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## Effect of conservation tillage practices on growth attributes of different fodder crops and soil moisture depletion

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### Abstract

A field experiment was conducted at Central Research Farm, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India during summer season of 2016 and 2017 to find out effects of various tillage practices on growth and yield of different fodder crops and soil moisture depletion. The experiment was framed in split plot design comprising 3 tillage practices (zero, minimum and conventional tillage) in main plot and 4 fodder crops (maize, sorghum, rice bean and cowpea) in sub plot, replicated thrice. Pooled data revealed that zero tillage significantly performed well in ensuring best growth of all the fodder crops over others. However, crops showed variable response among each other regarding growth attributes due to its differential genetic makeup and morphological features. Accordingly, green forage yield also varied. Soil moisture depletion was also found to be low when rice bean was grown under zero tillage practice. Overall, the study confirms the efficacy of conservation tillage (zero tillage and/or minimum tillage) on growth of these fodder crops and soil moisture conservation in this region and agro-climatic condition over conventional tillage.

**Keywords:** Fodder crops, growth, soil moisture depletion, tillage

### Introduction

Identification of an environmental friendly and sustainable crop production system is the demand of the hour for ensuring food security of the globe. Responding to high food demand by modern agricultural technologies leaves its bad foot prints on soil and environment and therefore, use of alternative technologies is now the needful to produce food in a sustainable manner. Conservation agriculture (CA) is one such alternative of modern day agriculture, which aims at sustainable, profitable crop growth and productivity through conservation of environmental resources by various ways (Corsi *et al.*, 2012) [3]. Among the ways, conservation tillage has emerged as a promising option to maintain sustainable food production through minimal soil disturbance and thus ensures environmental safety. The principle of conservation tillage involves maintenance of surface soil cover through retention of crop residues achievable through minimal mechanical soil disturbance. Retention of crop residue protects the soil from direct impact of raindrops (as well as erosion) and sunlight while the minimal soil disturbance enhances soil biological activities as well as soil air and water movement. Further, conservation tillage saves energy, cost and labour, which is very pertinent in present emaciated scenario. In India, fodder crop has always been neglected and livestock productivity thus gets hampered in consequence (Biswas *et al.*, 2019) [1]. In spite of very good livestock resource, surprisingly, this nation produces less quantity of livestock products than desired (Puneeth Raj and Vyakaranahal, 2014) [11]. It is needless to mention that livestock products are very much needed in our daily life and therefore, focus on improvement of livestock productivity simultaneously urges for adequate attention on fodder crop cultivation. Vegetative growth of fodder crops is of prime importance as it is consumed by livestock and researchers are, therefore, trying to implement various agro-technologies to uplift vegetative growth of fodder crops. In spite of numbers of researches, very few attempts have been made to enhance growth of fodder crop using conservation tillage operations (zero tillage and/or minimum tillage) specially, under the unique agro-ecological conditions of Eastern India,

West Bengal. Therefore, the present experiment was planned to evaluate the effect of various tillage practices on growth of fodder crops in new alluvial zone of West Bengal, India.

## Materials and Methods

### Location and field condition

The experiment was carried during summer season of 2016 and 2017 at Central Research Farm, Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur, Nadia, West Bengal, India. The farm is located at the 22°58'19" North latitude and 88°32' East longitude, at an elevation of 9.75 m above from the mean sea level (MSL). The site had been cropped with maize and lathyrus in sequence since last 2 decades. The experimental field was medium land with good irrigation and drainage facilities. As per the modern taxonomical classification, the experimental soil is under the series of Gayeshpur in the order of Entisols. The Gayeshpur series is a member of sandy loam soil and neutral in reaction (pH. 6.9) with available N (0.06%), available phosphorus (24.35 kg/ha), available K (186.50 kg/ha) and bulk density of soil was 1.33 g/cc.

### Trial description

#### Treatment details

The experiment was conducted in split plot design which was replicated thrice. Three tillage practices were allocated in main plot and four fodder crops were placed in sub plot.

#### The tillage practices used were

T<sub>1</sub>: Zero Tillage (Residues of previously grown crop was left on the soil surface; a hand hoe was used to open planting zone and weed control was done primarily by herbicide *viz.* glyphosate @ 5 ml/l), T<sub>2</sub>: Minimum Tillage (Single pass of cultivator and sown with seed drill) and T<sub>3</sub>: Conventional Tillage (Deep ploughing with the help of mould board plough and two disking and a harrowing and plots were prepared to ground level).

#### Different fodder crops chosen for this study were

C<sub>1</sub>: Maize, C<sub>2</sub>: Sorghum, C<sub>3</sub>: Rice bean and C<sub>4</sub>: Cowpea

#### Cultivation details

The crops were sown on 4<sup>th</sup> week of March and harvested at 60 days after sowing (DAS) in each year. Experimental land was prepared and layout was made as per the tillage treatment practices. The varieties *viz.* J-1006 (maize), PC-23 (sorghum), Bidhan Ricebean-2 (rice bean), Bundle Lobia-2 (cowpea) were sown at the seed rates of 55 kg/ha, 25 kg/ha, 45 kg/ha, 25 kg/ha, respectively. Leguminous fodder crops were sown continuously in line while, cereal fodder crops were sown at spacings of 30cm×15cm (maize) and 30cm × 10cm (sorghum). Recommended doses of fertilizers *viz.* 120:50:30 (maize), 100:50:30 (sorghum), 25:60:30 (rice bean) and 20:60:50 (cowpea) N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O kg/ha were applied (For legumes, entire doses were applied at basal while for cereals, 50% of total N were top dressed at 30 DAS apart from basal application of rest of the nutrients). Two irrigations were done at 20 and 40 DAS. Other intercultural practices were carried out as per the standard agronomic recommendations for the region.

#### Sampling and analysis

The samples were recorded from randomly selected five tagged plants for each treatment and mean value was computed. Data regarding parameters such as plant height (cm), leaf area index (LAI), dry matter accumulation (DMA)

(g/m<sup>2</sup>), crop growth rate (CGR) (g/m<sup>2</sup>/day), green forage yield (t/ha) and soil moisture depletion rate (mm/day) were recorded at definite intervals. Dry matter accumulation was measured by taking five plants randomly from each plot and then air-drying followed by oven-drying at 65±1 °C to a constant weight. Soil moisture depletion rate (mm/day) was recorded at 0-15 cm and 15-30 cm depth of soil.

The data recorded from the field was statistically analysed through the analysis of variance method (Goulden, 1952; Cochran and Cox, 1959) [7, 21] and treatment means were compared following critical differences (CD) suggested by Gomez and Gomez (1984) [6] for significance at 5%. Finally, Pearson's correlation coefficient between growth characters and green forage yield at 60 DAS was chalked out.

## Results

Observations recorded during the period of investigation of the present experiment were analysed and are presented and discussed below:

### Effect of different tillage practices on growth attributes of fodder crops

#### Plant height (cm)

It has been found that irrespective of different tillage, the height of plants went on increasing till harvest (60 DAS) in all dates of observation recorded during experimental period. Pooled results (Table 1) expressed that plant height of all the fodder crops (both cereals and legumes) was significantly influenced by different tillage practices throughout the crop growth period and the tallest plant was recorded at 30 DAS (72.6 cm), 45 DAS (125.7 cm) and 60 DAS (164.3 cm) from plot where zero tillage (T<sub>1</sub>) practice was imposed, followed by minimum tillage (T<sub>2</sub>) (71.4 cm at 30 DAS, 121.0 cm at 45 DAS and 157.7 cm at 60 DAS). On a contrary, lowest plant height was observed under conventional tillage (T<sub>3</sub>) in all the observation dates. It has been also found that at initial stage of crop growth (30 DAS), there was no statistical difference between zero tillage and minimum tillage in terms of plant height. However, zero tillage independently stood strongest after wards. Among the fodder crops, sorghum (C<sub>2</sub>) recorded the highest plant height (111.3 cm, 172.0 cm and 208.9 cm) in respective observation dates which was followed by maize (C<sub>1</sub>) (79.4 cm, 136.4 cm and 166.6 cm, respectively). Legume crop rice bean (C<sub>3</sub>), conversely, recorded lowest plant height among all (Table 1). Interaction effect between tillage and various fodder crops on plant height was found to be statistically significant. Maximum plant height (116.4 cm, 178.0 cm and 217.3 cm at 30, 45 and 60 DAS, respectively) was noticed in case of sorghum grown under zero tillage practice (T<sub>1</sub>C<sub>2</sub>) (Table 1).

#### Leaf Area Index (LAI)

The values of LAI were found to be gradually increasing up to 45 DAS and decreasing afterwards irrespective of the different tillage effects (Table 1). However, tillage significantly influenced LAI of fodder crops during the entire growth period. Among the tillage practices, highest LAI values were recorded under zero tillage (T<sub>1</sub>) (1.61, 3.76 and 3.58 at 30, 45 and 60 DAS, respectively). Conventional tillage (T<sub>3</sub>), on the other hand, exhibited poorest influence on LAI (1.47, 3.39, 3.31 at the respective above mentioned intervals). Among the fodder crops, variable response regarding LAI was noticed. At 30 DAS, although maize (C<sub>1</sub>) showed highest LAI (1.61), legume crops expressed their potential afterwards and rice bean (C<sub>3</sub>) recorded highest values of LAI (3.59 and

3.49) at both 45 and 60 DAS, respectively, which was marginally followed by cow pea ( $C_4$ ), maize ( $C_1$ ) and sorghum ( $C_2$ ) (Table 1). Combined result of tillage practices on various fodder crops revealed that highest LAI at 30 DAS (1.73) was recorded by maize grown under zero tillage

( $T_1C_1$ ). At 45 DAS, both maize and rice bean grown under zero tillage ( $T_1C_1$  and  $T_1C_3$ ) recorded the highest LAI (3.79) and at 60 DAS, rice bean grown under zero tillage ( $T_1C_3$ ) showed best value of LAI (3.66) (Table 1).

**Table 1:** Effect of different levels of tillage practices on plant height and leaf area index (LAI) of fodder crops (Pooled of 2 years)

| Treatments                     | Plant height (cm) |        |        | Leaf area index (LAI) |        |        |      |      |      |      |      |      |
|--------------------------------|-------------------|--------|--------|-----------------------|--------|--------|------|------|------|------|------|------|
|                                | 30 DAS            | 45 DAS | 60 DAS | 30 DAS                | 45 DAS | 60 DAS |      |      |      |      |      |      |
| <b>Tillage (T)</b>             |                   |        |        |                       |        |        |      |      |      |      |      |      |
| Zero Tillage ( $T_1$ )         | 72.6              | 125.7  | 164.3  | 1.61                  | 3.76   | 3.58   |      |      |      |      |      |      |
| Minimum Tillage ( $T_2$ )      | 71.4              | 121.0  | 157.7  | 1.56                  | 3.53   | 3.44   |      |      |      |      |      |      |
| Conventional Tillage ( $T_3$ ) | 64.2              | 114.6  | 149.9  | 1.47                  | 3.39   | 3.31   |      |      |      |      |      |      |
| S.Em ( $\pm$ )                 | 0.34              | 0.28   | 0.38   | 0.01                  | 0.01   | 0.01   |      |      |      |      |      |      |
| C.D. at 5%                     | 1.4               | 1.1    | 1.5    | 0.04                  | 0.02   | 0.04   |      |      |      |      |      |      |
| <b>Fodder crops (C)</b>        |                   |        |        |                       |        |        |      |      |      |      |      |      |
| Maize ( $C_1$ )                | 79.4              | 136.4  | 166.6  | 1.61                  | 3.56   | 3.44   |      |      |      |      |      |      |
| Sorghum ( $C_2$ )              | 111.3             | 172.0  | 208.9  | 1.51                  | 3.54   | 3.38   |      |      |      |      |      |      |
| Rice bean ( $C_3$ )            | 36.4              | 65.3   | 103.8  | 1.53                  | 3.59   | 3.49   |      |      |      |      |      |      |
| Cow pea ( $C_4$ )              | 50.6              | 107.9  | 148.6  | 1.55                  | 3.56   | 3.45   |      |      |      |      |      |      |
| S.Em ( $\pm$ )                 | 0.42              | 0.42   | 0.39   | 0.01                  | 0.01   | 0.01   |      |      |      |      |      |      |
| C.D. at 5%                     | 1.2               | 1.2    | 1.2    | 0.03                  | 0.02   | 0.02   |      |      |      |      |      |      |
| <b>Interaction</b>             |                   |        |        |                       |        |        |      |      |      |      |      |      |
| $T_1C_1$                       | 83.1              | 144.2  | 172.8  | 1.73                  | 3.79   | 3.59   |      |      |      |      |      |      |
| $T_1C_2$                       | 116.4             | 178.0  | 217.3  | 1.55                  | 3.74   | 3.49   |      |      |      |      |      |      |
| $T_1C_3$                       | 38.0              | 68.5   | 111.4  | 1.59                  | 3.79   | 3.66   |      |      |      |      |      |      |
| $T_1C_4$                       | 52.9              | 111.9  | 155.9  | 1.59                  | 3.74   | 3.59   |      |      |      |      |      |      |
| $T_2C_1$                       | 82.1              | 135.8  | 167.2  | 1.62                  | 3.53   | 3.44   |      |      |      |      |      |      |
| $T_2C_2$                       | 113.3             | 172.4  | 212.6  | 1.53                  | 3.52   | 3.41   |      |      |      |      |      |      |
| $T_2C_3$                       | 40.2              | 65.9   | 102.9  | 1.54                  | 3.54   | 3.45   |      |      |      |      |      |      |
| $T_2C_4$                       | 49.8              | 109.8  | 148.2  | 1.56                  | 3.53   | 3.43   |      |      |      |      |      |      |
| $T_3C_1$                       | 72.8              | 129.2  | 159.7  | 1.48                  | 3.37   | 3.28   |      |      |      |      |      |      |
| $T_3C_2$                       | 104.1             | 165.6  | 196.9  | 1.45                  | 3.35   | 3.23   |      |      |      |      |      |      |
| $T_3C_3$                       | 30.9              | 61.3   | 97.3   | 1.47                  | 3.43   | 3.37   |      |      |      |      |      |      |
| $T_3C_4$                       | 49.1              | 102.1  | 141.7  | 1.49                  | 3.43   | 3.35   |      |      |      |      |      |      |
|                                | T×C               | C×T    | T×C    | C×T                   | T×C    | C×T    | T×C  | C×T  | T×C  | C×T  | T×C  | C×T  |
| S.Em ( $\pm$ )                 | 0.69              | 0.71   | 0.56   | 0.68                  | 0.75   | 0.70   | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.01 |
| C.D. at 5%                     | 2.3               | 2.3    | 2.3    | 2.2                   | 2.2    | 2.3    | 0.06 | 0.06 | 0.04 | 0.04 | 0.05 | 0.05 |

### Dry matter accumulation (DMA) ( $g/m^2$ )

Dry matter accumulation of fodder crops expressed significant variation under three different tillage practices (Table 2). From the experimental finding (pooled value), it was observed that DMA was highest under zero tillage ( $T_1$ ) at 30 DAS ( $179.08 g/m^2$ ), 45 DAS ( $390.35 g/m^2$ ) and 60 DAS ( $554.87 g/m^2$ ) and it was next followed by minimum tillage ( $T_2$ ) ( $170.01 g/m^2$  at 30 DAS,  $369.22 g/m^2$  at 45 DAS and  $533.33 g/m^2$  at 60 DAS). The lowest DMA for all the intervals was observed in conventional tillage ( $T_3$ ) (Table 2). Among the fodder crops, initially at 30 DAS, sorghum ( $C_2$ ) recorded highest DMA ( $203.50 g/m^2$ ) followed by maize ( $C_1$ ), rice bean ( $C_3$ ) and cow pea ( $C_4$ ). However, after wards, maize ( $C_1$ ) outperformed others by accumulating maximum dry matter ( $483.52 g/m^2$  and  $769.86 g/m^2$  at 45 and 60 DAS, respectively), which was followed by sorghum ( $C_2$ ), rice bean ( $C_3$ ) and cow pea ( $C_4$ ) (Table 2). Interaction effect of between tillage and fodder crops on DMA was also found to be statistically significant. At 30 DAS, sorghum grown under zero tillage ( $T_1C_2$ ) recorded highest DMA ( $219.68 g/m^2$ ). However, at 45 and 60 DAS, maize grown under zero tillage ( $T_1C_1$ ) accumulated maximum dry matter ( $502.65 g/m^2$  and  $783.91 g/m^2$ , respectively).

### Crop growth rate (CGR) ( $g/m^2/day$ )

In response to dry matter accumulation by various fodder crops under tillage practices, crop growth rate also showed the

identical trend (Table 2). Initially, the growth rate of all the crops under tillage practices remained slow which approached peak from 30 DAS onwards up to 45 DAS and then again declined a bit towards crops' harvest (60 DAS). However, among various tillage practices, zero tillage ( $T_1$ ) recorded best CGR ( $5.97 g/m^2/day$ ,  $14.08 g/m^2/day$  and  $10.97 g/m^2/day$ ) as compared to minimum tillage ( $T_2$ ) ( $5.67 g/m^2/day$ ,  $13.28 g/m^2/day$  and  $10.94 g/m^2/day$ ) and conventional tillage ( $T_3$ ) ( $5.27 g/m^2/day$ ,  $13.14 g/m^2/day$  and  $10.53 g/m^2/day$ ) at 0-30 DAS, 31-45 DAS and 46-60 DAS, respectively (Table 2). Among various fodder crops, highest CGR ( $6.78 g/m^2/day$ ) at 0-30 DAS was observed in case of sorghum ( $C_2$ ) followed by maize ( $C_1$ ), rice bean ( $C_3$ ) and cow pea ( $C_4$ ). But later at 31-45 DAS and 46-60 DAS, maize ( $C_1$ ) recorded highest CGR ( $19.59 g/m^2/day$  and  $19.09 g/m^2/day$ , respectively), which was followed by sorghum ( $C_2$ ), rice bean ( $C_3$ ) and cow pea ( $C_4$ ) (Table 2). Interaction effect expressed that sorghum and maize grown under zero tillage showed highest CGR respectively at 0-30 DAS ( $7.32 g/m^2/day$ ) ( $T_1C_2$ ) and 31-45 DAS ( $20.36 g/m^2/day$ ) ( $T_1C_1$ ) (Table 2). However, at 46-60 DAS, maize grown under minimum tillage ( $T_2C_1$ ) recorded highest CGR ( $19.36 g/m^2/day$ ).

### Green forage yield (t/ha)

As a consequence of growth characters, green forage yield of various fodder crops was obtained at 60 DAS. Experimental results explored that zero tillage ( $T_1$ ) produced highest green

forage yield (31.07 t/ha) which was significantly higher than conventional tillage (T<sub>3</sub>) (28.73 t/ha) (Table 2). Among different fodder crops, Cereals outperformed legumes in terms of green forage yield. Maximum green forage yield (41.57 t/ha) was exhibited by maize (C<sub>1</sub>) while, cowpea (C<sub>4</sub>)

produced lowest green forage yield (23.34 t/ha). Interaction effect (Table 2) suggested that maize when grown under zero tillage practice (T<sub>1</sub>C<sub>1</sub>) produced greater green forage yield (42.33 t/ha) as compared to other combinations.

**Table 2:** Effect of different levels of tillage practices on dry matter accumulation (DMA), crop growth rate (CGR) and green forage yield (t/ha) of fodder crops (Pooled of 2 years)

| Treatments                             | Dry matter accumulation (DMA) (g/m <sup>2</sup> ) |        |        | Crop growth rate (CGR) (g/m <sup>2</sup> /day) |           |           | Green forage yield (t/ha) |      |
|--|---|--------|--------|--|-----------|-----------|---------------------------|------|
|  | 30 DAS  | 45 DAS | 60 DAS | 0-30 DAS                                       | 31-45 DAS | 46-60 DAS |                           |      |
| <b>Tillage (T)</b>                     |   |        |        |  |           |           |                           |      |
| Zero Tillage (T <sub>1</sub> )         | 179.08  | 390.35 | 554.87 | 5.97   | 14.08     | 10.97     | 31.07                     |      |
| Minimum Tillage (T <sub>2</sub> )      | 170.01  | 369.22 | 533.33 | 5.67   | 13.28     | 10.94     | 29.85                     |      |
| Conventional Tillage (T <sub>3</sub> ) | 158.19  | 355.29 | 513.25 | 5.27   | 13.14     | 10.53     | 28.73                     |      |
| S. Em (±)                              | 0.60  | 0.92   | 1.11   | 0.02   | 0.03      | 0.09      | 0.06                      |      |
| C.D. at 5%                             | 2.44  | 3.70   | 4.46   | 0.08   | 0.11      | 0.36      | 0.26                      |      |
| <b>Fodder crops (C)</b>                |   |        |        |  |           |           |                           |      |
| Maize (C <sub>1</sub> )                | 189.71  | 483.52 | 769.86 | 6.32   | 19.59     | 19.09     | 41.57                     |      |
| Sorghum (C <sub>2</sub> )              | 203.50  | 396.58 | 546.53 | 6.78   | 12.87     | 10.0      | 30.06                     |      |
| Rice bean (C <sub>3</sub> )            | 143.64  | 309.26 | 416.48 | 4.79   | 11.04     | 7.15      | 24.57                     |      |
| Cow pea (C <sub>4</sub> )              | 139.54  | 297.13 | 402.41 | 4.65   | 10.51     | 7.02      | 23.34                     |      |
| S. Em (±)                              | 1.31  | 0.99   | 0.72   | 0.04   | 0.08      | 0.07      | 0.04                      |      |
| C.D. at 5%                             | 3.92  | 2.96   | 2.17   | 0.13   | 0.25      | 0.20      | 0.12                      |      |
| <b>Interaction</b>                     |   |        |        |  |           |           |                           |      |
| T <sub>1</sub> C <sub>1</sub>          | 197.23  | 502.65 | 783.91 | 6.57   | 20.36     | 18.75     | 42.33                     |      |
| T <sub>1</sub> C <sub>2</sub>          | 219.68  | 420.54 | 577.45 | 7.32   | 13.39     | 10.46     | 31.76                     |      |
| T <sub>1</sub> C <sub>3</sub>          | 150.66  | 325.88 | 434.40 | 5.02   | 11.68     | 7.23      | 25.63                     |      |
| T <sub>1</sub> C <sub>4</sub>          | 148.76  | 312.33 | 423.73 | 4.96   | 10.90     | 7.43      | 24.58                     |      |
| T <sub>2</sub> C <sub>1</sub>          | 190.44  | 484.73 | 775.15 | 6.35   | 19.62     | 19.36     | 41.86                     |      |
| T <sub>2</sub> C <sub>2</sub>          | 201.77  | 392.65 | 544.92 | 6.73   | 12.73     | 10.15     | 29.97                     |      |
| T <sub>2</sub> C <sub>3</sub>          | 145.23  | 305.27 | 412.49 | 4.84   | 10.67     | 7.15      | 24.34                     |      |
| T <sub>2</sub> C <sub>4</sub>          | 142.61  | 294.23 | 400.77 | 4.75   | 10.11     | 7.10      | 23.24                     |      |
| T <sub>3</sub> C <sub>1</sub>          | 181.44  | 463.18 | 750.51 | 6.05   | 18.78     | 19.16     | 40.53                     |      |
| T <sub>3</sub> C <sub>2</sub>          | 189.04  | 376.53 | 517.21 | 6.30   | 12.50     | 9.38      | 28.45                     |      |
| T <sub>3</sub> C <sub>3</sub>          | 135.04  | 296.62 | 402.54 | 4.50   | 10.77     | 7.06      | 23.75                     |      |
| T <sub>3</sub> C <sub>4</sub>          | 127.25  | 284.81 | 382.72 | 4.24   | 10.50     | 6.53      | 22.20                     |      |
|  | T×C   | C×T    | T×C    | C×T  | T×C       | C×T       | T×C                       | C×T  |
| S. Em (±)                              | 1.21  | 2.06   | 1.84   | 1.74   | 2.21      | 1.55      | 0.04                      | 0.07 |
| C.D. at 5%                             | 3.14  | 6.34   | 5.62   | 5.72   | 4.42      | 5.47      | 0.24                      | 0.21 |

### Soil moisture depletion rate (mm/day)

The observations on soil moisture depletion rate (from 0-15 cm and 16-30 cm soil depths) were recorded in two intervals viz. 31-45 DAS and 46-60 DAS. Significant variation of soil moisture depletion rate irrespective of the mentioned soil depths and observation intervals was found under different tillage practices (Table 3). Soil under zero tillage practice (T<sub>1</sub>) exhibited lowest moisture depletion rate at both 31-45 DAS (0.42 mm/day and 0.39 mm/day from 0-15 cm and 16-30 cm soil depths, respectively) and 46-60 DAS (0.46 mm/day and 0.44 mm/day from 0-15 cm and 16-30 cm soil depths, respectively), while soil under conventional tillage practice (T<sub>3</sub>) was reported to cause highest moisture depletion rate (from 0-15 cm soil depth: 0.45 mm/day and 0.48 mm/day at 31-45 DAS and 46-60 DAS, respectively; from 16-30 cm soil depth: 0.43 mm/day and 0.46 mm/day at 31-45 DAS and 46-60 DAS, respectively). Among the fodder crops, during both the intervals, lowest moisture depletion rate (from 0-15 cm soil depth: 0.35 mm/day and 0.38 mm/day at 31-45 DAS and 46-60 DAS, respectively; from 16-30 cm soil depth: 0.32

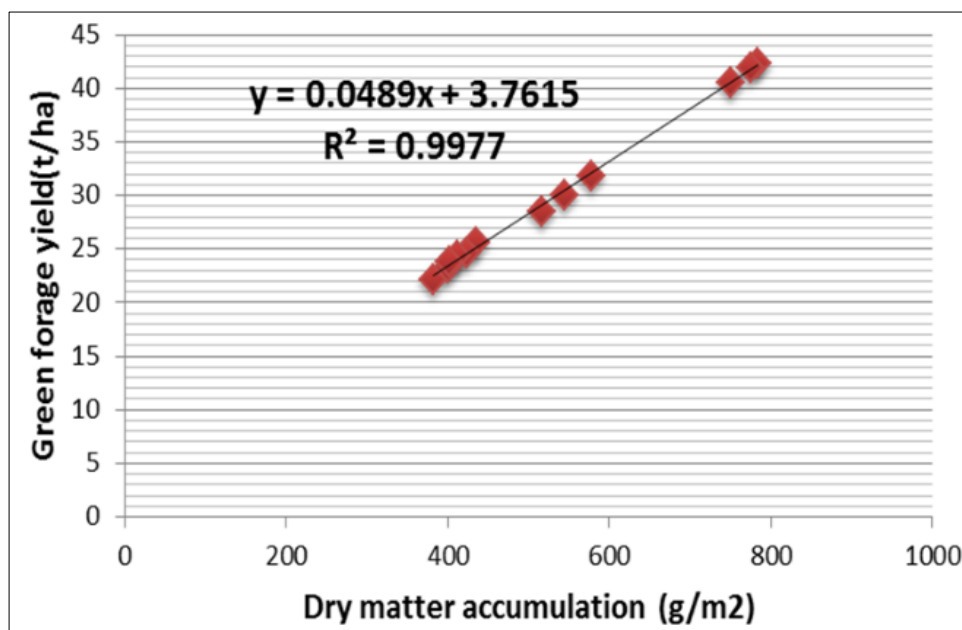
mm/day and 0.36 mm/day at 31-45 DAS and 46-60 DAS, respectively) was noticed from the soil where rice bean (C<sub>3</sub>) was grown, while maize (C<sub>1</sub>) grown plot exhibited highest soil moisture depletion rate (from 0-15 cm soil depth: 0.52 mm/day and 0.56 mm/day at 31-45 DAS and 46-60 DAS, respectively; from 16-30 cm soil depth: 0.50 mm/day and 0.54 mm/day at 31-45 DAS and 46-60 DAS, respectively) (Table 3). Combined results of effect of tillage practices on various fodder crops (Table 3) showed that lowest and highest soil moisture depletion rates were observed respectively from rice bean grown under zero tillage (T<sub>1</sub>C<sub>3</sub>) (from 0-15 cm soil depth: 0.33 mm/day and 0.36 mm/day at 31-45 DAS and 46-60 DAS, respectively; from 16-30 cm soil depth: 0.30 mm/day and 0.34 mm/day at 31-45 DAS and 46-60 DAS, respectively) and maize grown under conventional tillage (T<sub>3</sub>C<sub>1</sub>) (from 0-15 cm soil depth: 0.54 mm/day and 0.59 mm/day at 31-45 DAS and 46-60 DAS, respectively; from 16-30 cm soil depth: 0.53 mm/day and 0.57 mm/day at 31-45 DAS and 46-60 DAS, respectively).

**Table 3:** Effect of different levels of tillage practices on soil moisture depletion rate under various fodder crops cultivation (Pooled of 2 years)

| Treatments                             | Soil moisture depletion rate (mm/day) |  |                |  |               |  |                |  |
|--|---------------------------------------|--|----------------|--|---------------|--|----------------|--|
|  | 31-45 DAS                             |  |                |  | 46-60 DAS     |  |                |  |
|  | 0-15 cm depth                         |  | 16-30 cm depth |  | 0-15 cm depth |  | 16-30 cm depth |  |
| <b>Tillage (T)</b>                     |                                       |  |                |  |               |  |                |  |
| Zero Tillage (T <sub>1</sub> )         | 0.42                                  |  | 0.39           |  | 0.46          |  | 0.44           |  |
| Minimum Tillage (T <sub>2</sub> )      | 0.44                                  |  | 0.42           |  | 0.48          |  | 0.45           |  |
| Conventional Tillage (T <sub>3</sub> ) | 0.45                                  |  | 0.43           |  | 0.48          |  | 0.46           |  |
| S. Em (±)                              | 0.002                                 |  | 0.003          |  | 0.003         |  | 0.003          |  |
| C.D. at 5%                             | 0.01                                  |  | 0.01           |  | 0.01          |  | 0.01           |  |
| <b>Fodder crops (C)</b>                |                                       |  |                |  |               |  |                |  |
| Maize (C <sub>1</sub> )                | 0.52                                  |  | 0.50           |  | 0.56          |  | 0.54           |  |
| Sorghum (C <sub>2</sub> )              | 0.49                                  |  | 0.46           |  | 0.52          |  | 0.50           |  |
| Rice bean (C <sub>3</sub> )            | 0.35                                  |  | 0.32           |  | 0.38          |  | 0.36           |  |
| Cow pea (C <sub>4</sub> )              | 0.38                                  |  | 0.37           |  | 0.42          |  | 0.41           |  |
| S. Em (±)                              | 0.003                                 |  | 0.003          |  | 0.004         |  | 0.004          |  |
| C.D. at 5%                             | 0.01                                  |  | 0.01           |  | 0.01          |  | 0.01           |  |
| <b>Interaction</b>                     |                                       |  |                |  |               |  |                |  |
| T <sub>1</sub> C <sub>1</sub>          | 0.49                                  |  | 0.46           |  | 0.53          |  | 0.51           |  |
| T <sub>1</sub> C <sub>2</sub>          | 0.48                                  |  | 0.45           |  | 0.52          |  | 0.49           |  |
| T <sub>1</sub> C <sub>3</sub>          | 0.33                                  |  | 0.30           |  | 0.36          |  | 0.34           |  |
| T <sub>1</sub> C <sub>4</sub>          | 0.36                                  |  | 0.35           |  | 0.41          |  | 0.39           |  |
| T <sub>2</sub> C <sub>1</sub>          | 0.52                                  |  | 0.50           |  | 0.56          |  | 0.52           |  |
| T <sub>2</sub> C <sub>2</sub>          | 0.49                                  |  | 0.47           |  | 0.53          |  | 0.50           |  |
| T <sub>2</sub> C <sub>3</sub>          | 0.35                                  |  | 0.33           |  | 0.39          |  | 0.36           |  |
| T <sub>2</sub> C <sub>4</sub>          | 0.38                                  |  | 0.37           |  | 0.43          |  | 0.41           |  |
| T <sub>3</sub> C <sub>1</sub>          | 0.54                                  |  | 0.53           |  | 0.59          |  | 0.57           |  |
| T <sub>3</sub> C <sub>2</sub>          | 0.50                                  |  | 0.48           |  | 0.51          |  | 0.49           |  |
| T <sub>3</sub> C <sub>3</sub>          | 0.37                                  |  | 0.34           |  | 0.38          |  | 0.36           |  |
| T <sub>3</sub> C <sub>4</sub>          | 0.40                                  |  | 0.38           |  | 0.43          |  | 0.41           |  |
|  | T×C                                   |  | C×T            |  | T×C           |  | C×T            |  |
| S. Em (±)                              | 0.005                                 |  | 0.005          |  | 0.006         |  | 0.007          |  |
| C.D. at 5%                             | 0.02                                  |  | 0.02           |  | 0.02          |  | 0.02           |  |

**Correlation between growth characters and green forage yield:** Pearson's correlation coefficients (Table 4) expressed that there was highly significant correlations between growth characters and green forage yield of various fodder crops under different tillage practice. Among them, positive and strongest correlation was observed among plant height and LAI ( $r=0.998$ ). However, positive and very strong correlation was also observed between plant height and DMA ( $r=0.982$ ), plant height and green forage yield ( $r=0.982$ ), LAI and DMA ( $r=0.983$ ), LAI and green forage yield ( $r=0.983$ ), DMA and

green forage yield ( $r=0.982$ ). It indicated that tillage exerted significant impact on growth and thereby green forage yield and change in variable caused change in other variables. Fig 1 represented linear relationship between DMA and green forage yield of various fodder crops under different tillage practices. Based on coefficient of determination value ( $R^2=0.9977$ ), it was clear that the linear regression model was able to explain 99.77% variation between DMA and green forage yield. Specifically, change in X-axis provided change in Y-axis (Fig 1).

**Fig 1:** Relationship between dry matter accumulation and green forage yield of fodder crops grown under various tillage practices

## Discussion

Growth attributes such as plant height, leaf area index, dry matter accumulation and crop growth rate of various fodder crops during all the observation intervals were superior when zero tillage was imposed. It has been speculated that as the experimental soil was sandy loam in texture, its loose nature due to good amount of sand content might be enough for plant to perform well and express good vegetative growth without practicing heavy tillage (conventional one). Ewansiha *et al.* (2015) [5] also noticed superiority of zero tillage on cowpea under sandy loam type of soil. Compaction of soil below layers of tilling due to mechanical pressure of tillage implements used under conventional practice might be also there behind its low impact on fodder crop growth. Rabo and Ahmed (2013) [12] similarly reported inferiority of conventional tillage in expressing growth of groundnut as compared to conservation tillage (zero tillage and/or minimum tillage). We have also speculated that minimum disturbance of soil through zero tillage resulted in better root growth, soil aeration, soil structure and aggregation which might be behind such good vegetative growth of fodder crops. Besides, our study reported that conservation tillage practices, especially zero tillage effectively conserved soil moisture (Table 3) and thereby, facilitated in nutrients' movement in soil, their uptake and translocation inside the plant. Effective conservation of soil moisture also ensured greater photosynthesis and light interception which might be some other factors in ensuring vegetative growth of fodder crops. Earlier, Sakthivel *et al.* (2003) [14] also reported the positive effect of tillage on water conservation, nutrient uptake, photosynthesis and thereby improvement of crop growth. Under conservation tillage, improvement of soil organic matter content, mobility of less mobile nutrients near the effective root zone, suitable soil biological activities etc. are also some other reasons behind its better performance over conventional one. Similar findings also were observed by Mukherjee (2019) [10], Rajanna *et al.* (2018) [13] and Khaemba *et al.* (2016) [8] on better growth of barley, wheat and cowpea under conservation tillage over conventional tillage.

It has been noticed that up to 45 DAS, growth of crops was on increasing rate and thereafter, growth occurred at declining rate. This might be due to progress towards end of active vegetative growth phase. Besides, the crops used in this study showed variable response. For instances, cereal crops like sorghum and maize being tall stature exhibited better plant height as compared to legume crops. On the other hand, legume crops produced high leaf area index due to their broad leaf area and land coverage. However, cereal crops specially maize outperformed others regarding crop growth rate due to high dry matter accumulation potential. So, all these variable response of crops regarding expressing growth under tillage practices were because of their variable genetic makeup and morphological differences. As a consequence of positive impact of zero tillage practice on various growth characters of fodder crops, green forage yield was thereby improved under the same. It was probably due to the positive correlation between growth characters and green forage yield as mentioned in Table 4 and Fig 1. Similar types of positive correlation between growth and yield was observed by Das *et al.* (2020) [4] in rapeseed –mustard varieties.

Soil moisture depletion rate expressed that more moisture was depleted from 0-15 cm soil depth as compared to 16-30 cm soil depth. It confirmed the fact of more evapo-transpiration (ET) loss of water from surface of soil as compared to deeper layers. Among the tillage practices, conservation tillage

(specially, zero tillage) caused comparatively lowest soil moisture depletion than conventional tillage. It might be due to the fact that minimal disturbance of soil and adequate residue retention on surface of soil under conservation tillage condition effectively checked ET loss of water and thereby, conserved the soil moisture (Mukherjee, 2015) [9]. In this study, greater soil moisture depletion was observed at 46-60 DAS as compared to 31-45 DAS. We have speculated that as compared to early growth stage, more water uptake to meet the demand of crops under full grown condition at later stage was probably the reason behind such result. Among the crops, soil moisture depletion rate was also found to be variable due to variable crop architectures and genetic variations. Legumes gave full coverage of soil and thereby checked evaporation loss of water to an extent. Soil moisture depletion rate in case of maize was comparatively high. It might be due to greater water demand of the crop during vegetative growth period over others.

**Table 4:** Correlation matrix between growth characters and green forage yield of fodder crops

|                    | Plant height | LAI     | DMA     | Green forage yield |
|--------------------|--------------|---------|---------|--------------------|
| Plant height       | 1            |         |         |                    |
| LAI                | 0.998**      | 1       |         |                    |
| DMA                | 0.982**      | 0.983** | 1       |                    |
| Green forage yield | 0.982**      | 0.983** | 0.982** | 1                  |

\*\*Highly significant

## Conclusion

The two years' pooled experimental results displayed that growth characters of fodder crops as well as soil moisture depletion were greatly influenced by various tillage practices. Overall, the study observed the efficacy of conservation tillage (zero tillage and/or minimum tillage) on growth of fodder crops and soil moisture conservation over conventional tillage and therefore, conservation tillage specially, zero tillage can be recommended to the farmers of new alluvial zone of West Bengal, India for cultivation of fodder crops.

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