizers, considering the soil environment and associated ecological and human health and at the same time, for the improved quality of cotton fibre yield and to sustain the livelihood of cotton growers and industries, by adopting the Cleaner Development Mechanism.

MATERIALS AND METHODS

Study area: The experiment was carried out in the Botanical Garden, Thiagarajar College Campus, Madurai. The College is located on the eastern side of Madurai, south India (N 9° 91", E 78° 15", Altitude-134.00 m/439.63 ft., MSL). The General eco-climatic condition of the experimental area is tropical semi-arid.

Cotton cultivar, seed treatment and nursery trail: The experimental trial was conducted between August 2016 and March 2017. The experiment was done using soil mix filled plastic containers, with a dimension of 55×45 cm, when flat was used and filled with black soil, sand and farmyard manure mixed in the ratio of 2:1:1. Polythene bags, filled with the soil mix were kept under the treatment regime, using a randomized block design with three replicated blocks. The experimental seedlings were grouped for three different treatments kept in a row, leaving equal distance between each block. Likewise, three different rows were prepared with equal distance between each row. Certified cotton seeds of SVPR2 variety were purchased and soaked in cattle dung followed by drying under open sunlight, before planting. In each bag, one pre-soaked cotton seed was dibbled, with a total of 135 containers grown individuals of the cotton plant in each treatment was used to grow under open sunlight conditions in the experiment. Three treatment regimes were imposed by applying with (i) *Panchagavya* solution, (ii) *Trichoderma viride* and (iii) Normal water as the control treatment.

Commercially available *Panchagavya* and *Trichoderma viride* as the bio-fertilizers were applied, four times, at 30 days regular interval during the experiment in a ratio of 1:10 (W/V), to the reach of complete saturation of the soil mix filled in the container bags. Besides these treatment applications done, the rest of the experimental period and the plants used in the control treatments were reared with care by regular watering and with weeding out, whenever necessary.

To control the dilution effect due to precipitation, the entire nursery-grown experimental plants were covered using a tarpaulin sheet, above 3 ft. over the seedlings canopy.

Growth parameters: Shoot length, number of leaves and root collar diameter were determined for 20 days old experimental plants, following germination and growth measurements were continued for four equal time intervals of 20 days, during the experiment.

Biochemical contents: Spectrophotometry analytical methods were employed in the determination of chlorophyll pigments, protein and total phenol estimation. Fresh green leaves samples were collected from the experimental cotton plants, kept under different treatments, on their fourth leaf position, following 10-20 days of the first-time treatment.

Cotton yield and lint fibre quality analysis: Cotton fibre popped out from the matured cotton balls were collected from each plant, kept under each treatment and the fibre weight was determined, using a high-sensitive electronic balance. Cotton lint fibre quality, in terms of fibre length, texture, strength, elongation, colour grade, maturity ratio and cotton grade were determined using the cotton lint quality instrument (Premier ART Make, V1.1.8 model) installed in GHCL Meenakshi Mills, Paravai, Madurai, southern India.

Statistical methods: Descriptive statistical procedure was used to determine the mean and standard deviation, one-way ANOVA method using Duncan's Multiple Range Test and Karl Pearson's correlation coefficient (r-values) between the analysed variables in this experiment were computed using SPSS program (version: 16.0).

RESULTS

In two to three days after seeds dibbled in the container bags, radicle emergence was noticed, followed by the development of the first leaf, after 10-12 days. Flower bud formation was noticed between 40-45 days and the fruit setting and cotton balls development were noticed during the third month of the experimental period.

Growth analysis: During the first sampling period at the 20 days growth, both biofertilizer and bio-pesticide treated SVPR2 cotton plants were observed with no much growth variation. However, during the subsequent sampling periods, the rate of increments in the analyzed growth parameters showed a significant variation among the treatments (Table 1).

Table 1: Growth attributes of cotton cultivars and bio-control agents application, used in pot cultures, Mean $\pm$ SD (n = 3)

Treatments	Shoot length (cm)				Root collar diameter (mm)				Number of leaves			
	20	40	60	80	20	40	60	80	20	40	60	80
Control	8.25 $\pm$ 0.29 ^a	29.50 $\pm$ 1.11 ^a	43.00 $\pm$ 2.91 ^a	48.75 $\pm$ 4.33 ^a	0.38 $\pm$ 0.06 ^a	0.53 $\pm$ 0.03 ^a	0.58 $\pm$ 0.06 ^a	0.65 $\pm$ 0.03 ^a	7.00 $\pm$ 0.47 ^a	12.50 $\pm$ 1.20 ^a	22.33 $\pm$ 1.45 ^a	27.25 $\pm$ 1.72 ^a
<i>Panchagavya</i> application	7.75 $\pm$ 0.55 ^a	32.00 $\pm$ 1.41 ^b	45.00 $\pm$ 5.23 ^a	52.25 $\pm$ 7.08 ^a	0.35 $\pm$ 0.03 ^a	0.68 $\pm$ 0.06 ^b	0.70 $\pm$ 0.05 ^a	0.83 $\pm$ 0.10 ^b	8.00 $\pm$ 0.47 ^b	11.75 $\pm$ 0.55 ^a	29.67 $\pm$ 1.76 ^b	37.25 $\pm$ 4.20 ^{ab}
<i>Trichoderma viride</i> application	7.50 $\pm$ 0.75 ^a	31.75 $\pm$ 0.55 ^a	44.00 $\pm$ 3.50 ^a	50.75 $\pm$ 4.41 ^a	0.30 $\pm$ 0.05 ^a	0.63 $\pm$ 0.06 ^{ab}	0.68 $\pm$ 0.07 ^a	0.85 $\pm$ 0.11 ^b	8.25 $\pm$ 0.55 ^b	12.50 $\pm$ 0.33 ^a	34.67 $\pm$ 3.18 ^c	46.50 $\pm$ 9.43 ^b

Different alphabets in the columns indicate significantly ($p < 0.05$), according to Duncan's Multiple Range Test

Table 2: Fibre yield and quality attributes of cotton, grown under different experimental conditions

Treatments	Cotton fibre quantity (g)	Fibre length (mm)	Fibre strength	Fibre elongation (%)	Colour grade	Maturity ratio (Mm)	Cotton grade
Control	123.75	14.14	21.2	6.1	5.4	0.8	41.1
<i>Panchagavya</i> applied cotton	122.26	14.8	23.4	6.3	5.7	0.81	51.2
<i>Trichoderma viride</i> applied cotton	123.4	15.81	23.1	6.3	5.7	0.79	51.1

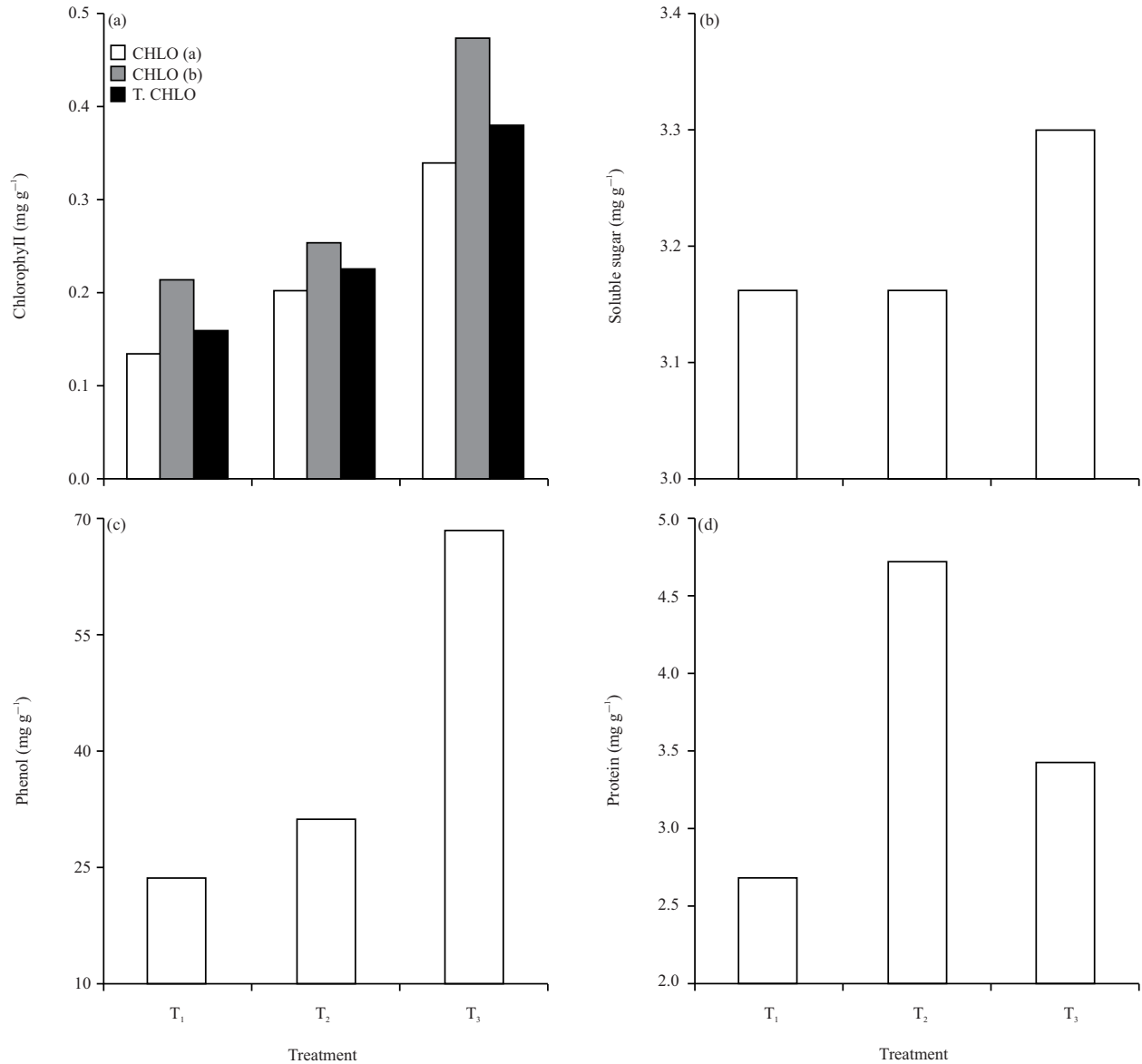


Fig. 1(a-d): Biochemical contents of SVPR2 cotton, grown under different treatment conditions, (a) Chlorophyll, (b) Soluble sugar, (c) Phenol and (d) Protein
T₁: Control, T₂: *Panchagavya* T₃: *Trichoderma viride*

Cotton plants, supplied with *Panchagavya* and *Trichoderma viride* were observed with more shoot growth at 20 and 40 days of growth in the experimental conditions. *Panchagavya*, treatment was found influential to the container-grown cotton plants to attain greater shoot length than in the other two treatments, observed in 80 days old plants (Table 1), whereas, control treatment showed with significantly lesser shoot height during the same measurement period. A marked increase in the root collar diameter and with more number of leaves production was observed for the cotton plants, treated with *Trichoderma*

viride, followed by *Panchagavya* treatment, when compared with the control treatment.

Biochemical contents: *Panchagavya* applied experimental cotton plants were found relatively with a higher amount of chlorophyll pigment production, followed by the plants that received the supply of *Trichoderma viride* used in this experiment. Cotton plant, subjected under the control treatment was found with a lesser quantity of chlorophyll (Fig. 1a). *Trichoderma viride* treated cotton plants were found relatively more soluble sugar content than in the control and

Table 3: Correlation coefficient (r values) determined for the analyzed growth, biochemical substances and fibre quality variables of SVPR2 cotton variety

Parameters	Total chlorophyll	No. of leaves	Total soluble sugar	Total soluble protein	Phenol	Cotton fibre quantity	Cotton fibre length	Cotton fibre strength	Cotton fibre elongation	Cotton colour grade	Maturity ratio	Cotton grade
Total chlorophyll	1											
Number of leaves	0.594*	1										
Total soluble sugar	0.082	0.850**	1									
Total soluble protein	0.963**	0.356	-0.189	1								
Phenol	0.278	0.938**	0.980**	0.010	1							
Cotton fibre quantity	-0.929**	-0.254	0.293	-0.994**	0.097	1						
Cotton fibre length	-0.293	0.595*	0.929**	-0.539	0.837**	0.626*	1					
Cotton fibre strength	-0.004	-0.807**	-0.997**	0.265	-0.962**	-0.367	-0.955**	1				
Cotton fibre elongation	-0.904**	-0.881**	-0.500	-0.756**	-0.662*	0.682*	-0.144	0.430	1			
Cotton colour grade	0.904**	0.881**	0.500	0.756**	0.662*	-0.682*	0.144	-0.430	-1.000**	1		
Maturity ratio	0.082	-0.850**	-1.000**	0.189	-0.980**	-0.293	-0.929**	0.997**	0.500	-0.500	1	
Cotton grade	-0.822**	-0.030	0.500	-0.945**	0.318	0.974**	0.785**	-0.566	0.500	-0.500	-0.500	1

*Correlation is significant at $p \leq 0.05$ level, **Correlation is significant at $p \leq 0.01$ level

Panchagavya treatment (Fig. 1b). The concentration of phenol was observed in the increasing order to the respective treatments: Control < *Panchagavya* < *Trichoderma viride* (Fig. 1c). *Panchagavya* application caused to produce a relatively higher level of total soluble protein when compared with the other two treatments used in the experiment (Fig. 1d).

Cotton fibre yield and quality: There was no marked difference found existed in the cotton fibre yield in all the three treatments, imposed to the SVPR2 cotton variety used in the experiment. However, *Panchagavya* and *Trichoderma viride* applied cotton plants exhibited improved lint qualities, in terms of fibre length, strength, cotton colour and cotton grade, over the control treatment (Table 2), which produces an intermediate quality in the experiment.

Relationship between growth, biochemical substance and fibre quality of cotton: The number of leaves highly correlated to protein content ($r = 0.96$) and with the cotton colour grade ($r = 0.90$) and a moderate relationship was found with chlorophyll content ($r = 0.59$) (Table 3). These results indicated that the quantity of leaf protein is responsible for cotton colour and the agronomy practices, which could enhance the leaf protein content can improve the cotton colour grade.

Soluble sugar highly correlated with phenol content ($r = 0.93$), the number of leaves ($r = 0.85$) and fibre elongation ($r = 0.92$) (Table 3) and this result denoted that *Panchagavya* and *Trichoderma viride* applied SVPR2 cotton variety, found with higher sugar content; which could be improved the production of cotton with longer lint fibre. Moreover, *Panchagavya* and *Trichoderma viride*,

respectively acted as biofertilizers and biocontrol agents because they were observed with higher phenol.

DISCUSSION

Morphological growth improvement and physiologically active foliage production with the eventual increment of crop biomass due to the application of *Panchagavya* and *Trichoderma viride*, further corroborated with the similar works, done for other crops¹⁷. *Trichoderma viride* was found enhancing soil nutrient uptake, combined with the solubilizing effects by phosphates and micronutrients makes available to the plant¹⁸. Soil nutrient conditions and its alteration through soil microbes and organic matter applied to the crop plants enhancing the uptake of essential minerals to achieve the growth and biomass productivity in crop plants were explained¹⁹⁻²¹. However, there is no experimental proof on plant nutrition status in this experiment, studies were done by Ahmed and Elzaawely²² and Reshma Sutar *et al.*²³ would possibly explain the effect of *Panchagavya* application in facilitating auxin translocation, further triggering of cell elongation, followed by cell division for the onset of several shoot buds.

Geng *et al.*²⁴ and Yang *et al.*²⁵ explored the growth of cotton plants efficiently by the application of inorganic fertilizer. Meanwhile, the continuous supplement of inorganic fertilizer spoils the native microflora presents in the soil thereby leading to degradation of the land fertility. Soil fertility improvement on crop growth and better yield response could be achieved through biofertilizer, a better alternative to chemical fertilizer as the nitrogenous fertilizer application was experienced with pH reduction of topsoil²⁶.

Cotton fibre quality indices such as length, uniformity, strength, elongation, short fibre ratio and maturation rate

were found irrespective of nitrogen availability, but dependent on the balanced nutrient status of the soil environment, as evident from the works of Pettigrew²⁷, Zhao *et al.*²⁸.

The benefits of *Trichoderma* on the sustainable soil quality management system has been greatly emphasized²⁹, especially its enhancing effect on the productivity, fibre quality of cotton crop³⁰. Similarly, foliar-spray and seed pre-treatment, using *Panchagavya*³¹ were also found with yield improvement. The usage of biofertilizers on crop management was also found to be preventing the ill-effects of the causes done by chemical inputs in the agro practices Jana *et al.*³², Banik and Sharma³³ and Raikar *et al.*³⁴, to which the sustainable soil environment can be developed using specific agronomy practices³⁵. Enhanced chlorophyll content in the biofertilizer applied leaves (Fig. 1) of cotton was found with the similar results of Praveena Kumar *et al.*³⁶. This phenomenon, further explains *Panchagavya* application improves the kinetin and enzymes synthesis, responsible to chlorophyll biosynthesis. Karademir *et al.*³⁷ has been reported the chlorophyll content in the cotton leaves were positively and significantly correlated with the seed cotton yield. A similar result was obtained in the application of *Panchagavya* and *Trichoderma viride* treated the plant compared to control.

A higher rate of phenol content estimated in the *Panchagavya* application of this study (Fig. 1) corroborates with the report of Onte *et al.*³⁸. Further, the application of *Panchagavya* and *Trichoderma viride* was found with similar effects to bio-control agents Yao *et al.*³⁹, facilitates the yield potential, by controlling pest and disease menace in cotton. Results on the growth enhancement of *Panchagavya* and *Trichoderma viride* applied experimental plants (Table 1), could be attributed to the ability of cotton plants, to synthesize enhanced levels of phytohormones, vitamins and solubilizing minerals which favouring the inhibition of pathogen attack on the plants.

Cotton fibre grade was found dependent on the elongation of lint, as the correlation analysis showed a high positive correlation between these factors in this experiment. The maturity ratio was observed a negative correlation with the total number of leaves produced and with sugar and phenol contents, which indicates the possibility of extended vegetative growth gets delaying the time required for the fruit maturation period.

Panchagavya and *Trichoderma viride* treated the plant had a better fibre strength and length compared to control plant fibre quality due to the availability of nitrogen content, as *Panchagavya* has the nitrogen fertilizer effect. Foliar proteins especially the synthesis of photosynthetic pigment requires higher levels of leaf nitrogen⁴⁰ and in this case, the

bio-fertilizer effects of *Panchagavya* would be useful. A similar result was also found in Shukla *et al.*⁴¹, Read *et al.*⁴² and Zeng and Pettigrow⁴³ and they have suggested the nitrogen level has a beneficial effect on cotton fibre length and strength. Cotton fibre grade was found dependent on the elongation of lint, as the correlation analysis showed a high positive correlation between these factors in this experiment (Table 3). The maturity ratio was observed a negative correlation with the total number of leaves produced and with sugar and phenol contents, which indicates the possibility of extended vegetative growth gets delaying the time required for the fruit maturation period.

Carbon content was shown as the most important determinant factor, from the present study results (Table 2) and with the previous report⁴³. The higher level of organic substances analyzed in the leaf samples, obtained using the *Panchagavya* and *Trichoderma viride* treatments (Fig. 1), have caused in the formation of improved cotton fibre quality (Table 2), in terms of improved cotton fibre strength, over the control treatment, which produced intermediate quality. Colour grade is determined by the degrees of reflectance (Rd) and yellowness (+b) as established by official standards and measured by the high volume instrument. The treatment regime used in this experiment could produce a better colour grade, than the control treatment. This result is comparable with the work shown by Liu *et al.*⁴⁴, observed with farmyard manure application on cotton crop exhibited the improved uniformity ratio. Cotton farming is valued for the production of quality fibre through improved length and strength, leading to merchantable fibre maturity⁴⁵ and these attributes have been considered to have a better spinning ability during the industrial process.

CONCLUSION

The use of *Panchagavya* and *Trichoderma viride* to SVPR2 cotton variety, in the present study, exhibited improved growth and cotton fibre yield and its quality. The result is warranted to the variety used in this work and as well as under the given experimental conditions. The research work has a further scope on the bio-fertilizers and the application of bio-control agents in the cotton plantations to test for the quality production of cotton lint, which would be a great deal to cotton producers and industries.

SIGNIFICANCE STATEMENT

This study discovers the application of *Panchagavya* and *Trichoderma viride* application to the container-nursery

grown cotton plants to improve the growth, yield and fibre quality. The results of the work would be beneficial for sustainable cotton farming, using the bio-fertilizer application. Environmental management developed, besides offering cost-effectiveness through the bio-fertilizer applications. This study further explored the correlation factors demonstrated through the experiment to relate the biochemical quality of the plant foliage with the cotton fibre quality, that many researchers were not able to explore.

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