Original Research Article

Effect of cotton residue incorporation with conservation tillage and integrated nutrient management practices on growth rates of *Bt* cotton (*Gossypium hirsutum* L.) under rainfed conditions in Marathwada region of Maharashtra

Abstract

A field experiment was conducted to evaluate the effect of cotton residue incorporation with conservation tillage and integrated nutrient management practices on *Bt* cotton (*Gossypium hirsutum* L.) at AICRP on Dryland Agriculture farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif* 2021-22. Fifteen treatment combinations consisting of three tillage practices (conventional tillage, reduced tillage and zero tillage) and five integrated nutrient management practices (100% RDF (120:60:60 kg NPK ha^{-1}), 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}, 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}, 50% RDF + FYM 12 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} and Control) were evaluated in split plot design with three replications. The highest average growth rates (AGR) for both plant height and dry matter in the context of conventional tillage were observed during specific growth intervals: 61-90 days after sowing (DAS) for plant height (1.352 cm day^{-1} $plant^{-1}$) and 91-120 DAS for dry matter (3.327 g day^{-1} $plant^{-1}$). Similarly, when considering integrated nutrient management practices, the combination of 100% RDF with cotton residue at 3 t ha^{-1} and DM at 12 kg ha^{-1} showed the highest AGR for plant height (1.408 cm day^{-1} $plant^{-1}$) during 61-90 DAS and for dry matter (3.293 g day^{-1} $plant^{-1}$) during 91-120 DAS. Furthermore, various growth parameters such as CGR, RGR, NAR, and LAI also exhibited their maximum values under both conventional tillage and the mentioned integrated nutrient management practice.

Keywords: *Bt* cotton, Cotton residue, integrated nutrient management, LAI, NAR, tillage

1. Introduction

Cotton, often referred to as the "King of Fibre" and "White Gold," holds immense global significance as it is the primary fibre and commercial crop cultivated in over seventy countries across tropical and subtropical regions. In India, cotton has a deep-rooted cultural and historical significance and plays a crucial role in the country's agricultural economy. It provides employment to approximately 70 million people and contributes to nearly 75 percent of the raw materials used in the textile industry (Ushanandini *et al*., 2017).

India stands out as the leading cotton producer globally, with the largest area dedicated to cotton cultivation. Worldwide, cotton is grown on 33.16 million hectares, yielding 25.89 million tons. India alone cultivates cotton on 12.06 million hectares, accounting for 36% of the world's cotton-growing area and producing 21% of the world's cotton (Anonymous, 2021a). However, India's cotton yield per hectare is relatively low, averaging around 445 kg/ha, compared to the global average of 781 kg/ha (Anonymous, 2021b). Furthermore, only 35.8% of the cotton crop area in India is irrigated.

Indian agriculture has transitioned from the Green Revolution era, focused on increasing crop productivity, to addressing new challenges. The need of the hour is efficient resource use and conservation to address emerging agricultural issues (Himoud *et al.,* 2022). Approaches like sustainable agriculture and conservation agriculture have gained prominence, not only for their ability to maintain high productivity but also for their role in preserving biodiversity and safeguarding the environment (Madagoudra *et al*., 2022). Sustainable agriculture practices focus on maintaining ecological balance, natural processes like nitrogen fixation, nutrient cycling, soil regeneration, and minimizing the use of inputs (Bhattacharyya *et al*., 2013).

Intensive tillage practices have contributed to declining air, water, and soil quality. Conservation tillage, including zero and minimum tillage, has shown promise in improving soil organic carbon, microbial activity, and nutrient content by leaving crop residues on the soil surface instead of burying them, as is common in conventional tillage (Vu *et al.,* 2009).

Conservation agriculture has emerged as a paradigm to achieve sustainable agricultural production (Terin *et al.,* 2022). It emphasizes resource conservation and seeks to reverse the degradation associated with conventional practices such as intensive cultivation and removal of crop residues (Ghosh *et al*., 2015). Given the vast nutrient requirements of Indian agriculture, resource conservation and innovative soil management practices have become essential.

Cotton's high and sustainable productivity is closely linked to balanced soil nutrition. Integrated Nutrient Management (INM) practices can enhance nutrient supply systems and improve soil health. Combining organic and inorganic sources of nutrients, such as farmyard manure, not only supplies major and micronutrients but also enriches soil organic matter and water retention capacity (Kumar *et al*., 2013).

Cotton cultivation in India generates a significant quantity of cotton stalks, typically 25-30 million tons annually, with an average production of 2-3 tons per hectare (Ramanjaneyulu *et al*., 2021). The conventional practice involves manual removal and burning of these stalks, contributing to about 8% of the total residue burned in India (Zhang et al., 2019). This method is labour-intensive and increases the cost of subsequent crop cultivation. Alternatively, incorporating these cotton stalks into the soil can reduce labour costs and enrich the soil with valuable organic matter (Madagoudra *et al*., 2021). Recycling crop residues is a key strategy to enhance soil fertility and productivity. The availability of plant nutrients in the soil is a measure of soil fertility, and the soil's physical properties, including bulk density, porosity, and hydraulic conductivity, are crucial for regulating moisture, air, nutrients, and temperature, ultimately influencing crop growth (Ramanjaneyulu *et al*., 2021).

With this context, the present study was conducted to investigate the effects of incorporating cotton residues using conservation tillage and integrated nutrient management in *Bt* cotton cultivation, with the following objectives.

2. Materials and methods

A field experiment was conducted in the *Kharif* season of 2021-22 at the AICRP on dryland farming in Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra (India). The purpose was to assess the impact of incorporating cotton residue with conservation tillage and integrated nutrient management in *Bt* cotton cultivation. The soil at the site was clayey, slightly alkaline (pH 7.98), low in salt content (0.29 dSm-1), and had a high calcium carbonate content (46.79 g kg^{-1}) during the cropping season. The soil had 5.57 g kg^{-1} of organic carbon, low available nitrogen (178.45 kg ha^{-1}), medium available phosphorus (12.75 kg ha^{-1}), and very high available potassium (556.68 kg ha^{-1}) in the 2020-21 season.

In total, fifteen treatment combinations were tested, involving three tillage practices (conventional tillage, reduced tillage, and zero tillage) and five integrated nutrient management practices (100% recommended dose of fertilizer (RDF) at 120:60:60 kg NPK ha^{-1}, 100% RDF with cotton residue at 3 t ha^{-1} and DM at 12 kg ha^{-1}, 75% RDF with FYM at 6 t ha^{-1} + cotton residue at 3 t ha^{-1} + DM at 12 kg ha^{-1}, 50% RDF with FYM at 12 t ha^{-1} + cotton residue at 3 t ha^{-1} + DM at 12 kg ha^{-1} and control). The experiment followed a split-plot design with three replications. Before cotton sowing, pigeon pea was cultivated in the field, harvested in January, and the field was left fallow. Cotton variety NHH-44 was sown on June 16, 2021, with row-to-row and plant-to-plant distances maintained at 120 cm and 45 cm, respectively, resulting in a plant population of 18,500 plants per hectare. Sowing was done manually by dibbling with a 45 cm plant spacing.

Well-decomposed farmyard manure (FYM) was uniformly applied to the plots before sowing according to the treatment specifications. Fertilizers were applied based on the treatments, with 40% of nitrogen and the full dose of phosphorus and potassium applied as a basal dose at sowing. After 30 days and 60 days after sowing, the remaining 40% and 20% of nitrogen, respectively, were applied through urea. Urea (46% N), single superphosphate (16% P_2O_5), and muriate of potash (60% K_2O) were used as nutrient sources for nitrogen, phosphorus, and potassium, respectively.

Data on various growth parameters were collected at 30-day intervals from the sowing date until harvest, and different growth rates were calculated using specific formulas given below.

2.1 Absolute growth rate (AGR)

The rate of in a growth variable *i.e.* height (H) or dry weight (W) by a plant at a specific time interval (t) is called as absolute growth rate. It is expressed as cm per day in case of plant height and g per day in case in case of dry matter accumulation per plant. The AGR of two growth variables *viz.*, plant height and total dry matter per plant were computed by the formula given by Richards (1969).

$$\text{AGR (Height) (cm day}^{-1}) = \frac{H_2 - H_1}{t_2 - t_1}$$

$$\text{AGR (Dry matter) (g day}^{-1}) = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

H_2 and H_1 are plant heights, while W_2 and W_1 are dry matter weights per plant at t_2 and t_1 times, respectively.

2.2 Crop growth rate (CGR)

The crop growth rate is commonly used for the determination of production efficiency of plant stand. CGR represents total dry matter productivity of the community per unit land area over a certain time span. CGR enables comparison to be made between stand communities of different types in different habitat (Hunt, 1978). This is determined by using the following formula.

$$CGR\ (g\ day^{-1}\ m^{-2}) = \frac{W_2 - W_1}{t_2 - t_1} \times \text{number of plants } m^{-2}$$

Where,

W_2 = dry weight of plant at time t_2 (g plant^{-1})

W_1 = dry weight of plant at time t_1 (g plant^{-1})

2.3 Relative growth rate (RGR)

Blackman (1919) pointed out that the increase in dry matter of plant is a process of continuous compound interest wherein the increment in any interval adds to the capital for the subsequent crop growth. This rate of increment is known as relative growth rate (RGR), which was worked out by the formula given by Fisher (1921).

$$RGR\ (g\ g^{-1}\ day^{-1}) = \frac{Log_e W_2 - Log_e W_1}{t_2 - t_1}$$

Where,

W_1 and W_2 are the weights of dry matter in g per plant at times t_1 and t_2, respectively and t_2- t_1 is the time interval in days.

Log_e = natural logarithm to the base 'e' = 2.3026.

2.4 Net assimilation rate (NAR)

Gregory (1917) introduced the concept of net assimilation rate (NAR) to obtain simple growth measurement as an estimate of the assimilatory efficiency of leaves. It is the rate of increase in whole plant dry weight per unit leaf area. It indicates rate of net photosynthesis and is expressed as

$$NAR\ (g\ dm^{-2}\ day^{-1}) = \frac{(W_2 - W_1)\ (Log_e A_2 - Log_e A_1)}{}$$

$$(t_2 - t_1)\ (A_2 - A_1)$$

Where,

W_2 = dry weight of plant at time t_2 (g plant^{-1})

W_1 = dry weight of plant at time t_1 (g plant^{-1})

A_2 = leaf area plant^{-1} at time t_2 (dm^2)

A_1 = leaf area plant^{-1} at time t_1 (dm^2)

Log_e = natural logarithm to the base 'e' = 2.3026

2.5 Leaf area index (LAI)

Leaf area ratio is the ratio of surface leaf area (one side only) to the ground area occupied by the crop plant. Crop yield in general is assessed based on per unit of ground area instead of per plant. The leaf area index was determined by using the formula given by Watson (1952).

$$\text{LAI} = \frac{\text{Leaf area per plant (dm}^2\text{)}}{\text{Ground area per plant (dm}^2\text{)}}$$

3. Results

The results of the present study have been summarised under following heads.

3.1 Absolute growth rate (AGR) for plant height (cm day^{-1} plant^{-1})

The mean absolute growth rate (AGR) for plant height (cm day^{-1} plant^{-1}) of *Bt* cotton was influenced by different tillage practices. From the data given in Table 1, it was evident that the mean absolute growth rate (AGR) values for plant height (cm day^{-1} plant^{-1}) was maximum under conventional tillage (T_1) at all growth interval stages, which was followed by reduced tillage (T_2). The highest mean AGR values of 1.352 cm day^{-1} was recorded between 61-90 DAS under conventional tillage (T_1), while zero tillage (T_3) recorded lower values of 1.043 cm day^{-1} at same growth interval.

Among different integrated nutrient management practices, the application 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_2) resulted in maximum mean absolute growth rate (AGR) for plant height (cm day^{-1} plant^{-1}) at all growth interval stages. It was followed by 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_3) and 100% RDF (120:60:60 kg NPK ha^{-1}) (N_1) during both the years of study. The highest mean AGR values of 1.408 cm day^{-1} was recorded between 61-90 DAS under 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_2), while control (N_5) recorded lowest values of 0.805 cm day^{-1} at same growth interval.

3.2 Absolute Growth Rate (AGR) for dry matter (g day^{-1} plant^{-1})

The mean absolute growth rate (AGR) for dry matter (g day^{-1} plant^{-1}) of *Bt* cotton was influenced by different tillage practices. It was evident from the data given in Table 1, that the mean absolute growth rate (AGR) values for dry matter (g day^{-1} plant^{-1}) was maximum under conventional tillage (T_1) at all growth interval stages, which was followed by reduced tillage (T_2). The highest mean AGR value of 3.327 g day^{-1} plant^{-1} were recorded between 91-120 DAS under conventional tillage (T_1), while zero tillage (T_3) recorded lower value of 2.674 g day^{-1} at same growth interval.

The maximum mean absolute growth rate (AGR) for dry matter was observed under 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_2) at all growth interval stages. It was followed by 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_3) and 100% RDF (120:60:60 kg NPK ha^{-1}) (N_1). The highest mean AGR value of 3.293 g day^{-1} was recorded between 91-120 DAS under 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_2), while control (N_5) recorded lowest value of 2.659 g day^{-1} at same growth interval.

3.3 Crop growth rate (CGR) for dry matter (g day^{-1} m^{-2})

The conventional tillage (T_1) resulted in maximum mean crop growth rate (CGR) for dry matter at all the growth intervals from sowing up to harvest, while zero tillage (T_3) recorded lowest CGR (Table 2). However, the highest CGR value of 6.154 g day^{-1} m^{-2} were recorded under conventional tillage, while zero tillage (T_3) recorded minimum CGR value of 4.946 g day^{-1} m^{-2} between 91-120 DAS.

The maximum mean crop growth rate (CGR) for dry matter was observed under 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_2) at all growth interval stages. It was followed by 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_3) and 100% RDF (120:60:60 kg NPK ha^{-1}) (N_1). The highest mean CGR value of 6.091 g day^{-1} m^{-2} was recorded between 91-120 DAS under 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_2), while control (N_5) recorded lowest value of 4.919 g day^{-1} m^{-2} at same growth interval.

3.4 Relative growth rate (RGR) for dry matter (g g^{-1} day^{-1})

The mean relative growth rate (RGR) for dry matter (g g^{-1} day^{-1}) of *Bt* cotton was influenced by tillage practices. The conventional tillage (T_1) resulted in maximum mean relative growth rate (RGR) for dry matter at all the growth intervals from sowing up to harvest, while zero tillage (T_3) recorded lowest RGR. However, the highest RGR value of 0.0694 g g^{-1} day^{-1} was recorded under conventional tillage, while zero tillage (T_3) recorded minimum RGR value of 0.0654 g g^{-1} day^{-1} between 31-60 DAS.

Among different integrated nutrient management practices, application of 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_2) resulted in maximum mean relative growth rate (RGR) value at all growth interval stages. It was followed by 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_3) and 100% RDF (120:60:60 kg NPK ha^{-1}) (N_1). The highest mean RGR value of 0.0703 g g^{-1} day^{-1} was recorded between 31-60 DAS under 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_2), while control (N_5) recorded lowest value of 0.0619 g g^{-1} day^{-1} at same growth interval.

3.5 Net assimilation rate (NAR) (g dm^{-2} day^{-1})

The mean net assimilation rate (NAR) (g dm^{-2} day^{-1}) of *Bt* cotton was influenced by tillage practices. The conventional tillage (T_1) resulted in maximum mean net assimilation rate (NAR) at all the growth intervals from sowing up to harvest, while zero tillage (T_3) recorded lowest RGR. The highest NAR value of 0.0708 g dm^{-2} day^{-1} was recorded under conventional tillage, while zero tillage (T_3) recorded minimum NAR value of 0.0683 g dm^{-2} day^{-1} between 31-60 DAS.

Among different integrated nutrient management practices, application of 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_2) resulted in maximum mean net assimilation rate (NAR) value at all growth interval stages. It was followed by 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_3) and 100% RDF (120:60:60 kg NPK ha^{-1}) (N_1). The highest mean NAR value of 0.0709 g dm^{-2} day^{-1} was recorded between 31-60 DAS under 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_2), while control (N_5) recorded lowest value of 0.0682 g dm^{-2} day^{-1} at same growth interval.

3.6 Leaf area index (LAI)

Appraisal of data in Table 3 revealed that the conventional tillage (T_1) resulted in highest leaf area index (LAI) value, which was followed by reduced tillage (T_2). Among different tillage treatments, highest leaf area index value of 3.125 was recorded under conventional tillage (T_1), while the lowest value of 2.299 was recorded under zero tillage (T_3) at 91-120 DAS.

Application of 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_2) resulted in maximum leaf area index (LAI) value at all growth interval stages. It was followed by 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_3) and 100% RDF (120:60:60 kg NPK ha^{-1}) (N_1). The highest LAI value of 3.263 was recorded under 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_2), while control (N_5) recorded lowest value of 1.688 at 120 DAS.

4. Discussion

Conventional tillage methods, such as ploughing followed by the use of a rotavator and cultivator, have led to improvements in the physical characteristics of the soil. This has created a more favourable environment for plant growth, including a well-prepared seedbed, loose and crumbly soil with good aeration and enhanced root development, which in turn facilitates better uptake of water and nutrients by plants, resulting in increased plant growth. Additionally, these tillage operations have helped increase water infiltration into the soil, leading to greater water and nutrient absorption by crops and promoting their growth. The growth of plants, including their height, the number of main and side branches, functional leaves, and leaf area, has all contributed to higher accumulation of plant dry matter (Pawar *et al*., 2022). Consequently, the increased plant height and dry matter accumulation have led to higher growth rates.

The superior growth rates observed when using 100% recommended dose of fertilizer (RDF) along with cotton residue at a rate of 3 tons per hectare and decomposing microorganisms at the rate of 12 kilograms per hectare (N_2) can be attributed to the increased nutrient supply. These nutrients play a crucial role in promoting plant growth by facilitating cell division and elongation in plants. The combination of chemical fertilizers and cotton residue helps prolong the release of nutrients while also improving soil properties such as aeration, water retention capacity, and bulk density. These improvements are closely linked to various aspects of crop growth, including plant height, the number of main and side branches, functional leaves, leaf area, and the accumulation of dry matter. Consequently, the higher plant height and increased dry matter accumulation contribute to the overall higher growth rates.

5. Conclusion

Conventional tillage with application of 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} resulted maximum AGR for plant height (cm day^{-1} plant^{-1}) and dry matter (g day^{-1} plant^{-1}). Mean Crop Growth Rate (CGR), Relative Growth Rate (RGR), Net Assimilation Rate (NAR) and Leaf Area Index (LAI) were also maximum under conventional tillage with application of 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}.

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Table 1: Mean Absolute Growth Rate (AGR) for plant height (cm day^{-1} plant^{-1}) and for dry matter (g day^{-1} plant^{-1}) of *Bt* cotton hybrid as influenced by tillage and integrated nutrient management practices

Treatments	Mean Absolute Growth Rate (AGR) for plant height (cm day^{-1} plant^{-1})						Mean Absolute Growth Rate (AGR) for dry matter (g day^{-1} plant^{-1})					
	0-30 DAS	**31-60 DAS**	**61-90 DAS**	**91-120 DAS**	**121-150 DAS**	**151-At harvest**	**0-30 DAS**	**31-60 DAS**	**61-90 DAS**	**91-120 DAS**	**121-150 DAS**	**151-At harvest**
A) Main plot treatments (Tillage practices)												
T_1 - Conventional tillage	0.810	1.222	1.352	0.794	0.484	0.100	0.224	1.571	2.457	3.327	1.201	-2.346
T_2 - Reduced tillage	0.796	1.154	1.296	0.772	0.458	0.087	0.221	1.535	2.412	3.254	1.164	-2.311
T_3 - Zero tillage	0.735	0.851	1.043	0.681	0.370	0.087	0.216	1.324	2.118	2.674	1.028	-1.970
B) Sub plot treatments (Integrated nutrient management practices)												
N_1 - 100% RDF (120:60:60 kg NPK ha^{-1})	0.799	1.213	1.303	0.794	0.443	0.106	0.223	1.544	2.424	3.225	1.187	-2.217
N_2- 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}	0.812	1.283	1.408	0.853	0.520	0.111	0.225	1.630	2.511	3.293	1.196	-2.260
N_3 - 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}	0.802	1.236	1.374	0.827	0.483	0.109	0.224	1.585	2.459	3.260	1.192	-2.245
N_4 - 50% RDF + FYM 12 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}	0.778	1.134	1.264	0.744	0.432	0.070	0.221	1.479	2.273	2.986	1.128	-2.199
N_5 - Control	0.713	0.512	0.805	0.527	0.308	0.059	0.211	1.143	1.979	2.659	0.950	-2.058
General mean	**0.781**	**1.076**	**1.231**	**0.749**	**0.437**	**0.091**	**0.221**	**1.476**	**2.329**	**3.085**	**1.131**	**-2.209**

Table 2: Mean Crop Growth Rate (CGR) (g day^{-1} m^{-2}) and mean Relative Growth Rate (RGR) (g g^{-1} day^{-1}) of *Bt* cotton hybrid as influenced by tillage and integrated nutrient management practices

Treatments	Mean Crop Growth Rate (CGR) (g day^{-1} m^{-2})						Mean Relative Growth Rate (RGR) (g g^{-1} day^{-1})					
	0-30 DAS	31-60 DAS	61-90 DAS	91-120 DAS	121-150 DAS	151-At harvest	0-30 DAS	31-60 DAS	61-90 DAS	91-120 DAS	121-150 DAS	151-At harvest
A) Main plot treatments (Tillage practices)												
T_1 - Conventional tillage	0.414	2.906	4.546	6.154	2.221	-4.339	0.0635	0.0694	0.0290	0.0193	0.0052	-0.0105
T_2 - Reduced tillage	0.409	2.840	4.462	6.019	2.153	-4.275	0.0631	0.0690	0.0288	0.0192	0.0049	-0.0104
T_3 - Zero tillage	0.400	2.449	3.918	4.946	1.902	-3.645	0.0623	0.0654	0.0286	0.0183	0.0047	-0.0104
B) Sub plot treatments (Integrated nutrient management practices)												
N_1 - 100% RDF (120:60:60 kg NPK ha^{-1})	0.412	2.857	4.484	5.967	2.195	-4.101	0.0633	0.0690	0.0286	0.0189	0.0049	-0.0099
N_2- 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}	0.416	3.015	4.645	6.091	2.213	-4.180	0.0637	0.0703	0.0300	0.0195	0.0051	-0.0098
N_3 - 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}	0.414	2.932	4.549	6.031	2.205	-4.153	0.0635	0.0697	0.0288	0.0190	0.0049	-0.0099
N_4 - 50% RDF + FYM 12 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}	0.408	2.736	4.204	5.525	2.087	-4.068	0.0630	0.0680	0.0285	0.0187	0.0048	-0.0106
N_5 - Control	0.391	2.115	3.662	4.919	1.758	-3.807	0.0616	0.0619	0.0283	0.0187	0.0047	-0.0117
General mean	**0.408**	**2.731**	**4.309**	**5.707**	**2.092**	**-4.087**	**0.0630**	**0.0680**	**0.0288**	**0.0190**	**0.0049**	**-0.0104**

Table 3: Mean Net Assimilation Rate (NAR) (g dm^{-2} day^{-1}) and Mean Leaf Area Index (LAI) of *Bt* cotton hybrid as influenced by tillage and integrated nutrient management practices

Treatments	Mean Net Assimilation Rate (NAR) (g dm^{-2} day^{-1})						Mean Leaf Area Index (LAI)					
	0-30 DAS	31-60 DAS	61-90 DAS	91-120 DAS	121-150 DAS	151-At harvest	0-30 DAS	31-60 DAS	61-90 DAS	91-120 DAS	121-150 DAS	151-At harvest
A) Main plot treatments (Tillage practices)												
T_1 - Conventional tillage	0.0671	0.0708	0.0290	0.0268	0.0069	-0.0217	0.111	1.002	2.347	3.125	1.991	1.212
T_2 - Reduced tillage	0.0664	0.0704	0.0286	0.0265	0.0068	-0.0212	0.110	0.950	2.241	2.968	1.826	1.125
T_3 - Zero tillage	0.0657	0.0683	0.0283	0.0263	0.0064	-0.0200	0.104	0.754	1.753	2.299	1.285	0.855
B) Sub plot treatments (Integrated nutrient management practices)												
N_1 - 100% RDF (120:60:60 kg NPK ha^{-1})	0.0669	0.0704	0.0284	0.0264	0.0068	-0.0203	0.109	0.971	2.272	3.028	1.850	1.138
N_2- 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}	0.0671	0.0709	0.0304	0.0295	0.0070	-0.0198	0.113	1.064	2.476	3.263	2.046	1.254
N_3 - 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}	0.0670	0.0706	0.0293	0.0271	0.0069	-0.0202	0.111	1.026	2.384	3.154	1.928	1.197
N_4 - 50% RDF + FYM 12 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1}	0.0665	0.0698	0.0279	0.0259	0.0067	-0.0209	0.108	0.913	2.146	2.853	1.679	1.071
N_5 - Control	0.0647	0.0682	0.0278	0.0255	0.0061	-0.0249	0.100	0.536	1.291	1.688	1.000	0.660
General mean	**0.0665**	**0.0700**	**0.0286**	**0.0266**	**0.0068**	**-0.0210**	**0.108**	**0.902**	**2.114**	**2.797**	**1.701**	**1.064**