Original Research Article

Assessing the impact of combining cotton residue, conservation tillage and nutrient management on rainfed *Bt* cotton growth in Marathwada region of Maharashtra, India

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) [Madagoudra et al. 2023].

“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" [Madagoudra et al. 2023].

"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" [Madagoudra et al. 2023].

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 absolute growth rate (AGR) of a specific plant characteristic, such as height (H) or dry weight (W), during a particular time interval (t), is a measure of how fast it is growing. This rate is typically expressed as centimetres per day for plant height and grams per day for the accumulation of dry matter in each plant. The formula used to calculate the AGR for both plant height and total dry matter per plant was developed by Richards (1969).

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

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

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)

Crop growth rate (CGR) is a widely utilized metric for assessing the effectiveness of a plant stand in terms of production. CGR signifies the overall amount of dry matter produced by a group of plants within a specific land area during a specific timeframe. It allows for the comparison of various plant communities in different environments (Hunt, 1978). This is determined by using the following formula.

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

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) highlighted that the growth of plant matter follows a continuous compound interest-like process, where the growth during one period contributes to the base for the subsequent crop growth. This growth rate is referred to as the relative growth rate (RGR), and Fisher (1921) developed a formula to calculate it.

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

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 notion of the "net assimilation rate" (NAR) as a straightforward way to gauge the efficiency of leaf assimilation. NAR represents the speed at which the entire plant's dry weight grows in relation to the leaf area. Essentially, it serves as a measure of the rate of net photosynthesis and is typically expressed as:

$$\text{NAR}\ (\text{g dm}^{-2}\ \text{day}^{-1}) = \frac{(W_2 - W_1)\ (\text{Log}_e A_2 - \text{Log}_e A_1)}{(t_2 - t_1)\ (A_2 - A_1)}$$

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)

The leaf area ratio represents the proportion of a crop plant's single-sided leaf surface area to the area of the ground it covers. Typically, when evaluating crop yield, it's measured per unit of ground area rather than per individual plant. The formula for calculating the leaf area index, as proposed by Watson (1952), was used to determine this value.

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

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 data in Table 1 clearly shows that plant height growth rate (measured in centimetres per day per plant) in *Bt* cotton was most favourable under conventional tillage (T_1), followed by reduced tillage (T_2). Specifically, between days 61 and 90 after sowing, conventional tillage resulted in the highest growth rate of 1.352 cm per day, while zero tillage (T_3) only reached 1.043 cm per day during the same period.

Among different nutrient management methods, the application of 100% recommended dose of fertilizer (RDF) along with cotton residue at a rate of 3 tons per hectare and decomposing microorganisms at 12 kg per hectare (N_2) resulted in the highest growth rate for plant height at all growth stages. This was followed by 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + decomposing microorganisms (DM) @ 12 kg ha^{-1} (N_3) and 100% RDF (120:60:60 kg NPK ha^{-1}) (N_1) in both study years. Between days 61 and 90 after sowing, the highest growth rate of 1.408 cm per day was observed under the application of 100% RDF + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_2), while control (N_5) had the lowest growth rate during the same growth interval, with only 0.805 cm per day.

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

Different tillage practices had an impact on the mean absolute growth rate (AGR) of dry matter (in grams per day per plant) in *Bt* cotton, as shown in Table 1. The data clearly indicate that the highest AGR values were consistently observed in the case of conventional tillage (T_1) across all growth stages, followed by reduced tillage (T_2). Specifically, during the 91-120 days after sowing (DAS) period, the highest AGR value of 3.327 grams per day per plant was recorded under conventional tillage (T_1), while zero tillage (T_3) had a lower value of 2.674 grams per day per plant during the same growth interval.

Furthermore, when considering nutrient management treatments, the maximum mean AGR for dry matter was found with the application of 100% recommended dose of fertilizer (RDF) along with cotton residue at a rate of 3 tons per hectare and decomposing microorganisms at 12 kg per hectare (N_2). This trend was consistent across all growth stages. The second-highest AGR values were observed with a treatment of 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + decomposing microorganisms (DM) @ 12 kg ha^{-1} (N_3) and 100% RDF (120:60:60 kg NPK ha^{-1}) (N_1) in both study years. Specifically, during the 91-120 DAS period, the highest mean AGR value of 3.293 grams per day was recorded under 100% recommended dose of fertilizer (RDF) along with cotton residue at a rate of 3 tons per hectare and decomposing microorganisms at 12 kg per hectare (N_2), while the control treatment (N_5) had the lowest value of 2.659 grams per day during the same growth interval.

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

Conventional tillage (T_1) consistently resulted in the highest average crop growth rate (CGR) for dry matter throughout all growth stages from planting to harvest, with a peak CGR value of 6.154 g day^{-1} m^{-2}. On the other hand, zero tillage (T_3) consistently exhibited the lowest CGR, with a minimum value of 4.946 g day^{-1} m^{-2} recorded between 91-120 days after sowing.

The maximum CGR for dry matter was observed under 100% recommended dose of fertilizer (RDF) along with cotton residue at a rate of 3 tons per hectare and decomposing microorganisms at 12 kg per hectare (N_2). This high CGR was consistent across all growth intervals. Following closely in terms of CGR were treatments with 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 days after sowing under the application of 100% recommended dose of fertilizer (RDF) along with cotton residue at a rate of 3 tons per hectare and decomposing microorganisms at 12 kg per hectare (N_2), while the control (N_5) exhibited the lowest CGR value of 4.919 g day^{-1} m^{-2} during the 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 in *Bt* cotton was influenced by different tillage practices. Conventional tillage (T_1) consistently resulted in the highest RGR values at all growth stages, while zero tillage (T_3) had the lowest RGR values. Specifically, the highest RGR value, 0.0694 g g^{-1} day^{-1}, was observed with conventional tillage, whereas zero tillage (T3) had the lowest RGR value of 0.0654 g g^{-1} day^{-1} between 31-60 days after sowing (DAS).

Among various integrated nutrient management practices, applying 100% recommended dose of fertilizer (RDF) along with cotton residue at a rate of 3 tons per hectare and decomposing microorganisms at 12 kg per hectare (N_2) resulted in the highest RGR values across all growth intervals. This was followed by the treatment of 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_3), as well as the application of 100% RDF (120:60:60 kg NPK ha^{-1}) (N_1). The peak mean RGR value of 0.0703 g g^{-1} day^{-1} occurred between 31-60 DAS under the treatment of 100% recommended dose of fertilizer (RDF) along with cotton residue at a rate of 3 tons per hectare and decomposing microorganisms at 12 kg per hectare (N_2) while, the control (N_5) had the lowest RGR value of 0.0619 g g^{-1} day^{-1} during the same growth interval.

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

Tillage practices significantly affected the mean net assimilation rate (NAR) of *Bt* cotton. Conventional tillage (T_1) consistently resulted in the highest NAR values at all growth stages, while zero tillage (T_3) consistently had the lowest relative growth rate (RGR). The maximum NAR value of 0.0708 g dm^{-2} day^{-1} was observed under conventional tillage, whereas zero tillage (T_3) recorded the lowest NAR value of 0.0683 g dm^{-2} day^{-1} between 31-60 days after sowing (DAS).

Among different integrated nutrient management practices, the application of 100% recommended dose of fertilizer (RDF) along with cotton residue at a rate of 3 tons per hectare and decomposing microorganisms at 12 kg per hectare (N_2) resulted in the highest NAR values across all growth intervals. This 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 peak mean NAR value of 0.0709 g dm^{-2} day^{-1} occurred between 31-60 DAS with the application of 100% recommended dose of fertilizer (RDF) along with cotton residue at a rate of 3 tons per hectare and decomposing microorganisms at 12 kg per hectare (N_2), while the control (N_5) recorded the lowest value of 0.0682 g dm^{-2} day^{-1} during the same growth interval.

3.6 Leaf area index (LAI)

The analysis of the data presented in Table 3 shows that in terms of leaf area index (LAI), conventional tillage (T_1) produced the highest value, followed by reduced tillage (T_2). Specifically, conventional tillage (T_1) resulted in the highest LAI value of 3.125, while zero tillage (T_3) had the lowest value of 2.299 during the period from 91 to 120 days after sowing (DAS).

When looking at the different fertilizer treatments, the application of 100% recommended dose of fertilizer (RDF) along with cotton residue at a rate of 3 tons per hectare and decomposing microorganisms at 12 kg per hectare (N_2) consistently led to the highest LAI values at all growth intervals. This was followed by the treatment involving 75% RDF + FYM 6 t ha^{-1} + cotton residue @ 3 t ha^{-1} + DM @ 12 kg ha^{-1} (N_3), as well as the standard 100% RDF treatment (120:60:60 kilograms of NPK per hectare) (N_1). The highest LAI value of 3.263 was observed under the 100% recommended dose of fertilizer (RDF) along with cotton residue at a rate of 3 tons per hectare and decomposing microorganisms at 12 kg per hectare (N_2), while the control (N_5) recorded the lowest LAI value of 1.688 at 120 DAS.

4. Discussion

Traditional soil tillage methods, such as ploughing followed by the use of a rotavator and cultivator, have resulted in enhancements to the physical qualities 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 improved root development. These improvements, in turn, promote better water and nutrient uptake by plants, leading to increased plant growth (Leghari *et al.*, 2015). "Additionally, these tillage practices have facilitated greater water infiltration into the soil, resulting in improved water and nutrient absorption by crops, further promoting their growth. The growth of plants, including their height, 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 rates of growth.

The improved 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 supply of nutrients. These nutrients play a vital role in promoting plant growth by supporting cell division and elongation in plants. The combination of chemical fertilizers and cotton residue helps extend the release of nutrients while also enhancing soil properties such as aeration, water retention capacity, and bulk density. These improvements are closely associated with 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 (Magsi *et al*., 2022). Consequently, the greater plant height and increased dry matter accumulation contribute to overall higher growth rates.

5. Conclusion

The highest growth rate for plant height (measured in centimetres per day per plant) and dry matter accumulation (measured in grams per day per plant) were observed when conventional tillage was combined with the application of 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. Additionally, the mean crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), and leaf area index (LAI) were all at their maximum levels under the same treatment of conventional tillage with 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.

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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**