International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(6): 2204-2208

Received: 13-09-2018
Accepted: 15-10-2018

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In-Situ enhancement of soybean straw decomposition by *Trichoderma viride* and its Empact on soybean growth parameter

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Abstract
A field experiment was conducted during the year 2015-16 at the Research Farm of Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra).Results revealed that soybean growth characters *viz*., plant height (cm), number of functional leaves plant^{-1}, leaf area (dm^2) plant^{-1}, leaf area index plant^{-1}, number of branches plant^{-1} and plant dry matter accumulation (g) plant^{-1}, get significantly improved with application of RDF through chemical fertilizers. The next best treatment which improved all these growth characters was that of application of 75% RDN + 25% N through soybean straw + *T. viride*.

Keywords: *Trichoderma viride*, soybean, growth, straw

1. Introduction
Soybean is grown as major crop in many countries of the world and USA, Brazil, China, and Argentina are the main soybean growing countries. In India, soybean is grown over an area of 116.28 lakh ha with production of 781 kg ha^{-1} and average productivity of 86.42 lakh MT. In India Madhya Pradesh, Maharashtra and Utter Pradesh are major soybean producing states. Maharashtra is the second largest producer in country having 37.73 lakh ha area with production of 776 kg ha^{-1} and productivity 27.83 lakh MT, while Vidharbha region has 17.85 lakh ha area 26.20 lakh tones production and 13.28 q ha^{-1} productivity (Anonymous, 2014). The oil seed and pulses are receiving more attention owing to higher market value and change the economic situation of the farmer. Thus, overall it can be seen that agriculture is becoming more intensive, as with limited availability of land, farmers are expecting maximum output per unit investment.

It is obvious that continuous use of chemical fertilizers reduces the soil fertility on a long run, apart from deteriorating the soil health. However under these circumstances, the crop residues, which possess the tremendous potential to provide essential plant nutrients and to improve the soil health, can be applied to soil to replace a measured amount of chemical fertilizers. However, in-situ decomposition of crop residues takes a longer time to release the essential nutrients in the soil and make it available to the crop plants. Enhancement of crop residue decomposition under field condition can be possible if *Trichoderma viride*, a free-living fungi is applied to the soil. The efficiency of *Trichoderma viride* to reduce the residues can thus be tested chemically and through estimation of crop growth

2. Materials and Methods
Field experiment was carried out during *Kharif* season of 2015-16 at the Research Farm of Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola, situated at the latitude of 22°42’ North and longitude of 77°02’ East and 281.12 meter above the mean sea level. The experiment was laid out in randomized block design with four replications. The treatments were comprised of five nutrient management practices *viz*., T1: RDF Alone, T2: 75% RDN + 25% N thr. Soy. Straw, T3: 75% RDN + 25% N thr. Soy. Straw + *T. viride*, T4: 50% RDN + 50% N through soybean straw and T5: 50% RDN + 50% N through soybean straw+ *T. viride.*

2.1 Plant Growth characters studies

1. Plant population

The plant population was recorded by actually counting the number of plants in each net plot after thinning and at harvest.

2. Plant height (cm)

Height is generally considered as an indication of crop growth. It was measured from ground level to the base of terminal bud. Five sampling plants were selected for recording height and average height per plant was worked out at various crop growth stages.

3. Number of branches plant^{-1}

The number of branches plant^{-1} was recorded from the five selected plants and mean number of branches plant^{-1} was worked out.

4. Number of functional leaves plant^{-1}

The number of functional trifoliate leaves on each randomly selected plant was counted and recorded at different observation dates. All the fully opened green leaves from each plant were recorded as functional leaves at all observation dates.

5. Leaf area plant^{-1} (dm^2).

The leaves from the plants sampled for dry matter study were used for estimating the leaf area. The leaf area (dm^2) was estimated by using the automatic laser leaf area meter model CI-203, CID Inc USA at Department of Agronomy, Dr. P.D.K.V. Akola.

6. Leaf area index

The leaves from the plants sampled for dry matter study were used for estimating the leaf area index. The leaf area index was estimated by following formulae.

$$\text{Leaf area index} = \frac{\text{Leaf area plant}^{-1}(\text{cm}^2)}{\text{Ground area (m}^2)} \times 100$$

7. Dry matter plant^{-1} (g)

The dry matter accumulation was recorded by taking three plants from each plot at 30 days interval. Plant was cut from surface of soil from each plot. The plant was kept in brown paper bag, for sun drying first and then kept in oven at 60-65^{0}C for oven drying. The weight of oven dried plants were recorded treatment wise.

8. Dry matter partitioning (g)

Observations on dry matter partitioning recorded at harvest. Plants selected for recording the dry matter were partitioned into vegetative and reproductive parts and weighted separately.

3. Results and discussion

Crop studies

In this section, the soybean growth and ancillary characters has been studied and the results obtained for various plant parameters are placed and discussed under appropriate sub titles.

3.1 Growth characters of soybean

The growth characters of soybean *viz*, germination count and final plant stand, plant height, number of branches, number of leaves, leaf area, leaf area index and plant dry matter were observed periodically at an interval of 20 days after sowing or otherwise at a specified time and presented below.

1. Emergence count and final plant stand of soybean

The Emergence count was taken on 8th day after sowing and the final plant stand was recorded at harvest of the crop. Data pertaining to initial stand and final stand are presented in Table 1. The data revealed that various nutrient management treatments did not influenced the initial and final plant stand to a level of significance; thereby indicating uniform emergence and its persistence throughout the crop growth period; giving rise to a conclusion that plant population was not a variable factor. It also indicate that the variation in various plant parameters (which are presented and discussed here after) were emerged due to the treatment differences and not due to variation caused by differing plant population, either at emergence or harvest stage.

2. Plant height (cm) of soybean

Data on plant height (cm) were recorded periodically and presented in Table 2. and graphically depicted in fig 1. Treatment of RDF alone recorded significantly greatest plant height (67.23 cm), which was followed by treatments 75% RDN + 25% N thr. soy. straw + *T. viride* (65.61cm) and 75% RDN + 25 % N through soybean straw (63.01cm).

3. Number of functional leaves plant^{-1} of soybean

The Number of functional trifoliate leaves per pant of soybean was counted to record the variations due to various nutrient management treatments.The data regarding to mean number of functional leaves per plant as influenced by various treatments at different plant growth stages are presented in Table.3. and graphically represented in Fig. 2. Significantly maximum number of functional leaves (10.10, 15.21 and 11.09) at 40, 60 and 80 DAS, respectively was registered with treatment RDF alone, where the fertilization was done solely with chemical fertilizers, however, this treatment was statistically similar with that of 75% RDN + 25 % N through soybean straw by recording the number of leaves to an extent of 9.25, 14.07 and 10.42, respectively at 40, 60 and 80 DAS.

4. Leaf area (dm^2) plant^{-1} of soybean

The respected data was obtained by measuring the leaf area plant^{-1} of soybean and presented in appropriate manner. The leaf area per plant as influenced by various nutrient management treatments are presented in Table. 4. The data related to mean leaf area per plant was recorded at an interval of 20 DAS up to harvest. The mean leaf area per plant reduced drastically among all the treatments, however, treatment RDF alone was found significantly superior over rest of the treatments with its value of 10.82 dm^2. The next best treatments at this stage were those where 25% N was replaced with soybean straw with and without *T. viride* application.

5. Leaf area index plant^{-1} of soybean

Leaf area index was computed periodically and the respective data are presented in Table. 5. At 40, 60 and 80 DAS, the leaf area index was significantly improved with treatment RDF alone (4.83, 6.72 and 4.82, respectively) which was followed by treatment 75% RDN+25% N through soybean straw + *T. viride* (4.55, 6.43 and 4.38, respectively). During this period the lowest leaf area index was noted at treatment 50% RDN + 50% N thr. soy. straw + *T. viride*.

6. Mean number of branches plant^{-1} of soybean

Mean number of branches plant^{-1} of soybean was measured at periodical interval of 20 DAS and the concerned data are presented in Table 6. And its graphic representation is made at Fig. 3. At 80 DAS and finally at harvest all the treatments showed statistically similar number of branches (4.45, 3.64, 4.24 and 4.16 with treatments T1, T2, T3 and T5, respectively) with significant improvement over treatment T4 (50% RDN+50%N thr. soy. straw) (3.28).

7. Dry matter accumulation (g) plant^{-1} of soybean

Highest dry matter accumulation was noticed at harvest with treatment RDF alone (13.17 g) being at par with treatment 75%RDN +25% N through soybean straw + *T. Viride* (13.10 g), while, lowest amount of dry matter (12.16 g) was noticed with treatments where 50% of RDN was replaced with soybean straw without adding *T. Viride*. The data thus derived are presented in Table. 7. And graphically represented in Fig. 4.

Table 1: Initial and final plant stand of soybean as influenced by various treatments

Treatments	Initial plant stand (per net plot)	Plant stand at harvest (per net plot)
T1 (RDF Alone)	703	674
T2 (75% RDN + 25% N thr. soy. straw	700	661
T3 (75% RDN + 25% N thr. soy. straw + *T. viride*	699	670
T4 (50% RDN + 50% N thr. soy. straw	704	670
T5 (50% RDN + 50% N thr. soy.straw + *T.viride*	696	669
SE(m)+	13.023	13.041
CD at 5%	NS	NS
GM	700	669

Table 2: Mean plant height of soybean (cm) as influenced by different treatments

Treatments	Mean plant height (cm)				
	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
T1 (RDF Alone)	12.01	51.61	65.45	67.10	67.23
T2 (75% RDN + 25% N thr. soy. straw	10.84	48.79	60.16	62.62	63.01
T3 (75% RDN + 25% N thr. soy. straw + *T. viride*	12.64	50.11	63.53	65.13	65.61
T4 (50% RDN + 50% N thr. soy. straw	9.92	45.21	54.33	56.37	56.50
T5 (50% RDN + 50% N thr. soy.straw + *T.viride*	11.04	47.20	58.08	60.80	61.04
SE (m)±	0.811	1.909	1.279	0.853	0.824
CD at 5%	NS	5.893	3.952	2.641	2.543
GM	11.29	48.58	60.31	62.40	62.68

Table 3: Mean number of functional leaves plant^{-1} as influenced by various treatments

Treatments	Number of functional leaves plant^{-1}			
	20 DAS	40 DAS	60 DAS	80 DAS
T1 (RDF Alone)	2.61	10.10	15.21	11.09
T2 (75% RDN + 25% N thr. soy. straw	2.40	8.03	13.45	8.73
T3 (75% RDN + 25% N thr. soy. straw + *T.viride*	2.52	9.25	14.07	10.42
T4 (50% RDN + 50% N thr. soy. straw	2.06	6.68	10.86	5.13
T5 (50% RDN + 50% N thr. soy. straw + *T. viride*	2.27	7.33	11.95	6.37
SE (m)±	0.189	0.339	0.501	0.223
CD at 5%	NS	1.038	1.529	0.682
GM	2.37	8.28	13.11	8.35

Table 4: Mean leaf area (dm^2) plant^{-1} of soybean as influenced by various treatments

Treatments	Leaf area (dm^2) plant^{-1}			
	20 DAS	40 DAS	60 DAS	80 DAS
T1 (RDF Alone)	2.96	10.86	15.12	10.85
T2 (75% RDN + 25% N thr. soy. straw	2.57	9.80	13.65	9.36
T3 (75% RDN + 25% N thr. soy. straw + *T.viride*	2.82	10.23	14.46	9.86
T4 (50% RDN + 50% N thr. soy. straw	2.39	9.18	14.20	7.80
T5 (50% RDN + 50% N thr. soy. straw + *T. viride*	2.43	9.45	12.42	8.23
SE (m)±	0.237	0.341	0.372	0.181
CD at 5%	NS	1.029	1.152	0.558
GM	2.63	9.91	13.97	9.22

Table 5: Leaf area index plant^{-1}of soybean as influenced by various treatments

Treatments	Leaf area index plant^{-1}			
	20 DAS	40 DAS	60 DAS	80 DAS
T1 (RDF Alone)	1.32	4.83	6.72	4.82
T2 (75% RDN + 25% N thr. soy. straw	1.14	4.36	6.07	4.16
T3 (75% RDN + 25% N thr. soy. straw + *T. viride*	1.25	4.55	6.43	4.38
T4 (50% RDN + 50% N thr. soy. straw	1.06	4.08	6.31	3.47
T5 (50% RDN + 50% N thr. soy.straw + *T. viride*	1.08	4.20	5.52	3.66

SE (m)±	0.062	0.014	0.060	0.053
CD at 5%	0.190	0.031	0.185	0.162
GM	1.17	4.40	6.21	4.10

Table 6: Mean number of branches plant^{-1} of soybean as influenced by various treatments

Treatments	Number of branches plant^{-1}			
	40 DAS	60 DAS	80 DAS	At harvest
T1 (RDF Alone)	3.08	4.34	4.45	4.45
T2 (75% RDN + 25% N thr. soy. straw	2.55	3.54	3.64	3.64
T3 (75% RDN + 25% N thr. soy. straw + *T. viride*	3.05	4.14	4.24	4.24
T4 (50% RDN + 50% N thr. soy. straw	2.28	3.16	3.28	3.28
T5 (50% RDN + 50% N thr. soy.straw + *T.viride*	3.00	4.05	4.16	4.16
SE (m)±	0.132	0.261	0.292	0.286
CD at 5%	0.401	0.813	0.903	0.902
GM	2.79	3.85	3.95	3.95

Table 7: Dry matter accumulation (g) plant^{-1}of soybean as influenced by various treatments

Treatments	Dry matter accumulation (g) plant^{-1}				
	20 DAS	40 DAS	60 DAS	80 DAS	At harvest
T1 (RDF Alone)	1.07	6.29	11.04	13.17	14.22
T2 (75% RDN + 25% N thr. soy. straw	0.91	5.92	9.58	12.06	13.10
T3 (75% RDN + 25% N thr. soy. straw + *T. viride*	1.03	6.03	10.54	13.04	14.09
T4 (50% RDN + 50% N thr. soy. straw	0.63	5.05	9.02	11.11	12.16
T5 (50% RDN + 50% N thr. soy.straw + *T. viride*	0.80	5.54	9.22	12.01	13.07
SE (m)±	0.049	0.135	0.486	0.374	0.362
CD at 5%	0.151	0.416	1.483	1.152	1.104
GM	0.89	5.77	9.88	12.28	13.33

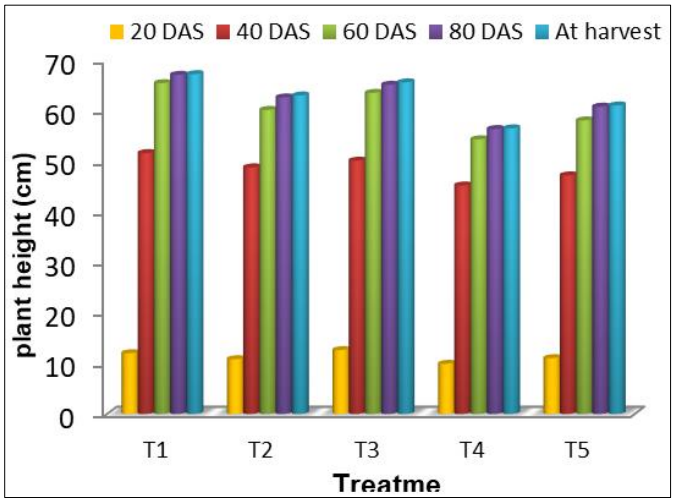

Fig 1: Plant height (cm) as influenced by different treatments

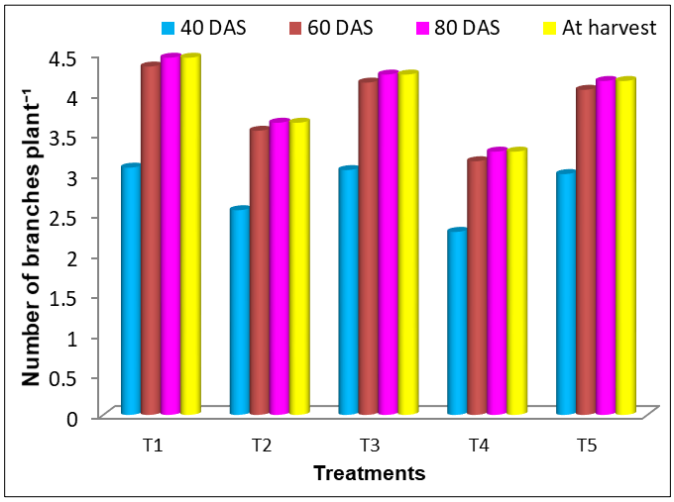

Fig 3: Number of branches as influenced by different treatments

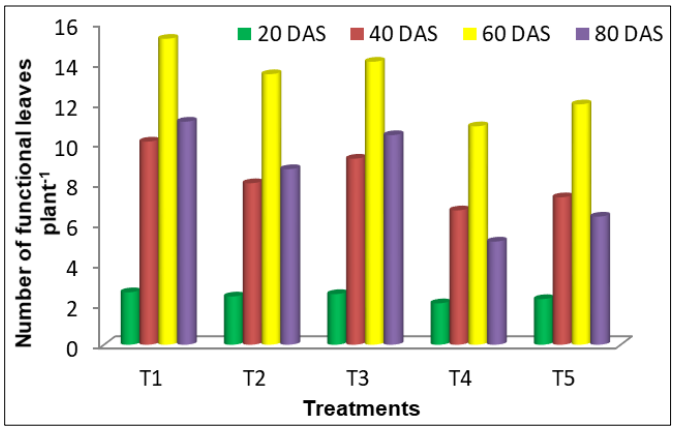

Fig 2: Number of functional leaves as influenced by different treatments

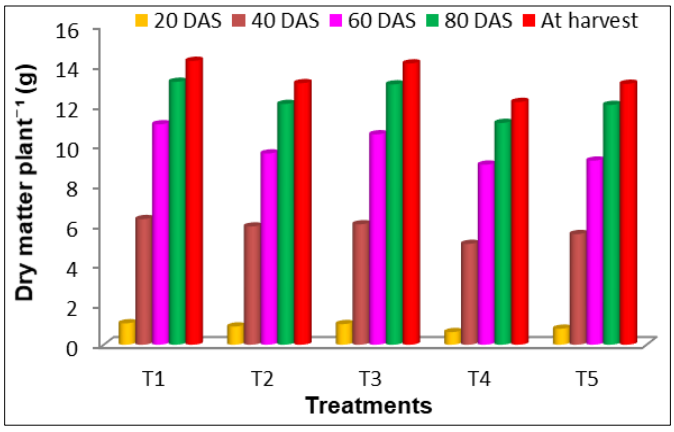

Fig 4: Dry matter Accumumlation (g) plant^{-1} as influenced by different Tretments

4. Conclusion

Soybean growth characters *viz*., plant height (cm), number of functional leaves plant^{-1}, leaf area (dm^2) plant^{-1}, leaf area index plant^{-1}, number of branches plant^{-1} and plant dry matter accumulation (g) plant^{-1} get significantly improved with application of RDF through chemical fertilizers. The next best treatment which improved all these growth characters was that of application of 75% RDN + 25% N through soybean straw + *T. viride*.

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