Effect of Conservation Tillage on Yield and Economics of Fodder Crops

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Authors’ contributions

This work was carried out in collaboration among all authors. Authors RK and SB carried out the field experiment, conducted the statistical analysis. Author RK performed laboratory analysis. Author SB wrote the article. Authors CKK and KJ planned the experiment and supervised as and when required. All authors read and approved the final manuscript.

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ABSTRACT

In order to find out the efficacy of conservation tillage on yield and economics of fodder crops over conventional tillage in new alluvial zone of West Bengal, a field experiment was conducted at Central Research Farm, Gayeshpur, West Bengal, India during summer season of 2016 and 2017 comprising 3 tillage practices (T₁: zero tillage, T₂: minimum tillage, T₃: conventional tillage) in main plot and 4 fodder crops (C₁: maize, C₂: sorghum, C₃: rice bean, C₄: cowpea) in subplot and replicated thrice in a split plot design. Mean data confirmed the superiority of conservation tillage over conventional tillage in improving soil status and thereby, crop performance. Cereal crop maize when grown under zero tillage produced highest green forage yield (42.33 t/ha), dry matter yield (7.84 t/ha). However, regarding crude protein yield, cowpea showed superiority over others specially when grown under zero tillage condition (1.071 t/ha). Mean data also stated that legume crops under conservation tillage remained economically more viable than cereal crops. Specifically, cultivation of cowpea under zero tillage condition was economically most profitable (B:C of 2.21) and therefore can be recommended in this region.

Keywords: Conservation tillage; economics; fodder crops; yield.
1. INTRODUCTION

Since the ancient days farmers are practicing tillage to create favourable growth condition of the plants. It is one of the basic and vital operations of crop production system. Tillage includes all operations of seedbed preparation that optimize soil and environmental conditions for seed germination, seedling establishment and crop growth [1]. But over the decades, field experiments helped the scientists to understand the concept of tillage management little more finely. The conventional tillage encourages major soil erosion, high soil moisture loss, timeliness considerations, high fuel and labour costs. Appropriate tillage practices are those that avoid the degradation of soil properties but maintain crop yields as well as ecosystem stability. Conservation tillage provides the best opportunity for halting degradation and for restoring and improving soil productivity [1, 2]. According to the previous researchers [3, 4, 5], the no-till system of cultivation with crop residue mulches forms a basis for conservation farming because it conserves water, prevents erosion, maintains organic matter content at a high level, and sustains economic productivity. In recent years interest in conservation tillage systems has increased in response to the need to limit erosion and promote water conservation [6].

According to Biswas et al. [7], livestock productivity is less in India as compared to its potential and it was mainly due to lack of green forage availability. The fact is undoubtedly established that the production of livestock particularly that of ruminants depends on the availability of quality feeds and green forage. Therefore, suitable production strategy must be implemented in fodder crops for enhancing their productivity. In addition to many advantages, obvious benefits of conservation tillage have also included favourable effects on growth and production of fodder crops—both legumes and cereals. Production of green forage under conservation tillage system can lead us one more step closer to maintain livestock productivity and its sustainability. Researches are available stating that both, conservation tillage and legumes maintain and enhance the soil environment, by disturbing the soil less and by adding fertility components to the soil profile. Keeping the above facts in mind an investigation has been carried out with the aim to find out the suitable tillage practice for higher quantitative and profitable production of fodder crops.

2. MATERIALS AND METHODS

Two years (2016 and 2017) of field experiment was carried out at Central Research Farm, Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur, Nadia, West Bengal, India during summer season. The experiment was placed in split plot design under 3 replications. Main plot comprised 3 tillage practices (T\textsubscript{1}: zero tillage, T\textsubscript{2}: minimum tillage, T\textsubscript{3}: conventional tillage), while sub plot consisted of 4 fodder crops (C\textsubscript{1}: maize, C\textsubscript{2}: sorghum, C\textsubscript{3}: rice bean, C\textsubscript{4}: cowpea). The experimental soil was sandy loam in texture and neutral in reaction (pH. 6.9) with organic carbon (OC) of 0.49%, total N of 0.06 %, available phosphorus of 24.35 kg/ha, available potassium of 186.50 kg/ha and bulk density of soil (1.33 g/cc). The varieties of crops (J-1006, PC-23, Bidhan Ricebean-2, Bundle Lobia-2 for maize, sorghum, rice bean, cowpea, respectively) were sown on 4\textsuperscript{th} weeks of March in each year at the seed rates of 55 kg/ha, 25 kg/ha, 45 kg/ha, 25 kg/ha, respectively and harvested at 60 days after sowing (DAS). Legumes were sown continuously in line and cereals were sown at the spacings of 30 cm × 15 cm (maize) and 30 cm × 10 cm (sorghum). Recommended doses of fertilizers for maize, sorghum, rice bean and cowpea were 120:50:30, 100:50:30, 25:60:30 and 20:60:50 N: P\textsubscript{2}O\textsubscript{5}: K\textsubscript{2}O kg/ha, respectively which were entirely applied at basal except the cases of maize and sorghum where total quantities of N were applied in two splits (50% at basal and 50% at 30 DAS). Experimental field was irrigated twice at 20 DAS and 40 DAS. Other agronomic practices were done as per standard recommendations. In case of zero tillage, residues of previous crop (lathyrus) was kept on the soil and only sowing rows were exposed using hand hoe and herbicidal measure (glyphosate @ 5 ml/l) was taken for weed control. In case of minimum tillage, land was prepared with single pass of cultivator and drilling was done to sow the seeds. Conventionally tilled experimental plot was prepared by deep ploughing (25 cm depth) using mould board plough followed by two disking and one harrowing.

Observation included leaf-stem ratio, green forage yield (GFY), dry matter yield (DMY) and crude protein yield (CPY) by cutting the crops at 60 DAS. Crude protein yield was computed by multiplying dry matter yield with crude protein percentage (analysed in laboratory). Thereafter, production economics i.e. cost of cultivation (COC), gross monetary return (GMR), net
monetary return (NMR) and benefit-cost ratio (B:C) was chalked out. Post-harvest topsoil status (pH, organic carbon, total nitrogen, available phosphorus and potassium) was also estimated as per the standard laboratory protocols.

The data were statistically analysed through analysis of variance method [8,9] and treatment means were compared using critical differences (CD) at 5% level of significance [10].

3. RESULTS AND DISCUSSION

3.1 Leaf Stem Ratio

Experimental results (mean of two years) reported that irrespective of tillage practices, leaf: stem of all the fodder crops declined towards the progress of crop growth. It can be speculated that there might be sound photosynthates partitioning and more translocation towards stem than leaf as growth of the crops progressed. Although zero tillage (T₁) exhibited best leaf: stem (1.56, 1.30 and 1.0) throughout the observation period, minimum tillage (T₂) (1.55, 1.28 and 0.99 at 30, 45 and 60 DAS, respectively) remained statistically indifferent with it (Table 1). Among the fodder crops, rice bean (C₃) outshined others with leaf: stem of 1.70, 1.42 and 1.14 at the respective intervals. Sorghum (C₂), on the other hand, expressed lowest leaf: stem throughout the observation period (Table 1). Legume crops produced greater leaf: stem over cereal crops due to their high number of leaves. Interaction effect as shown in Table 1 expressed that rice bean grown under zero tillage (T₁C₃) exhibited highest leaf: stem (1.72, 1.44 and 1.16 at 30 DAS, 45 DAS and 60 DAS, respectively). However, rice bean grown under minimum tillage (T₂C₃) and conventional tillage (T₃C₃) also remained statistically similar to each other and with T₁C₃.

3.2 Yield

Mean data of two years of experiment expressed that tillage practices significantly imparted variable effects on green forage yield (GFY) of all the fodder crops. Conservation tillage (zero tillage and/or minimum tillage) showed superiority over conventional tillage regarding delivering GFY of fodder crops. Specifically, zero tillage (T₁) ensured best GFY of fodder crops (31.07 t/ha), while conventional tillage (T₃) produced lowest quantity of GFY (28.73 t/ha) (Table 2 and Fig. 1). Fodder crops showed variable response based on their variable growth habits due to genetic differences. However, among the crops, maize (C₁) produced highest quantity of GFY (41.57 t/ha), which was next followed by sorghum (C₂) (30.06 t/ha) and legume crop cowpea (C₄), on the other hand, provided smallest quantity of GFY (23.34 t/ha) (Table 2 and Fig. 1).

Similar type of trend was visible in case of dry matter yield (DMY) also. Maximum quantity of DMY (5.55 t/ha) was achieved by practicing zero tillage (T₁) which was next followed by minimum tillage (T₂) (5.33 t/ha) and both those remained superior over conventional tillage (T₃) (5.13 t/ha) (Table 2 and Fig. 2). Experimental results (mean of 2016 and 2017) also showed that among the crops, maize (C₁) produced highest DMY (7.70 t/ha), which was followed by sorghum (C₂) (5.46 t/ha), rice bean (C₃) (4.16 t/ha) and cowpea (C₄) (4.02 t/ha) (Table 2 and Fig. 2).

Crude protein yield (CPY) was dependent on crude protein percentage and dry matter yield of fodder crops. Mean results of two years of experiment revealed that here also, conservation tillage practices outperformed the conventional tillage practice. Highest CPY of fodder crops (0.793 t/ha) was recorded when zero tillage (T₁) was practiced (Table 2 and Fig. 3). Conversely, conventional tillage (T₃) produced lowest CPY (0.720 t/ha). However, unlike GFY and DMY, different trend was visible among the crops in recording CPY. Highest CPY (1.011 t/ha) was produced by cowpea (C₄) which was next followed by rice bean (C₃) (0.850 t/ha) (Table 2 and Fig. 3). On a contrary, lowest CPY (0.446 t/ha) was produced by sorghum (C₂).

Interaction between tillage practices and various fodder crops expressed that highest GFY (42.33 t/ha), DMY (7.84 t/ha) were produced by maize when grown under zero tillage practice (T₁C₁), while lowest GFY (22.20 t/ha) and DMY (3.83 t/ha) were observed in cowpea grown under conventional tillage (T₃C₄) (Table 2 and Figs. 1, 2). However, in case of CPY, cowpea grown under zero tillage (T₁C₄) remained best (1.071 t/ha) over other combinations. On a contrary, sorghum grown under conventional tillage (T₃C₄) produced lowest CPY (0.420 t/ha) (Table 2 and Fig. 3).

Zero tillage performed better over others possibly due to its beneficial effect on soil physico-chemical and biological properties. Better conservation of
Table 1. Effect of tillage practices on leaf-stem ratio of various fodder crops (Mean of 2016 and 2017)

| Treatments | Leaf: Stem |
|------------|-----------|
|            | 30 DAS    | 45 DAS | 60 DAS |
| Tillage (T)|           |        |        |
| Zero Tillage (T₁) | 1.56 | 1.30 | 1.0 |
| Minimum Tillage (T₂) | 1.55 | 1.28 | 0.99 |
| Conventional Tillage (T₃) | 1.52 | 1.24 | 0.96 |
| S.E m (±) | 0.01       | 0.01   | 0.01   |
| C.D. at 5% | 0.02       | 0.02   | 0.02   |
| Fodder crops (C) |           |        |        |
| Maize (C₁) | 1.46       | 1.19   | 0.90   |
| Sorghum (C₂) | 1.41   | 1.14   | 0.85   |
| Rice bean (C₃) | 1.70   | 1.42   | 1.14   |
| Cow pea (C₄) | 1.60     | 1.33   | 1.04   |
| S. Em (±) | 0.01       | 0.01   | 0.01   |
| C.D. at 5% | 0.02       | 0.02   | 0.02   |
| Interaction |           |        |        |
| T₁C₁ | 1.51     | 1.25   | 0.95   |
| T₁C₂ | 1.41     | 1.14   | 0.85   |
| T₁C₃ | 1.72     | 1.44   | 1.16   |
| T₁C₄ | 1.60     | 1.35   | 1.04   |
| T₂C₁ | 1.47     | 1.21   | 0.91   |
| T₂C₂ | 1.42     | 1.16   | 0.86   |
| T₂C₃ | 1.69     | 1.42   | 1.13   |
| T₂C₄ | 1.61     | 1.33   | 1.05   |
| T₃C₁ | 1.41     | 1.12   | 0.85   |
| T₃C₂ | 1.39     | 1.13   | 0.83   |
| T₃C₃ | 1.68     | 1.41   | 1.12   |
| T₃C₄ | 1.59     | 1.31   | 1.03   |
| S. Em (±) | 0.01   | 0.01   | 0.01   |
| C.D. at 5% | 0.04   | 0.04   | 0.04   |

Fig. 1. Effect of tillage practices on GFY of various fodder crops (Mean of 2016 and 2017)
Table 2. Effect of tillage practices on GFY, DMY and CPY of various fodder crops (Mean of 2016 and 2017)

| Treatments | Green forage yield (GFY) (t/ha) | Dry matter yield (DMY) (t/ha) | Crude protein yield (CPY) (t/ha) |
|------------|---------------------------------|-----------------------------|--------------------------------|
| Tillage (T) |                                 |                             |                                |
| Zero Tillage (T₁) | 31.07                           | 5.55                        | 0.793                          |
| Minimum Tillage (T₂) | 29.85                           | 5.33                        | 0.751                          |
| Conventional Tillage (T₃) | 28.73                           | 5.13                        | 0.720                          |
| S.Em (±) | 0.06                            | 0.01                        | 0.001                          |
| C.D. at 5% | 0.26                            | 0.04                        | 0.005                          |
| Fodder crops (C) |                                 |                             |                                |
| Maize (C₁) | 41.57                           | 7.70                        | 0.713                          |
| Sorghum (C₂) | 30.06                           | 5.46                        | 0.446                          |
| Rice bean (C₃) | 24.57                           | 4.16                        | 0.850                          |
| Cow pea (C₄) | 23.34                           | 4.02                        | 1.011                          |
| S.Em (±) | 0.04                            | 0.01                        | 0.001                          |
| C.D. at 5% | 0.12                            | 0.02                        | 0.004                          |
| Interaction |                                 |                             |                                |
| T₁C₁ | 42.33                           | 7.84                        | 0.731                          |
| T₁C₂ | 31.76                           | 5.77                        | 0.474                          |
| T₁C₃ | 25.63                           | 4.34                        | 0.897                          |
| T₁C₄ | 24.58                           | 4.24                        | 1.071                          |
| T₂C₁ | 41.86                           | 7.75                        | 0.716                          |
| T₂C₂ | 29.97                           | 5.45                        | 0.444                          |
| T₂C₃ | 24.34                           | 4.12                        | 0.838                          |
| T₂C₄ | 23.24                           | 4.01                        | 1.005                          |
| T₃C₁ | 40.53                           | 7.51                        | 0.690                          |
| T₃C₂ | 28.45                           | 5.17                        | 0.420                          |
| T₃C₃ | 23.75                           | 4.03                        | 0.814                          |
| T₃C₄ | 22.20                           | 3.83                        | 0.956                          |
| T×C | 0.13                            | 0.09                        | 0.02                           | 0.01                           | 0.002                          | 0.003                          |
| C×T | 0.25                            | 0.31                        | 0.04                           | 0.05                           | 0.008                          | 0.008                          |

soil and water was observed under zero tillage which resulted in greater nutrient availability and uptake [11]. Enrichment soil rhizosphere with greater nutrient mobility and microbiological activity under zero tillage might also be some reasons behind such result. Greater photosynthesis and thereby growth improvement also finally reflected on greater yield achieved under zero tillage. Besides, in sandy loam soil, crop without tilling can perform well. The present study was also made on sandy loam soil. Rajanna et al. [12] observed similar type of result in case of wheat. Among the crops, maize performed better over other due to its genetic makeup. Vigorous growth habit and dry mater accumulation capacity of maize probably made it to attain maximum GFY and DMY. However, legumes showed its superiority regarding CPY. It was due to the fact that legumes contained more crude protein percentage (CP %) as compared to cereals [13]. Better fixation of atmospheric nitrogen and thereby its uptake made the legumes to produce maximum CP % and thereby, highest CPY. Among the legumes, cowpea produced better CPY than rice bean due to its greater CP %.

3.3 Economics

Production economics of various fodder crops (mean of two years) revealed that it was greatly influenced by tillage practices. Greater gross monetary return (GMR) (INR. 43,626/ha) was observed under zero tillage (T₁) practice while lowest GMR (INR. 40,218/ha) was noticed from conventional tillage (T₃). It was due to production of greater economic yield under conservation tillage (specially, zero tillage) over conventional one. As cost of cultivation (COC) was found to less (INR. 23,416/ha) in zero tillage (T₁) practice,
net monetary return (NMR) (INR. 20,210/ha) and B:C (1.86) were also attained highest by it. Oppositely, conventional tillage (T1) due to its high COC (INR. 24,748/ha) provided lowest NMR (INR. 15,469/ha) and B:C (1.62) (Table 3). Among the crops, legumes fetched greater GMR, NMR and B:C over cereals due to their higher market price. Rice bean (C2) created better GMR (INR. 49,145/ha) over others, while sorghum (C3) showed lowest GMR (INR. 30,059/ha). However, NMR (INR. 23,847/ha) and B:C (2.05) were found to be best under cowpea (C4). It was mainly due to comparatively low COC (INR. 22,832/ha) over rice bean (C2) (INR. 25,558/ha). Among the crops, sorghum (C3) provided lowest NMR (INR. 7,215/ha) and B:C (1.32) (Table 3). Interaction results of effect of tillage on fodder crops revealed that cowpea grown under zero tillage (T1C4) fetched lowest COC (INR. 22,240/ha), while rice bean grown under conventional tillage (T3C3) required highest COC (INR. 26,298/ha). However, highest GMR (INR. 51,260/ha) was noticed when rice bean was grown under zero tillage (T1C3). Conversely, lowest GMR (INR. 28,447/ha) was observed in case of sorghum grown under conventional tillage (T3C3). Due to less COC over others, cowpea grown under zero tillage (T1C4) showed highest profitability (NMR: INR. 26,912/ha and B:C of 2.21). Sorghum grown under conventional tillage (T3C2), on the other hand, showed least profitability (NMR: INR. 4,863/ha and B:C of 1.21) (Table 3). Conservation tillage (specially, zero tillage) incurred lowest COC as the use of tilling machinery and operations are kept to a very least level. As already mentioned, although cereals (specially, maize) produced greater yield over legumes, due to greater market value, legumes (specially cowpea) generated better GMR, NMR and profitability, particularly, under zero tilled condition. Earlier, Yigezu et al. [14] confirmed the economic advantages of legume based rotations over mono crop cereal.

3.4 Post-Harvest Status of Topsoil

Mean results of two years’ of study stated that tillage practices impacted significantly on soil pH as well as residual fertility status of top soil (Table 4). Compared to conventional tillage, conservation tillage practices made the soil more acidic. Specifically, highest acidity of topsoil (pH 6.73) was exhibited under zero tillage (T1). It might be due to the accumulation of organic matter at top soil under zero tillage condition resulting in production of electrolyte and thereby,

![Fig. 2. Effect of tillage practices on DMY of various fodder crops (Mean of 2016 and 2017)](image-url)
Fig. 3. Effect of tillage practices on CPY of various fodder crops (Mean of 2016 and 2017)

Table 3. Effect of tillage practices on economics of various fodder crops (Mean of 2016 and 2017)

| Treatments         | Cost of cultivation (COC) (INR./ha) | Gross monetary return (GMR) (INR./ha)* | Net monetary return (NMR) (INR./ha) | B:C    |
|--------------------|-------------------------------------|----------------------------------------|-------------------------------------|--------|
| **Tillage (T)**    |                                     |                                        |                                     |        |
| Zero Tillage (T₁) | 23,416                              | 43,626                                  | 20,210                              | 1.86   |
| Minimum Tillage   | 23,860                              | 41,748                                  | 17,888                              | 1.75   |
| Conventional      | 24,748                              | 40,218                                  | 15,469                              | 1.62   |
| **Fodder crops (C)** |                                     |                                        |                                     |        |
| Maize (C₁)        | 24,798                              | 41,572                                  | 16,774                              | 1.68   |
| Sorghum (C₂)      | 22,844                              | 30,059                                  | 7,215                               | 1.32   |
| Rice bean (C₃)    | 25,558                              | 49,145                                  | 23,586                              | 1.92   |
| Cow pea (C₄)      | 22,832                              | 46,679                                  | 23,847                              | 2.05   |
| S.Em (±)          | -                                   | 101.22                                  | 102.15                              | 0.004  |
| C.D. at 5%        | -                                   | 408                                     | 412                                 | 0.02   |
| **Interaction**   |                                     |                                        |                                     |        |
| T₁C₁              | 24,206                              | 42,331                                  | 18,125                              | 1.75   |
| T₁C₂              | 22,252                              | 31,760                                  | 9,508                               | 1.43   |
| T₁C₃              | 24,966                              | 51,260                                  | 26,293                              | 2.05   |
| T₁C₄              | 22,240                              | 49,153                                  | 26,912                              | 2.21   |
| T₂C₁              | 24,650                              | 41,858                                  | 17,208                              | 1.70   |
| T₂C₂              | 22,696                              | 29,971                                  | 7,275                               | 1.32   |
| T₂C₃              | 25,410                              | 48,674                                  | 23,263                              | 1.92   |
| T₂C₄              | 22,684                              | 46,490                                  | 23,805                              | 2.05   |
| T₃C₁              | 25,538                              | 40,528                                  | 14,989                              | 1.59   |
| T₃C₂              | 23,584                              | 28,447                                  | 4,863                               | 1.21   |
| T₃C₃              | 26,298                              | 47,500                                  | 21,202                              | 1.81   |
| T₃C₄              | 23,572                              | 44,396                                  | 20,824                              | 1.88   |
| **S.Em (±)**      | -                                   | 202.44                                  | 139.92                              | 0.008  |
| C.D. at 5%        | -                                   | 395                                     | 495                                 | 0.02   |

*Market selling price of cereal fodder crops: INR. 1000/t; Market selling price of legume fodder crops: INR. 2000/t; Costs under zero tillage, minimum tillage and conventional tillage: INR. 888/ha INR. 1332/ha and INR. 2220/ha, respectively.
Table 4. Effect of tillage practices on post-harvest status at 0-15 cm depth (Mean of 2016 and 2017)

| Treatments            | Post-harvest soil status at 0-15 cm depth |        |        |        |        |
|-----------------------|-------------------------------------------|--------|--------|--------|--------|
|                       | pH | OC (%) | Total N (%) | Available P₂O₅ (kg/ha) | Available K₂O (kg/ha) |
| **Tillage (T)**       |    |        |             |                       |                      |
| Zero Tillage (T₁)     | 6.73 | 0.51 | 0.063 | 27.99 | 193.23 |
| Minimum Tillage (T₂)  | 6.78 | 0.50 | 0.061 | 25.49 | 189.34 |
| Conventional Tillage (T₃) | 6.87 | 0.48 | 0.054 | 21.12 | 179.56 |
| S.E m (±)             | 0.001 | 0.002 | 0.0001 | 0.10 | 0.21 |
| C.D. at 5%            | 0.01 | 0.01 | 0.001 | 0.26 | 0.85 |
| **Fodder crops (C)**  |    |        |             |                       |                      |
| Maize (C₁)            | 6.83 | 0.49 | 0.055 | 22.72 | 182.65 |
| Sorghum (C₂)          | 6.85 | 0.48 | 0.055 | 23.58 | 183.37 |
| Rice bean (C₃)        | 6.76 | 0.51 | 0.065 | 26.80 | 192.19 |
| Cow pea (C₄)          | 6.73 | 0.51 | 0.064 | 26.37 | 191.30 |
| S. Em (±)             | 0.004 | 0.002 | 0.0001 | 0.12 | 0.35 |
| C.D. at 5%            | 0.01 | 0.01 | 0.001 | 0.56 | 1.04 |
| **Interaction**       |    |        |             |                       |                      |
| T₁C₁                  | 6.77 | 0.50 | 0.058 | 25.26 | 187.89 |
| T₁C₂                  | 6.80 | 0.50 | 0.059 | 26.17 | 188.52 |
| T₁C₃                  | 6.69 | 0.53 | 0.069 | 30.66 | 198.53 |
| T₁C₄                  | 6.66 | 0.52 | 0.068 | 29.86 | 197.97 |
| T₂C₁                  | 6.83 | 0.49 | 0.055 | 23.55 | 183.19 |
| T₂C₂                  | 6.85 | 0.48 | 0.055 | 24.10 | 183.96 |
| T₂C₃                  | 6.75 | 0.51 | 0.067 | 27.30 | 195.85 |
| T₂C₄                  | 6.71 | 0.51 | 0.066 | 27.02 | 194.37 |
| T₃C₁                  | 6.89 | 0.47 | 0.050 | 19.33 | 176.87 |
| T₃C₂                  | 6.92 | 0.46 | 0.051 | 20.48 | 177.63 |
| T₃C₃                  | 6.86 | 0.49 | 0.058 | 22.43 | 182.19 |
| T₃C₄                  | 6.81 | 0.50 | 0.058 | 22.24 | 181.56 |
| **S. Em (±)**         | 0.003 | 0.006 | 0.003 | 0.001 | 0.13 |
| C.D. at 5%            | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 |
| **Initial**           | 6.90 | 0.49 | 0.06 | 24.35 | 186.50 |
reduced N leaching, improved N mineralization, decreased C:N ratio, due to improvement soil OC as zero tillage. Improved residual total N, available P and K showed identical trend of soil OC content. Zero tillage (T2) significantly improved phosphorus content of topsoil under zero tillage practice especially, due to residue retention on the surface and upward movement and accumulation of phosphorus from deeper layers through roots. The result was in conformity with the finding of Yin and Vyn [26]. Among the crops, cereals depleted soil nutrients as they were heavy feeder for their growth and development. Conversely, legume crops through their ability of biological nitrogen fixation (BNF) improved the soil nitrogen content [27]. Besides, legumes also mobilise particle bound phosphorus through root exudates and thereby, improved its availability [28]. Similarly, available potassium content of topsoil was also improved under legume crop cultivation [29]. Like the present results, Armstrong et al. [30] also reported beneficial impacts of zero tillage and legume crop on soil fertility status.

4. CONCLUSION

Overall, the study confirmed the efficacy of conservation tillage over conventional tillage in improving soil status which reflected directly on growth and yield (both qualitative and quantitative) of fodder crops. Consequently, improvement of fodder yield under conservation tillage practices ensured greater economic viability over conventional tillage. Based on the results, cultivation of cowpea under zero tillage can be recommended to the fodder growers of new alluvial zone of West Bengal, India for realizing best qualitative and profitable fodder production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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