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EFFECTS OF PROBIOTIC AND ORGANIC FERTILIZERS AS SOIL AMENDMENTS ON THE GROWTH AND YIELD OF WHEAT

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ABSTRACT

Present study aimed to comprehensively assess the impact of organic amendments on crop health without compromising on growth and yield. To evaluate the effect of organic amendment a comprehensive study in wheat was conducted in a randomized complete block design with three replications for three consecutive wheat growing seasons (2017-2019). The experiment comprised of was nine soil amendment treatments wherein organic manures, probiotics and chemical fertilizer were used. The dry matter accumulation, leaf area index, and crop growth rate were assessed at 25, 40, 55, 70 and 85 days after sowing (DAS). At 85 DAS, the maximum TDM accumulation (769.89 g m^{-2}) was recorded by the chemical fertilizer which was statically similar (752.48 g m^{-2}) with poultry manure + vermicompost + green manure (*Sesbania rostrata*). Similar trend was found in case of LAI (4.07 followed by 3.84) at 55 DAS. Likewise, the maximum CGR 20.30 and 19.07 g m^{-2} d^{-1} was noted at 55-70 DAS under the same treatment condition. The study revealed that the growth attributes significantly increased in chemical fertilizer than poultry manure + vermicompost + green manure treatment and untreated control. Application of probiotic and organic manures significantly influenced the growth attributes of wheat. The information generated is very useful for farmers and agriculturist for enhancing the growth and yield of wheat.

Keywords: Green and poultry manure, growth attributes, probiotics, vermicompost, yield, wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) has long been a highly popular cereal crop all over the world including Bangladesh. It is recognized as a pioneer source of protein for human consumption than other cereals. The major composition of wheat includes 66.0-71.6% carbohydrates, 13-16.7% protein, 2.5-3.1% fats and 2.5-3% crude fiber (Khan, 1984). Nearly 50% world grain production is occupied by wheat (Banglapedia, 2014; Haydar *et al*., 2020). Bangladesh possesses 31st positions rank among wheat growing countries in the world. In Bangladesh, wheat crop occupies 4% of the total cropped area, 11% of area cropped in *rabi* and contributes 7% to the total output of food cereals (Anonymous, 2008).

Bangladesh is known as a rapidly increasing populated country and thus land under cultivation is decreased to provide their accommodation. To keep harmony with increased population intensive cultivation of wheat and other cereal crops like barley, maize, rye, etc. and its cultivated lands were affected by using many chemicals and fertilizers that directly affects to food security (Haque and Islam, 2018). The long-term application of excess inorganic fertilizer or poor fertilization practice results in soil acidification and nutrient depletion, besides deteriorating the soil and environmental health (Liebig *et al*., 2002). Further, synthetic fertilizers are chemical in natures that are harmful human, animals and environments. It has been reported that initial period of three years organic farming could give equal or more yields as compared to chemical use alone (Ramesh *et al*., 2005). To create a favorable crop growth environment and sustainable production, organic farming may be an alternative way without using chemical fertilizers in the soil (Kshirsagar, 2008) and it may contribute to increase 80% of the yield the developing countries (Badgley *et al*., 2007). Probitic i.e. *Trichoderma* is a common symbiont of plant root system (Vinale *et al*., 2012) which is used as biocontrol agent and plant growth enhancer (Talukder *et al*., 2017). Organic manures mainly poultry manure accelerates vegetative growth reported by Rasul *et al.* (2015) and Abubakar and Ali (2018). So, for achieving better crop yield and growth and retaining sound soil health, the use of high yielding varieties along with organic amendments are considered important. Hence, in view of above, a study was undertaken to assess the impact of probiotic and organic manure on wheat growth and yield.

MATERIALS AND METHODS

Preparation of soil and plant growth

The present research work was carried out in the experimental field and in the Laboratory of Plant Biotechnology & Genetic Engineering, Institute of Biological Sciences and Plant Pathology Lab., Department of Agronomy and Agricultural Extension, University of Rajshahi, Bangladesh during July 2016 to June 2019. The experimental field geographically was situated at 24°17` N latitude and 88°28` E longitude at an elevation of 20 m masl and belonged to the Agro-Ecological Zone-11 (AEZ-11). The soil of experimental field was poorly drained with moderately permeability, loam and slightly alkaline (pH, 8.1). The experimental soil had moisture content 19.4%, particle density 2.65 g cc^{-1}, bulk density 1.27 g cc^{-1} and porosity 51.34%. Further, the soil had organic matter content of 1.2%, K 0.150 cmol (+) kg^{-1}, total N 0.07%, P 26.30 µg g^{-1}, S 12.50 µg g^{-1}, Zn 0.75 µg g^{-1} and EC 145 µs cm^{-1} with C: N of 10:1.

Experimental design and treatments

The experiment was laid out in a randomized complete block design with three replications. The treatments comprised of three wheat varieties *viz*., 'BARI Wheat-28', 'BARI Wheat-29' and 'BARI Wheat-30' [Bangladesh Agricultural Research Institute, Joydebpur, Gazipur] and nine soil amendments [control, rice straw + vermicompost + green manure, cow dung + vermicompost + green manure, compost + vermicompost + green manure, poultry manure + vermicompost + green manure, *Trichoderma harzianum* + vermicompost + green manure, mung bean straw + vermicompost + green manure, *T. viride* + vermicompost + green manure, and chemical fertilizer]. The unit plot size was 5.0 m^2 having a plot to plot 0.5 m, bed to bed 0.25 cm distance and 1 m from the surrounding boundary. The total unit plot was 81. Crop residues (rice straw and mung bean straw), cow dung, compost and poultry litter were applied at the rate 10 t ha^{-1} 7 days prior to sowing [BARI, 2014]. Vermicompost was applied 5 t ha^{-1} and *Trichoderma* spp. suspension (1×10^6 cfu g^{-1} @ 5 kg ha^{1}) before sowing. In case of chemical treatment, one third of urea (200 kg ha^{-1}), triple super phosphate 160 kg ha^{-1}, muriate of potash 45 kg ha^{-1} and gypsum 115 kg ha^{-1} were applied as basal dose (BARI, 2014). Rest urea was applied in two installments, one at 21 days after sowing (DAS) and another at 55 DAS. Crop residues were collected from the research field of IBSc, RU. Cow dung and compost were collected from a trained farmers pit under DAE Bagatipara, Natore. Poultry litter was collected from a poultry farm. Vermicompost was collected from Sumi Seed Vander, Rajshahi. *Trichoderma* spp. were cultured in Plant Pathology Laboratory, Department of Agronomy & Agriculture Extension, University of Rajshahi, Rajshahi, Bangladesh. The collected organic manures contained NPK as green manure (N 0.70%, P 0.40% and K 0.38%), rice straw (N 0.50%, P 0.08% and K 1.60%), cow dung (N 1.20%, P 0.80% and K 1.30%), compost (N 1.80%, P 0.25% and K 0.94%), vermicompost (N 1.75%, P 1.00% and K 0.75%) and poultry manure (N 1.85%, P 0.60% and K 0.76%) were used respectively.

Data collection on growth attributes

Total dry matter (TDM): For TDM, five plants were collected at 25, 40, 55, 70 and 85 DAS from each plot and sundried before the collected samples were packed individually in a labeled brown paper bag and dried in an oven at 70-80°C for 72 h till constant weight was attained.

Leaf area index (LAI): For LAI determination, five plants were collected from each plot at 25, 40, 55, 70 and 85 DAS. At each time period, the collected plants were separated into leaf, stem and spike (when appeared) and leaf area was measured by disc method (Radford, 1967). For this, every leaf was segmented into three portion and middle portion length and breadth of each leaf were measured. Among the total leaves of a plant, each leaf was packed individually in a labeled brown paper bag and placed in an oven at 70-80°C for 72 h. The leaf area was measured and calculated by using the formula:

$$\text{Area of leaf} = \frac{\text{Weight of leaves} \times \text{Area of segments}}{\text{Weight of segments}} \times \text{cm}^2$$

As growth and physiological parameters leaf area index (LAI) and crop growth rate (CGR) were calculated by using standard formulae (Radford, 1967).

$$\text{Leaf area index (LAI)} = \frac{\text{Leaf area}}{\text{Ground area}}$$

Crop growth rate (CGR): The crop growth rate was calculated from total dry matter in respect of sampling dates using the formulae (Radford, 1967):

$$\text{Crop groth rate (CGR)} = \frac{(\text{W2}-\text{W1})}{(\text{t2}-\text{t1})} \times \text{g m}^{-2}\,\text{d}^{-1}$$

Where, W_2 and W_1 are the total dry weight plant at different DAS and t_2 and t_1 are the harvest time of total dry weight at the latter and former, respectively.

Statistical analysis

The data were compiled and tabulated for statistical analysis. The data was analyzed using analysis of variance and Duncan's multiple range tests through r-studio by the "Agricolae" package.

RESULTS AND DISCUSSION

The study revealed that the chemical fertilizer and combination of poultry manure + vermicompost + green manure (*Sesbania rostrata*) showed parallel results regarding total dry matter (TDM), leaf area index (LAI) and crop growth rate (CGR) with few exceptions.

Total dry matter

The study was planned to investigate the effects of different organic manures as soil amendment on TDM accumulation of wheat at 25, 40, 55, 70 and 85 DAS (Table 1). The soil amendments showed significant variations in TDM production. Three years pooled data revealed that TDM accumulation at 25 DAS was highest (30.7 g m^{-2}) due to the application of chemical fertilizer followed by poultry manure + vermicompost + green manure (28.5 g m^{-2}), while untreated control gave the lowest value (18.0 g m^{-2}). The maximum TDM accumulation at 40, 55 and 70 DAS were recorded from chemical fertilizer (102.4, 227.9 and 533.3 g m^{-2}) and minimum in untreated control (51.8, 136.1 and 363.1 g m^{-2}). At the peak (85 DAS) of TDM accumulation, the most statistical identity was found between chemical fertilizer (769.9 g m^{-2}) and poultry manure + vermicompost + green manure (752.5 g m^{-2}). Poultry manure-based treatment, in general followed a pattern similar to that of chemical fertilizer treatment for TDM accumulation. Generally, with the advancement of time the TDM accumulation of wheat positively increased. This increment of TDM might be for creating a favourable environment for plant growth activities employed by probiotic and organic amendments of soil (Ahmad *et al.*, 2008). Such increment of TDM might be found for the development of a large number of late tillers (Balyan, 1992; Rahman *et al*. 2006). The improvement of dry matter accumulation with poultry manure + vermicompost + green manure possibly due to high content of essential nutrients present in poultry manure, which accelerates vegetative growth (Muhammad *et al*. 2018). This finding is supported by Bakhtiar *et al*. (2017) who observed that N in poultry manure significantly improves leaf and stem diameter of wheat.

Table 1: Effect of probiotic and organic fertilizers for soil amendment on total dry matter (g m^{-2}) in wheat

T	TDM at 25 DAS				TDM at 40 DAS				TDM at 55 DAS				TDM at 70 DAS				TDM at 85 DAS			
	2016-2017	2017-2018	2018-2019	Mean	2016-2017	2017-2018	2018-2019	Mean	2016-2017	2017-2018	2018-2019	Mean	2016-2017	2017-2018	2018-2019	Mean	2016-2017	2017-2018	2018-2019	Mean
T_0	18.0 ± 0.6g	19.1 ± 0.6f	17.0 ± 0.6g	18.0 ± 0.6e	45.9 ± 1.2h	50.7 ± 1.0h	58.9 ± 2.0h	51.8 ± 3.8f	124.1 ± 3.1h	136.7 ± 3.6o	147.6 ± 3.9h	136.1 ± 6.8g	329.9 ± 7.4h	365.3 ± 8.0h	394.1 ± 9.2g	363.1 ± 18.6g	532.3 ± 11.0j	551.9 ± 12.2g	574.7 ± 12.6h	553.0 ± 12.2f
T_1	20.6 ± 0.4f	22.2 ± 0.5e	23.2 ± 0.5f	22.0 ± 0.8d	61.0 ± 2.0g	69.0 ± 2.1g	76.7 ± 2.7g	68.9 ± 4.5e	157.3 ± 4.8g	169.7 ± 5.3mn	181.4 ± 5.3g	169.5 ± 7.0f	383.7 ± 10.0g	403.2 ± 10.5g	433.5 ± 11.2f	406.8 ± 14.5f	585.3 ± 14.2h	601.3 ± 17.0f	620.0 ± 15.5g	602.2 ± 10.0e
T_2	21.5 ± 0.4e	23.6 ± 0.4d	24.6 ± 0.4e	23.2 ± 0.9d	73.6 ± 2.2e	80.2 ± 1.9e	87.6 ± 2.5e	80.6 ± 5.8d	175.2 ± 4.0e	192.3 ± 4.3kl	201.6 ± 4.4e	189.7 ± 7.7de	412.7 ± 10.7e	438.8 ± 9.5e	457.1 ± 10.9e	436.2 ± 12.9de	634.7 ± 13.9f	655.2 ± 15.0d	680.8 ± 14.9e	656.9 ± 13.3cd
T_3	22.8 ± 0.5d	25.2 ± 0.4c	26.6 ± 0.4d	24.9 ± 1.1c	78.5 ± 1.2d	84.5 ± 1.3d	96.9 ± 1.8d	86.7 ± 5.4c	189.1 ± 3.2c	200.4 ± 3.2ghi	211.0 ± 3.3d	200.2 ± 6.3cd	433.4 ± 7.1d	454.9 ± 7.6d	486.8 ± 9.0cd	458.3 ± 15.5cd	654.8 ± 10.8e	677.3 ± 11.2c	706.4 ± 11.3d	679.5 ± 14.9bc
T_4	26.0 ± 0.9b	29.0 ± 0.7a	30.6 ± 0.8b	28.5 ± 1.4b	86.0 ± 1.9b	93.5 ± 2.2b	108.5 ± 2.8b	96.0 ± 6.6b	199.1 ± 4.5b	218.1 ± 4.9bcd	230.0 ± 5.0b	215.7 ± 9.0b	472.1 ± 11.7b	505.0 ± 12.1b	528.4 ± 12.1b	501.8 ± 16.4b	729.7 ± 18.0b	750.9 ± 19.0a	776.8 ± 19.1b	752.5 ± 13.6a
T_5	24.0 ± 0.6 c	26.4 ± 0.5b	28.1 ± 0.7c	26.1 ± 1.2c	81.5 ± 1.5c	89.0 ± 1.7c	101.8 ± 2.3c	90.8 ± 5.9c	192.5 ± 3.6c	205.5 ± 3.8ghi	216.7 ± 3.9c	204.9 ± 7.0bc	444.6 ± 9.0c	473.5 ± 9.1c	498.5 ± 10.2c	472.2 ± 15.6c	686.8 ± 15.4c	703.0 ± 13.9b	732.3 ± 14.8c	707.4 ± 13.3b
T_6	21.3 ± 0.4e	22.7 ± 0.4e	24.3 ± 0.5e	22.8 ± 0.9d	65.0 ± 1.7f	71.7 ± 1.7f	83.9 ± 2.1f	73.5 ± 5.5e	163.2 ± 4.3f	177.6 ± 4.6m	195.5 ± 4.2f	178.8 ± 9.3ef	398.5 ± 8.3f	417.1 ± 10.0f	449.0 ± 10.3e	421.5 ± 14.7ef	609.8 ± 12.4g	631.6 ± 13.3e	664.0 ± 14.0f	635.1 ± 15.8de
T_7	23.1 ± 0.5d	25.7 ± 0.5bc	27.2 ± 0.6d	25.4 ± 1.2c	80.8 ± 1.8c	85.9 ± 1.8d	96.3 ± 2.2d	87.7 ± 4.6c	185.1 ± 3.9d	196.0 ± 4.2ijk	208.6 ± 4.3d	196.5 ± 6.8cd	438.6 ± 9.3cd	455.4 ± 10.0d	480.3 ± 10.6d	458.1 ± 12.1cd	667.1 ± 15.5d	684.4 ± 14.9c	712.3 ± 16.3d	687.9 ± 13.2bc
T_8	27.9 ± 0.9a	29.4 ± 0.8a	34.8 ± 1.4a	30.7 ± 2.1 a	92.4 ± 2.5a	96.7 ± 2.6a	118.0 ± 3.3a	102.4 ± 7.9a	215.6 ± 5.5a	225.2 ± 5.4ab	242.5 ± 6.4a	227.8 ± 7.9a	504.0 ± 4.6a	534.2 ± 13.8a	561.6 ± 14.6a	533.3 ± 16.6a	744.4 ± 20.1a	767.1 ± 21.0a	798.2 ± 22.1a	769. 9 ± 15.6a
LS	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CV (%)	1.9	2.2	2.6	6.2	2.2	2.4	2.5	6.5	2.0	2.3	2.3	6.6	1.9	2.2	2.2	6.5	1.8	2.2	2.1	6.5

Each value represents the average of three replicates. In column, the mean values superscripted with similar letter(s) are statistically identical as per Duncan's Multiple Range Test. T = Treatments, T_0 = control, T_1 = rice straw + vermicompost + green manuring, T_2 = cow dung + vermicompost + green manuring, T_3 = compost + vermicompost + green manuring, T_4 = poultry manure + vermicompost + green manuring, T_5 = *T. harzianum* + vermicompost + green manuring, T_6 = mung bean straw + vermicompost + green manuring, T_7 = *T. viride* + vermicompost + green manuring, T_8 = chemical fertilizer, LS = Level of significance, **= 1% level of significance, CV = Coefficient of variation

Leaf area index (LAI)

Leaf area index expresses the efficacy of photosynthetic processes which ultimately indicates the good vegetative growth and yield. The data indicated that the positive residual effects of manures, especially poultry manure, on LAI were still evident for three growing seasons. It was observed that all the soil amendments provided significant results for LAI at every sampling date in each year of this study. The chemical fertilizer performed better performance for LAI followed by poultry manure + vermicompost + green manure in comparison to the untreated control (Table 2). The pooled data of three years study showed highest value (4.1) of LAI from chemical fertilizer and lowest LAI (2.4) was in untreated control at 55 DAS. The increment of LAI had an ascending tendency up to 55 DAS, whereas descending nature was exhibited in the next 70 and 85 DAS during the experiment. Throughout the study period chemical fertilizer and poultry manure + vermicompost + green manure exhibited almost similar results (2.5 and 2.4) at the last sampling date of LAI. Al-Rawashdeh and Abdel-Ghani (2008) supported the decline of LAI due to the losses of nitrogen (gaseous form) at the end of vegetative stage and leaf senescence. The possible reason of parallel performance of chemical fertilizer and poultry manure + vermicompost + green manure might be due to delivering more nutrients required for crop growth which were released from poultry manure combination. Continuous release of plant nutrients from organic manures which directed to plant growth and

Table 2: Effect of probiotic and organic fertilizers for soil amendment on leaf area index (LAI) in wheat

T	LAI at 25 DAS				LAI at 40 DAS				LAI at 55 DAS				LAI at 70 DAS				LAI at 85 DAS			
	2016-2017	2017-2018	2018-2019	Mean	2016-2017	2017-2018	2018-2019	Mean	2016-2017	2017-2018	2018-2019	Mean	2016-2017	2017-2018	2018-2019	Mean	2016-2017	2017-2018	2018-2019	Mean
T_0	0.2 ± 0.0j	0.3 ± 0.0i	0.2 ± 0.0i	0.2 ± 0.0i	1.2 ± 0.0f	1.4 ± 0.0i	1.3 ± 0.0i	1.3 ± 0.1g	2.1 ± 0.1i	2.5 ± 0.1i	2.5 ± 0.1i	2.4 ± 0.1g	2.0 ± 0.1e	2.2 ± 0.1g	2.3 ± 0.1i	2.1 ± 0.1h	1.4 ± 0.0f	1.5 ± 0.0e	1.6 ± 0.1i	1.5 ± 0.1g
T_1	0.2 ± 0.0h	0.3 ± 0.0h	0.3 ± 0.0h	0.3 ± 0.0h	1.3 ± 0.0e	1.6 ± 0.1e	1.6 ± 0.1h	1.5 ± 0.1f	2.3 ± 0.1h	2.7 ± 0.1h	2.8 ± 0.1h	2.6 ± 0.1fg	2.1 ± 0.1e	2.4 ± 0.1g	2.6 ± 0.1h	2.3 ± 0.2g	1.5 ± 0.0e	1.8 ± 0.1d	1.8 ± 0.1h	1.7 ± 0.1f
T_2	0.3 ± 0.0f	0.4 ± 0.0f	0.4 ± 0.0f	0.4 ± 0.0f	1.5 ± 0.1d	1.7 ± 0.1d	1.8 ± 0.1f	1.7 ± 0.1e	2.5 ± 0.1f	3.0 ± 0.1f	3.1 ± 0.1f	2.9 ± 0.2e	2.4 ± 0.1d	2.8 ± 0.1e	2.9 ± 0.1f	2.7 ± 0.2e	1.6 ± 0.0d	1.9 ± 0.1d	2.2 ± 0.1f	1.9 ± 0.2e
T_3	0.4 ± 0.0e	0.5 ± 0.0e	0.5 ± 0.0e	0.5 ± 0.0e	1.7 ± 0.0c	1.9 ± 0.1c	2.1 ± 0.1d	1.9 ± 0.1d	2.8 ± 0.1e	3.2 ± 0.1e	3.3 ± 0.1e	3.1 ± 0.2d	2.5 ± 0.1c	3.0 ± 0.1d	3.1 ± 0.1e	2.9 ± 0.2d	1.8 ± 0.1c	2.1 ± 0.1c	2.4 ± 0.1d	2.1 ± 0.2d
T_4	0.6 ± 0.0b	0.6 ± 0.0b	0.7 ± \0.0b	0.6 ± 0.0b	1.9 ± 0.0b	2.3 ± 0.0a	2.4 ± 0.1b	2.2 ± 0.2b	3.4 ± 0.1b	4.0 ± 0.1b	4.2 ± 0.1b	3.8 ± 0.2b	2.9 ± 0.1b	3.5 ± 0.1b	3.8 ± 0.1b	3.4 ± 0.3b	2.1 ± 0.0ab	2.5 ± 0.1a	2.8 ± 0.1b	2.4 ± 0.2b
T_5	0.5 ± 0.0c	0.5 ± 0.0c	0.6 ± 0.0c	0.5 ± 0.0c	1.9 ± 0.0b	2.1 ± 0.1b	2.2 ± 0.1c	2.1 ± 0.1c	3.2 ± 0.1c	3.6 ± 0.1c	3.8 ± 0.1c	3.5 ± 0.2c	2.9 ± 0.1b	3.2 ± 0.1c	3.4 ± 0.1c	3.2 ± 0.2c	2.0 ± 0.0b	2.2 ± 0.1b	2.5 ± 0.1c	2.2 ± 0.1c
T_6	0.3 ± 0.0g	0.3 ± 0.0g	0.4 ± 0.0g	0.3 ± 0.0g	1.5 ± 0.0d	1.7 ± 0.1de	1.7 ± 0.1g	1.6 ± 0.1e	2.4 ± 0.0g	2.8 ± 0.1g	2.9 ± 0.1g	2.7 ± 0.2ef	2.2 ± 0.0d	2. 6 ± 0.1f	2.7 ± 0.1g	2.5 ± 0.2f	1.6 ± 0.0de	1.8 ± 0.1d	2.1 ± 0.1g	1.8 ± 0.1e
T_7	0.5 ± 0.0d	0.5 ± 0.0d	0.5 ± 0.0d	0.5 ± 0.0d	1.7 ± 0.0c	1.9 ± 0.1c	2.0 ± 0.1e	1.9 ± 0.1d	3.1 ± 0.1g	3.4 ± 0.1d	3.6 ± 0.1d	3.3 ± 0.2c	2.6 ± 0.1c	3.0 ± 0.1d	3.2 ± 0.1d	3.0 ± 0.2d	1.8 ± 0.0c	2.1 ± 0.1c	2.3 ± 0.1e	2.1 ± 0.1d
T_8	0.6 ± 0.0a	0.7 ± 0.0a	0.7 ± 0.0a	0.7 ± 0.0a	2.2 ± 0.1a	2.3 ± 0.1a	2.6 ± 0.1a	2.4 ± 0.1a	3.7 ± 0.1g	4.1 ± 0.1a	4.3 ± 0.1a	4.1 ± 0.2a	3.1 ± 0.1a	3.7 ± 0.1a	4.0 ± 0.1a	3.6 ± 0.3a	2.2 ± 0.1a	2.6 ± 0.1a	2.9 ± 0.1a	2.5 ± 0.2a
LS	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CV (%)	3.7	4.1	2.4	4.1	6.4	6.4	2.4	4.3	2.2	1.6	1.4	7.0	6.3	5.8	1.6	4.1	6.6	6.4	2.1	4.3

Each value represents the average of three replicates. In column, the mean values superscripted with similar letter(s) are statistically identical as per Duncan's Multiple Range Test. T = Treatment, T_0 = control, T_1 = rice straw + vermicompost + green manuring, T_2 = cow dung + vermicompost + green manuring, T_3 = compost + vermicompost + green manuring, T_4 = poultry manure + vermicompost + green manuring, T_5 = *T. harzianum* + vermicompost + green manuring, T_6 = mung bean straw + vermicompost + green manuring, T_7 = *T. viride* + vermicompost + green manuring, T_8 = chemical fertilizer, LS = Level of significance, **= 1% level of significance, CV = Coefficient of variation.

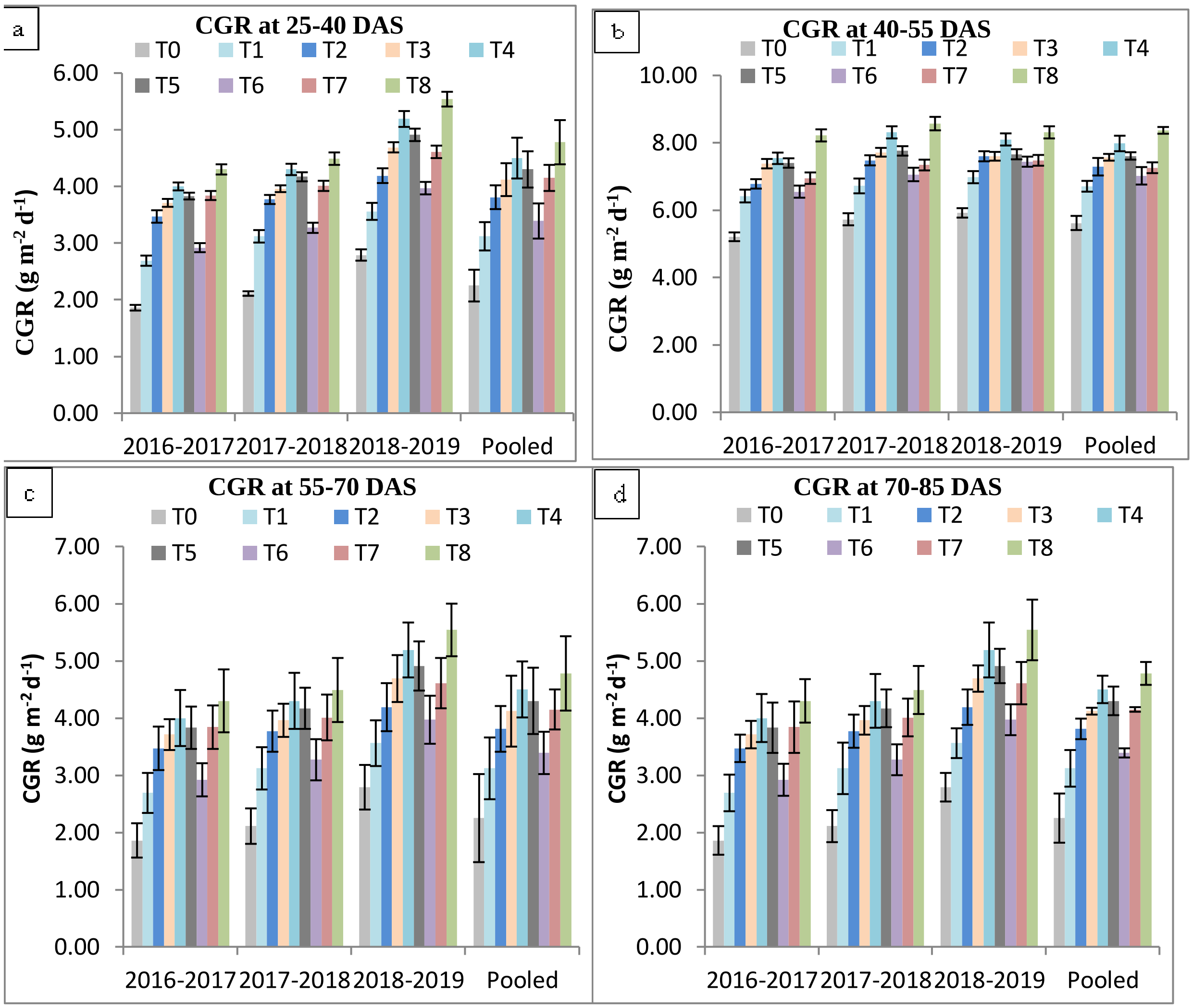

Fig. 1: Effect of probiotic and organic fertilizers as soil amendment on crop growth rate at a) 25-40, b) 40-55, c) 55-70 and d) 70-85 days after sowing of wheat [T_0 = control, T_1 = rice straw + vermicompost + green manuring, T_2 = cow dung + vermicompost + green manuring, T_3 = compost + vermicompost + green manuring, T_4 = poultry manure + vermicompost + green manuring, T_5 = *T. harzianum* + vermicompost + green manuring, T_6 = mung bean straw + vermicompost + green manuring, T_7 = *T. viride* + vermicompost + green manuring, T_8 = chemical fertilizer].

production of more leaves resulting in increased leaf area (Sims and Wolf, 1992). Ogundare *et al.* (2012) and Kareem *et al.* (2017) confirmed the judgments through their research outcome.

Crop growth rate (CGR)

The data indicated that the soil amendments had significant effect on wheat CGR for all sampling dates. However, with few exceptions pooled data revealed that the chemical fertilizer had the highest activity in the enhancement of CGR than poultry manure + vermicompost + green manure where the lowest value was recorded in untreated control (Fig. 1). The maximum CGR rate (20.3 g m^{-2} d^{-1}) was found in chemical fertilizer treatment while 2nd highest value (19.1 g m^{-2} d^{-1}) was recorded from poultry manure-based combination. The minimum CGR value (15.1 g m^{-2} d^{-1}) was recorded in untreated control at 55-70 DAS. In case of 70-85 DAS, poultry manure + vermicompost + green manure showed the higher value (16.7 g m^{-2} d^{-1}) for CGR than chemical fertilizer treatment (15.8 g m^{-2} d^{-1}). The crop growth rate was demonstrated slow increase at the initial stage of wheat and later reached the peak at 55-70 DAS, and then declined in late growth stage. This observation may be linked to the delayed nutrient availability from poultry manure at early plant growth stage that produced less dry matter and then produced more dry matter in slow-fast-slow growth trend (Geng *et al.*, 2019). However, afterwards the decrease in CGR was noticed due to leaf senescence and tiller drying. These results are is an agreement with those of Boateng *et al.* (2006) and Ram (2017).

Conclusion: Chemical fertilizer gave effective results but its long-term use is not good for crop and soil health, therefore, organic soil amendment needs to be emphasized. Under this study potential and sustainable improvement of wheat growth with organic soil amendment was found. Inclusion of green manure, vermicompost and poultry manure may be a suitable alternative of chemical fertilizer for wheat growth. The capacity of surprising decomposition and nutrient release from those organic manures could be used to synchronize the nutrient demand of wheat. Data revealed that organic manures particularly poultry manure is a healthier source for improvement wheat growth as compared to other manures.

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